TOTAL PERFORMANCE
VAN'S AIRCRAFT

14401 Keil Road NE, Aurora, Oregon, USA 97002
PHONE 503-678-6545 · FAX 503-678-6560 · www.vansaircraft.com · info@vansaircraft.com
Service Letters and Bulletins: www.vansaircraft.com/public/service.htm

IMPORTANT INFORMATION!

READ THIS BEFORE YOU START BUILDING!

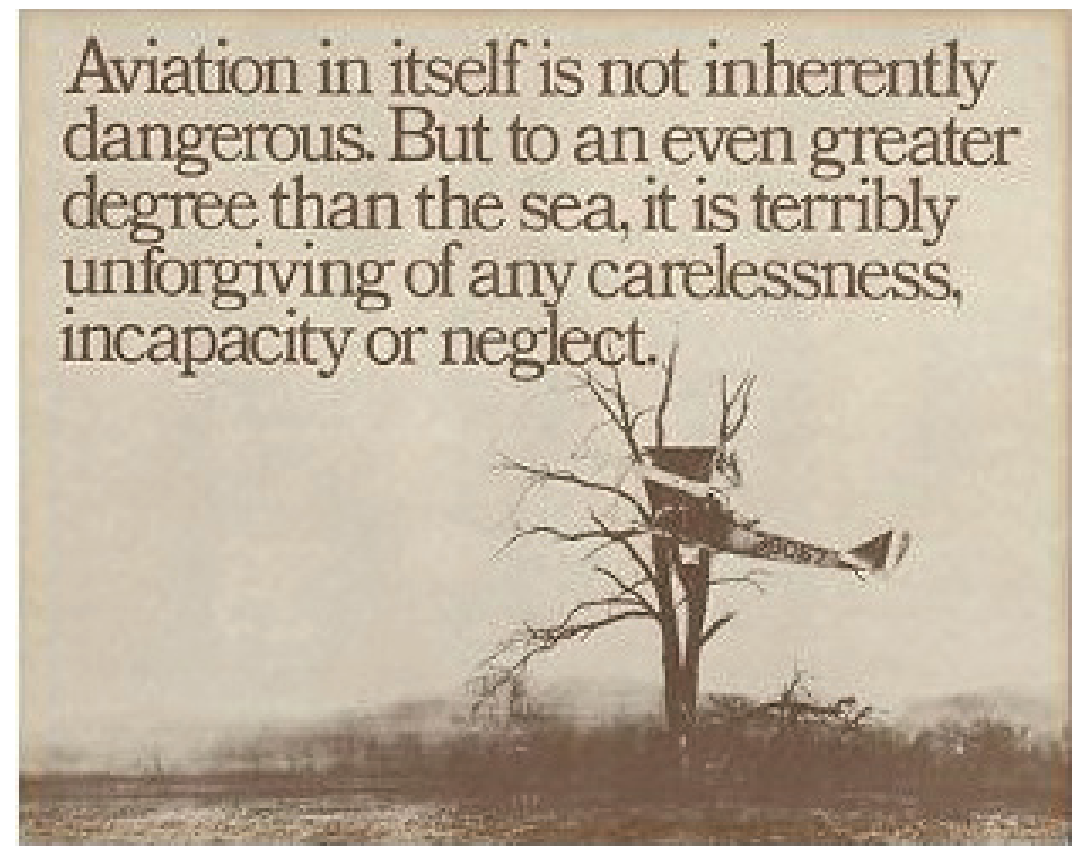
<u>Your life and the lives of those riding in your plane will depend on your attention to detail and safety while building this aircraft</u>.

The documentation provided with your kit is quite comprehensive but does not include all the information that you will need to complete an airworthy aircraft. Your previous experience and choice of systems installations will dictate how extensively you will need to 'supplement' the documentation provided with the Kit. **If you are not absolutely sure about the correct/safest way to complete a particular step during your build, STOP! ...seek help from an experienced, knowledgeable person and/or research that step until you are confident that you have the necessary detail to complete the step in a safe, airworthy manner!**

There are many supplemental sources of information on safe, industry accepted standards for completing any of the tasks involved in building an RV. A quick call to an EAA Technical Councilor or Van's Aircraft Technical Support or even a simple web search will often provide all the information a person needs to safely complete a build step.

We strongly recommend that you utilize these and other sources of supplemental information whenever possible and <u>ALWAYS</u> when there is any question as to the correct/safest way to complete a specific step during the build.

<u>Enjoy your project and remember this…</u>



Captain A. G. Lamplugh,
British Aviation Insurance Group,
London. c. early 1930's.

RV-7/7A CONSTRUCTION MANUAL

MARCH 2001

MY BUILDER NUMBER

VAN'S AIRCRAFT, Inc.

14401 NE KEIL ROAD
AURORA, OR 97002
503-678-6545 FAX: 503-678-6560
www.vansaircraft.com e-mail support@vansaircraft.com

U.S. Department of Transportation
Federal Aviation Administration

Transport Airplane Directorate
Aircraft Certification Service
Seattle MIDO
2500 East Valley Road, Suite C2
Renton, Washington 98055

September 6, 2001

Van's Aircraft, Inc.
14401 NE Keil Road
Aurora, Or 97002

Dear Mr. VanGrunsven:

The Federal Aviation Administration (FAA) has completed evaluation of the RV-7/RV-7A kit. We have determined that the kit, as evaluated at your facility on September 5, 2001 and defined by the parts list dated 3/20/01, meets the intent of Federal Aviation Regulations (FAR) §21.191(g) because the major portion of a completed aircraft may be fabricated and assembled by person(s) who will undertake the construction project solely for their own education or recreation. The FAA Engineering and Manufacturing Branch, AFS-610, will notify the appropriate FAA field offices of the eligibility of the kit and add the kit to the listing of eligible amateur-built aircraft kits.

This evaluation should not be construed as meaning the kit or Van's Aircraft, Inc, is **FAA CERTIFIED, CERTIFICATED, OR APPROVED** and is not appropriate to represent it as such. The kit may be represented as eligible for airworthiness certification under FAR §21.191(g).

Copies of the kit parts list, identified by the date and/or revision, should be provided with kits supplied to customers. This will assist builders in identifying the configuration of the kits to personnel who will be responsible for determining the eligibility of the completed aircraft for airworthiness certification.

If ownership of the company changes, there is a change in the manufacturing facility location, or changes are made to the kit that affect fabrication and assembly operations, this FAA Manufacturing Inspection Office (MIO) shall be notified.

Failure to notify this MIO may result in removal of the kit from the listing of eligible amateur-built aircraft kits.

Sincerely,

for Linda Nava

Kaylene C. Yanamura
Manager, Manufacturing
Inspection Office.

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NOTE:

Van's Aircraft Inc. kits are carefully designed and tested. They will demonstrate performance very close to quoted figures with the engines and propellers recommended. Van's Aircraft recommends that the kits only be assembled according to the supplied plans. If the builder chooses to deviate from the plans and install a non-standard engine or to modify the aircraft to a configuration other than what is called out in the plans, he or she is assuming responsibility for the airworthiness of that modification and any effect it may have on the airworthiness of the airframe and/or powerplant. Technical support may not be available for modifications that deviate from the plans nor for installations that are not specifically recommended by Van's Aircraft.

Keep in mind that insurance companies may not be willing to write a policy on an aircraft that has been modified to a configuration other than that recommended by the manufacturer. Prior to modification, the builder should check with their insurance provider regarding this matter.

If a kit is modified in any significant manner, it should not be considered an RV (type) for registration purposes.

A WORD ABOUT THE PLANS:

When the kits are shipped, they have the latest plans and manual revisions. The plans match the parts as shipped. Over time, we make changes, corrections and improvements to the manual and plans. There is no need to request newer versions. New drawings may not match the parts that you have. Changes of a minor nature are published in the bi-monthly newsletter, the Rvator. Builders are strongly urged to subscribe to the Rvator at least until the project is completed.

If there is a significant change to the kit that affects flight safety, we will send letters to all builders effected. Service Bulletins are posted on our web site as well as published in the Rvator.

INTRODUCTION

Welcome to the wonderful world of homebuilt aircraft. The project you are about to undertake (assuming that this is your first homebuilt airplane) will probably be the most frustrating, time-consuming, enjoyable, fulfilling, and rewarding that you have ever experienced. The ultimate success of this project is determined by many factors, the most important of which only you control. These include your skills, patience, willingness to learn, willingness to seek help when necessary, and a firm desire to create for yourself a very special, high performance, personal airplane.

The Federal Aviation Administration allows us to build and fly experimental aircraft for the purpose of <u>education</u> and recreation. The <u>education</u> part is up to you. This instruction manual is to help you achieve your goal. Though we have made it as detailed and instructive as we feel is practical, it does not supply everything you need to know to complete an RV. These instructions tell you how to build an RV, and pre-supposes that you already know (or will learn) the basics of aluminum aircraft construction. We have listed several books and manuals that are helpful in this regard. We also present some general sheet aluminum working information, but caution that this manual alone can not be viewed as a complete education on the subject.

In addition, this manual is written on the assumption (based on our many years in the plans/kits business) that nearly all RVs are built from kits of pre-formed, pre-bent, and pre-molded materials. We do not cover these manufacturing operations in depth, and consider that those choosing to build an RV from raw materials either have these skills and knowledge, or will acquire them elsewhere.

Additional help during construction can be had by becoming a member of the Experimental Aircraft Association (EAA), reading their *Sport Aviation* magazine, and most of all, by being an active member of one of their 600+ chapters. Associating with other homebuilders, particularly RV builders, can be extremely helpful, and can even make the difference between success and failure of your project. It can provide actual building assistance, technical knowledge, and moral support.

In many places RV builders have formed their own organizations, often modeled on EAA chapters. They publish newsletters hold regular meetings and exchange techniques, information and tools. We have been highly impressed by the craftsmanship and camaraderie demonstrated by these Builders Groups and encourage any RV builder to join or form one whenever possible. (A list of Builders Groups and contact persons is available from VAN'S AIRCRAFT.) Building an airplane is a big undertaking, and a builder should never be too proud or individualistic to take advantage of what others have to offer. It is indeed a rare person who is so skilled that he or she cannot benefit from others.

CERTIFICATION AND REGISTRATION

Amateur built aircraft must be inspected and certified by the Federal Aviation Administration before flight. The FAA has made a package available, spelling out the steps a homebuilder must take before his or her airplane is allowed to fly. Contact your nearest General Aviation (GADO) or Flight Standards (FSDO) Office of the FAA for this package, which also includes information on the Repairman's Certificate and the useful Flight Testing Handbook.

Foreign builders should contact the appropriate agencies of their governments for regulations that pertain to them.

VAN'S BUILDER ASSISTANCE

Van's offers builders assistance on the telephone between the hours of 7:00AM to 9:00AM and 3:30PM and 4:30PM Pacific Time. You can also e-mail us at <u>support@vansaircraft.com</u>. Please, for speedier answers when you call, have your plans with you and be ready with your 5-digit customer/builder number. When e-mailing questions please refer to the plans page and what plane you are building. Also, include your customer/builder number.

COMMERCIAL ASSISTANCE

Particularly with the more expensive kits for exotic airplanes, buyers have been hiring private individuals or small Custom Builder shops to assemble the kits for them. While this procedure did not and does not necessarily constitute a violation of FAA rules, it can contradict the FAA intent. While the argument has often been made that an experienced "Custom Builder" can build a safer aircraft than a first-time homebuilder, that determination is not the real issue.

Yes, safety is the paramount concern at the FAA--that is the reason for their existence. That's why certification requirements for production aircraft exist, to set design standard and quality control procedures. It seems fair to

state the FAA's position as: "If you want to be a manufacturer and build an airplane commercially (for hire), then you must comply with FAR Part 23 certification requirements. If you want to by-pass the extensive requirements of FAR 23, you can do so through the Experimental Amateur-built category, but only if you comply with the intent (education and recreation) of that sub-category."

As mentioned above, paying for or accepting payment for the construction of an aircraft is not in itself a violation of any regulation. The possibility of violation occurs when the applicant for airworthiness inspection of an amateur built aircraft must signify on an affidavit that he or she has constructed that aircraft "For the purpose of education and recreation." Falsification is punishable by a penalty of up to $10,000 fine, five years imprisonment, or both.

In April 1996, the FAA published Advisory Circular 20-139 “Commercial Assistance during Construction of Amateur-Built Aircraft”. This document, available on the FAA web site, should be studied carefully by anyone considering using commercial assistance when building a homebuilt. The "commercial assistance" issue is really one of FAA enforcement. Our purpose here is providing you an understanding of the nature and background of this issue, so that you will know what is expected and permitted during the construction and licensing of your homebuilt.

HELPFUL BOOKS AND MANUALS

AIRCRAFT SHEET METAL CONSTRUCTION AND REPAIR

SHEET METAL, Vol. #1

THE SPORTPLANE BUILDER

FIREWALL FORWARD

SPORTPLANE CONSTRUCTION TECHNIQUES

CAM 18 MAINTENANCE, REPAIR, AND ALTERATION OF AIRFRAMES, POWERPLANTS, AND APPLIANCES

THE AEROELECTRIC CONNECTION (A great source for wiring information)

BUILDING THE METAL AIRPLANE

LIGHT AIRPLANE CONSTRUCTION

STANDARD AIRCRAFT HANDBOOK

FAA ADVISORY CIRCULAR 41.13

Sources for some or all of these include:

Van's Aircraft, Inc.

Robert L. Nuckolls III (The Aeroelectric Connection)
6936 Bainbridge Rd
Wichita, KS 67226
316-685-8671

Avery Enterprises
411 Aviator Drive
Ft. Worth TX 76179
phone: 817-439-8400
1-800-652-8379
fax: 817-439-8402
www.averytools.com

Builder's Bookstore
PO Box 270
Tabernash, CO 80489
970-887-2207
<u>www.buildersbooks.com</u>

Experimental Aircraft Association
PO Box 3086
Oshkosh WI 54903-3086
<u>www.eaa.org</u>

SECTION 2: DESIGN PHILOSOPHY

Before getting into the construction details of your RV, let's take a look at the design philosophy and goals that are the basis for this airplane. The goal was to achieve the maximum overall performance, flying enjoyment, ease of construction, building and flying economy, ease of maintenance, and pleasing appearance possible for a two-place airplane. Understanding how this was achieved might help you better appreciate many of the RV's features as you encounter them during construction.

The formula for achieving total performance is amazingly simple: Maximize thrust, minimize drag; maximize lift, minimize weight. The implementation of this formula is a bit more complex, however. Thrust, for a given HP engine, has been maximized through use of a good propeller, streamlining of the engine cowl (through the use of a crankshaft extension), and directing the engine outlet rearward. Drag was minimized by keeping the aircraft frontal area to a minimum, using smooth surfaces, and shaping all airframe components to reduce aerodynamic drag. Lift was maximized through use of a wing with adequate area, good airfoil, and smooth surface finish. Weight is minimized by careful structural design, by using the best airframe materials, and by installation of only essential instrumentation and equipment.

Most of the literally hundreds of features which comprise the overall RV package have been determined in the design stage and involve no choices for the builder unless he chooses to make major modifications. There is little that a builder is likely to do which will have much effect on either thrust or lift of his RV. However, construction techniques and choices of installed equipment can have noticeable effects on both drag and weight; the archenemies of performance.

The RV's “traditional” configuration; tractor engine, monoplane, stabilizer in the rear, is an exercise in logic, not simply a concession to convention. There are many good reasons why light planes have been built this way for decades, other than the often heard arguments of “entrenched design mentality” from those seeking “technological breakthroughs”. The bottom line is that this configuration has proven to offer the best compromise resulting in the best all around airplane. A discussion of every factor involved in analyzing and choosing each design feature is too involved for this presentation. However, let's examine one choice; tractor vs. pusher engine/prop installations.

Pusher engine/props have always intrigued designers. They offer the possibility of drag reduction, by eliminating the disturbed airflow over the fuselage and inboard wing surfaces, and contribute to better cockpit visibility. So far so good, but with the propeller aft of the main wheels, ground clearance becomes a problem as rotation is required for take-off and landing. If the pusher engine and prop are located near the trailing edge of the wing, this problem is minimized, but others are encountered; i.e.: the blunt shape of the aft fuselage and the need to build a more complex twin boom arrangement. The end result is of questionable value from the drag reduction standpoint. Locating the prop at the extreme rear of the airplane, behind the tail surfaces, optimizes streamlining but requires a complex, heavy, and expensive drive shaft system between the engine and prop. Either way, engine cooling is impaired. One other seldom discussed drawback of a pusher is that, for any given take-off and landing requirement, it will require more wing area (and thus additional weight and drag) than a tractor. Ironically, the reason for this is the same as given as the benefit of the pusher configuration; the fuselage, inboard wings, and tail surfaces are out of the prop stream. Without the accelerated airflow from the tractor propeller over these surfaces, some lift and controllability is lost, thus requiring a higher landing speed for any given wing loading. The point is, some otherwise good ideas don't always work well in the real world.

The constant chord wing planform chosen for the RV-3/4/6/7/8 series offers the ultimate in construction ease, stability, and lifting ability. The possible drag and aesthetic penalties for the rectangular wing are negligible in light of its advantages. The airfoil used is a modified NACA 23013.5, an old wing section often maligned in “airfoil selection” articles and texts. However, this basic airfoil section has been used on some of the world's most successful airplanes ranging from the Taylorcraft and Helio Courier on one end of the scale, to the Turbo Commander and even the Cessna Citation on the other end. Others using it include the DC-3, all tapered wing Beechcrafts, and many of the Cessna twins.

The RV-9 series uses a Roncz airfoil, designed specifically for the job the RV-9 is intended to do.

In addition to a good stable wing planform, the RVs incorporate a relatively long fuselage along with large tail surfaces for plenty of control authority.

Seating arrangements vary between the RV designs, depending on the primary mission envisioned. Side-by-side seating was chosen for the RV-7/9 because this arrangement is generally preferred for its primary mission: cross-country flying. Specific advantages of the side by side configuration include equal visibility for both occupants, more easily achieved dual control capability, lots of instrument panel space, minimized CG travel for various loading conditions, and a full cowling with room for engine accessories and plumbing.

Tandem seating was chosen for the RV-4 because this arrangement offers lower drag, better pilot visibility, and better aesthetics with more appeal to the “sport" pilot. Because the visibility is better, the airplane is flown solo from the front seat. Handling and center of gravity would be better with rear seat solo, but visibility is of sufficient importance to override these considerations. The superb front seat visibility of the RV-4 adds much to its ease of landing and the feeling of confidence experienced by the pilot.

The RV-8/8A retains all the advantages of tandem seating, but the roomier cockpit and second baggage compartment make cross-country travel more comfortable and practical. The full width cowling was designed to handle engines up to 200 horsepower.

Designers often use the term “Mission Profile” which simply refers to the function an airplane is designed to perform. The RV's mission profile is rather broad -- they were intended to fill nearly all sport flying needs - speed, STOL, limited sport aerobatic. Meeting all these needs required a design “balancing act". Favoring one need often adversely affects others. An example would be emphasizing cross country cruise performance by installing extra radio, instruments, and upholstery. The weight added would adversely affect all other performance parameters. This is not a “maybe”, it is a certainty. Whether the trade-off is worthwhile is a decision that can only be made by the builder.

We feel that an RV in its basic form with fixed pitch prop, modest instrumentation and radio, and a carburated engine, represents the best compromise.

Cruise speed of an RV can best be improved by reducing drag through attention to finish and fitting details. Constant speed props do not necessarily improve cruise speed, but they do offer the opportunity for RPM control, which improves cruise fuel consumption. Additions of instrumentation, radio, and interior appointments do not help cruise speed, but do add to the ease and comfort of X-C flying.

STOL performance, or at least take-off and climb, can be improved with a constant speed prop. However, under most conditions, landing performance dictates field length requirements, so the constant-speed would offer unneeded performance at the expense of dollars and weight.

Obviously, we could go on and on, covering every design decision, compromise, or concession. However, it should be obvious by now that every feature of the RVs, whether major or minor, was the end product of much deliberation. In almost all instances, these features are so inter-related that altering one will affect several others; meaning that a builder should not consider making changes unless he is willing and capable of analyzing the *overall* impact of the change.

SECTION 3: TOOLS AND WORKSPACE

While building an RV requires some investment in special tools, most builders with home workshops already own many of the basics. In addition, there are a number of tools which are nice to have, but not essential. See the *Builder's Tool Requirements* list in this section for specific tool types and sizes required.

Unless you live in a major metropolitan area, you probably have to order specialized tools by mail or online. Several mail order tool houses offer excellent quality and service. Van's surveyed RV builders about the quality and service provided by the various mail order tool houses. The results generally agreed with the old adage: "you get what you pay for." Inexpensive tools often proved to be of inferior quality, resulting in frustration and poor results. We have supplied a list of tool suppliers in our printed and online catalogs.

STATIONARY TOOLS

Bench Grinder: A bench grinder with a Scotchbrite polishing wheel is extremely useful. While the edges of sheet metal parts can be deburred and/or sanded smooth, the grinder will save many hours. Grinders with totally enclosed motors will endure the abrasive dust better.

Belt sander: Many builders report that a benchtop 1" belt sander is one of their most used tools. Most of the jobs it does could be accomplished with a file and sandpaper, so it is not essential, but it will save a lot of time.

Air Compressor: Output and tank volume are not critical, but it should be capable of 75 psi. If you plan to use rotary air tools like air drills or die grinders, a larger tank (20 gallons or more) will keep the compressor from running continuously. Any 1 1/2 to 2 hp home shop compressor with enough volume to power a spray gun will be adequate. If lower noise level is desired, a compressor that uses a belt and speed reduction pulleys is preferable.

Band Saw: Another non-essential but handy tool.

Drill Press: One of the most useful auxiliary tools. Kit builders can manage without, but will find many uses if they have one.

HAND TOOLS

Hand Held Drill Motor: A 1/4 or 3/8 inch electric hand drill will do. A variable speed reversible drill is better. Battery drills can be convenient, and some of the high power, high rpm models do an excellent job. A minimum of 1100 to 1200 rpm are necessary. Two or more electric drill motors is a good idea. For instance, you might have a drill bit in one, and a machine counter-sink in another. They are cheap enough to make this convenience affordable. Air drills are preferred by many builders because of their small size, high speed, and variable speed feature. They do use a lot of air, however, so plan on having a compressor with a larger tank.

Drill Bits: The basic tool of RV building. We have found that High Speed Steel bits work well for small holes. "Split point" drill bits, either the 118 deg or the 135 deg, work especially well, giving a clean start and a round hole. Split points almost eliminate the ugly "worm track" left when a bit does not start cleanly and spins off across the work-piece. Plexi or plastic drilling bits are designed to minimize the risk of chipping or cracking.

Unibits: Also known as step drills. Drilling holes larger than 1/4 inch in thin sheet metal with a twist drill often results in distorted holes or parts. The Unibit cuts these larger holes in sheet aluminum cleanly and quickly, and also work very well in plexiglass. They are stepped in 32nds and 16ths of an inch.

Deburring bits: Several styles are available. A hand swiveling type is inexpensive and works well. Adapters that fit deburring bits to slow turning electric screwdrivers and hand drills have become popular for large jobs, such as deburring big skins. Three flute deburring cutters are widely available and generally work well, but they do have a tendency to chatter. Single flute deburring bits work beautifully.

Rivet Gun: The 3X size is preferred by most builders, although good results are possible with the lighter duty 2X. Better guns are distinguished by a progressive or variable "hit" rate controlled by trigger squeeze. With a good gun, it is possible to drive various size rivets without changing the air pressure or flow rate. Lower quality guns tend to be single speed tools, which means that once you pull the trigger, you get all of the speed and force that the line pressure will produce. The only control you then have is the duration (how long you hold the trigger down) or the line pressure. An inexpensive air flow regulator installed at the air inlet of the gun is essential on these lower quality guns and is a useful accessory on the better guns as well. Many "air chisel" pneumatic tools are now available for prices far below the cost of a rivet gun. They look similar to aircraft rivet guns, but they won't do the job very well. Saving $150 on a rivet gun but ending up with several thousand bad looking rivets is not a good trade.

Rivet Cutter: Needed for shortening rivets when the exact length rivet is not available. Not used too often, a good pair of wire snips can be used instead.

Rivet Sets: Several are required. Some builders prefer a flush set with a rubber guard around the edge to help eliminate "smiles" in the metal. Others don't. A flush rivet set with a swivel joint between the face and the shaft is available. This will help eliminate "smiles" by keeping the face of the set square to the work, even if the gun is held at a slight angle. These come with a rubber guard that must be sanded back flush with the face of the set.

Dimple Dies: Many of the skins are too thin to machine away metal for the countersunk rivets and screws, and dimpling is required. Dimple dies, made from high quality tool steel, come in male/female pairs. Used in a squeezer, they form rivet shaped depressions in sheet metal.

Pop-rivet Dimple Dies: A special version of the dies above works with a pop rivet tool. Not used often, but goes where no other tool can go. They use a common nail as a mandrel.

Bucking Bars: It seems that one never has enough sizes and shape bucking bars. Fortunately, any smooth piece of steel with a sufficient mass can be used for a bucking bar. Get two or three good all-around bars, and improvise with anything you have laying around the shop when you encounter a riveting situation where these won't fit.

Hand Seamer: Required for bending small tabs and flanges, and for straightening or re-aligning major flanges.

MicroStop Countersink: or "machine countersink cage". This tool holds a piloted cutter and has a micro-adjustable sliding sleeve to set the depth of cut. Only one is necessary, but two, set up with different cutters, are a nice convenience.

Cleco Fasteners: Cleco is a trade name which has come into common use to mean Temporary Sheet Metal Fastener. This is a little cylindrical shaped device about the size of a 45 caliber bullet. It has a spring loaded barbed pin in the end which fits into a drilled hole in two or more thicknesses of sheet and locks them together. More is better....many builders measure them by the quart.

Cleco Pliers: As the name implies, this is a pliers-like tool used for installing and removing temporary sheet metal fasteners.

C-Clamps: About 2 inch size.

Other Clamps: You can never have too many spring clamps. They are a quick and inexpensive way of setting up and holding assemblies together. Do not trust them to hold parts in alignment when drilling -- the springs do not provide enough clamping pressure to resist power tools. There are many types of cam clamps, almost like mini-vice grips available from different manufacturers. They hold much better than spring clamps and are usually a worthwhile investment.

Metal Cutting Snips: 3 types required. Right hand, left hand, and straight cutting. WISS brand cutters are widely used. The right and left hand cutters usually have serrated edges which help in cutting curves, but leave small marks on the edge of the aluminum. Choose a straight snips with smooth jaws for the neatest possible cuts.

Pop-Rivet Puller: Used to set blind or pop-rivets. Most commonly available flush head Blind Rivets (often referred to as Pop-rivets, a trade name) have 120 deg. head angles rather than the 100 deg. for flush head AN rivets. Thus, special dimple die sets are needed for a perfect fit, although almost all builders we know use regular dimple dies and report acceptable results. We recommend using the "Pop" Riveter PRP-26A, USM Corp., which will fit into the tighter spaces better than other rivet pullers. Although not required, a pneumatic puller is useful and can be run with a small air-compressor.

Body File: Also known as a Vixen file or a SuperShear (Nicholson brand name.) Distinguished by the crescent shaped cutters across the width of the file. Not an absolutely essential tool, but is very useful for smoothing the edges of thicker gauges of aluminum.

Files: A minimum of 3 or 4 will do. Small round, flat, and flat-face/round back.

Protractor/Carpenters Level: A bubble protractor can measure the angle of any surface from a horizontal or vertical reference plane. The carpenters level (2-3 ft. in length) is useful in measuring the horizontal and vertical alignment of RV parts and structural components. A bubble protractor mounted on a straight edge of comparable length will serve the same purpose. Either the bubble protractor or the level should be checked for accuracy before use. This can be done by finding a level (or nearly level) surface and laying the level on it. Note the position of the bubble, and then reverse the level end for end. Now check the bubble position again. If not the same, loosen the adjustment screw on the bubble and re-position. Then switch ends again and re-check. Repeat until the reading is the same regardless of the orientation of the level. Use digital protractors and levels or "smart" levels whenever possible.

Circle Cutter: Also known as a fly-cutter. Used for cutting lightening holes in ribs and other thin webs, plus instrument panel holes. A wicked little tool that can cause nasty damage to hands and unguarded body parts. Should be used in drill press only, never on a hand-held drill.

Fluting Pliers: Used for crimping rib flanges, etc. to effectively shrink them and straighten the part. Several styles are available. We prefer pliers that leave a crisp indentation, and avoid the type with the large rubber tips. These make a wide shallow flute which gives less flat area for rivets.

Edge Deburring Tools: A selection of tools as listed in the required parts list. Deburring tools are used for rounding and smoothing the edges of sheet metal parts.

Hand Rivet Squeezer: Used for dimpling and setting rivets near material edges. There are cheap ones on the market, but they give poor results. Spend the money.

Pneumatic Rivet Squeezer: Used for dimpling and setting rivets near material edges. More expensive than the hand rivet squeezer, but much easier on the arms.

Paint Spray Gun/Respirator: Priming of internal parts of an RV requires a spray gun. Almost any quality gun will do because primer finishes are not as critical as exterior painting. One of the biggest problems involved in priming is cleaning up. Often only a small amount of priming is needed. Small spray guns with disposable cup reservoirs are adequate for priming. Clean up of the spray nozzle is very simple, and the spray pattern quality is more than adequate for priming.

Respiratory protection from primers and paints should not be taken lightly. Those warnings are on paint cans for a reason! A good respirator (not a dust mask) is essential. In the last year or two, "fresh air" spray systems, using an oil-less compressor to supply fresh air from a remote source to a respirator or spray helmet, have become affordable.

Hand Riveting and Dimpling Tool: This hand operated, bench mounted riveting and dimpling tool is one of the most useful tools a builder could have. It consists of a large "C" shaped frame with a driver and anvil at the open end. The driver shaft and anvil have guides and holders for the rivet sets and dimple dies. It uses the same dies as do the rivet guns and hand rivet squeezers previously discussed. The force for doing the riveting or dimpling is provided by hitting the guided tool holder with a hammer. Because the dies and sets are held accurately in place, good quality dimpling and setting is simple. The depth of the "C" frame is sufficient to dimple almost all the skins on RVs. It is rigid enough to permit setting rivets up to 3/16 inch dia., so some builders use it even for the heavy riveting on the main wing spar (older model kits).

Torque wrench: This is a must have tool. Get one calibrated in inch-pounds, a foot pound wrench will do you no good. Aircraft nuts and bolts have specific torque values (see the Standard Aircraft Handbook or the table reprinted in Section 5V of this manual) that can only be set accurately with this tool. It is very easy to over torque the small AN3 (10-32) bolts without one.

Taps: Used to add internal threads to drilled holes. See required tool list for specific sizes.

Tubing bender: Although there are not a lot of aluminum tubes in the RVs, those that are there need to be bent properly. Fuel lines, pitot lines etc. need to be kink free.

Tubing Flaring Tool: Fuel lines need to have the proper 37° flare on the end in order to seal properly. Buy one or borrow one, but don't try to use an automotive 45° tool.

Heavy soft faced hammer: Select one between 12 and 24oz.

Hollow Ground Planer Blade (Older Model Kits): Used in a table saw for cutting any aluminum sheet too thick for a hand shear. This results in a relatively smooth cut edge which needs little clean up afterwards. Just knock off the edges with a file and smooth the cut surface either with a fine file or a polishing wheel.

All required riveting equipment can be purchased from one of the suppliers listed in our accessories catalog. While other suppliers are available, these have catalogs available which make shopping easier. These catalogs are also useful as a general information source about sheet metal tools.

Studying any one or more of the tool catalogs will introduce you to many more metal working tools, some of which can also be used to advantage in aluminum aircraft construction. Several of the larger general parts suppliers such as Aircraft Spruce and Wicks publish extensive catalogs which are very valuable not only introducing the builder to the wide variety of hardware, tools, and parts available, but also including useful charts and table of aircraft standards.

While we feel that those tools we have listed are sufficient, some builders (or groups of builders) might have the resources and desire to have a super well equipped shop and should be aware that there is practically no limit to the variety of tools available. Within reason, money spent on good tools is seldom regretted.

Following is a list of tools compiled specifically for building the RV.

BUILDER'S TOOL REQUIREMENTS

NOTE: Tools listed as "Optional" in the following tools and materials lists make the build process easier, but are not required to complete construction. Tools required for a specific model but optional for others will be indicated with that aircraft model number (i.e. "REQ RV-14").

CATEGORY	QTY	ITEM	Required/Optional
Clecos	125	Clecos 1/8"	
	350	Clecos 3/32"	
	10	Clecos 3/16"	
	10	Clecos 5/32"	
	4	Cleco Clamps -1" Jaws - Side Grip	
	4	Cleco Clamps -1/2" Jaws - Side Grip	
	1	Pliers - Cleco	

CATEGORY	QTY	ITEM	Required/Optional
Cutting/Deburring Tools	1	Abrasive Cutting Disk	
	1	Hacksaw (Fine Tooth 32 Teeth per Inch Blade) or Bandsaw	
	1	Scotch Brite Wheel	
	3	Scotch Brite Pads - Maroon	
	1	Speed Deburring Tool	
	1	Emery Cloth	
	1	Files - Assorted (Vixen, Bastard, Rat Tail, Rasp, Etc)	
	1	File Card / Brush	
	1	Multi-Burr Deburring Tool (Royal Style)	

(Continued next page)

CATEGORY	QTY	ITEM	Required/Optional
Drills/Countersink/Taps	1	#3 Drill Bit	
	1	#10 Drill Bit	
	1	#11 Drill Bit	
	2	#12 Drill Bit	
	1	#16 Drill Bit	
	2	#19 Drill Bit	
	1	#21 Drill Bit	
	1	#27 Drill Bit	
	1	#29 Drill Bit	
	3	#30 Drill Bit	
	1	#30 Drill Bit 12" Long	
	1	#33 Drill Bit 6" Long	
	1	#36 Drill Bit	
	5	#40 Drill Bit	
	1	#40 Drill Bit, 12 " Long	
	1	#43 Drill Bit	
	1	#52 Drill Bit	
	1	1/4" Drill Bit	
	1	5/16" Drill Bit	
	1	Q (or 11/32nd) Drill Bit	
	1	Ream .311"	
	1	Ream 3/8"	
	1	Step Drill (Uni-bit) Preferably 1/4 to 7/8"X1/16 Step Increment	
	1	Countersink #8 Screw	
	1	Countersink #10 Screw	
	1	100° Machine Countersink Cutter with #12 Pilot	
	1	100° Machine Countersink Cutter with #19 Pilot	
	1	100° Machine Countersink Cutter with #27 Pilot	
	1	100° Machine Countersink Cutter with #30 Pilot	
	1	120° Machine Countersink Cutter with #30 Pilot	REQ RV-14
	1	100° Machine Countersink Cutter with #40 Pilot	
	1	Countersink Micro Stop Cage	
	1	Drill Stops - #30 #40 #12	Optional
	1	Angle Drill Kit (Alternately use the Economy 90° Attachment Listed Below)	Optional
	1	Economy 90° Drilling Attachment	REQ RV-14
	1	Threaded Shank Drill Set 6 pc. (or min. 1 ea. #40, #30, #12 bits) for 90° Drill	REQ RV-14
	1	1/4-28 Tap	
	1	5/16-24 Tap	
	1	3/8-16 Tap	
	1	3/8-24 Tap	
	1	4-40 Tap	
	2	6-32 Tap	
	1	8-32 Tap	
	1	10-24 Tap	

CATEGORY	QTY	ITEM	Required/Optional
Dimpling/Riveting	1	Dimple Die-Reduced diam. (3/8" diam.) 3/32" Female Dimple Die	
	1	Dimple Die-Reduced diam. 1/8" diam Female Dimple Die	REQ FOR RV-14
	1	Dimple Die Set 1/8" (100°)	
	1	Dimple Die Set 3/32" (100°)	
	1	Dimple Die Set #6 Screw	
	1	Dimple Die Set #8 Screw	
	1	Dimple Die Set #10 Screw	
	1	Dimpler 3/32" Pop Rivet	
	1	Dimpler 3/32" Vice Grip	
	1	Flush Head Rivet Set (Tall, 1/2" Thick - Squeezer)	
	2	Flush Head Rivet Set (Short, 1/8" Thick - Squeezer)	
	1	Flush Swivel Rivet Set - Rivet gun	Optional
	1	Rivet Set - Offset 1/8" (With a Flat Ground on One Edge) - Rivet Gun	
	1	Rivet Set - 1/8" Cupped Set 3.5" - Rivet Gun	
	1	1/8 Protuding Head Rivet Set (Tall, 1/2" Thick - Squeezer)	
	1	Rivet Set - 3/32" (Cupped Set 3.5" - Squeezer)	
	1	Beehive Retainer Spring (Often Supplied with Rivet Gun)	
	1	Quick Change Spring (For Flush Rivet Sets, maybe Supplied with Rivet Gun)	
	1	Back Rivet Set	
	1	Hand Squeezer with 3" Deep Yoke	
	1	C Frame Riveting/Dimpling Tool	
	1	Back-Riveting Plate, .375[9.5mm] X 6[152mm] X 12[305mm]	
	1	Dimple Die Organizer	
	1	3M F9460PC VHB Tape (or Fuel Tank Sealant)	
	1	Rivet Tape	
	1	Rivet Cutter	
	1	Rivet Gauge Set	
	1	Hand Blind Rivet Puller "POP" Riveter PRP-26A, USM Corp./ or Equivelant	
	1	Bucking Bar - Anvil 1.9 lb.	
	1	Bucking Bar - Tungsten	Optional
	1	Bucking Bar - Mini 1 lb.	

(Continued next page)

RV-14 BUILDER'S SUPPLIES REQUIREMENTS

CATEGORY	QTY	ITEM	Required/Optional
Power/Air/Shop Tools	1	Drill Motor 1/4" - Air - 2500-4000 RPM	
	1	Drill Motor - Battery Powered	
	1	Air Tool Oil	
	1	Air Tool Regulator	
	1	Air Swivel	
	1	Die Grinder	
	1	Drill Press	
	1	Rivet Gun , 2X and 3X or 3X Rivet Gun Only	
	1	6" Bench Vise	

CATEGORY	QTY	ITEM	Required/Optional
Hand Tools	1	Pliers - Duck Bill	
	1	Pliers - Fluting	
	1	Pliers - Needlenose	
	1	Diagonal Cutter	
	1	Tape Measure - Combination Fractional/Decimal Rule	
	1	12" Steel Rule	
	1	Punch - Assorted Sizes	
	1	Wiss Snips - Offset - Left	
	1	Wiss Snips - Offset - Right	
	1	Hammer - 12 oz. Dead Blow	
	1	Dimpling Mallet	Optional
	1	Rubber Mallet or Heavy Soft Faced Hammer	REQ RV-14
	1	Hearing Protector	
	1	Safety Glasses	
	1	Caliper (6") Dial or Digital	
	1	Edge Rolling Tool	
	1	Hand Seamer	
	2	Screwdriver Bits - Size #2	
	10	Small (2") "C" Clamps	
	4	Large (3") Spring or "Pony" Clamps	
	1	Combination Wrench Set (1/4"-3/4")	
	1	Fish Scale (0-50lbs)	
	1	Torque Wrench (Inch/Pounds & Foot/Pounds Scale)	
	1	Aviation Flaring Tool (Tube) 37°	
	1	Tubing Cutter	
	1	Tubing Bender, 1 inch centerline radius	
	1	Wire Crimper/Stripper	
	1	OLFA RTY-2/G 45mm Rotary Cutter (or Equivalent)	
	1	Multimeter (with Continuity Check Capability)	
	1	Digital Level	
	1	0-2lb Scale (for Measuring Tank Sealant)	Optional
	1	Socket Set 1/4-3/8 Drive	
	4	3/8" dia. Drift Pin (Fabricate from hardware store bolts by tapering the end)	

CATEGORY	QTY	ITEM	Required/Optional
Ref. Mat'ls/Supplies	1	A/C STRUCTURAL TECHNICIAN BOOK	
	1	STANDARD AIRCRAFT HANDBOOK	
	1	Tape Dispenser	
	1 Box	Permanent Markers ("Sharpie" Xtra or Ulta Fine Point)	
	1 Roll	String	
	1 Tube	Super Glue	
	1 Tube	Boelube	
	1 Can	LPS#1, 2 3, or a light motor oil.	
	1 Can	Pipe Thread Sealant	
	1-2 Qt	Fuel Tank Sealant	
	1 Tube	RTV Sealant - Red	
	1 Tube	Clear Silicone	
	1 Tube	Threadlocker - Loctite or Permatex - Red	
	1 Tube	Threadlocker - Loctite or Permatex - Blue	
	1 Tube	Anti-Seize Paste (High temp)	
	3 Yds	9oz/sq yd Plain Weave "E-glass" Fabric	
	1 Yd	Peel Ply (optional)	
	1 Qt	Kit of Epoxy Resin & Hardener	
	1 Qt	Acetone (for Clean-Up)	
	25	Mixing Cups (Solo™ Clear Plastic Cups Recycle Code #1 or #5)	
	100	Craft Sticks (a.k.a. Popsicle Sticks)	
	1/4 lb	Flocked Cotton Fiber (a.k.a. "Flox")	
	1/4 lb	Glass Spheres (a.k.a. "Micro-Balloons")	
	1 Roll	Low-Tack "Painters" Masking Tape	
	1 Roll	Mylar Packing Tape	
	1 Roll	Duct Tape	
	1 Kit	Fuel Tank Test Kit - See Van's Aircraft Catalog	
	1 Roll	Masking Paper - 24"	
	1 Sheet	Sandpaper - 60 Grit - 8.5X11 Sheet	
	2 Sheet	Sandpaper - 80 Grit - 8.5X11 Sheet	
	2 Sheet	Sandpaper - 100 Grit - 8.5X11 Sheet	
	1 Sheet	Sandpaper - 150 Grit - 8.5X11 Sheet	
	2 Sheet	Sandpaper - 220 Grit - 8.5X11 Sheet	
	2 Sheet	Sandpaper - 320 Grit - 8.5X11 Sheet	
	5	Sanding Blocks - Various Sizes/Shapes	
	3	Paint Brush - 1" Wide (Cheap, Natural Bristle Type)	
	2	Paint Brush - 2" Wide (Cheap, Natural Bristle Type)	
	2	Paint Brush - 3" Wide (Cheap, Natural Bristle Type)	

PARTS DESIGNATION SYSTEM

All parts in an RV structure (other than standard aircraft hardware items or common vendor items) have a part number assigned to them. Here is a typical part number, followed by an explanation of the numbering system: W-00006

1. The first letter designates the major portion of the airframe in which the part is used. In this instance, "W" denotes "WING". Other prefix examples are: W - Wing, F - Fuselage, HS - Horizontal Stabilizer or Stabilator, VS - Vertical Stabilizer, R - Rudder, A - Aileron or Flaperon, FF - Firewall Forward, T - Tank, U - Undercarriage, WD - Weldment, C - Canopy.

2. The first numbers (in RV models 3, 4, 6 and 6A, 7 and 7A, 8 and 8A, 9 and 9A and 10) were allocated in blocks of 100 for our various models. Thus, most 800 series numbers are for the RV-8, 1000 series numbers are for the RV-10, 1200 series numbers for the RV-12, etc. The RV-14 and later series aircraft parts are numbered using a more generic numbering system that is not aircraft specific. For example: The W-00006 does not specify a specific aircraft model, but pertains only to a wing part number 00006.

In some cases, the construction manual calls out parts from lower model number aircraft. For instance, the RV-14 ailerons use parts that were previously used in the RV-10 aileron. In these cases, the part is common to more than one aircraft and to avoid the confusion of having one part with two possible part numbers, only one part number is used.

3. The suffix letter is used when a part, such as the wing spar in this instance, consists of two or more assembled parts. For example: the W-1026 Torque Tube Support Assembly consists of the parts W-1026A, W-1026B, W-1026C, W-1026D.

4. Parts which are specific to a left or right configuration will be followed by "-L" or "-R". For example FL-1005-R is a flap rib with flanges that are bent towards the right when the part is installed in the aircraft. This is a "-R" part regardless of which side of the aircraft the part is installed on.

Raw materials use a different numbering system.

AA Aluminum Angle
AB Aluminum Bar
AS Aluminum Sheet
AT Aluminum Tube
PS Plastic Sheet/Strip
PT Plastic Tube
SS Steel Sheet
SSP Stainless Steel Pin
ST Steel Tube

The next number denotes the temper, condition or alloy:

0 Soft Aluminum
3 T-3 (aluminum)
6 T-6 (aluminum)
4130 Steel alloy

The number following the dash shows the thickness of the material

-025 0.025"
-032 0.032"

Next the size is specified: An example: AS3-032x15x20 shows a part of Aluminum Sheet, temper T-3, 0.032" thick, 15"x20"

When referring to parts for re-ordering or technical assistance purposes, please use the full number so that confusion can be avoided.

Standard aircraft hardware is listed by the most common designation, usually numbers with either AN, MS, or NAS prefixes. "AN" is for Army/Navy, "MS" is for Military Standard, and "NAS" is for National Aerospace Standard. The numbers and letter in an aircraft hardware designation all tell something about the part. For example, one of the most basic is that of aircraft bolts. One example would be an AN3-4A, which means that it is a 3/16" diameter bolt (first number) which is 4/8 (1/2) inch long, has fine threads (std. for aircraft hardware), and has an undrilled shank (A suffix).

It is not our purpose here to list information about all types of aircraft hardware used in an RV. We hope that one or more of the reference texts you purchase as construction aids will provide such listings. Catalogs from aircraft hardware suppliers listed in our accessories catalog usually have a wealth of general information of this nature, and are a valuable reference source even if they are old and prices are out of date.

WORKSPACE REQUIRED

We rarely encounter builders who feel that they have too much workspace; it's about like having too large a bank account -- there is no such thing! The derivation of the word "Homebuilt" is obvious, and most of us have heard stories of airplanes being built in basements or attics where the walls had to be knocked down to get them out when finished. We expect that some RVs will also be built, or partially built, in some rather strained quarters. However, we suggest that the desired building space be about that of a two-car garage (about 20 x 20 ft). While this is more than enough for building individual airframe components, it will come in handy for storing completed components while others are being built, and for final assembly, etc.

One of the tougher problems is finding a place to spray paint. Some builders choose to corrosion proof their airplanes, and the two part epoxy primers usually used can be toxic, or, at best, unpleasant. A well ventilated spray area, partitioned or in a separate building from the work area is necessary. A corner of the shop cordoned off with plastic sheet and equipped with an exhaust fan is a common solution.

A firm table with a smooth, level surface of about 3' x 6' is needed for RV construction. You will probably want a larger table or tables than this to hold tools, hardware, and other completed or semi-completed surfaces. Did you ever see anything even vaguely resembling a table top which wasn't immediately cluttered beyond the point of use? Like shop space, you never seem to have enough table space either.

MECHANICAL DRAWINGS AND MECHANICAL DRAWING READING

While mechanical drawings are not a tool in the same sense of a hammer and saws, they indeed are tools in the contribution they make to completion of a homebuilt airplane. They are drawings which present a picture of parts and assemblies from one or more viewpoints. Like a written language, mechanical drawings are only useful if the viewer can read them. RV drawings have been prepared using a blend of accepted mechanical drawing practices and presentations which we feel can be most easily understood by the average homebuilder. The individual drawings of the respective views show what can be seen from that viewpoint plus, at times, all hidden lines and features. Looking at the front view shows the presence of hidden lines which can only be clarified by the addition of one or more views. The side view provides enough information to fully understand the shape of the part. The top view provides yet more clarification.

Since a mechanical drawing is composed mostly of lines of one form or another, we must define them. Following is a description of some symbols and lines used.

Solid Line: Represents a surface or an edge which is visible to the viewer.

Hidden Line: Is a uniform line of short dashes representing an edge or surface which cannot be seen by the viewer but is important to present in the drawing.

Phantom Line: A line of interspaced long and short dashes shows the position that another part will occupy at another state of construction or assembly. It is used to make the builder aware of the relationship of other parts of the structure, without the clutter of an assembly drawing.

Bend Line: Indicates the line about which a bend is to be made.

Section Line: This is used to indicate a view of a part which could be seen if the part were cut in two and viewed from the direction of arrows at end of the line. The letters correspond to the view located elsewhere on the drawing.

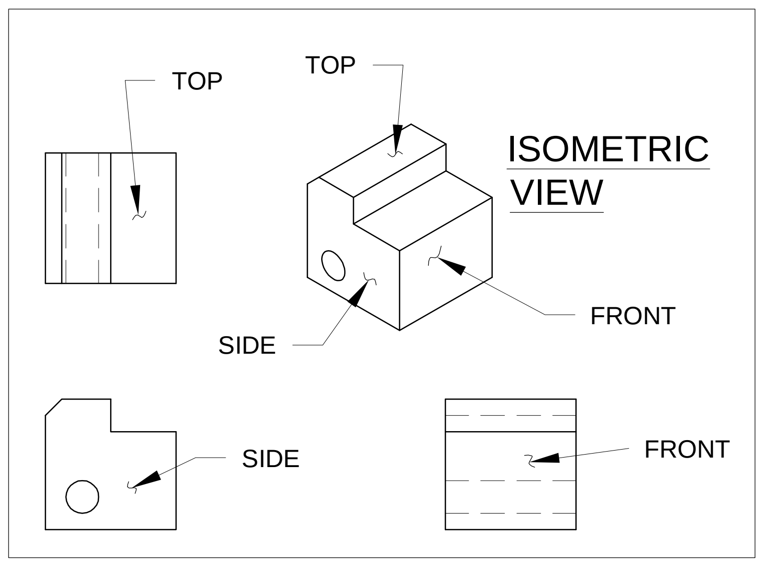


FIGURE 1: ORTHO VIEWS

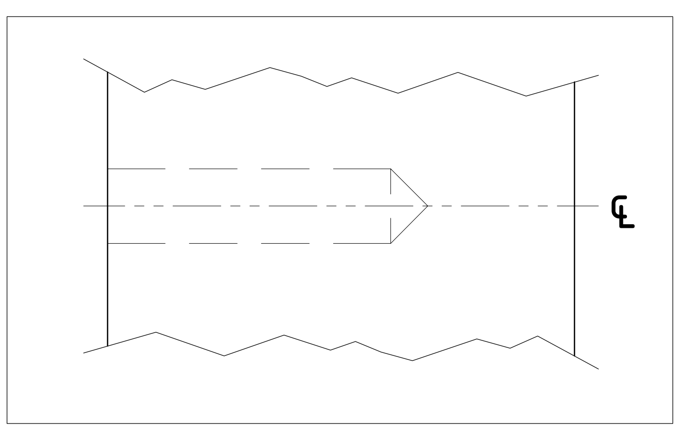


FIGURE 2: DRILLED HOLE
(NOTE THE POINTED TIP)

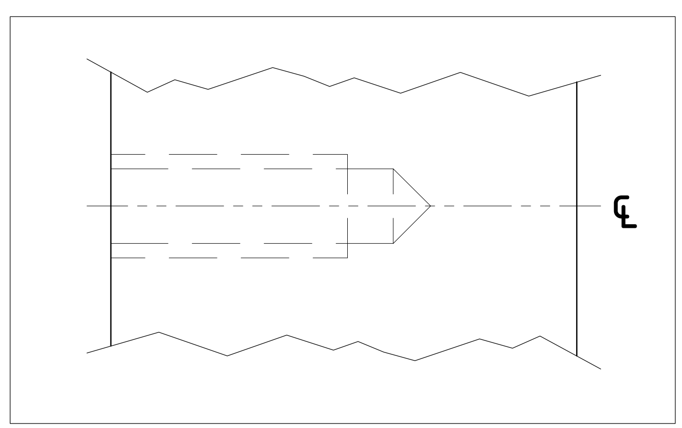


FIGURE 3: DRILLED AND THREADED HOLE
(NOTE DOUBLE LINE SEGMENT INDICATING DEPTH OF THREAD)

Center Line: Used for the center line of holes, tubes, discs, and any other part which is symmetrical on each side of the center line. This is a series of long and short dashes.

Detail "X": Denotes that the portion of the drawing enclosed within the circle is shown elsewhere in greater detail.

Dimensions: Holes and radius parts are dimensioned from the center of the hole or from the center point of the arc describing the rounded surface. Thus, the overall height of the part is the base to radius center plus the arc radius. The overall height dimension is not usually given, but if it is, would be listed as a reference dimension because the other is primary.

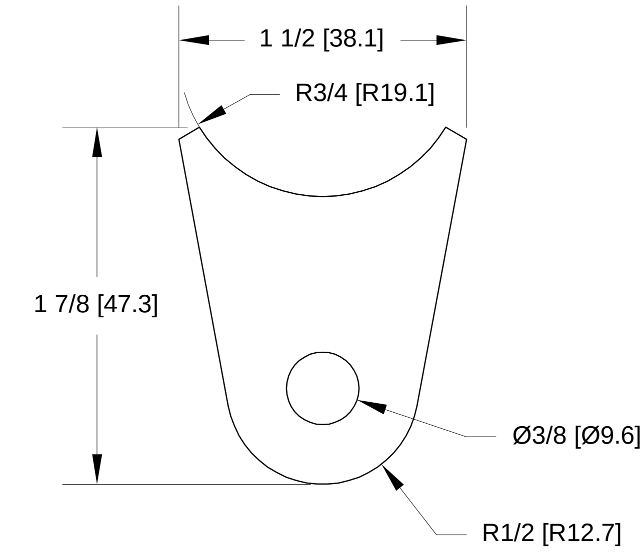


FIGURE 4: DIMENSIONED PART

PLANS PAGE TEMPLATE SCALING

Some plans pages contain templates that are printed at a scale of 1:1. Double check that a plans page is scaled correctly by measuring the border **before using the template!** A properly scaled border is shown in Figure 5.

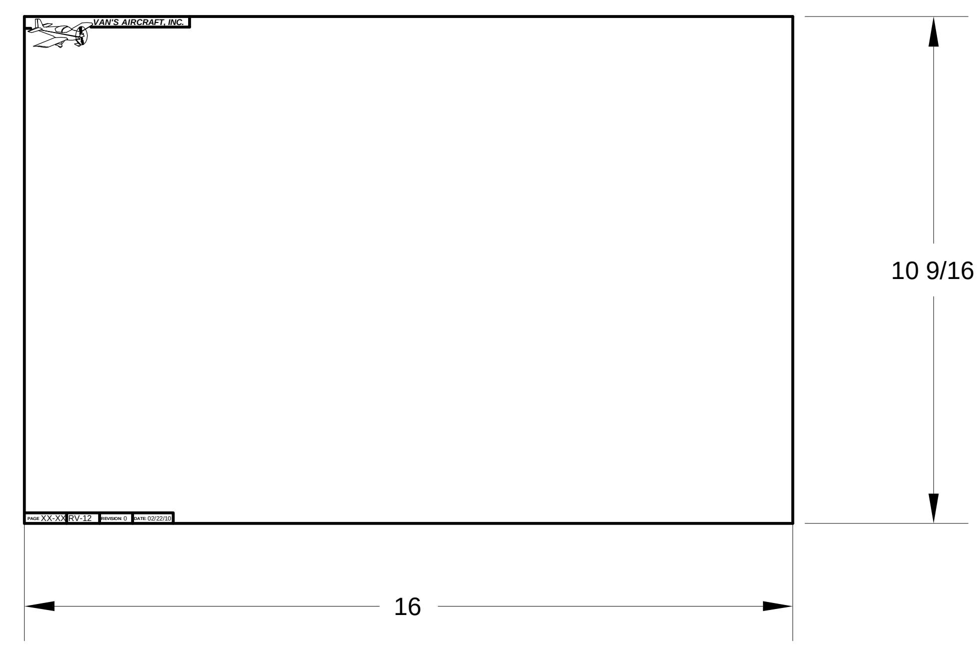


FIGURE 5: BORDER DIMENSIONS

PART NUMBER	NOMENCLATURE	# PER A/C	RV-7 PLAN PG #	PART TYPE	MAKE FROM MATERIAL	SUB-KIT
"P" STRIP	ADHESIVE RUBBER STRIP	1		MATERIAL	ADHESIVE RUBBER STRIP	FIN-T
A-403PP-L	AILERON SPAR	1	9,13A	MANUFACTURED	.040 2024-T3 ALCLAD	AILERON
A-403PP-R	AILERON SPAR	1		MANUFACTURED	.040 2024-T3 ALCLAD	AILERON
A-404-L	AILERON NOSE RIB	2	9,13A	MANUFACTURED	.040 2024-T0 OR T3 ALCLAD	AILERON
A-404-R	AILERON NOSE RIB	2	9,13A	MANUFACTURED	.040 2024-T0 OR T3 ALCLAD	AILERON
A-405-L	AILERON RIB	2	9,13A	MANUFACTURED	.025 2024-T0 OR T3 ALCLAD	AILERON
A-405-R	AILERON RIB	2	9,13A	MANUFACTURED	.025 2024-T0 OR T3 ALCLAD	AILERON
A-406-1-PC	OUTBOARD AILERON BRACKET	2	13A	MANUFACTURED	.050 4130 STEEL	AILERON
A-407-L-PC	INBOARD AILERON BRACKET	1	13A	MANUFACTURED	.050 4130 STEEL	AILERON
A-407-R-PC	INBOARD AILERON BRACKET	1		MANUFACTURED	.050 4130 STEEL	AILERON
A-408	SPAR REINF. PLATE	4	13A	MATERIAL	AS3-040X2.5X2.75	AILERON
A-409	AILERON COUNTERBALANCE	2	9,13A	MATERIAL	1/2" GALVANIZED WATER PIPE	AILERON
A-610PP	AILERON SKIN STIFFENER ANGLES	32	13A	MANUFACTURED	.025 2024-T3 ALCLAD	AILERON
A-711	INBD UPR AILERON SPACER	2	13A	MATERIAL	AT6-058X5/16	AILERON
A-712	INBD LWR AILERON SPACER	2	13A	MATERIAL	AT6-058X5/16	AILERON
A-713	OUTBOARD AILERON SPACER	2	13A	MATERIAL	AT6-058X5/16	AILERON
A-801PP-L	AILERON SKIN	1	9,12,13A	MANUFACTURED	.020 2024-T3 ALCLAD	AILERON
A-801PP-R	AILERON SKIN	1		MANUFACTURED	.020 2024-T3 ALCLAD	AILERON
A-802PP	AILERON LEADING EDGE SKIN	2	12,13A	MANUFACTURED	.020 2024-T3 ALCLAD	AILERON
A-914	AILERON CONTROL STOP	2	13A	MATERIAL	AA6-125X1X1	AILERON
BRAKE LINE	BRAKE LINE	1	36,36A	MATERIAL	AT0-032X1/4	FUSE-ALL
BRAKE MAST CYL LEFT-1	LEFT BRAKE MASTER CYLINDER	1	36,36A	MANUFACTURED	MATCO	FUSE-ALL
BRAKE MAST CYL RGHT-1	RIGHT BRAKE MASTER CYLINDER	1	36,36A	MANUFACTURED	MATCO	FUSE-ALL
BRAKE RESERVOIR LINE	LOW PRESSURE BRAKE LINES	1	36,36A	MATERIAL	PT-062X1/4	FUSE-ALL
C-601-1	CANOPY	1	17,17A,41,43,48,49	MANUFACTURED	ACRYLIC PLASTIC	FIN-ALL
C-603	CANOPY SIDE SKIN	2	48,49	MATERIAL	AS3-032 X 3 X 29	FIN-T
C-605	BEAM IDLER	1	48,49	MANUFACTURED	.125 2024-T3 ALCLAD	FIN-T
C-606	LINK	2	48,49	MANUFACTURED	.040 4130 STEEL	FIN-T
C-607	LATCH HANDLE	1	48,49	MANUFACTURED	.125 2024-T3 ALCLAD	FIN-T
C-608	CANOPY HANDLE BLOCK	1	48,49	MANUFACTURED	.750 UHMW	FIN-T
C-609	CANOPY LATCH	1	48,49	MANUFACTURED	.125 2024-T3 ALCLAD	FIN-T
C-611	BUSHING BLOCK	2	48,49	MANUFACTURED	.750 UHMW	FIN-T
C-613	CANOPY SPLICE PLATE	2	48,49	MANUFACTURED	.063 6061-T6	FIN-T
C-614	CANOPY SPLICE PLATE	1	47	MANUFACTURED	.063 6061-T6	FIN-T
C-615	SPRING	1	48,49	MANUFACTURED	SPRING STEEL	FIN-T
C-616	WIRE CORE	1	48	MANUFACTURED	STAINLESS STEEL	FIN-T
C-617	BLOCK	2	47,49	MANUFACTURED	.750 UHMW	FIN-T
C-618	BLOCK	2	47,49	MANUFACTURED	.125 UHMW	FIN-T
C-619	SPACER	2	47,49	MATERIAL	AB4-250 x 1	FIN-T
C-620	BEARING BLOCK	1	47,49	MANUFACTURED	.750 UHMW	FIN-T
C-621	CANOPY RELEASE LINK	1	47,49	MATERIAL	ST-4130 035 X 3/8	FIN-T
C-622	CANOPY RELEASE LINK	1	47,49	MATERIAL	ST-4130 035 X 3/8	FIN-T
C-627	SPRING	1	47,48,49	MANUFACTURED	SPRING STEEL	FIN-T
C-653	COVER STRIP	1	41,43	MATERIAL	AS3-032 x 1 X 41 1/2	FIN-S
C-654	SLIDING CANOPY LATCH ARM	1	42,43	MANUFACTURED	.125 2024-T3 ALCLAD	FIN-S
C-655	SPRING	1	43	MANUFACTURED	SPRING STEEL	FIN-S
C-656	CANOPY HANDLE	1	43	MANUFACTURED	6061-T6	FIN-S
C-657	CANOPY ROLLER TRACK	2	41,42,43	MATERIAL	AEX ROLLER TRACK	FIN-S
C-658	ROLLER	2	41	MANUFACTURED	NYLON	FIN-S
C-660	CANOPY SKIRT	2	41,43	MATERIAL	AS3-032 4 9/16X32	FIN-S
C-661	CANOPY SLIDE BLOCK	1	43	MANUFACTURED	.750 UHMW SHEET	FIN-S
C-664	THREADED ROD	1	43	MANUFACTURED	1/4-28 THREADED STEEL ROD	FIN-S
C-665	SLIDING CANOPY REAR ANCHOR BLOCK	2	41	MATERIAL	PS UHMW .750 X 1 1/4 X 2	FIN-S
C-666	AFT CANOPY SKIRT	2	41,42,43	MANUFACTURED	.032 2024-T3 ALCLAD	FIN-S
C-667	BUSHING	1	43	MANUFACTURED	BRONZE	FIN-S
C-668	SPACER	4	42	MANUFACTURED	.250 X 1.25 2024-T4 BAR	FIN-S
C-669	BUSHING	2	41	MANUFACTURED	.500 OD X .063 BRASS TUBE	FIN-S
C-670	BUSHING	2	41	MANUFACTURED	.375 OD X .063 BRASS TUBE	FIN-S
C-671	THRUST WASHER	1	43	MANUFACTURED	NYLON	FIN-S
C-677	REAR PIN MOUNT	2	41,42	MANUFACTURED	.063 6061-T6	FIN-S
C-679	SLIDE SEAL	1	41,42	MANUFACTURED	UHMW	FIN-S
C-690	LIFT STRUT	2	48,49	MANUFACTURED	N/A	FIN-T
C-702	TIP-UP CANOPY FWD SKIN	1	48,49	MANUFACTURED	.032 2024-T3 ALCLAD	FIN-T
C-704	SPLICE PLATE	1	49	MANUFACTURED	.063 2024-T3 OR 6061-T6	FIN-T
C-710	PUSHROD	1	48,49	MATERIAL	AT6-058 X 5/16	FIN-T
C-712	CANOPY LATCH ANGLE	2	48,49	MATERIAL	AA6-063X3/4X3/4	FIN-T
C-723	WEDGE SPACER	2	48	MATERIAL	AB3-1.25 X .625	FIN-T
C-725	BALL STUD FORWARD MOUNT	2	48,49	MATERIAL	AB3-1 1/2X3/4	FIN-T
C-728	BALL STUD AFT MOUNT	2	48,49	MATERIAL	AS3-125X1 1/4X1 3/4	FIN-T
C-729	BALL STUD MOUNT SPACER	4	49	MATERIAL	AS3-125X1 1/4X13/16	FIN-T
C-731	LIFT HANDLE	1	48	MATERIAL	AA6-063X3/4X3/4	FIN-T
C-759	INSIDE CANOPY SKIRT	2	41,43	MANUFACTURED	.032 2024-T3 ALCLAD	FIN-S
C-762	CANOPY SLIDE RAIL	1	41,42,43	MANUFACTURED	.063 2024-T3 ALCLAD	FIN-S
C-763	CANOPY SLIDE SPACER	1	41,42,43	MANUFACTURED	.250 X .500 6061-T6 BAR	FIN-S
C-791	CANOPY SKIRT BRACE	2	41	MANUFACTURED	.020 2024-T3 ALCLAD	FIN-S
C-792	DOGHOUSE	1	41,42,43	MANUFACTURED	.020 2024-T0 ALCLAD	FIN-S
CAV-110	DRAIN VALVE	2	16A	MANUFACTURED	ALUMINUM	WING
COWL AFT HINGE BOTTOM	COWL AFT HINGE BOTTOM	2	45	MATERIAL	HINGE PIANO 1/8	FIN-ALL
COWL AFT HINGE SIDE	COWL AFT HINGE SIDE	2	45	MATERIAL	HINGE PIANO 1/8	FIN-ALL
COWL AFT HINGE TOP LEFT	COWL AFT HINGE TOP LEFT	1	45	MATERIAL	HINGE PIANO 1/8	FIN-ALL
COWL AFT HINGE TOP RIGHT	COWL AFT HINGE TOP RIGHT	1	45	MATERIAL	HINGE PIANO 1/8	FIN-ALL

PART NUMBER	NOMENCLATURE	# PER A/C	RV-7 PLAN PG #	PART TYPE	MAKE FROM MATERIAL	SUB-KIT
COWL HINGE PIN - 090	COWL HINGE PIN 3/32"	1	45	MATERIAL	SSP 090	FIN-ALL
COWL HINGE PIN - 120	COWL HINGE PIN 1/8"	1	45	MATERIAL	SSP 120	FIN-ALL
COWL OIL DOOR HINGE	COWL OIL DOOR HINGE	1	45	MATERIAL	AN257-P3	FIN-ALL
COWL SIDE HINGE	COWL SIDE HINGE	2	45	MATERIAL	AN257-P3	FIN-ALL
COWL, 6/6A BOT O-320	0-320 LOWER COWL	1	45	MANUFACTURED	Pre-Preg Epoxy/Fiberglass	FIN-ALL
COWL, 6/6A BOT O-360	LOWER COWL	1	45	MANUFACTURED	Pre-Preg Epoxy/Fiberglass	FIN-ALL
COWL, 6/6A INLET LEFT-1	LEFT INLET	1	45	MANUFACTURED	Pre-Preg Epoxy/Fiberglass	FIN-ALL
COWL, 6/6A INLET RIGHT-1	RIGHT INLET	1	45	MANUFACTURED	Pre-Preg Epoxy/Fiberglass	FIN-ALL
COWL, 6/6A OIL DOOR	OIL DOOR	1	45	MANUFACTURED	Pre-Preg Epoxy/Fiberglass	FIN-ALL
COWL, 6/6A TOP C/S-1	UPPER COWL	1	45	MANUFACTURED	Pre-Preg Epoxy/Fiberglass	FIN-ALL
COWL, 7/7A BOT IO-360	LOWER COWL	1	45	MANUFACTURED	Pre-Preg Epoxy/Fiberglass	FIN-ALL
COWL, 7/7A TOP IO-360	UPPER COWL	1	45	MANUFACTURED	Pre-Preg Epoxy/Fiberglass	FIN-ALL
COWL, 8/8A INLET LEFT-1	LEFT INLET	1	45	MANUFACTURED	Pre-Preg Epoxy/Fiberglass	FIN-ALL
COWL, 8/8A INLET RIGHT-1	RIGHT INLET	1	45	MANUFACTURED	Pre-Preg Epoxy/Fiberglass	FIN-ALL
E-00001	HINGE DOUBLER	1	4,5	MANUFACTURED	.063 2024-T3 ALCLAD	EMPENNAGE
E-606PP	ELEVATOR TRIM SPAR	1	4	MANUFACTURED	.032 2024-T3 ALCLAD	EMPENNAGE
E-607PP	TRIM TAB SPAR	1	4	MANUFACTURED	.032 2024-T3 ALCLAD	EMPENNAGE
E-610PP	ELEVATOR SPAR REINFORCEMENT PLATE	2	4,5	MANUFACTURED	.063 2024-T3 ALCLAD	EMPENNAGE
E-611PP	ELEVATOR SPAR REINFORCEMENT PLATE	2	4,5	MANUFACTURED	.063 2024-T3 ALCLAD	EMPENNAGE
E-612	ELEVATOR TIP	2	4,5	MANUFACTURED	Polyester Resin Fiberglass Cloth	EMPENNAGE
E-614-020	COUNTERWEIGHT	1	7	MANUFACTURED	LEAD	EMPENNAGE
E-615PP	TRIM ACCESS REINF PLATE	1	4	MANUFACTURED	.032 2024-T3 ALCLAD	EMPENNAGE
E-616PP	TRIM COVER PLATE	1	4	MANUFACTURED	.032 2024-T3 ALCLAD	EMPENNAGE
E-619PP-1-020	TRIM TAB SKIN	1	4	MANUFACTURED	.020 2024-T3 ALCLAD	EMPENNAGE
E-701-L	ELEVATOR SKIN	1	4	MANUFACTURED	.020 2024-T3 ALCLAD	EMPENNAGE
E-701-R	ELEVATOR SKIN	1	5	MANUFACTURED	.020 2024-T3 ALCLAD	EMPENNAGE
E-702	ELEVATOR SPAR	2	4,5	MANUFACTURED	.032 2024-T3 ALCLAD	EMPENNAGE
E-703	ELEVATOR END RIB	2	4,5	MANUFACTURED	.025 2024-TO OR T3 ALCLAD	EMPENNAGE
E-704	ELEVATOR COUNTERBALANCE RIB	2	4,5	MANUFACTURED	.025 2024-T3 ALCLAD	EMPENNAGE
E-705	ELEVATOR ROOT RIB LEFT	1	4	MANUFACTURED	.032 2024-T3 ALCLAD	EMPENNAGE
E-709	ELEVATOR ROOT RIB RIGHT	1	5	MANUFACTURED	.032 2024-T3 ALCLAD	EMPENNAGE
E-713	ELEVATOR COUNTERBALANCE SKIN	2	4,5	MANUFACTURED	.032 2024-T3 ALCLAD	EMPENNAGE
E-714	ELEVATOR COUNTERBALANCE	2	4,5	MANUFACTURED	LEAD	EMPENNAGE
E-717	OUTBD TRIM TAB HORN	1	4	MANUFACTURED	.032 2024-T3 ALCLAD	EMPENNAGE
E-718	INBD TRIM TAB HORN	1	4	MANUFACTURED	.032 2024-T3 ALCLAD	EMPENNAGE
E-720ABCH	ELEVATOR STIFFENER	2	4,5	MANUFACTURED	.025 2024-T3 ALCLAD	EMPENNAGE
E-720DEFG	ELEVATOR STIFFENER	4	4,5	MANUFACTURED	.025 2024-T3 ALCLAD	EMPENNAGE
E-720H5	ELEVATOR STIFFENER	1	4,5	MANUFACTURED	.025 2024-T3 ALCLAD	EMPENNAGE
E-721	TRIM TAB HINGE	1	4	MATERIAL	AN257-P2	EMPENNAGE
EMP FAIRING RUBBER	RUBBER CHANNEL	2	44	MATERIAL	RUBBER CHANNEL	FIN-ALL
ES PC680 BATTERY TRAY	ODYSSEY PC680 BATTERY TRAY	1	31A	MANUFACTURED	STEEL	FUSE-ALL
ES86515-157	FLAP ACTUATOR	1	32,32A	MANUFACTURED	N/A	FUSE-ALL
F-601A-2	FIREWALL BULKHEAD	1	A,36,36A,46	MANUFACTURED	.0179 304 STAINLESS	FUSE-ALL
F-601B-L-1	FIREWALL STIFFENER	1	19	MANUFACTURED	AA6-125X3/4X3/4	FUSE-ALL
F-601B-R-1	FIREWALL STIFFENER	1	19	MANUFACTURED	AA6-125X3/4X3/4	FUSE-ALL
F-601C-1	FIREWALL GUSSET	2	19	MANUFACTURED	.125 2024-T3 ALCLAD	FUSE-ALL
F-601D-L-1	FIREWALL STIFFENER	1	19	MANUFACTURED	AA6-063X3/4X3/4	FUSE-ALL
F-601D-R-1	FIREWALL STIFFENER	1	19	MANUFACTURED	AA6-063X3/4X3/4	FUSE-ALL
F-601F-1	FIREWALL GUSSET	2	19	MANUFACTURED	.125 2024-T3 ALCLAD	FUSE-ALL
F-601G-1	FIREWALL GUSSET	2	19	MANUFACTURED	.063 2024-T3 ALCLAD	FUSE-ALL
F-601H-1	FIREWALL GUSSET	2	19	MANUFACTURED	.063 2024-T3 ALCLAD	FUSE-ALL
F-601J	FIREWALL ANGLE	2	19	MATERIAL	AA6-187X2X2 1/2	FUSE-ALL
F-601K-1	FIREWALL RECESS	1	19	MANUFACTURED	.0179 304 STAINLESS	FUSE-ALL
F-601L-1	FIREWALL STIFFENER	1	19	MANUFACTURED	AA6-125X3/4X3/4	FUSE-ALL
F-601M-1	FIREWALL STIFFENER	1	19	MANUFACTURED	AA6-125X3/4X3/4	FUSE-ALL
F-601N-L	FIREWALL STIFFENER	1	19,37	MANUFACTURED	AA6-063X3/4X3/4	FUSE-ALL
F-601N-R	FIREWALL STIFFENER	1	19	MANUFACTURED	AA6-063X3/4X3/4	FUSE-ALL
F-601P	SPACER	2	19	MATERIAL	AS3-063X.625X3	FUSE-ALL
F-601R	FIREWALL ANGLE	1	19	MATERIAL	AA6-063X3/4X3/4	FUSE-ALL
F-601TD	BRAKE PLATE	1	19	MATERIAL	AS3-063 X 1 3/4 X 3	FUSE-ALL
F-601Y	COWL PIN RETAINER	1	45	MATERIAL	AS3-016X2X2 3/8	FIN-ALL
F-601Z	AUX FUEL PUMP FIREWALL DOUBLER	1	19	MATERIAL	AS3-063X2.95X3.438	FUSE-ALL
F-605C	BAR DOUBLER	2	20,38	MANUFACTURED	AB4-125X1 1/2	FUSE-ALL
F-6111-L	LEFT AFT SKIN REINFORCING RIB	1	17A,41,42,43	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-S
F-6111-R	RIGHT AFT SKIN REINFORCING RIB	1	41	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-S
F-6114A	SHOULDER HARNESS CABLE	2	26,32,32A	MANUFACTURED	N/A	FUSE-ALL
F-6114B	WEAR BLOCK	2	29	MATERIAL	1/2 X 2 .125 UHMW	FUSE-ALL
F-6114C	WEAR BLOCK	2	29	MATERIAL	1 X 2 .125 UHMW	FUSE-ALL
F-6115	RUDDER PEDAL BEARING BLOCK	1	37	MANUFACTURED	.750 UHMW	FUSE-ALL
F-6116	RUDDER PEDAL BEARING BLOCK	2	37	MANUFACTURED	.750 UHMW	FUSE-ALL
F-6117A	BRAKE SIDE PLATE	2	37	MANUFACTURED	.125 2024-T3 ALCLAD	FUSE-ALL
F-6117B	BRAKE PLATE	2	37	MANUFACTURED	.125 2024-T3 ALCLAD	FUSE-ALL
F-6117C	ANGLE	4	37	MATERIAL	AA6-063X3/4X3/4	FUSE-ALL
F-6118	RUDDER BRACE	1	32,32A,37	MANUFACTURED	.063 2024-T3 ALCLAD	FUSE-ALL
F-6119	RUDDER CABLE LINK	4	37	MATERIAL	4130 STEEL STRIP 1/2 INCH WIDE	FUSE-ALL
F-6122-1	TRI-GEAR BRAKE BRACKET	1	19,36A	MANUFACTURED	.063 2024-T3 ALCLAD	FUSE-ALL
F-623A	STUB RIB ATTACH STRAP	4	22	MATERIAL	AS3-032X3/4X2 3/4	FUSE-ALL
F-623-L	CORNER RIB	1	22,25,29	MANUFACTURED	.025 2024-T0 ALCLAD	FUSE-ALL
F-623-R	CORNER RIB	1	22,29	MANUFACTURED	.025 2024-T0 ALCLAD	FUSE-ALL
F-631A-L	CHANNEL	3	39,49	MANUFACTURED	.063 6061-T6	FUSE-T
F-631A-R	CHANNEL	3	39,49	MANUFACTURED	.063 6061-T6	FUSE-T

PART NUMBER	NOMENCLATURE	# PER A/C	RV-7 PLAN PG #	PART TYPE	MAKE FROM MATERIAL	SUB-KIT
F-631B	STRAP	1	39	MATERIAL	AS3-063X1 1/4X56	FUSE-T
F-631B-L	STRAP	1	39	MATERIAL	AS3-063X1 1/4X66	FUSE-T
F-631C	ANGLE	2	39,40	MATERIAL	AA6-187X2X2 1/2	FUSE-T
F-631D	ANGLE	2	39,40	MATERIAL	AA6-125X2X1 1/2	FUSE-T
F-631E	PLATE	2	39	MATERIAL	AS3-063 X 3 X 2.625	FUSE-T
F-633-L	CONTROL COLUMN MOUNT	1	11,38	MANUFACTURED	AA6-250X1 1/5X2	FUSE-ALL
F-633-R	CONTROL COLUMN MOUNT	1	11,38	MANUFACTURED	AA6-250X1 1/5X2	FUSE-ALL
F-634-L-PC	SEAT BELT ANCHOR	4	20	MANUFACTURED	.050 4130 STEEL	FUSE-ALL
F-634-R-PC	SEAT BELT ANCHOR	4	20	MANUFACTURED	.050 4130 STEEL	FUSE-ALL
F-635A	ELEVATOR BELLCRANK	2	26,32,32A	MANUFACTURED	.063 2024-T3 ALCLAD	FUSE-ALL
F-635B	SPACER	1	26	MATERIAL	AS3-063 X .500 X 1.4375	FUSE-ALL
F-635C	SPACER	2	26	MATERIAL	AT6-058X3/8	FUSE-ALL
F-636	SHOULDER HARNESS ANCHOR	2	26	MANUFACTURED	.125 2024-T3 ALCLAD	FUSE-ALL
F-637A	SEAT BACK SKIN	2	30	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-637B	ANGLE	4	30	MATERIAL	AA6-125X3/4X3/4	FUSE-ALL
F-637C	ANGLE	4	30	MATERIAL	AA6-063X3/4X3/4	FUSE-ALL
F-637D	SEAT BACK UPPER HINGE	2	30	MATERIAL	AN257-P3	FUSE-ALL
F-637E	SEAT BACK LOWER HINGE	4	30	MATERIAL	AN257-P3	FUSE-ALL
F-638	SEAT BACK BRACE	2	30	MANUFACTURED	.040 2024-T3 ALCLAD	FUSE-ALL
F-643-1	FWD FUSELAGE CHANNEL	1	17,24A	MANUFACTURED	.032 2024-T3 ALCLAD	FUSE-T
F-644	FWD FUSELAGE CHANNEL	2	24A,47	MANUFACTURED	.032 2024-T3 ALCLAD	FUSE-T
F-652	UPPER BAGGAGE BULKHEAD	1	29	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-656-L	GUSSET PLATE	2	26	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-656-R	GUSSET PLATE	2	26	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-661EF	FLAP BEARING BLOCK	2	20,33	MANUFACTURED	.750 UHMW	FUSE-ALL
F-665	PUSHROD	1	32,32A,38	MANUFACTURED	1/2 HEX ROD 6061	FUSE-ALL
F-669-PC	RIGHT CONTROL STICK	1	32,32A,38	MANUFACTURED	ST-4130 7/8 X .049	FUSE-ALL
F-680	FLAP BEARING BLOCK	1	33	MANUFACTURED	.750 UHMW	FUSE-ALL
F-684	GUSSET	2	23,36,36A	MANUFACTURED	.063 2024-T3 ALCLAD	FUSE-ALL
F-691	CT 23V42-DF-2-178 TRIM CABLE	1	4,32,32A	MANUFACTURED	CONTROL CABLE	FUSE-ALL
F-695-L	FWD FUSE GUSSET	1	23,36,36A	MANUFACTURED	.063 2024-T3 ALCLAD	FUSE-ALL
F-695-R	FWD FUSE GUSSET	1	23,36,36A	MANUFACTURED	.063 2024-T3 ALCLAD	FUSE-ALL
F-697	CHANNEL	1	24A,47	MANUFACTURED	.032 2024-T3 ALCLAD	FIN-T
F-703	INSTRUMENT PANEL (TIP-UP)	1	17,24A,47,49	MANUFACTURED	.063 2024-T3 ALCLAD	FUSE-T
F-703B	STIFFENING FLANGE	1	24A	MATERIAL	AA6-063X3/4X3/4	FUSE-T
F-703C	STIFFENING FLANGE	2	24A	MATERIAL	AA6-063X3/4X3/4	FUSE-T
F-704H	CENTER SECTION SIDE PLATE	2	11,22	MANUFACTURED	.063 2024-T3 ALCLAD	FUSE-ALL
F-704K	UPRIGHT CAP STRIP	2	23	MANUFACTURED	.040 2024-T3 ALCLAD	FUSE-ALL
F-704M	WEB STIFFENER	2	11	MATERIAL	AA6-063X3/4X3/4	FUSE-ALL
F-705A	REAR SPAR ATTACH BULKHEAD	1	17,17A,20,22,29	MANUFACTURED	.032 2024-T3 ALCLAD	FUSE-ALL
F-705B	CENTER SECTION BAR	1	20,22,25,38	MATERIAL	AB4-125X1 1/2	FUSE-ALL
F-705D-L	BULKHEAD SIDE CHANNEL	1	20,22	MANUFACTURED	.032 2024-T3 ALCLAD	FUSE-ALL
F-705D-R	BULKHEAD SIDE CHANNEL	1	20,22,25	MANUFACTURED	.032 2024-T3 ALCLAD	FUSE-ALL
F-705E-L	BULKHEAD SIDE DOUBLER	1	20	MANUFACTURED	.032 2024-T3 ALCLAD	FUSE-ALL
F-705E-R	BULKHEAD SIDE DOUBLER	1	20,25	MANUFACTURED	.032 2024-T3 ALCLAD	FUSE-ALL
F-705F	CHANNEL	1	20,25,40	MANUFACTURED	.040 2024-T3 ALCLAD	FUSE-ALL
F-705G-L	ANGLE	1	20,40	MATERIAL	AA6-187X2X2 1/2	FUSE-T
F-705G-R	ANGLE	1	20	MATERIAL	AA6-187X2X2 1/2	FUSE-T
F-705H	SPACER	2	20	MATERIAL	AB4-250X1 1/2	FUSE-ALL
F-705J	ANGLE	2	20	MATERIAL	AA6-063X3/4X3/4	FUSE-ALL
F-705K	PLATE	2	20	MATERIAL	AS3-040X1.875X16.25	FUSE-ALL
F-705L	SHIM	2	20	MATERIAL	AS3-063X.500X16.25	FUSE-ALL
F-706A-L	FUSELAGE BULKHEAD	1	17,17A,21,26,29,40	MANUFACTURED	.025 2024-T0 OR T3 ALCLAD	FUSE-ALL
F-706A-R	FUSELAGE BULKHEAD	1	21,25,26,29,40	MANUFACTURED	.025 2024-T0 OR T3 ALCLAD	FUSE-ALL
F-706B	FUSELAGE BULKHEAD	1	17,17A,21,26,29	MANUFACTURED	.025 2024-T0 OR T3 ALCLAD	FUSE-ALL
F-707B	ANGLE CLIP	1	26	MATERIAL	AA6-063X3/4X3/4	FUSE-ALL
F-707-L	FUSELAGE BULKHEAD	1	17,17A,21,26	MANUFACTURED	.025 2024-T0 OR T3 ALCLAD	FUSE-ALL
F-707-R	FUSELAGE BULKHEAD	1	21,26	MANUFACTURED	.025 2024-T0 OR T3 ALCLAD	FUSE-ALL
F-708-L	FUSELAGE BULKHEAD	1	17,17A,21,26	MANUFACTURED	.025 2024-T0 OR T3 ALCLAD	FUSE-ALL
F-708-R	FUSELAGE BULKHEAD	1	21,26	MANUFACTURED	.025 2024-T0 OR T3 ALCLAD	FUSE-ALL
F-709	BULKHEAD	1	17,17A,21,26,27A	MANUFACTURED	.025 2024-T0 OR T3 ALCLAD	FUSE-ALL
F-710	BULKHEAD	1	17,17A,21,26,27A	MANUFACTURED	.025 2024-T0 OR T3 ALCLAD	FUSE-ALL
F-7101-L	WEB - GEAR ATTACH	1	23,34,34A	MANUFACTURED	.063 2024-T3 ALCLAD	FUSE-ALL
F-7101-R	WEB - GEAR ATTACH	1	23	MANUFACTURED	.063 2024-T3 ALCLAD	FUSE-ALL
F-7103	INSTRUMENT PANEL (SLIDER)	1	17A,24	MANUFACTURED	.063 2024-T3 ALCLAD	FUSE-S
F-7103B-L	ATTACH ANGLE	1	24	MANUFACTURED	.032 2024-T3 ALCLAD	FUSE-S
F-7103B-R	ATTACH ANGLE	1	24	MANUFACTURED	.032 2024-T3 ALCLAD	FUSE-S
F-7103C	ATTACH ANGLE	2	24	MATERIAL	AA3-032X3/4X3/4	FUSE-S
F-7105A	CENTER SUB PANEL (SLIDER)	1	17A,24	MANUFACTURED	.032 2024-T3 ALCLAD	FUSE-S
F-7105B-L	OUTBD SUB PANEL (SLIDER)	1	24	MANUFACTURED	.032 2024-T0 OR T3 ALCLAD	FUSE-S
F-7105B-R	OUTBD SUB PANEL (SLIDER)	1	24	MANUFACTURED	.032 2024-T0 OR T3 ALCLAD	FUSE-S
F-7106	FWD TOP SKIN (SLIDER)	1	28	MANUFACTURED	.032 2024-T3 ALCLAD	FUSE-S
F-7107-L	FWD FUSELAGE RIB (SLIDER)	1	17A,24	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-S
F-7107-R	FWD FUSELAGE RIB (SLIDER)	1	24	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-S
F-7108A	FWD FUSELAGE RIB (SLIDER)	1	17A,24	MANUFACTURED	.032 2024-T3 ALCLAD	FUSE-S
F-7108B	ANGLE	1	24	MATERIAL	AA6-125X3/4X3/4	FUSE-S
F-7108C	CLIP	1	24	MATERIAL	AA3-032X3/4X3/4	FUSE-S
F-7109	PLATE	1	24	MATERIAL	AS3-063-2.1875X7.75	FUSE-S
F-710B	ANGLE	1	27A	MATERIAL	AA6-125X1X1	FUSE-ALL
F-710C	SPACER	1	27A	MATERIAL	AS3-125X1.000X9.313	FUSE-ALL
F-7110	STICK BOOT RING	2	34,34A	MATERIAL	AS3-032-5.438X5.032	FUSE-ALL

PART NUMBER	NOMENCLATURE	# PER A/C	RV-7 PLAN PG #	PART TYPE	MAKE FROM MATERIAL	SUB-KIT
F-7112	AFT TOP SKIN (SLIDER)	1	28	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-S
F-7114-L	FUSELAGE GUSSET	1	34	MANUFACTURED	.063 2024-T3 ALCLAD	FUSE-ALL
F-7114-R	FUSELAGE GUSSET	1	34	MANUFACTURED	.063 2024-T3 ALCLAD	FUSE-ALL
F-7116	SEAT BELT ATTACH SPACER/BUSHING	4	29	MATERIAL	AT6-058X5/16	FIN-ALL
F-7117A	FRONT CROTCH STRAP ATTACH BRACKET	2	OP-24	MANUFACTURED	.032 2024-T3 ALCLAD	FUSE-ALL
F-7117B	AFT CROTCH STRAP ATTACH BRACKET	2	OP-24	MANUFACTURED	.032 2024-T3 ALCLAD	FUSE-ALL
F-711A	BULKHEAD	1	17,17A,21,26,27	MANUFACTURED	.032 2024-T0 OR T3 ALCLAD	FUSE-ALL
F-711B	BULKHEAD	1	17,17A,21,26	MANUFACTURED	.032 2024-T0 OR T3 ALCLAD	FUSE-ALL
F-711C	HORIZ STAB ATTACH BAR	2	21,27	MATERIAL	AB4-187X1 1/4	FUSE-ALL
F-711D	ANGLE	1	21	MATERIAL	AA6-125X3/4X3/4	FUSE-ALL
F-711E	ELEVATOR STOP	1	21	MATERIAL	AS3-125X1.500X5.063	FUSE-ALL
F-7121	RUDDER CABLE ASSEMBLY	2	32,32A,37	MANUFACTURED	1/8" 7 X 19 GALVANIZED CABLE	FUSE-ALL
F-7127A-L	SIDE ANGLE	1	31A	MANUFACTURED	4130 STEEL	FUSE-ALL
F-7127A-R	SIDE ANGLE	1	31A	MANUFACTURED	4130 STEEL	FUSE-ALL
F-7127B	SPACER	2	31A	MATERIAL	AT6-058X5/16	FUSE-ALL
F-7127C	RETAINER STRIP	1	31A	MATERIAL	AB4-125X1 1/2	FUSE-ALL
F-7127D	DOUBLER	1	31A	MATERIAL	AS3-063X2 3/4X3 1/8	FUSE-ALL
F-712A	FUSELAGE BULKHEAD	1	17,17A,21,26,27	MANUFACTURED	.032 2024-T3 ALCLAD	FUSE-ALL
F-712B	FUSELAGE BULKHEAD	1	17,17A,21,26	MANUFACTURED	.032 2024-T3 ALCLAD	FUSE-ALL
F-712D	ELEVATOR STOP	1	21,27A	MATERIAL	AA6-125X3/4X1 1/4	FUSE-ALL
F-712E	TIE DOWN BAR	1	21	MATERIAL	AEX TIE DOWN X 7.500	FUSE-ALL
F-713-L	LEFT AUXILIARY LONGERON	1	17,17A,23	MANUFACTURED	AA6-125X3/4X3/4	FUSE-ALL
F-713-R	RIGHT AUXILIARY LONGERON	1	23	MANUFACTURED	AA6-125X3/4X3/4	FUSE-ALL
F-714	AFT DECK	1	18,26,27A	MANUFACTURED	.040 2024-T3 ALCLAD	FUSE-ALL
F-715-L	OUTBOARD SEAT RIB	1	17,17A,22	MANUFACTURED	.025 2024-T0 OR T3 ALCLAD	FUSE-ALL
F-715-R	OUTBOARD SEAT RIB	1	22	MANUFACTURED	.025 2024-T0 OR T3 ALCLAD	FUSE-ALL
F-716B	SEAT RIB ACCESS PLATE	2	22	MANUFACTURED	.063 2024-T3 ALCLAD	FUSE-ALL
F-716-L	INBOARD SEAT RIB	4	17,17A,22,32,32A	MANUFACTURED	.025 2024-T0 OR T3 ALCLAD	FUSE-ALL
F-716-R	INBOARD SEAT RIB	4	22,32,32A	MANUFACTURED	.025 2024-T0 OR T3 ALCLAD	FUSE-ALL
F-717	LOWER LONGERON	2	17,17A,23	MATERIAL	AA6-125X1X1 1/4	FUSE-ALL
F-718-L	UPPER LONGERON	1	17,17A,23,26,27A	MATERIAL	AA6-125X3/4X3/4	FUSE-ALL
F-718-R	UPPER LONGERON	1	18,25,23,26,27A,29	MATERIAL	AA6-125X3/4X3/4	FUSE-ALL
F-719B	ANGLE CLIP	2	23	MATERIAL	AA6-063X3/4X3/4	FUSE-ALL
F-719-L	FWD SKIN STIFFENER	1	17,17A,23,37	MANUFACTURED	AA6-063X3/4X3/4	FUSE-ALL
F-719-R	FWD SKIN STIFFENER	1	23,37	MANUFACTURED	AA6-063X3/4X3/4	FUSE-ALL
F-720-L	ARMREST	1	17,17A,23	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-720-R	ARMREST	1	25	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-721A-L	FWD CANOPY DECK	1	24,24A,25	MANUFACTURED	.040 2024-T3 ALCLAD	FUSE-ALL
F-721A-R	FWD CANOPY DECK	1	24,24A,25	MANUFACTURED	.040 2024-T3 ALCLAD	FUSE-ALL
F-721B-L	AFT CANOPY DECK	1	48,49	MANUFACTURED	.040 2024-T3 ALCLAD	FUSE-ALL
F-721B-R	AFT CANOPY DECK	1	18,25,49	MANUFACTURED	.040 2024-T3 ALCLAD	FUSE-ALL
F-721C	ANGLE CLIP	2	24,24A	MATERIAL	AA6-063X3/4X3/4	FUSE-ALL
F-721D	BRACKET	2	24,24A	MATERIAL	AA3-032X3/4X3/4	FUSE-ALL
F-722-L	AFT FUSELAGE BULKHEAD	1	17,17A	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-722-R	AFT FUSELAGE BULKHEAD	1	25	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-724-L	AFT FUSELAGE BULKHEAD	1	17,17A,29	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-724-R	AFT FUSELAGE BULKHEAD	1	25,29	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-725-L	OUTBOARD BAGGAGE RIB	1	17,17A,22,25,29	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-725-R	OUTBOARD BAGGAGE RIB	1	22,25,29	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-726-L	MID BAGGAGE RIB	1	17,17A,22,25,29	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-726-R	MID BAGGAGE RIB	1	22,25,29	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-727-L	INBOARD BAGGAGE RIB	1	17,17A,22,25,29	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-727-R	INBOARD BAGGAGE RIB	1	22,25,29	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-728A	BELLCRANK CHANNEL	1	17,17A,26,29	MANUFACTURED	.032 2024-T3 ALCLAD	FUSE-ALL
F-728B	ANGLE	1	26	MATERIAL	AA6-063X3/4X3/4	FUSE-ALL
F-729A	BELLCRANK RIB	1	17,17A,26	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-729B	ANGLE	1	26	MATERIAL	AA6-063X3/4X3/4	FUSE-ALL
F-729C	ANGLE	1	26	MATERIAL	AA6-063X3/4X3/4	FUSE-ALL
F-730	REINFORCEMENT PLATE	1	26	MANUFACTURED	.032 2024-T3 ALCLAD	FUSE-ALL
F-732A	CHANNEL	1	39,40	MANUFACTURED	.040 2024-T3 ALCLAD	FUSE-T
F-732D	ANGLE	1	39,40	MATERIAL	AA6-063X3/4X3/4	FUSE-T
F-732E	ANGLE	2	39,40	MATERIAL	AA6-063X3/4X3/4	FUSE-T
F-732F	SPACER	1	39	MANUFACTURED	.125 2024-T3 ALCLAD	FUSE-T
F-739	RIGHT FORWARD SEAT FLOOR	1	34,34A	MANUFACTURED	.040 2024-T3 ALCLAD	FUSE-ALL
F-740	LEFT FORWARD SEAT FLOOR	1	34,34A	MANUFACTURED	.040 2024-T3 ALCLAD	FUSE-ALL
F-741A	TUNNEL COVER SUPPORT	2	17,17A,30	MATERIAL	EXTR	FUSE-ALL
F-741B	TUNNEL COVER	1	17,17A,30	MATERIAL	AS3-040 X 2.75 X 8.969	FUSE-ALL
F-742-L	AFT SEAT FLOOR	1	29,30,33	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-742-R	AFT SEAT FLOOR	1	29,30	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-743B	ANGLE CLIP	1	24A	MATERIAL	AA6-063X3/4X3/4	FUSE-T
F-745-L	FWD FUSELAGE RIB (TIP-UP)	1	17,24A	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-T
F-745-R	FWD FUSELAGE RIB (TIP-UP)	1	24A	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-T
F-746	ENGINE CONTROL BRACKET	2	24,24A	MANUFACTURED	.040 2024-T3 ALCLAD	FUSE-ALL
F-747-L	BAGGAGE FLOOR	1	29	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-747-R	BAGGAGE FLOOR	1	29,33	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-748	BAGGAGE TUNNEL COVER	1	29,33	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-749-L	FWD BAGGAGE SIDE COVER	1	29	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-749-R	FWD BAGGAGE SIDE COVER	1	29	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-750-L	AFT BAGGAGE SIDE COVER	1	29	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-750-R	AFT BAGGAGE SIDE COVER	1	29	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-751	LOWER BAGGAGE BULKHEAD	1	29	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL

PART NUMBER	NOMENCLATURE	# PER A/C	RV-7 PLAN PG #	PART TYPE	MAKE FROM MATERIAL	SUB-KIT
F-757	PLATE	2	25,40	MANUFACTURED	.063 2024-T3 ALCLAD	FUSE-ALL
F-758	FLAP ACTUATOR BRACKET	1	33	MANUFACTURED	.063 2024-T3 ALCLAD	FUSE-ALL
F-759A	FLAP PUSHROD	2	33	MATERIAL	AT6-058X5/16	FUSE-ALL
F-760-L	FLAP ACTUATOR COVER	1	33	MANUFACTURED	.016 2024-T3 ALCLAD	FUSE-ALL
F-760-R	FLAP ACTUATOR COVER	1	33	MANUFACTURED	.016 2024-T3 ALCLAD	FUSE-ALL
F-766A	FLAP ACTUATOR CHANNEL	1	33	MANUFACTURED	.040 2024-T3 ALCLAD	FUSE-ALL
F-766B	FLAP ACTUATOR ANGLE	1	33	MATERIAL	AA6-125X1X1	FUSE-ALL
F-766C	FLAP ACTUATOR PLATE	1	33	MATERIAL	AB6-125X1	FUSE-ALL
F-766D	FLAP ACTUATOR SPACER	1	33	MATERIAL	AT6-058X3/8	FUSE-ALL
F-767	FLAP ACTUATOR ATTACH PLATE	1	33	MATERIAL	AS3-063 X 2 X 2.427	FUSE-ALL
F-768A	CENTER SUB-PANEL (TIP-UP)	1	17,24A,47	MANUFACTURED	.032 2024-T3 ALCLAD	FUSE-T
F-768B-L	OUTBD SUB PANEL (TIP-UP)	1	24A,47	MANUFACTURED	.032 2024-T0 OR T3 ALCLAD	FUSE-T
F-768B-R	OUTBD SUB PANEL (TIP-UP)	1	24A,47	MANUFACTURED	.032 2024-T0 OR T3 ALCLAD	FUSE-T
F-768C	SEAL SUPPORT ANGLE - CENTER	1	24A	MATERIAL	AA3-025X1/2X1/2	FUSE-T
F-768D	SEAL SUPPORT ANGLE - OUTBOARD	2	24A	MATERIAL	AA3-025X1/2X1/2	FUSE-T
F-770	FWD SIDE SKIN	2	28	MANUFACTURED	.032 2024-T3 ALCLAD	FUSE-ALL
F-771	FWD TOP SKIN (TIP-UP)	1	28	MANUFACTURED	.032 2024-T3 ALCLAD	FUSE-T
F-772	FWD BOTTOM SKIN	1	23,28,34,34A,36A	MANUFACTURED	.040 2024-T3 ALCLAD	FUSE-ALL
F-772B-L	FLOOR STIFFENER	2	23,34,34A	MANUFACTURED	AA6-063X3/4X3/4	FUSE-ALL
F-772B-R	FLOOR STIFFENER	2	23,34,34A,36,38	MANUFACTURED	AA6-063X3/4X3/4	FUSE-ALL
F-773-L	AFT SIDE SKIN	1	28	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-773-R	AFT SIDE SKIN	1	28	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-774	AFT TOP SKIN (TIP-UP)	1	28,48,49	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-T
F-775	REAR TOP SKIN	1	28	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-776	CENTER BOTTOM SKIN	1	22,28,38	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-777C	BATTERY SUPPORT ANGLE	1	31	MATERIAL	AA6-125X3/4X3/4	FUSE-ALL
F-777D	BATTERY SUPPORT ANGLE	1	31	MATERIAL	AA6-125X3/4X3/4	FUSE-ALL
F-777E	BATTERY HOLD DOWN ANGLE	1	31	MATERIAL	AA6-063X3/4X3/4	FUSE-ALL
F-777F	BATTERY HOLD DOWN ANGLE	1	31	MATERIAL	AA6-063X3/4X3/4	FUSE-ALL
F-777G	BATTERY TRAY ATTACH ANGLE	1	31	MATERIAL	AA6-063X3/4X3/4	FUSE-ALL
F-777H	SHIM	1	31	MATERIAL	AS3-125-3/4X1.71875	FUSE-ALL
F-778	AFT BOTTOM SKIN	1	28	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-779	TAIL BOTTOM SKIN	1	28	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-781	VERT STAB ATTACH PLATE	1	27A	MANUFACTURED	.063 2024-T3 ALCLAD	FUSE-ALL
F-782A-L	COVER PLATE	1	36	MANUFACTURED	.020 2024-T3 ALCLAD	FUSE-ALL
F-782A-R	COVER PLATE	1	36	MANUFACTURED	.020 2024-T3 ALCLAD	FUSE-ALL
F-782B-L	COVER SUPPORT RIB	1	11,36,36A	MANUFACTURED	.040 2024-T3 ALCLAD	FUSE-ALL
F-782B-R	COVER SUPPORT RIB	1	11,34,34A,36,36A	MANUFACTURED	.040 2024-T3 ALCLAD	FUSE-ALL
F-782C	CENTER CABIN COVER	1	34,36,36A	MANUFACTURED	.020 2024-T3 ALCLAD	FUSE-ALL
F-782D	ATTACH ANGLE	2	34	MATERIAL	AA3-032X3/4X3/4	FUSE-ALL
F-783B-L	COVER SUPPORT RIB	1	11	MANUFACTURED	.040 2024-T3 ALCLAD	FUSE-ALL
F-783B-R	COVER SUPPORT RIB	1	11,34,34A	MANUFACTURED	.040 2024-T3 ALCLAD	FUSE-ALL
F-785A	BACKREST BRACE	1	33	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-785B	ATTACH ANGLE	1	33	MATERIAL	AA6-063X3/4X3/4	FUSE-ALL
F-786A	TOP FUSELAGE J STIFFENER	2	18,26	MATERIAL	J-STIF	FUSE-ALL
F-786B	UPPER SIDE FUSELAGE J STIFFENER	2	18,25,26,27A	MATERIAL	J-STIF	FUSE-ALL
F-786C	LOWER SIDE FUSELAGE J STIFFENER	2	18,26,27A	MATERIAL	J-STIF	FUSE-ALL
F-787	STIFFENER WEB	1	17,17A,26	MANUFACTURED	.032 2024-T3 ALCLAD	FUSE-ALL
F-788	GUSSET	1	26	MANUFACTURED	.040 2024-T3 ALCLAD	FUSE-ALL
F-789	ELEVATOR PUSHROD	1	32,32A,38	MATERIAL	AT6-058X3/4	FUSE-ALL
F-790	ELEVATOR PUSHROD	1	32,32A,38	MATERIAL	AT6-035X1 1/2	FUSE-ALL
F-792	RUDDER STOP	2	26,27A	MATERIAL	AA6-125X1X1 1/4	FUSE-ALL
F-793	VENT SUPPORT ANGLE	2	24,24A	MATERIAL	AA3-032X3/4X3/4	FUSE-ALL
F-794A	EMPENNAGE GAP COVER	2	44	MANUFACTURED	.025 2024-T3 ALCLAD	FIN-ALL
F-794B	EMPENNAGE FAIRING	1	17,17A,44	MANUFACTURED	Epoxy Resin Fiberglass Cloth	FIN-ALL
F-796A-L	FUEL TANK ATTACH BRACKET	1	17A,23,38	MANUFACTURED	.063 4130 STEEL	FUSE-ALL
F-796A-R	FUEL TANK ATTACH BRACKET	1		MANUFACTURED	.063 4130 STEEL	FUSE-ALL
F-796B	REINFORCEMENT ANGLE	2	38	MATERIAL	AA6-125X3/4X3/4	FUSE-ALL
F-796C	SPACER	2	38	MATERIAL	AS3-063X.750X2.875	FUSE-ALL
F-796D	SPACER	2	38	MATERIAL	AS3-032X.750X2.875	FUSE-ALL
F-798	SHIM - HOR. STAB ATTACH	2	27	MATERIAL	AB4-125X1 1/2	FUSE-ALL
F-799	WING ROOT FAIRING	2	38	MANUFACTURED	.025 2024-T3 ALCLAD	FIN-ALL
F-824B	COVER PLATE	2	44	MANUFACTURED	.025 2024-T3 ALCLAD	FUSE-ALL
F-877APP	BATTERY TRAY	1	31	MANUFACTURED	.063 2024-T3 ALCLAD	FUSE-ALL
F-877B	BATTERY TRAY ANGLE	2	31	MATERIAL	AA6-063X3/4X3/4	FUSE-ALL
F-902-L	BULKHEAD	1	8	MANUFACTURED	.032 2024-T3 ALCLAD	FUSE-ALL
F-902-R	BULKHEAD	1	23,24A,36,36A	MANUFACTURED	.032 2024-T3 ALCLAD	FUSE-ALL
F-904J	CENTER SECTION SPACER	2	11	MATERIAL	AT6-058 X 3/8	FUSE-ALL
F-904L	ATTACH STRIP	4	23	MATERIAL	AS3-063X.625	FUSE-ALL
F-916C	SPACER	4	22	MATERIAL	AB4-125X1 1/2	FUSE-ALL
F-982A-L	COVER PLATE	1	34,36A	MANUFACTURED	.020 2024-T3 ALCLAD	FUSE-ALL
F-982A-R	COVER PLATE	1	36A	MANUFACTURED	.020 2024-T3 ALCLAD	FUSE-ALL
F-982D	HEAT BAFFLE	1	34,34A	MANUFACTURED	.020 OR .025 2024-T3 ALCLAD	FUSE-ALL
F-982E	ACCESS PLATE	1	34,34A	MANUFACTURED	.020 OR .025 2024-T3 ALCLAD	FUSE-ALL
F-983A	FUEL VALVE PLATE	1	34,34A,36,36A	MANUFACTURED	.063 2024-T3 ALCLAD	FUSE-ALL
F-983C	FUEL VALVE COVER	1	34,34A,36,36A	MANUFACTURED	.020 2024-T3 ALCLAD	FUSE-ALL
F-983D	FUEL VALVE SPACER	2	36,36A	MATERIAL	AT6-058X3/8	FUSE-ALL
FL-701-L	FLAP TOP SKIN	1	12,14A	MANUFACTURED	.025 2024-T3 ALCLAD	FLAP
FL-701-R	FLAP TOP SKIN	1	12	MANUFACTURED	.025 2024-T3 ALCLAD	FLAP
FL-702-L	FLAP BOTTOM SKIN	1	14A	MANUFACTURED	.025 2024-T3 ALCLAD	FLAP
FL-702-R	FLAP BOTTOM SKIN	1	12	MANUFACTURED	.025 2024-T3 ALCLAD	FLAP

PART NUMBER	NOMENCLATURE	# PER A/C	RV-7 PLAN PG #	PART TYPE	MAKE FROM MATERIAL	SUB-KIT
FL-703-L	FLAP SPAR	1	9,14A	MANUFACTURED	.040 2024-T3 ALCLAD	FLAP
FL-703-R	FLAP SPAR	1		MANUFACTURED	.040 2024-T3 ALCLAD	FLAP
FL-704-L	FLAP END RIB	2	9,14A	MANUFACTURED	.025 2024-T3 ALCLAD	FLAP
FL-704-R	FLAP END RIB	2		MANUFACTURED	.025 2024-T3 ALCLAD	FLAP
FL-705	FLAP RIB	8	9,14A	MANUFACTURED	.025 2024-T3 ALCLAD	FLAP
FL-706A	ANGLE	2		MATERIAL	AA6-125X1 1/2X2	FLAP
FL-706B	FLAP PLATE	2	14A	MANUFACTURED	AS3-125X3X5.875	FLAP
FL-708	SPACER	4	14A	MATERIAL	AS3-025 X 5/8 X 1.875	FLAP
FLAP HINGE RV-7	FLAP HINGE	2	14A	MATERIAL	AN257-P3	FLAP
FUEL LINE (FUSE)	FUEL LINE	1	36,36A	MATERIAL	AT0-035X3/8	FUSE-ALL
FUEL PICK-UP LINE RV-7/8	STANDARD FUEL PICK-UP LINE	2	10A,16A	MATERIAL	AT0-035X3/8	WING
FUEL VALVE	FUEL SELECTOR VALVE	1	36,36A	MANUFACTURED	BRASS BALL VALVE	FUSE-ALL
HS-00001	SPAR DOUBLER	1	3	MANUFACTURED	.063 2024-T3 ALCLAD	EMPENNAGE
HS-00005	INBOARD AFT RIB	2	3	MANUFACTURED	.032 2024-T0 OR T3 ALCLAD	EMPENNAGE
HS-00006	INBOARD FORWARD RIB	2	3	MANUFACTURED	.032 2024-T0 OR T3 ALCLAD	EMPENNAGE
HS-411APP	ELEVATOR HINGE BRACKET	1	3	MANUFACTURED	.050 4130 COND N STEEL	EMPENNAGE
HS-411BPP	ELEVATOR HINGE BRACKET	1	3	MANUFACTURED	.050 4130 COND N STEEL	EMPENNAGE
HS-412PP	ELEVATOR HINGE BRACKET	4	3	MANUFACTURED	.050 4130 COND N STEEL	EMPENNAGE
HS-413PP	ELEVATOR HINGE BRACKET	4	3	MANUFACTURED	.050 4130 COND N STEEL	EMPENNAGE
HS-601PP	HORIZ STAB SKIN	2	3	MANUFACTURED	.032 2024-T3 ALCLAD	EMPENNAGE
HS-603PP	HORIZ STAB REAR SPAR	2	3	MANUFACTURED	.032 2024-T3 ALCLAD	EMPENNAGE
HS-609PP	HORIZ STAB REAR SPAR REINF BAR	2	3	MANUFACTURED	AB4-1 1/4 x .187	EMPENNAGE
HS-615	HORIZONTAL STABILIZER TIP	2	3	MANUFACTURED	Polyester Resin Fiberglass Cloth	EMPENNAGE
HS-702	HORIZ STAB FRONT SPAR	2	3	MANUFACTURED	.032 2024-T3 ALCLAD	EMPENNAGE
HS-706	HORIZ. STAB TIP RIB	2	3	MANUFACTURED	.025 2024-T0 OR T3 ALCLAD	EMPENNAGE
HS-707	HORIZ. STAB. NOSE RIB	2	3	MANUFACTURED	.025 2024-T0 OR T3 ALCLAD	EMPENNAGE
HS-708	HORIZ. STAB. MAIN RIB	2	3	MANUFACTURED	.025 2024-T3 OR T0 ALCLAD	EMPENNAGE
HS-710	HORZ. STAB. REINF. ANGLE	1	3	MANUFACTURED	AA6-125X3/4X3/4	EMPENNAGE
HS-714	HORIZ. STAB.	1	3	MANUFACTURED	AA6-125X1X1	EMPENNAGE
MAIN LEG FAIRING HINGE	GEAR LEG FAIRING HINGE	2	C3	MATERIAL	HINGE PIANO 063	FIN-ALL
NOSE LEG FAIRING HINGE	GEAR LEG FAIRING HINGE	1	C1	MATERIAL	HINGE PIANO 063	FIN-ALL
PITOT LINE RV-7/8	PITOT TUBE MATERIAL	1	10A,15A	MATERIAL	ATO-032X1/4	WING
R-405PD	RUDDER HORN	1	7	MANUFACTURED	AA6-125X1 1/2X2	EMPENNAGE
R-411	RUDDER BOTTOM	1	7	MANUFACTURED	Polyester Resin Fiberglass Cloth	EMPENNAGE
R-606PP	REINFORCEMENT PLATE	1	7	MANUFACTURED	.063 2024-T3 ALCLAD	EMPENNAGE
R-607PP	REINFORCEMENT PLATE	1	7	MANUFACTURED	.063 2024-T3 ALCLAD	EMPENNAGE
R-608PP	REINFORCEMENT PLATE	1	7	MANUFACTURED	.063 2024-T3 ALCLAD	EMPENNAGE
R-703	RUDDER TIP RIB	1	7	MANUFACTURED	.032 2024-T0 OR T3 ALCLAD	EMPENNAGE
R-704	RUDDER BOTTOM RIB	1	7	MANUFACTURED	.032 2024-T3 OR T3 ALCLAD	EMPENNAGE
R-710	RUDDER HORN BRACE	1	7	MANUFACTURED	.040 2024-T3 ALCLAD	EMPENNAGE
R-710	RUDDER HORN BRACE	1	7	MANUFACTURED	.040 2024-T3 ALCLAD	EMPENNAGE
R-713	RUDDER COUNTERBALANCE SKIN	1	7	MANUFACTURED	.032 2024-T3 ALCLAD	EMPENNAGE
R-716	RUDDER BOTTOM ATTACH STRIP	2	7	MATERIAL	AAS-032X1 1/8X14 23/32	EMPENNAGE
R-717	RUDDER SHIM	1	7	MATERIAL	AAS-032X1/2X3 1/2	EMPENNAGE
R-801PP	RUDDER SKIN	1	7	MANUFACTURED	.020 2024-T3 ALCLAD	EMPENNAGE
R-901-L	RUDDER SKIN	1	7	MANUFACTURED	.016 2024-T3 ALCLAD	EMPENNAGE
R-901-R	RIGHT RUDDER SKIN	1	7	MANUFACTURED	.016 2024-T3 ALCLAD	EMPENNAGE
R-902	RUDDER SPAR	1	7	MANUFACTURED	.032 2024-T3 ALCLAD	EMPENNAGE
R-903	RUDDER TIP RIB	1	7	MANUFACTURED	.032 2024-T3 ALCLAD	EMPENNAGE
R-904	RUDDER BOTTOM RIB	1	7	MANUFACTURED	.032 2024-T3 ALCLAD	EMPENNAGE
R-909	RUDDER TIP	1	7	MANUFACTURED	Polyester Resin Fiberglass Cloth	EMPENNAGE
R-911	RUDDER BOTTOM	1	7	MANUFACTURED	Polyester Resin Fiberglass Cloth	EMPENNAGE
R-912	RUDDER COUNTERBALANCE RIB	1	7	MANUFACTURED	.032 2024-T3 ALCLAD	EMPENNAGE
R-913	RUDDER COUNTERBALANCE SKIN	1	7	MANUFACTURED	.032 2024-T3 ALCLAD	EMPENNAGE
R-915	RUDDER STIFFENER	8	7	MANUFACTURED	.025 2024-T3 ALCLAD	EMPENNAGE
R-916	RUDDER TRAILING EDGE	1	7	MANUFACTURED	AEX WEDGE 11.9	EMPENNAGE
R-917	SHIM	1	7	MATERIAL	AS3-032 X 1 1/8	EMPENNAGE
R-918	RUDDER BOTTOM ATTACH STRIP	2	7	MATERIAL	AS3-032 X 1 1/8	EMPENNAGE
RUBBER CHANNEL S-88D20	RUBBER SMOKE SEAL	1		MATERIAL	RUBBER SMOKE SEAL	FIN-T
S-601-1	SPINNER	1	C4	MANUFACTURED	Polyester Resin Fiberglass Cloth	SPINNER-COM
S-602B	SPINNER BACK PLATE DOUBLER - CS	1	C4	MANUFACTURED	.063 2024-T3 ALCLAD	SPINNER-CS
S-603	SPINNER FRONT PLATE - CS	1	C4	MANUFACTURED	.063 2024-T3 ALCLAD	SPINNER-CS
S-604	SPACER - CS SPINNER	4	C4	MANUFACTURED	N/A	SPINNER-CS
S-605	SPINNER FRONT PLATE - WOOD	1	C4	MANUFACTURED	.063 2024-T3 ALCLAD	SPINNER-WOOD
S-605 SEN	SPINNER FRONT PLATE - SENSENICH	1	C4	MANUFACTURED	.063 2024-T3 ALCLAD	SPINNER-SEN
SPINNER GAP FILLER	SPINNER GAP FILLER	2	C4	MATERIAL	AS3-063 4 1/2 X 4 1/2	SPINNER-COM
T-405-L	BRACKET	1	9,16A,38	MATERIAL	AA6-187X2X2 1/2	WING
T-405-R	BRACKET	1		MATERIAL	AA6-187X2X2 1/2	WING
T-406A	FUEL CAP	2		MANUFACTURED	ALUMINUM	WING
T-406B	FUEL CAP FLANGE	2	9,10A,16A	MANUFACTURED	SPUN ALUMINUM	WING
T-407/T-410	TANK RING (1) REINF (2)	2	9,10A,16A	MANUFACTURED	.063 2024-T3 ALCLAD	WING
T-407-GASKET	CORK GASKET	2	10A,16A	MANUFACTURED	CORK SHEET	WING
T-408	TANK ACCESS PLATE	2	9,10A,16A	MANUFACTURED	.063 2024-T3 ALCLAD	WING
T-701-L	FUEL TANK SKIN	1	9,12,16A,38	MANUFACTURED	.032 2024-T3 ALCLAD	WING
T-701-R	FUEL TANK SKIN	1		MANUFACTURED	.032 2024-T3 ALCLAD	WING
T-702-L	FUEL TANK BAFFLE	1	10A,16A	MANUFACTURED	.032 2024-T3 ALCLAD	WING
T-702-R	FUEL TANK BAFFLE	1		MANUFACTURED	.032 2024-T3 ALCLAD	WING
T-703-L	FUEL TANK END RIB	2	9,10A,12,16A,36,36A	MANUFACTURED	.032 2024-T0 OR T3 ALCLAD	WING
T-703-R	FUEL TANK END RIB	2	9,10A,16A,36,36A	MANUFACTURED	.032 2024-T0 OR T3 ALCLAD	WING
T-704-L	FUEL TANK INTERIOR RIB	5	9,10A,16A	MANUFACTURED	.025 2024-T0 OR T3 ALCLAD	WING
T-704-R	FUEL TANK INTERIOR RIB	5		MANUFACTURED	.025 2024-T0 OR T3 ALCLAD	WING

PART NUMBER	NOMENCLATURE	# PER A/C	RV-7 PLAN PG #	PART TYPE	MAKE FROM MATERIAL	SUB-KIT
T-711	FUEL TANK STIFFENER	4	9,10A,16A	MANUFACTURED	.032 2024-T3 ALCLAD	WING
T-712	FUEL TANK ATTACH BRACKET	14	10A,16A	MANUFACTURED	AZ6-063 X 1.125 X 625 6061-T6	WING
T-714	CLIP	2	16A	MATERIAL	AS3-020X1/2X2 9/16	WING
T-915	ANTI-ROTATION BRACKET	2	16A	MATERIAL	AA6-125X1X1	WING
U 5.00 X 5-6	5.00 X 5 TIRE	2	C2	MANUFACTURED	RUBBER	FIN-ALL
U 5.00 X 5-6 IT	5.00 X 5 INNER TUBE	2	C2	MANUFACTURED	RUBBER	FIN-ALL
U CLEVELAND 199-10200	5.00 X 5 WHEEL AND BRAKE ASSEMBLY	1	C2	MANUFACTURED	ASSEMBLY	FIN-ALL
U FSTW-ASSY	FULL SWIVEL TAIL-WHEEL ASSEMBLY	1	27,32	MANUFACTURED	N/A	FUSE-ALL
U LAMB TIRE	NOSE WHEEL TIRE	1	C1	MANUFACTURED	RUBBER	FIN-ALL
U LAMB TUBE	NOSE WHEEL TUBE	2	C1	MANUFACTURED	RUBBER	FIN-ALL
U NW501.25	MATCO NOSE WHEEL	1	C1	MANUFACTURED	ASSEMBLY	FIN-ALL
U-403-PC	BRAKE MOUNT FLANGE	2	C2	MANUFACTURED	4130 STEEL	FUSE-ALL
U-405	AXLE SPACER	4	C2	MANUFACTURED	2024-T351 AL	FIN-ALL
U-408	SPACER	6	C2	MATERIAL	AT6-058 X 3/8	FIN-ALL
U-601-L-PC	LEFT LANDING GEAR LEG	1	46	MANUFACTURED	6150 STEEL	FIN-ALL
U-601-R-PC	RIGHT LANDING GEAR LEG	1	46	MANUFACTURED	6150 STEEL	FIN-ALL
U-603-2-PC	NOSE GEAR STRUT	1	41,C1	MANUFACTURED	6150 STEEL	FIN-ALL
U-611	SPRING WASHER	2	C1	MANUFACTURED	STEEL	FIN-ALL
U-620B	BRACE	1	45	MANUFACTURED	.040 2024-T3 ALCLAD	FIN-ALL
U-620C	SPACER	1	45	MATERIAL	AS3-063 1 1/4 X 7	FIN-ALL
U-620D	SPACER	1	45	MATERIAL	AS3-032 1 1/4 X 7	FIN-ALL
U-621	SPACER	1	45	MATERIAL	AS3-063 2 3/8 X 6 1/2	FIN-ALL
U-623-1	AXLE BEARING ADAPTER	2	C1	MANUFACTURED	6061-T6	FIN-ALL
U-701A-L-PC	LEFT LANDING GEAR LEG	1	34A	MANUFACTURED	6150 STEEL	FUSE-ALL
U-701A-R-PC	RIGHT LANDING GEAR LEG	1	34A	MANUFACTURED	6150 STEEL	FUSE-ALL
U-713C-L	BRACKET	1	C1	MANUFACTURED	.040 2024-T3 ALCLAD	FIN-ALL
U-713C-R	BRACKET	1	C1	MANUFACTURED	.040 2024-T3 ALCLAD	FIN-ALL
U-720A	UPPER AIR OUTLET BRACE	1	45	MANUFACTURED	.040 2024-T3 ALCLAD	FIN-ALL
U-720B	LOWER AIR OUTLET BRACE	1	45	MANUFACTURED	.040 2024-T3 ALCLAD	FIN-ALL
U-808	OUTBD WHEEL FAIRING BRACKET	2	C2	MANUFACTURED	.063 2024-T3 ALCLAD	FIN-ALL
U-810-L	WHEEL FAIRING ATTACH BRACKET	1	C2	MANUFACTURED	.063 2024-T3 ALCLAD	FIN-ALL
U-810-R	WHEEL FAIRING ATTACH BRACKET	1	C2	MANUFACTURED	.063 2024-T3 ALCLAD	FIN-ALL
U-813A	NOSE WHEEL FAIRING - REAR	1	C1	MANUFACTURED	Polyester Resin/Fiberglass Cloth	FIN-ALL
U-813B	NOSE WHEEL FAIRING - FRONT	1	C1	MANUFACTURED	Polyester Resin/Fiberglass Cloth	FIN-ALL
U-817	GEAR LEG FAIRING	2	C3	MANUFACTURED	Epoxy Resin/Fiberglass Cloth	FIN-ALL
U-818	NOSE GEAR LEG FAIRING	1	C1	MANUFACTURED	Epoxy Resin/Fiberglass Cloth	FIN-ALL
U-TAIL WHEEL 6"	TAIL WHEEL	1	27	MANUFACTURED	ASSY	FIN-ALL
VA-101	THREADED ROD END	2	38	MANUFACTURED	ALUMINUM	FUSE-ALL
VA-104-1	KNOB	1	48,49	MANUFACTURED	PLASTIC	FIN-T
VA-105A	SPRING	2	27	MANUFACTURED	N/A	FUSE-ALL
VA-105B	SASH CHAIN	2	27	MANUFACTURED	#40 SASH CHAIN	FUSE-ALL
VA-105C	CLIP	4	27	MANUFACTURED	4130 STEEL WIRE	FUSE-ALL
VA-106	AXLE NUT	2	C2	MANUFACTURED	6061-T6 AL	FIN-ALL
VA-107	BRAKE RESERVOIR	1	36,36A	MANUFACTURED	6061 ALUMINUM	FUSE-ALL
VA-111	THREADED ROD END	4	15A	MANUFACTURED	ALUMINUM	WING
VA-112	DRAIN FLANGE	2	16A	MANUFACTURED	2024-T3 ALUMINUM	WING
VA-115 (AN490HT11P SDM)	THREADED ROD END	2	38	MANUFACTURED	ALUMINUM	FUSE-ALL
VA-118-1	BRAKE HOSE	2	36,36A	MANUFACTURED	AEROQUIP HOSE	FIN-ALL
VA-157A-1	WHEEL FAIRING FRONT HALF	2	C2	MANUFACTURED	Epoxy Resin/Fiberglass Cloth	FIN-ALL
VA-157B-1	WHEEL FAIRING REAR HALF	2	C2	MANUFACTURED	Epoxy Resin/Fiberglass Cloth	FIN-ALL
VA-172	FLUSH WING TIP LIGHT LENS	1		MANUFACTURED	POLYCARBONATE	WING
VENT LINE (FUSE)	VENT LINE	1	36,36A	MATERIAL	AT0-032X1/4	FUSE-ALL
VENT LINE RV-7	FUEL TANK VENT LINE MATERIAL	2	10A,16A	MATERIAL	AT0-032X1/4	WING
VENT SV COMBO	VENTILATION KIT	2	24,24A	MANUFACTURED	N/A	FUSE-ALL
VS-410PP-PC	HINGE BRACKET	2	6	MANUFACTURED	.050 4130 STEEL	EMPENNAGE
VS-411PP-PC	HINGE BRACKET	2	6	MANUFACTURED	.050 4130 STEEL	EMPENNAGE
VS-411PP-PC-	HINGE BRACKET	2	48,49	MANUFACTURED	.050 4130 STEEL	FUSE-T
VS-412PP-PC	HINGE BRACKET	2	6	MANUFACTURED	.050 4130 STEEL	EMPENNAGE
VS-702	VERT STAB FRONT SPAR	1	6	MANUFACTURED	.032 2024-T3 ALCLAD	EMPENNAGE
VS-702	VERTICALSTAB FRONT SPAR	1	6	MANUFACTURED	.032 2024-T3	EMPENNAGE
VS-704	VERTICAL STAB ROOT RIB	1	6	MANUFACTURED	.032 2024-T0 OR T3 ALCLAD	EMPENNAGE
VS-705	VERTICAL STAB NOSE RIB	1	6	MANUFACTURED	.032 2024-T0 OR T3 ALCLAD	EMPENNAGE
VS-706	VERTICAL STAB TIP RIB	1	6	MANUFACTURED	.025 2024-T0 OR T3 ALCLAD	EMPENNAGE
VS-707	VERTICAL STAB MAIN RIB	1	6	MANUFACTURED	.025 2024-T0 OR T3 ALCLAD	EMPENNAGE
VS-801PP	VERT STAB SKIN	1	6	MANUFACTURED	.032 2024-T3 ALCLAD	EMPENNAGE
VS-803PP	VERT STAB REAR SPAR	1	6	MANUFACTURED	.032 2024-T3 ALCLAD	EMPENNAGE
VS-808PP	VERT STAB SPAR DOUBLER	1	6	MANUFACTURED	.125 2024-T3 ALCLAD	EMPENNAGE
VS-909	VERT STAB TIP	1	6	MANUFACTURED	Polyester Resin Fiberglass Cloth	EMPENNAGE
W-408-1L	WING NOTCHED NOSE RIB	1	9,10A,12	MANUFACTURED	.032 2024-T0 OR T3 ALCLAD	WING
W-408-1R	WING NOTCHED NOSE RIB	1		MANUFACTURED	.032 2024-T0 OR T3 ALCLAD	WING
W-412	WING TIP RIB	2	9,12	MANUFACTURED	.025 2024-T0 OR T3 ALCLAD	WING
W-413-PP-L	AILERON MOUNT PLATE ASSEMBLY	1	10A,13A	MANUFACTURED	ASSEMBLY	WING
W-413-PP-R	AILERON MOUNT PLATE ASSEMBLY	1		MANUFACTURED	ASSEMBLY	WING
W-414-PP-L	AILERON HINGE BRACKET ASSEMBLY	1	10A,13A	MANUFACTURED	ASSEMBLY	WING
W-414-PP-R	AILERON HINGE BRACKET ASSEMBLY	1		MANUFACTURED	ASSEMBLY	WING
W-423	JOINT PLATE	2	10A,12	MATERIAL	AS3-032X1.5X36.5	WING
W-701-L	WING LEADING EDGE SKIN	1	9,12	MANUFACTURED	.025 2024-T3 ALCLAD	WING
W-701-R	WING LEADING EDGE SKIN	1	12	MANUFACTURED	.025 2024-T3 ALCLAD	WING
W-702	WING UPPER INBOARD SKIN	2	9,12,38	MANUFACTURED	.032 2024-T3 ALCLAD	WING
W-703	WING UPPER OUTBOARD SKIN	2	9,12,13A	MANUFACTURED	.025 2024-T3 ALCLAD	WING
W-704-L	WING LOWER INBOARD SKIN	1	9,38	MANUFACTURED	.032 2024-T3 ALCLAD	WING

PART NUMBER	NOMENCLATURE	# PER A/C	RV-7 PLAN PG #	PART TYPE	MAKE FROM MATERIAL	SUB-KIT
W-704-R	WING LOWER INBOARD SKIN	1	12,14A	MANUFACTURED	.032 2024-T3 ALCLAD	WING
W-705-L	WING LOWER OUTBOARD SKIN	1	9	MANUFACTURED	.025 2024-T3 ALCLAD	WING
W-705-R	WING LOWER OUTBOARD SKIN	1	12	MANUFACTURED	.025 2024-T3 ALCLAD	WING
W-707A-L	WING REAR SPAR WEB	1	9,10A,14A,38	MANUFACTURED	.040 2024-T3 ALCLAD	WING
W-707A-R	WING REAR SPAR WEB	1	38	MANUFACTURED	.040 2024-T3 ALCLAD	WING
W-707D	REAR SPAR DOUBLER PLATE	2	9,10A	MANUFACTURED	.125 2024-T3 ALCLAD	WING
W-707E	REAR SPAR CENTER REINF.	2	10A	MANUFACTURED	.040 2024-T3 ALCLAD	WING
W-707F	REAR SPAR END REINFORCMENT	2	10A	MANUFACTURED	.040 2024-T3 ALCLAD	WING
W-707G	REAR SPAR REINF. FORK	2	9,10A	MANUFACTURED	.125 2024-T3 ALCLAD	WING
W-709-L	WING LEADING EDGE RIB	5	9,10A	MANUFACTURED	.025 2024-T0 OR T3 ALCLAD	WING
W-709-R	WING LEADING EDGE RIB	5	10A	MANUFACTURED	.025 2024-T0 OR T3 ALCALD	WING
W-710-L	WING INBOARD RIB	1		MANUFACTURED	.032 2024-T0 OR T3 ALCLAD	WING
W-710-R	WING INBOARD RIB	1	9,10A	MANUFACTURED	.032 2024-T0 OR T3 ALCLAD	WING
W-711-L	WING INBOARD RIB	10	9,10A,15A	MANUFACTURED	.025 2024-T0 OR T3 ALCLAD	WING
W-711-R	WING INBOARD RIB	10	9,10A	MANUFACTURED	.025 2024-T0 OR T3 ALCLAD	WING
W-712-L	WING OUTBOARD RIB	3	9,10A	MANUFACTURED	.025 2024-T0 OR T3 ALCLAD	WING
W-712-R	WING OUTBOARD RIB	3	9,10A,12	MANUFACTURED	.025 2024-T0 OR T3 ALCLAD	WING
W-715-L	WING TIP	1		MANUFACTURED	Polyester Resin Fiberglass Cloth	WING
W-715-R	WING TIP	1		MANUFACTURED	Polyester Resin Fiberglass Cloth	WING
W-716	AILERON BELLCRANK TO STICK PUSHROD	2	9,10A,15A,38	MATERIAL	AT6-035X1.125	WING
W-721-L	FLAP BRACE	1	9,10A,14A	MANUFACTURED	.040 2024-T3 ALCLAD	WING
W-721-R	FLAP BRACE	1		MANUFACTURED	.040 2024-T3 ALCLAD	WING
W-724-L	AILERON GAP FAIRING	1	10A,13A	MANUFACTURED	.020 2024-T3 ALCLAD	WING
W-724-R	AILERON GAP FAIRING	1		MANUFACTURED	.020 2024-T3 ALCLAD	WING
W-726	WING TIE DOWN SPACERS	4	15A	MATERIAL	AB4-187X1.25	WING
W-727	WING WALK DOUBLER	2	12,38	MATERIAL	AS3-025X9.375X26	WING
W-728A	WING TIP REINF. STRIP TOP	2	12	MATERIAL	AS3-020X1/2X48	WING
W-728B	WING TIP REINF. STRIP BOTTOM	2	12	MATERIAL	AS3-020X1/2X45	WING
W-730	BELLCRANK JIG	1	15A	MANUFACTURED	.063 2024-T3 ALCLAD	WING
W-731	TIE DOWN BAR	2	9,15A	MATERIAL	AEX TIE DOWN X 7.500	WING
W-818	AILERON BELLCRANK TO AILERON PUSHROD	2	9,10A,15A	MATERIAL	ST4130-035X1/2	WING
W-822PP	ACCESS PLATE	4	9,12	MANUFACTURED	.032 2024-T3 ALCLAD	WING
W-822PP-	ACCESS PLATE	2	9,12	MANUFACTURED	.032 2024-T3 ALCLAD	WING
W-823PP-PC	BELLCRANK BRACKET	4	10A,15A	MANUFACTURED	.050 4130 STEEL	WING
W-929	AILERON BELLCRANK SPACER	2	15A	MATERIAL	AT6-058X5/16	WING
WD-409	TAIL SPRING MOUNT	1	27	MANUFACTURED	4130	FUSE-ALL
WD-415	TRIM CABLE ANCHOR	1	4	MANUFACTURED	4130 STEEL	FUSE-ALL
WD-421-L-PC	AILERON BELLCRANK	1	10A,15A	MANUFACTURED	4130 STEEL	WING
WD-421-R-PC	AILERON BELLCRANK	1		MANUFACTURED	4130 STEEL	WING
WD-602-L-1-PC	UPPER ENGINE MOUNT BRACKET	1	19,35	MANUFACTURED	4130 STEEL	FUSE-ALL
WD-602-R-1-PC	UPPER ENGINE MOUNT BRACKET	1	19,35	MANUFACTURED	4130 STEEL	FUSE-ALL
WD-603-L-1-PC	LOWER ENGINE MOUNT BRACKET	1	19,23,35	MANUFACTURED	4130 STEEL	FUSE-ALL
WD-603-R-1-PC	LOWER ENGINE MOUNT BRACKET	1	19,23,35	MANUFACTURED	4130 STEEL	FUSE-ALL
WD-605-L-1-PC	ELEVATOR HORN	1	4,5,32,32A	MANUFACTURED	4130 STEEL	EMPENNAGE
WD-605-R-1-PC	ELEVATOR HORN	1	4,5,32,32A	MANUFACTURED	4130 STEEL	EMPENNAGE
WD-610-PC	CONTROL COLUMN	1	32,32A,35,38	MANUFACTURED	STEEL	FUSE-ALL
WD-611-PC	CONTROL STICK - RIGHT	1	35,38	MANUFACTURED	STEEL	FUSE-ALL
WD-612-PC	CONTROL STICK - LEFT	1	32,32A,35,38	MANUFACTURED	STEEL	FUSE-ALL
WD-613-EF-PC	FLAP ACTUATOR WELDMENT	1	32,32A,33,35	MANUFACTURED	STEEL	FUSE-ALL
WD-617-PC	CANOPY LATCH	1	35,48,49	MANUFACTURED	STEEL	FIN-T
WD-618-PC	CANOPY RELEASE ARM	1	35,47,49	MANUFACTURED	4130 STEEL	FIN-T
WD-619-PC	CANOPY RELEASE SHAFT	1	35,47	MANUFACTURED	4130 STEEL	FIN-T
WD-620-PC	CANOPY JETTISON HANDLE	1	35,47,48,49	MANUFACTURED	4130 STEEL	FIN-T
WD-621-PC	CANOPY HANDLE	1	35,48,49	MANUFACTURED	4130 STEEL	FIN-T
WD-622	CANOPY LATCH LUG	2	35,48	MANUFACTURED	4130 STEEL	FIN-T
WD-630	NOSE WHEEL FORK	1	C1	MANUFACTURED	6061-T6 AL	FIN-ALL
WD-631-PC	NOSE STOP FLANGE	1	C1	MANUFACTURED	4130 STEEL	FIN-ALL
WD-635-PC	DYNA 1 ENGINE MOUNT	1	35,45,46	MANUFACTURED	4130 STEEL	FIN-ALL
WD-640-PC	CANOPY FRAME	1	17A,35,41,42,43	MANUFACTURED	4130 STEEL	FIN-S
WD-641-PC	ROLL BAR	1	17A,35,41,42,43	MANUFACTURED	4130 STEEL	FIN-S
WD-642-PC	CANOPY HANDLE	1	35,43	MANUFACTURED	4130 STEEL	FIN-S
WD-643-SS	CANOPY BRACE	1	17A,35,41,42,43	MANUFACTURED	STAINLESS STEEL	FIN-S
WD-644-PC	CANOPY ROLLER	2	35,41	MANUFACTURED	4130 STEEL	FIN-S
WD-655-L-PC	RUDDER PEDAL - LEFT	1	32,32A,35,37	MANUFACTURED	STEEL	FUSE-ALL
WD-655-R-PC	RUDDER PEDAL - RIGHT	1	32,32A,35,37	MANUFACTURED	STEEL	FUSE-ALL
WD-716	TIP-UP CANOPY FRAME	1	47,48,49	MANUFACTURED	6061 ALUMINUM	FIN-T
WD-721-L-PC	LANDING GEAR MOUNT - LEFT	1	34A,35,36A	MANUFACTURED	STEEL	FUSE-ALL
WD-721-R-PC	LANDING GEAR MOUNT - RIGHT	1	17A,35	MANUFACTURED	STEEL	FUSE-ALL
WD-725-L	CANOPY FRAME SIDE	1	48,49	MANUFACTURED	6061 ALUMINUM	FIN-T
WD-725-R	CANOPY FRAME SIDE	1	48,49	MANUFACTURED	6061 ALUMINUM	FIN-T
WD-762-D1-PC	DYNA 1 ENGINE MOUNT	1	46	MANUFACTURED	4130 STEEL	FIN-ALL
W-SPAR ASSY RV-7	FRONT SPAR AND CENTER SECTION ASSEMBLY	1	9,10A,11,12,15A,16A	MANUFACTURED	ASSEMBLY	WING

SECTION 5: GENERAL INFORMATION

NOTE: Plans pages may refer to Section 5 by a letter designation. Please refer to the conversion chart below to find the corresponding section's numerical designation.

#	LETTER	
5.1	5A	ALUMINUM PRIMING & PAINTING
5.2	5B	EDGE FINISHING, DEBURRING & SCRATCH REMOVAL
5.3	5C	MARKING PARTS
5.4	5D	RIVETING
5.5	5E	COUNTERSINKING & DIMPLING
5.6	5F	BACK RIVETING
5.7	5G	FOLDED TRAILING EDGES
5.7	5H	RIVETED TRAILING EDGES
5.9	5J	ROLLED LEADING EDGES
5.10	5K	LAP JOINTS
5.11	5L	FORMING ALUMINUM PARTS FROM SHEET
5.12	5M	VINYL COATING
5.13	5N	FLUTING
5.14	5P	ALUMINUM TUBING
5.15	5Q	STEEL
5.16	5R	INSTALLING NUTPLATES
5.17	5S	FUEL TANK SEALANT
5.18	5T	FIBERGLASS
5.19	5U	ACRYLIC CANOPY & Lexan WINDOWS
5.20	5V	NUT & BOLT TORQUES
5.21	5W	ELECTRICAL
5.22	5X	COMPRESSION FITTINGS
5.23	5Y	NYLON FLUID FITTINGS
5.24	5Z	DRILLING, TAPS & DIES
5.25	---	DIMENSIONS
5.26	---	HARDWARE REFERENCE
5.27	---	FLUID FITTINGS
5.28	---	CONCLUSION

NOTE: This section is not intended to be a complete manual on aircraft construction. Supplement this information with some of the publications listed in Section 1.

5.1 ALUMINUM PRIMING & PAINTING

The aluminum skins used on RV aircraft are all 2024-T3 alloy. They are "alclad", meaning that both sides of the sheet are coated at the mill with pure aluminum. This forms aluminum oxide, a corrosion resistant material which need not be primed or painted for adequate service as an airframe material. However, if the airplane is to be kept in a salt-air environment, or if a greater margin of corrosion protection is desired, priming the entire inside of the airframe is a good idea. Remember that priming will add cost, weight and time to your project.

WARNING: When installing threaded fittings/rod ends into primed tube be sure that the primer has cured fully. Failure to do so could result in seized bearings.

All non-alclad aluminum parts such as 6061-T6 must be primed. Control System Pushrods must be primed both inside and out. (Do not prime inside of fuel or brake lines.)

To prime the inside of pushrods with liquid primer, pour primer into one end and swirl it towards the other end, coating the entire inside surface. Alternatively, spray primer into one end of the pushrod, turn the pushrod around and spray again from the other end.

The majority of the parts in the kit have been coated in our plant with vinyl to protect them during manufacturing. We suggest that you remove the vinyl as soon as practical after inventorying your kit. (See 5.12) The pre-assembled spars are anodized and need no additional protection.

All aluminum bar, angle, and tube used is not alclad and must be primed to assure corrosion resistance. The traditional primer used on aircraft aluminum has been Zinc Chromate. With proper surface cleaning, this is still a good primer. However, there are many newer primers available which are superior. Most of these are two-part, catalytic curing primers.

Brand	Product
DITZLER -	DP-40/50 EPOXY PRIMER
DUPONT-	VERI-PRIME (PRIMER #615 and CONVERTER #616S)
MARHYDE -	Self-etching primer, available in a spray can as well as quarts
PRATT & LAMBERT -	Vinyl Zinc Chromate, EX-ER-7 and T-ER-4 Reducer
TEMPO -	Chromate in a spray can
SHERWIN WILLIAMS -	WASH PRIMER #P60G2 and Catalyst Reducer #R7K44

CAUTION: When spray painting ANY primer, work in a well ventilated area and wear, at the very least, a UL approved respirator with carbon filters. Systems providing fresh filtered air have become more affordable in the last few years and provide the operator a superior level of comfort and safety. As the name "Metal Etching Primer" implies, the catalyst component contains an acid which can be dangerous if breathed. Similar precautions must be taken for spraying any of the two-part primers and paints. Check with the paint supplier for exact precautions required.

Primers like P60G2, Vari-Prime and others are relatively inexpensive, light and easy to apply. These characteristics make them appeal to many builders. They do need to be sprayed with a gun, which is awkward for some, but the pain can be minimized if you prepare large batches of parts to reduce set up and clean up time.

Some aerosol primers are useful for small parts when you don't want to set up to spray a whole batch. Usually there will not be a problem with mixing and matching the type of primers used, but we do not know for sure. They are impractical for painting the whole airplane or large skins.

Though some disagree it is generally accepted that two-part epoxy primers provide the best corrosion resistance. However, they are expensive, toxic, heavy and dry slowly making them problematic for the home builder. If one can tolerate these issues and desires an RV that would be in good shape for grandchildren to inherit then two-part epoxy primers may be the "best" solution.

Van's Aircraft does not have an "approved" primer. We use Sherwin Williams P60G2. This is used on the Quick-Builds (QBs) and prototypes made here. The QB's primer has no pigment so it just makes the interior surfaces slightly darker and less shiny. In the US, this primer has a green tint so the two will not match exactly. We use this primer because it is inexpensive, dries fast, and is easy to apply. Sherwin Williams will tell you that the primer needs a top coat. While this is true for optimum corrosion resistance we feel that this is not necessary for the way in which most owners will maintain their RVs.

Whatever you use, prepare the surface as per the manufacturer's instructions. This can be as simple as washing with water or as complex as acid etching and alodining. We have nothing to add to whatever they may advise.

5.1 ALUMINUM PRIMING & PAINTING (continued)

Historically not many manufacturers primed the interior of their products, but there are still many flying 50 year old airplanes without corrosion problems. One favorite analogy around here is the car paint parable. Two cars leave the factory as identically primed and painted as is humanly possible. Five years later one looks as good as the day it left the showroom while the other looks fit for the wrecking yard. Same primer/paint, different result. How you treat it has a much greater effect than the primer you choose. How do you intend to treat your airplane?

An entire book could be written on the subject of aircraft painting and still leave many questions unanswered. There are many surface preparations, primers, and paints available, and more on the market every day. Paints range anywhere from the older enamels and acrylic lacquers up through the newer acrylic enamels, urethanes, and epoxy finishes. Which one is best probably depends on the end result desired by the individual builder. However, the urethanes seem to be favored by most builders now because of their relative ease of application and shiny, maintenance free finish. The purpose of this section is only to present some general ideas, not to provide the "best way" of applying the "best" paint.

COLOR SCHEME

Before getting serious about the type of paint to be used and the method and technique of application, most builders spend many months (or years?) while building trying to decide their paint scheme. Toward this end, little can be offered other than the suggestion that conservative colors and paint scheme will always look good on the basically good lines of an RV. More daring combinations of colors and patterns may result in a "fabulous" paint scheme, or could result in an eyesore too busy or gaudy to be appealing. Unless you have a very good eye for colors and patterns it may not be worth the gamble. We have provided a three-view drawing on which to practice. Just run off a few dozen copies on your office copier (when the boss isn't looking), buy a box of colored pencils and start sketching out your dream scheme. Aside from the aesthetic aspects of color scheme selection, you might also give serious thought to recognition; i.e.; how well will your combination of colors stand out from the background when in flight. How visible will it be to pilots of other aircraft in flight? With the dense air traffic and haze of air pollution encountered around many airports, see-and-be-seen should be a major safety concern to all pilots. Light colors are generally considered to be the most visible against typical backgrounds found while flying in the USA. Yellow is probably the most universally visible, and can also be trimmed to provide very attractive paint schemes.

The question of whether a painted or bare aluminum airplane goes faster is often raised. Experience with the prototype RVs has not provided a definitive answer. It would appear that there is little difference in skin friction drag from a typical painted surface to a typical bare aluminum surface.

PAINTING HEALTH HAZARDS

WARNING: PLEASE TAKE PAINT CAN TOXIC WARNINGS SERIOUSLY!!!

Spray painting can present a health hazard, particularly with most of the newer two-part paints. Chemicals used in the hardeners of urethane, acrylic enamel, and epoxy paints cause them to be potentially very hazardous if breathed, and can be harmful even through excessive exposure to the skin. For this reason, the painting area must be well ventilated and a UL approved respirator must be used. A simple particle filter is just not good enough. Keep in mind that many paint systems now contain chemicals for which a conventional filter-type respirator is not considered sufficient protection. Only a forced fresh air respirator system is recommended. Also, full coverage clothing should be used to prevent skin exposure. Builders sometimes disregard warnings on the likes of paint cans because they become indifferent after daily exposure to warnings on all sorts of relatively benign household items. But where modern paints products are concerned, warnings should be taken very seriously.

PAINTING

Painting an airplane obviously adds to its weight. The amount of weight depends on the type and amount of paint, primer and surface filler used. A "keep weight to a minimum" paint job will weigh about 15 lbs. A really elaborate paint job with all the extras could add two or three times this weight. In addition, heavy paint jobs will tend to shift the Center of Gravity rearward because of the paint weight on the empennage. Control surface balance on the RVs has not been found to be critical. A normal (light) paint application on the ailerons and elevator will not upset their balance to a noticeable degree. However, a heavy paint job will require that these surfaces be re-balanced and additional counterbalance weight added if necessary.

MASKING

Application of masking tape for color separation and pin-striping is perhaps the most time-consuming part of painting. Masking a straight line is tough enough, but getting just the right curve or "sweep" to a line is an art. Common hardware store masking tape usually gives poor results for distinct line separation because it permits too much "bleed under". Plastic "decorator" tape yields a nice crisp edge, but is rather expensive. Plastic electricians tape works fairly well and is relatively cheap. "Scotch" tape also works well but is hard to remove after painting.

There is no doubt that a smooth, wave free surface offers less aerodynamic drag than an imperfect one, but it is not known how much effect this will have on the speed of an RV. Probably not much unless the entire airframe is filled and smoothed before painting, and then the paint is rubbed-out perfectly smooth. This would entail much work, add weight, and probably not be advisable unless the builder wanted a 100% perfect airplane rather than a 98% perfect one. The price for that last 2% would be high in terms of added work required.

For the typical paint job, the builder obviously should try to work in a dust free environment so the paint surface will be as smooth as possible without the need for rub-out. Spanwise trim stripes should be avoided very near the wing leading edge. Much is being written about the effects of spanwise surface irregularities on the boundary layer control on airfoils, particularly those on canard configuration airplanes. The concern is that any surface irregularity near the wing leading edge, particularly spanwise ones, can disrupt the boundary layer airflow, upset laminar flow, and cause an increase in drag and a decrease in lift. On canard airplanes this can seriously affect not only performance, but also stability and control. On an RV, with its conventional configuration and non-laminar flow airfoil, the effects of surface irregularities are relatively minor. However, a rough paint trim line within the first few inches of the wing leading edge would probably cause a measurable effect on stall and top speeds. Trim lines more than 8-9 inches from the leading edge have a minimal effect, but even then should be rubbed out as smoothly as possible.

5.2 EDGE FINISHING, HOLE DEBURRING & SCRATCH REMOVAL

Aluminum sheet of the 2024-T3 variety is relatively hard and brittle. Maintaining the high strength of this material in use requires that care be taken in its cutting, bending, and finishing. Because it is a hard material, it is scratch and notch sensitive. This means that sharp or rough edges, corners, and scratches can cause stress concentrations which will greatly increase the possibility of local failure, usually in the form of a small crack. The problem with small cracks is that they soon become large cracks, one piece of aluminum becomes two pieces, etc. Obviously, we do not want this happening in our airframe, particularly when separated from solid earth by a lot of very thin air.

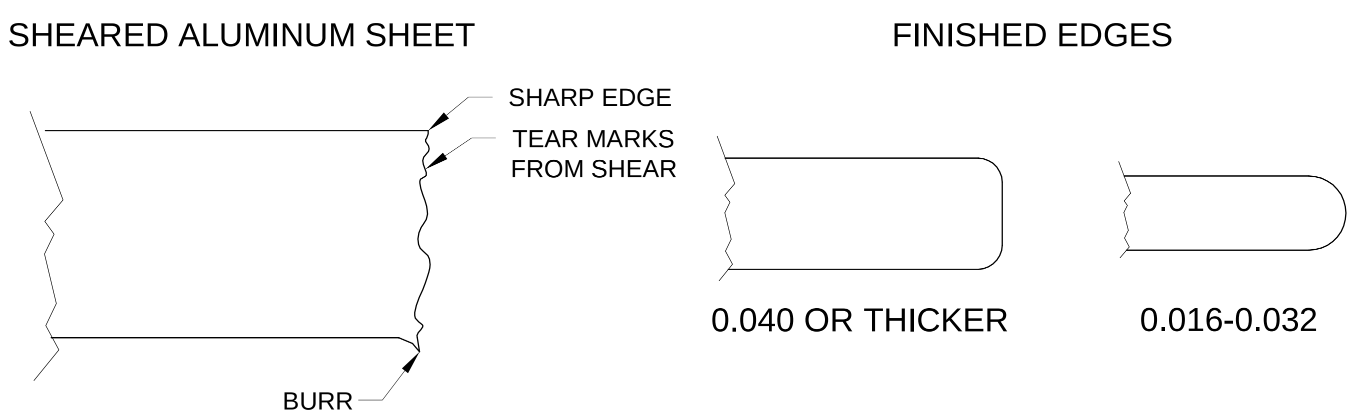


FIGURE 1: EDGES

All aluminum edges and corners must be smoothed and radiused to prevent this stress concentration from occurring. Any sheared edge, whether sheared by hand or by machine, has sharp corners and has a burr on one edge as shown in Figure 1. This burr must be removed and the sharp edges rounded off. This can be done a number of ways; with a file, a Scotchbrite polishing wheel, sandpaper, or an edge (de-burring) tool. In most instances, the tool, followed by a pass or two over a Scotchbrite wheel mounted in a bench grinder, is the best and quickest method. A good test for the edge finish of aluminum sheet is to run your finger over it. If you can't feel any roughness and there is no chance of drawing blood, the finish is OK. You should not be able to see the original cutting marks on the material. In other words, if the sheet had been sawed (bandsaw or hacksaw), the saw marks should be removed in the process of smoothing.

Corners, particularly inside ones, must be cut with a radius to prevent cracking. See Figure 2. This radius can vary from 1/16" for .016 thick aluminum to 1/8" for .040 aluminum. The radius edge then must be smoothed just as the straight edges discussed above. A small round file works well for this. This is especially important where a bend line is intersecting the inside corner in question. Cracks are likely to occur at the sheet edge even if the bend radius is great enough.

All drilled holes, or prepunched holes that have been final-drilled to a larger size, should also be deburred. Holes that were factory punched to final size can be inspected and only deburred if needed (with the exception of large holes to be dimpled for screws - see below). This is an easy but time-consuming chore, and can be done with an oversize drill bit, either held between your fingers and twisted, or in a variable speed drill running very slowly. Special swivel deburring tools are also available from tool supply houses. These work better and are much quicker. Burrs around holes are a problem mainly in riveting and dimple countersinking. The burr can prevent a rivet head from seating properly and can make dimple countersunk holes more prone to developing cracks radiating from the hole. Many novice builders deburr excessively deep. Deburring should not produce a significant chamfer/counter-sink on the edge of the hole. Be particularly careful deburring holes in .020 or thinner sheet. By the time both sides have been deburred the hole could be enlarged.

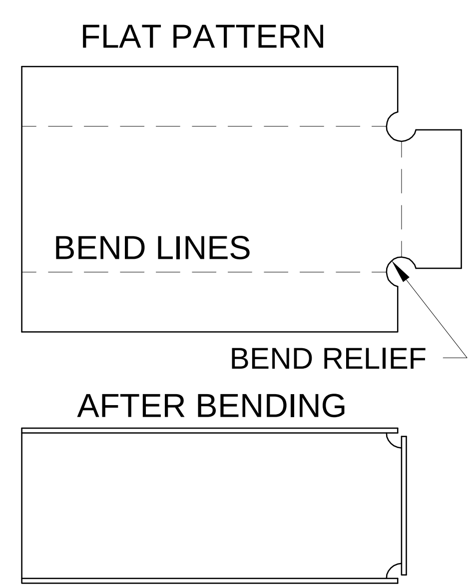


FIGURE 2: BENDING

The finishing procedures just described will constitute a sizable portion of the total building time. However, they are important for structural reasons as well as cosmetic. Most of these holes, edges, etc. will be inside the airframe and out of sight when the airplane is finished. This is no reason to consider them unimportant. The need for good edge finishing is most difficult to impress on new builders unaccustomed to aircraft standards.

Scratches in the surface of aluminum can have the same weakening effects as rough edges, corners and holes. The alclad sheet used is very easily scratched because of the thin surface layer of soft aluminum. Scratches within this layer will have little effect on strength, but deeper scratches will. The greatest difficulty is deciding how deep a scratch can be before it is a potential problem. The best approach is taking extra care to prevent scratches in the fist place. When a scratch does occur sand or buff it out no matter how small. Very light scratches can be removed with #600 wet sandpaper. Deeper ones will require #400 (or perhaps more coarse) sandpaper, followed by #600 for finishing. One thing to remember when removing scratches is that in doing so the corrosion resistant alclad surface of the aluminum is also removed. Therefore any area that has been sanded for scratch removal must be primed.

RIB FLANGE FACETING

As a skin wraps around the leading edge of the horizontal stabilizer, vertical stabilizer, or wing, among others, the skin must pass over the forward edge of the rib flange. See Figure 3. Shape the front edge of the flange to prevent this edge from forming a dent in the skin as the rib is riveted in place. A similar effect will occur at the notch between rib flanges. During manufacturing, as flanges form over the curved edge of a formblock, the ends or surface of the flanges may remain straight or flat rather than conforming to the curvature of the formblock. This results in faceted, instead of uniformly curved mating surfaces. A skin riveted on top of the rib would appear faceted and a bump would occur in the skin in the area of the notch between the rib flanges. Shape-deburr the edges of the flanges especially in the area of the flange radius as required. See Figure 3.

FIGURE 3: RIB FLANGE PREP

5.3 MARKING PARTS

WARNING: NEVER use a scribe to make layout lines or other marks on aircraft parts. Due to engine vibration part failure can occur along these scribe lines. The use of an ordinary lead pencil will cause the aluminum to corrode. We recommend that you only use an extra-fine point "Sharpie" pen. For some unexplained reason the blue ones seem to last longer than other colors. The sharpie ink will bleed through primer so you can still see the ID marks after priming the parts. Be sure to remove any markings in areas that will be visible after completion as the ink will bleed through primer and paint coatings.

5.4 RIVETING

Two types of rivets are used in the construction of an RV; "AN" rivets, and "blind" rivets. Blind rivets are often referred to as Pop Rivets (although "Pop" is actually a brand name). See the blind rivet identifier chart in 5.26. Van's designs utilize blind rivets in specific locations to simplify and speed the construction process and they are set using a pneumatic or hand-operated puller.

Two styles of AN rivets are used; universal head (AN470) and 100° countersunk head (AN426). Three rivet diameters are used; AD3 (3/32),AD4 (1/8), and AD6 (3/16 older kits only). While all the numbers and letters may be confusing at first, they convey useful information, as shown in the sketches at the end of this section. AN rivets are set with either a rivet gun and a bucking bar, or a rivet squeezer. Driving universal head rivets requires a rivet set of a size corresponding to the rivet head size.

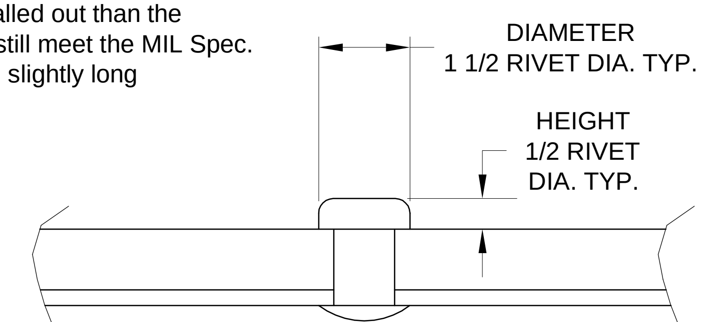
Main wing spar construction uses 3/16 rivets, which require a very high setting pressure, necessitating a heavy-duty rivet gun or a fairly large rivet squeezer. RV kits have pre-assembled spars so builders do not have to set 3/16 rivets.

Rivets must be the correct length. Too long and they tend to bend over like a nail, or "cleat". Too short and there is not enough material to form a full shop head. While the plans usually call out the rivet length required there will still be places where the builder will need to know the correct method of determining rivet length. The rule of thumb is that the length of the rivet shank should equal the thickness of the material being riveted, plus 1.5 times the rivet diameter. For example, if a .016 skin is to be riveted to a .032 rib the material thickness would equal .048. If a #3 rivet (3/32 diameter) is to be used, 1.5 times the rivet diameter would be 9/64. Checking a decimal equivalent chart we find that 9/64=0.140. By adding 0.140 to 0.048, we arrive at a rivet length of 0.188. Rivets come in increments of 1/16, so the nearest rivet would be an AD3-3; 3/16 or 0.1875. This formula works well for rivet lengths up to about 1/2. For thicker material, such as the wing spar, a greater rivet length allowance is required.

In general a properly set rivet will have a shop head diameter of 1.5 times the shank diameter and a height of 1/2 the shank diameter. See Figure 1. A simple gauge is available from tool suppliers. As you gain experience you will find that your eye is very accurate, and the gauge is needed only to "recalibrate" it.

Specification MIL-R-47196A for rivet installation allows for smaller shop heads. The specification is available free online, is informative and worth reading. In many instances, particularly in the newer kits, a shorter rivet will be called out than the one that would meet the guide line above. The shorter rivet will still meet the MIL Spec. requirement. This is done to avoid using a rivet size that may be slightly long and more difficult to properly install.

NOTE: There are times when the correct rivet length is not available. Depending on the application a shorter rivet can be used or a longer rivet cut to the proper length. Using a longer rivet, as is, can result in the shank being bent over like a nail. We have chosen to use a rivet that may seem too short in some places, but will do the job adequately.



RIVET DIA.	DRIVEN HEAD THICKNESS (INCHES) MIN	MAX
3/32	.038	.050
1/8	.050	.070
3/16	.075	.105

FIGURE 1: TYPICAL FORMED RIVET DIMENSIONS

REMOVING RIVETS

To avoid the possibility of deforming thinner material when removing a rivet, modify a pair of long handled side cutters as shown in Figure 2. This will allow the blades to grip as close to flush with the surface of the material as possible while twisting on the shop head of the rivet to remove it.

Use the method described in Figure 3 for removing rivets from thinner material.

Use the method described in Figure 4 for removing rivets from thicker material.

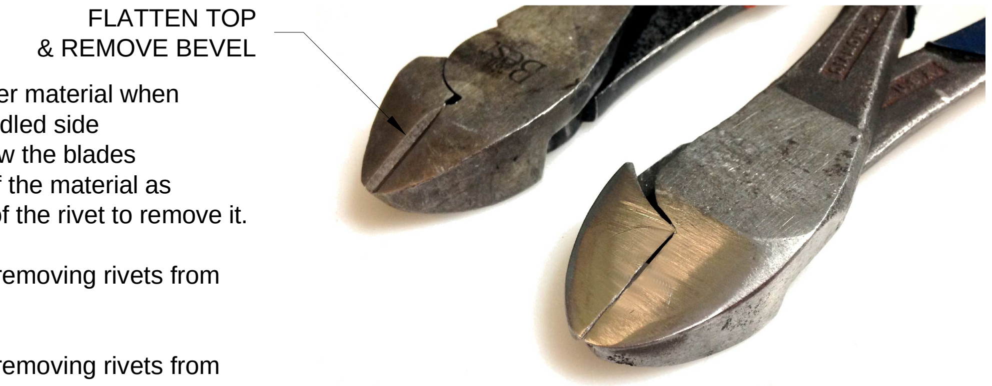


FIGURE 2: MODIFY SIDE CUTTERS

Note that the method used in Figure 3 can also be used for thicker material when punch and hammer access is limited.

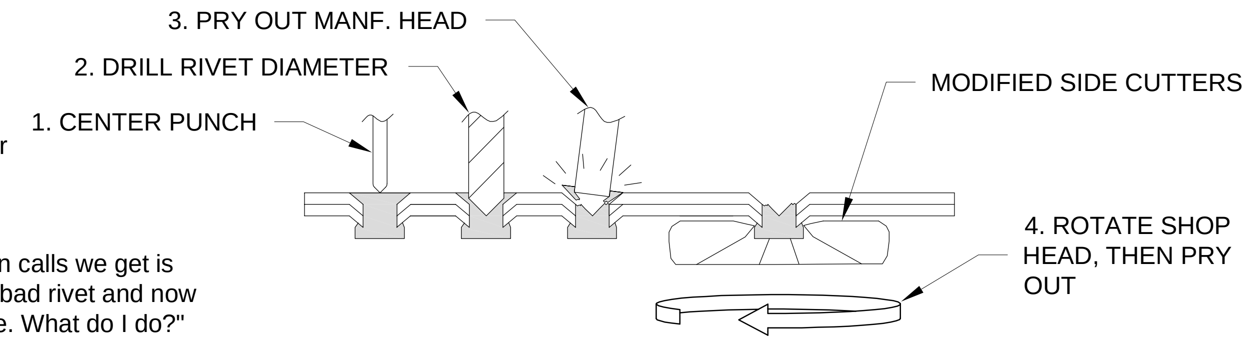


FIGURE 3: REMOVING RIVETS IN THIN MATERIAL

One of the common calls we get is "I had to drill out a bad rivet and now the hole is oversize. What do I do?" Sometimes this is done multiple times in the same hole and now the hole is so large that the builder has to use a bolt and nut instead of a rivet. To relieve the anxiety sometimes associated with an imperfectly set rivet and to avert potential problems arising from ill-advised attempts at repair, (not to say 'never repair a rivet'), guidance in the form of an excerpt from the Alcoa Aluminum Rivet Book, dated 1984, is provided here.

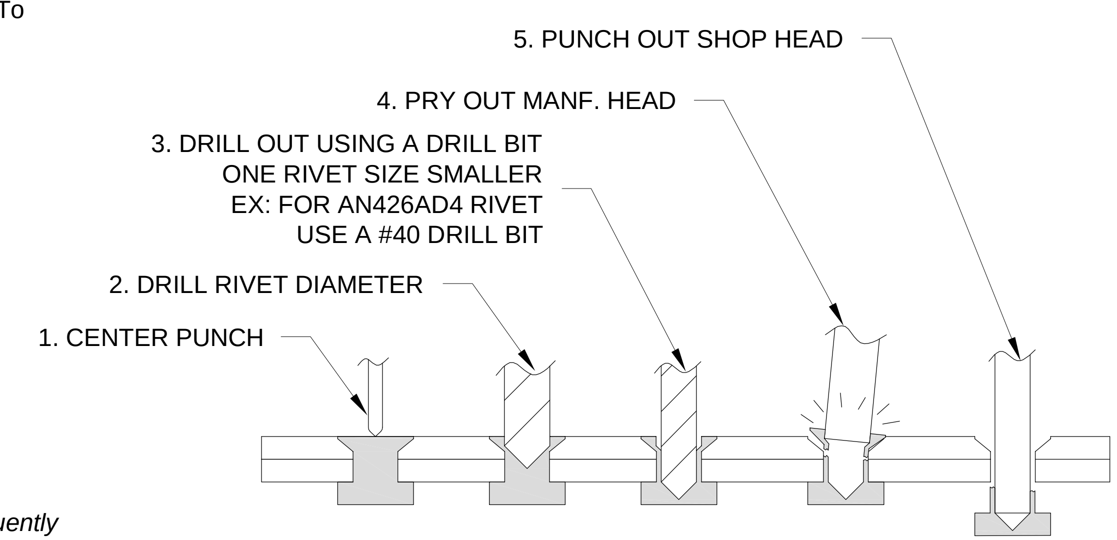
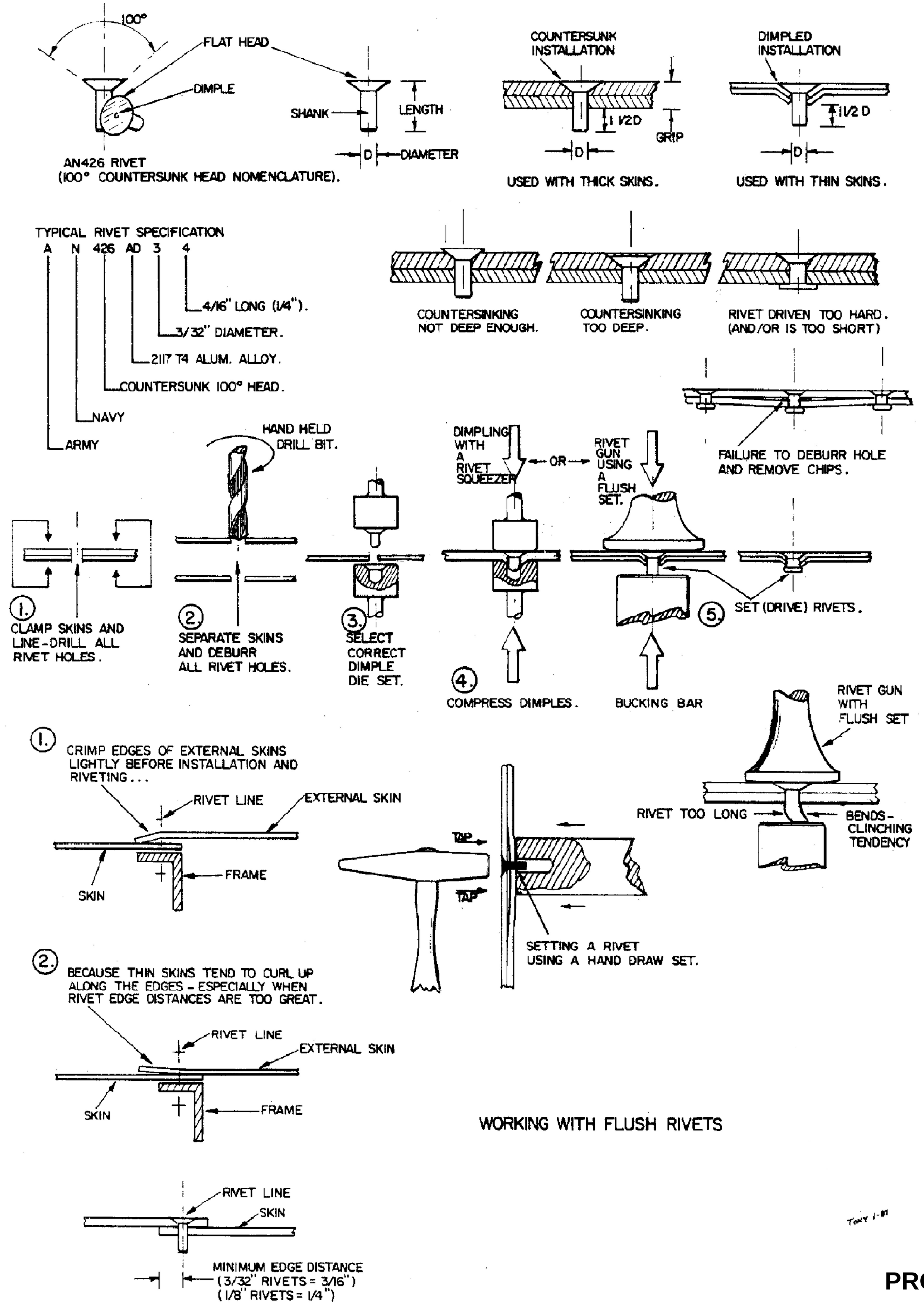
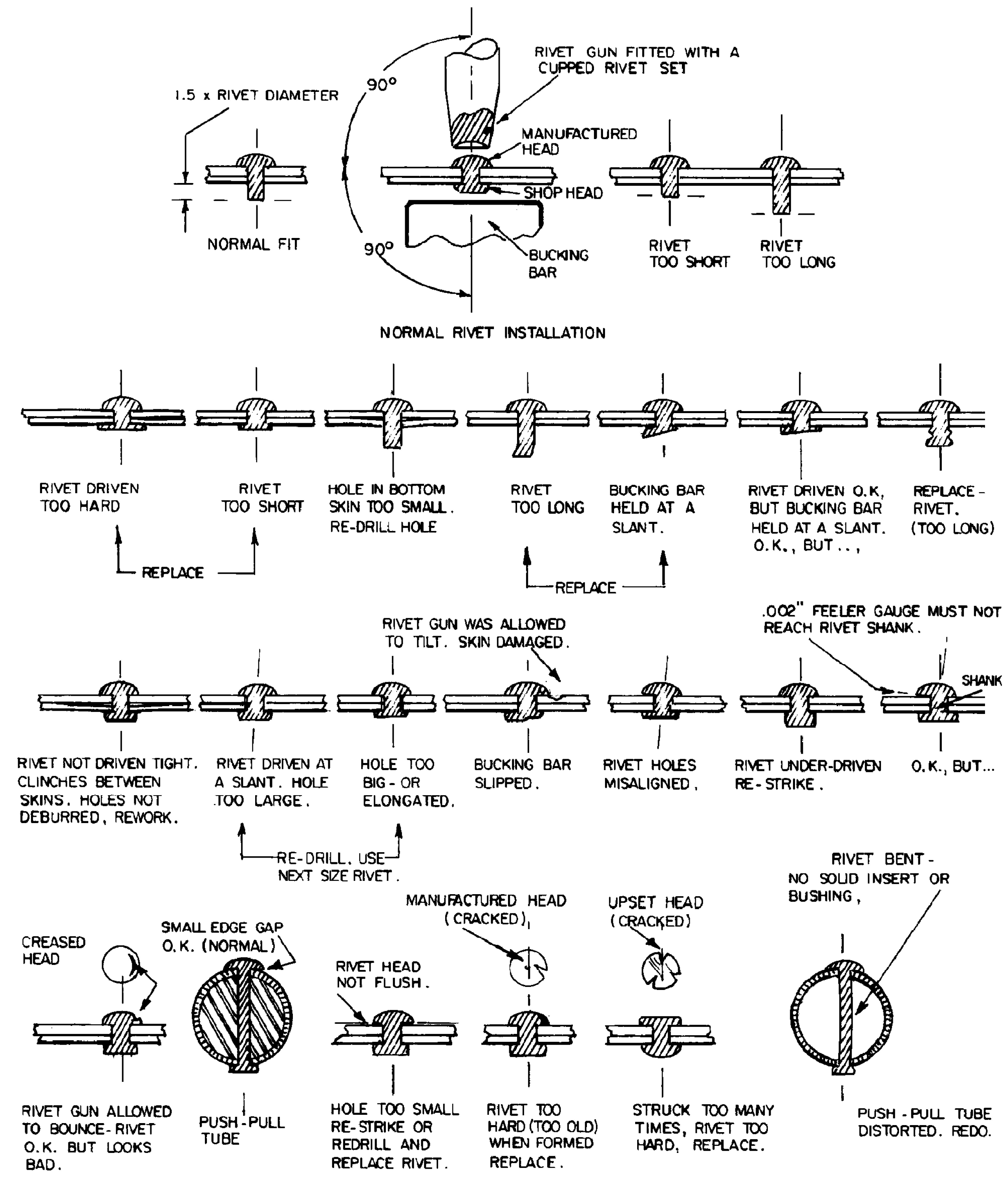


FIGURE 4: REMOVING RIVETS IN THICK MATERIAL

"The standards to which driven rivets should conform are frequently uncertain. In addition to dimensions and perfection of shape, inspection is concerned with whether the drive head is coaxial with the shank (not "clinched") and whether there is excessive cracking of the heads. It has been determined that even badly cracked heads are satisfactory from the standpoint of static strength, fatigue strength and resistance to corrosion. (Poorly set and cracked) rivet heads were tested in tension to determine how well formed a head has to be in order to develop full strength. The tensile strengths of all the rivets were within five percent of the strongest. The test indicated that minor deviations from the theoretically desired shape of head are not cause for concern or replacement. The second rivet that is driven in any one hole [is] likely to be more defective than the first because the hole is enlarged and [the] rivet will be more likely to buckle and form an imperfect head. Tests have shown that very small rivet heads are sufficient to develop the strength of the rivet shank, even when the rivets are subject to a straight tensile pull....where a large head is not needed for appearance, smaller sizes of drive head should be used to decrease the required driving pressures."





PROBLEM RIVETS

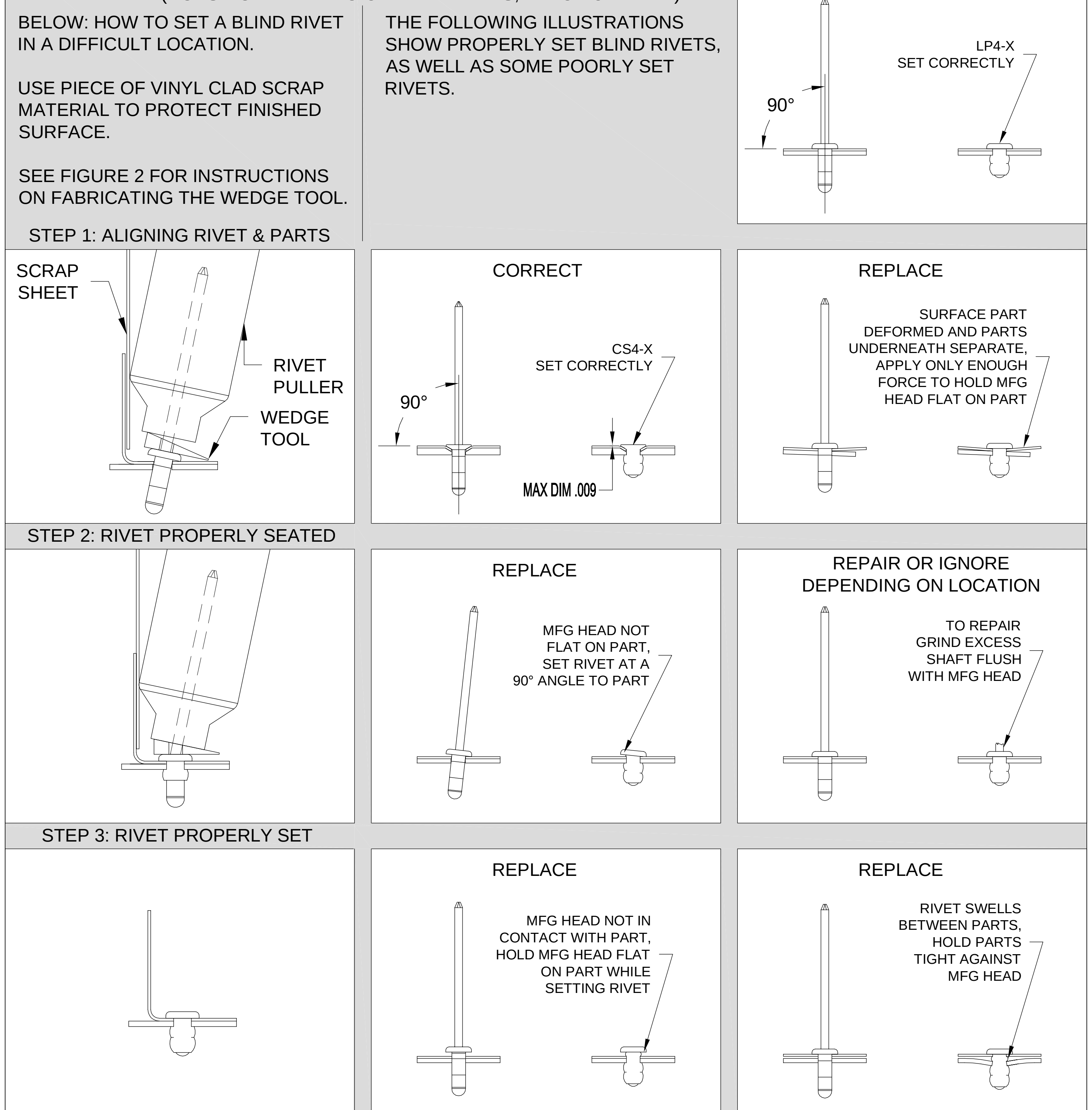
FIGURE 1: RIVETING PROCESS,NOMENCLATURE & COMMONLY ENCOUNTERED PROBLEMS.

Artwork by Tony Bingelis

5.4 (continued)

METHODS FOR SETTING RIVETS

FIGURE 1: SETTING BLIND RIVETS
(DOES NOT APPLY TO CHERRY RIVETS, PN: CR-32XX-X-X)



FABRICATING THE WEDGE TOOL

The wedge tool provides assistance when blind riveting in locations where it is not possible to align the tool and the rivet. The wedge tool(s) will be placed between the rivet and the riveting tool enabling the riveting tool to pull the rivet from an angle, yet still achieve a properly seated manufactured head.

Step 1: Cut a length of VA-140 Trailing Edge to the length shown in Figure 2, centered on a .094 hole.

Step 2: Remove the hatched area from the length of VA-140 Trailing Edge as shown in Figure 2.

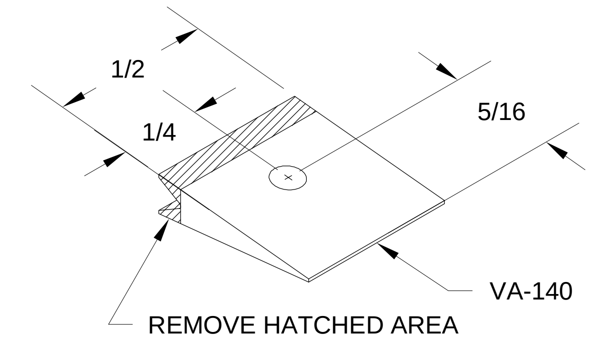


FIGURE 2: WEDGE TOOL FABRICATION

CCR-246SS-3-2

CCR-246SS-3-2 blind rivets that are specified in many locations should not be considered a replacement for 3/32” AN426 rivets that are being used in structural applications. They are acceptable for installation of nutplates or in other low load locations. When installing the CCR blind rivet it is normal for the stem to pull entirely out of the rivet.

5.4 (continued)

CHERRYMAX RIVET INSTALLATION

CHERRYMAX CR32XX style blind rivets are aircraft grade fasteners of high strength but only if properly installed.

NOTE: To achieve maximum rated strength use only the manufacturer's recommended method of installation. The *CHERRYMAX Process Manual was* the source of information for Tables 1, 2 and Figures 3, 4 and may be viewed and/or downloaded at: http://www.cherryaerospace.com/files/pdf/catalog/CA-1015.pdf

KEY POINTS TO REMEMBER:

RIVET SIZE

Rivets must be accurately sized for each application. Proper grip length selection is critical. Only use the rivet lengths called out in the builders manual.

RIVET HOLE

Rivets require close tolerance holes in parts where they are being installed. See Table 1.

TOOLS

CHERRYMAX rivets require a greater stem pull force than common blind rivets but can still be installed with most common blind rivet installation tools. Though the PRP-26A tool recommended for RV-12 construction is not compatible with CHERRYMAX rivets neither is an expensive Cherry brand tool required.

ALIGNMENT

Unlike other blind rivets used in RV construction the CHERRYMAX stem cannot be pulled at an angle relative to the rivet axis. If stem is not pulled straight (parallel) to rivet hole axis premature stem breakage can occur resulting in a rivet that has not fully formed or locked.

DRIVING ANVIL

This small washer like device located above the manufactured head is a critical component of the installation process and **must not be removed**. It will detach on its own after the stem breaks. See Figure 1.

RIVET DIAMETER	DRILL SIZE	HOLE SIZE	
		MIN.	MAX.
- 4 (1/8")[3.2mm]	#30	0.129[3.3mm]	0.132[3.4mm]

TABLE 1:

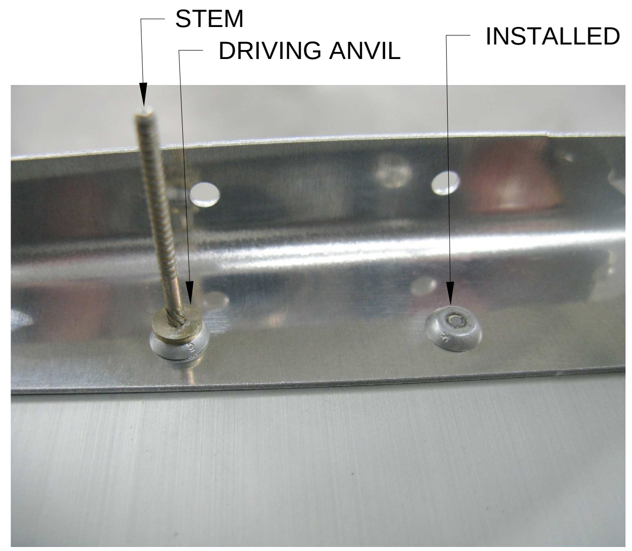


FIGURE 1: MANUFACTURED HEAD

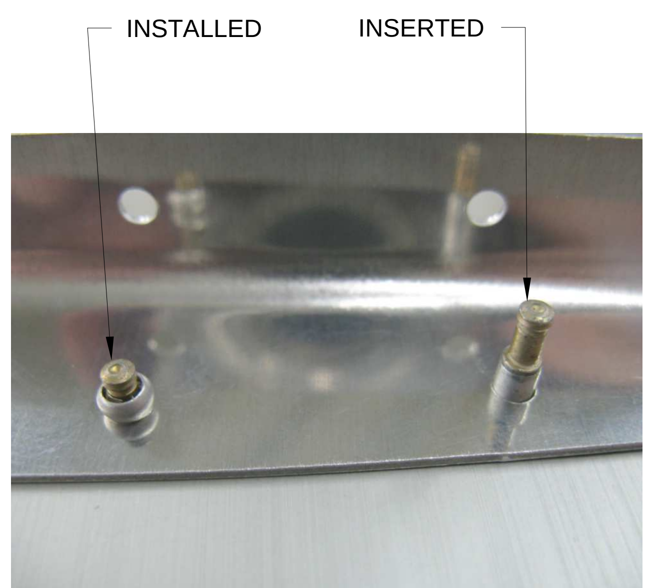


FIGURE 2: SHOP (BLIND) HEAD

PROPER INSTALLATION

Step 1: Verify tool and CHERRYMAX rivet compatibility by performing a test on an easily removed rivet, in the event that removal becomes necessary. For removal see the ***CHERRYMAX Process Manual*** mentioned earlier.

Step 2: Verify correct rivet grip length. The grip range of all CHERRYMAX rivets is in increments of 1/16"[1.6mm], with the last dash number indicating maximum grip length in 16ths (CRXXXX-X-MAX GRIP LENGTH). Example: -5 grip rivet has a grip range of 1/4"(.250)[6.4mm] to 5/16"(.313)[7.9mm].

Step 3: Insert rivet in hole and verify manufactured head fits square and flush to material surface. See Figure 1.

Step 4: Slip tool over rivet stem.

Step 5: Operate tool while taking care to not lean tool or bend rivet stem while doing so. Continue to pull rivet stem until it snaps free as shown in Figure 1.

Step 6: Inspect rivet to confirm proper installation per the following criteria:

Nearly flush surface due to stem fracture at top of manufactured head. See Figures 1 and 3.

Typical fastener flushness acceptance criteria is shown in Figure 3 and listed in Table 2. Locking collar is to be flush with top surface of rivet head. Collar flash permissible is .020 max. Stem flushness shall be as indicated.

Base of manufactured head should be tight against surface of material being riveted. See Figure 1.

Stem will not be pulled fully into rivet body at shop head end, but rivet body should have formed (closed up) around stem. See Figures 2 and 4 for acceptable blind head formations.

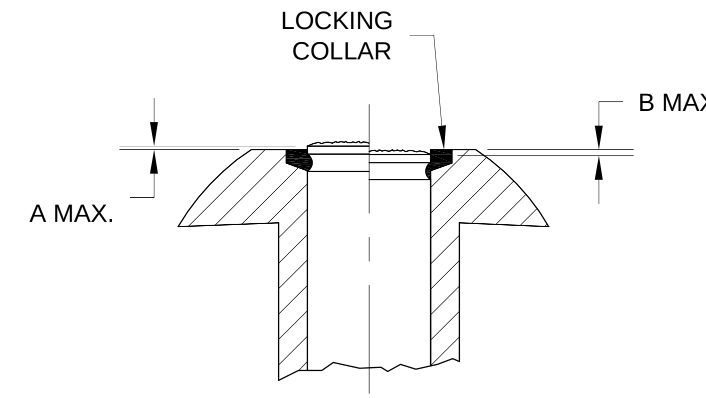


FIGURE 3: FLUSHNESS
(RIVET CROSS SECTION - NOT TO SCALE)

RIVET DIAMETER	A MAX.	B MAX.
- 4 (1/8") [3.2mm]	.010 [.25mm]	.015 [.38mm]

TABLE 2:

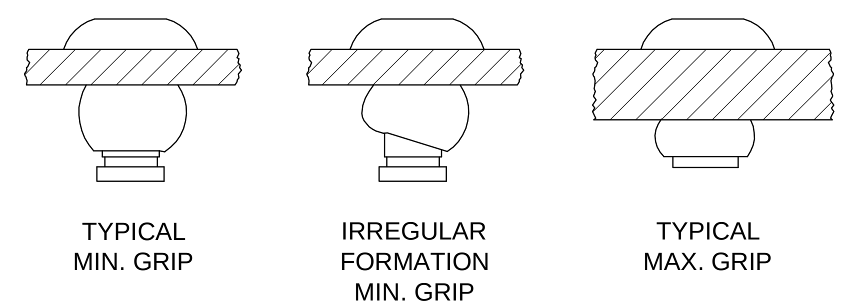


FIGURE 4: ACCEPTABLE BLIND HEAD FORMATIONS

5.5 COUNTERSINKING AND DIMPLING

Flush riveting requires that a flat or "mushroom" set be used and that the skin around the rivet hole be countersunk either by dimpling or machining. Be sure to remove any vinyl coating before machine countersinking or dimpling the parts. Dimple countersinking will be simply referred to as dimpling for the remainder of this manual.

For AD3 rivets, a total material thickness between .016 [.4 mm] and .032 [.8 mm] must be dimpled. Material thickness between .032 [.8 mm] and .040 [1.0 mm], should be dimpled, but a countersink may be used if necessary. Finally, for a thickness of .050 [1.3 mm] and above the material must be countersunk.

For AD4 rivets, .050 is the minimum thickness that may be countersunk.

Metal thicker than .040 is difficult to dimple, so it is common practice to machine countersink any material thickness that is more than .040. There are a couple of reasons for this. First, although RVs are designed so that a countersunk joint is acceptable, the interlocking nature of a dimpled rivet line is stronger. Second, dimpling leaves a thicker edge for the shop head of the rivet to form against, meaning that the metal deforms less and there is less chance of "working" rivets later.

This recommendation is meant as a guideline, not an absolute rule. There may be instances where countersinking 0.032 stock makes the job easier, and certainly can be used. One example is when a sheet is sandwiched between two other sheets. In this case, the sheet receiving the rivets manufactured flush head is dimpled, the sheet underneath is machine countersunk to receive the dimple, and the third sheet is left full thickness. When countersinking the second sheet you must go slightly deeper than you would for a rivet. See Figure 1.

There are a few instances on RVs where it is considered acceptable to enlarge holes when machine countersinking. Primarily this is done to countersink for the installation of flush screws. It is also done where multiple layers are already riveted together, and on material that is too thick to dimple, such as a wing spar flange.

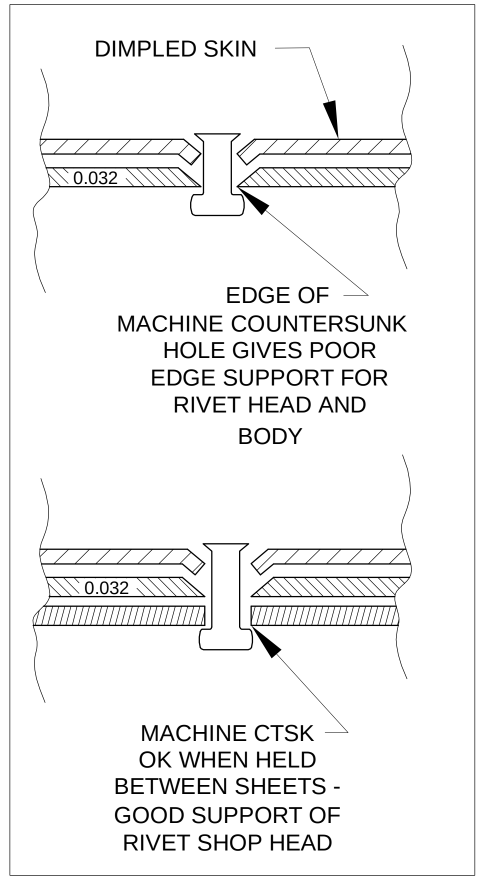


FIGURE 1: DIMPLING

MACHINE COUNTERSINKING

Machine countersinking removes metal and is done with a stop countersink tool and a drill motor . Machine countersinking can only be used in areas where the skin thickness is sufficient. **CAUTION**: **Check the machine countersink depth frequently since variation in part shape, hand pressure, and tool sharpness will cause the depth to vary.**

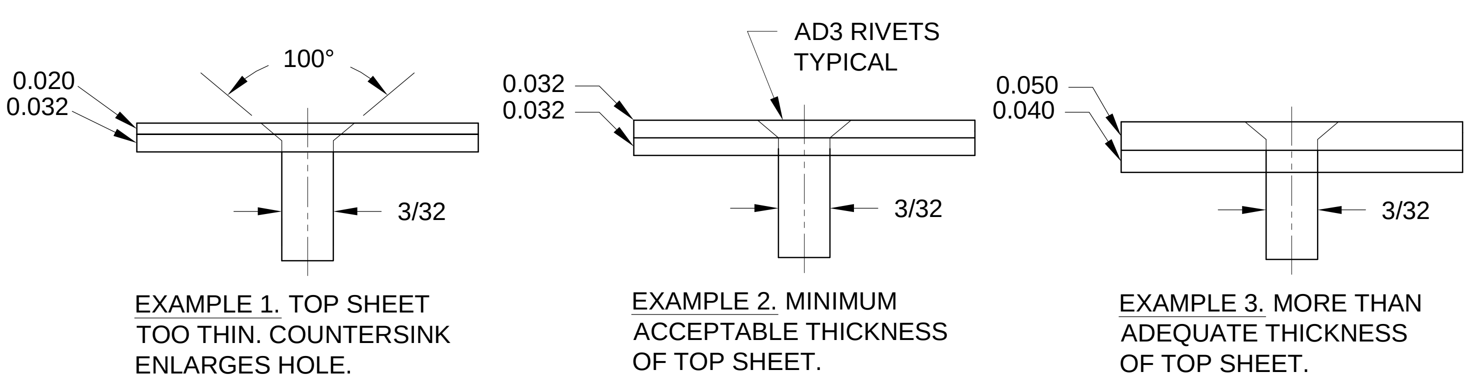


FIGURE 2: RIVETS AND SHEET THICKNESS

Where the skin thickness is insufficient, the countersunk hole for the rivet head enlarges the original rivet hole and no longer supports the shaft of the rivet. Only a portion of the rivet head is now contacting the skin, so it cannot achieve its design strength which is based on full head contact. See Figure 2, Example 1.

When using the minimum acceptable thickness, the full rivet head is supported and the original hole is not enlarged as shown in Example 2. Example 3, shows not only the fully supported rivet head, but also contact with the rivet shank.

Use the appropriate rivet or screw as a gauge when you machine countersink. Stop when the rivet or screw is flush. For a dimpled skin riveted onto a machine countersunk surface the countersink must be slightly deeper as mentioned earlier. Proper depth is .007 deeper than when the rivet head is flush. This depth correction corresponds to seven "clicks" on a microstop countersink tool indexed in .001 inch increments.

When countersinking for a #8 (or larger) screw, the countersink cutter is removing so much material that it can easily "chatter" resulting in a rough surface finish and an out-of-round countersink. A good process for obtaining a smooth finish is to set the microstop countersink tool .005 inch short of the final depth, make the first cut at a slow speed applying heavy pressure, readjust the microstop to the final depth, and make the final cut at high speed applying light pressure.

DIMPLING

The dimple dies can be used in most tools traditionally used for riveting such as hand and pneumatic squeezers and special dimpling tools such as one commonly referred to as a C-frame, which is used for dimpling in the middle of large sheets.

It is fully acceptable, and common practice, to use a rivet squeezer (hand or pneumatic) to dimple substructure that will be covered up, since the dimples will not be visible.

The best exterior finish quality possible starts with well formed rivet dimples. When dimpling any rivet hole that will show on the exterior it is best to only dimple with a C-frame or other tool that can produce crisply formed, quality dimples. Most rivet squeezers (particularly a hand squeezer) cannot deliver comparable results especially on the large dimples required for flush screws.

When dimples are not fully formed, the aluminum skin around the perimeter of the dimple (approx. .5 radius from hole center) will have a dished shape. Once you learn what to look for, this can easily be detected with your eyes by evaluating the reflection in the skin surface. When viewing the reflection of an overhead light source across the top of a dimple, the only place the reflection should be distorted is inside the dimple. The skin should look clear and distortion free all around the perimeter of the dimple. Under-formed dimples are a rather common problem. Fortunately it is difficult to "over do it" by hitting the arbor too hard when using a C-frame tool for dimpling, that is unless extreme force is used which may cause localized stretching of the material.

When correct technique is used dimple dies will scuff the surface of the skin within the entire die contact area. This scuff mark indicates the dies have fully seated together with the aluminum materiel tightly sandwiched between them. On the contrary if only a circular ring (formed by the dimple die outer diameter) is present on the skin surface the dimple has not fully formed. The amount of force required to accomplish this varies, depending upon material thickness and dimple size. Thin material like .016, and small dimples require much less force than .040 material and a #8 screw dimple.

It takes practice to learn good technique. The goal is learning how to judge when a dimple is well formed. When using a C-frame tool listen for the sound produced when striking the arbor. The sound of fully seating dies is different from the sound of not fully seating dies. This sound varies depending upon the type of hammer used, but there is always a noticeable difference.

The dimple countersinking process stretches the metal around the perimeter of the hole being dimpled. It is very important that holes drilled to final size be well deburred beforehand to reduce the likelihood of cracking. The bigger the dimple, the more stretching occurs and the greater the chance of cracking.

5.6 BACK RIVETING

When riveting thin aluminum skins to light ribs or stiffeners, it is difficult to avoid getting some slight indentations in the skin around the rivet. Particularly on shiny, unpainted aluminum, reflections make the skin look much rougher than it actually is.

One way to lessen this effect is "back riveting." Back riveting means holding the bucking bar on the *factory head* of the rivet and driving instead from the shop end with the rivet gun and a special back rivet set. The basic back rivet set has a spring loaded sleeve that helps keep the metal pieces firmly together, and prevents the rivet set from accidentally slipping off the rivet.

Back riveting works well for all of the moveable control surfaces where skins are the lightest and riveting distortion and/or skin damage potential is the greatest. Back riveting is also possible on some wing skins and most of the fuselage skins. This is a two person job and requires bucking bars which are larger than those typically used with specialty back riveting sets. We use this procedure extensively in our own shop.

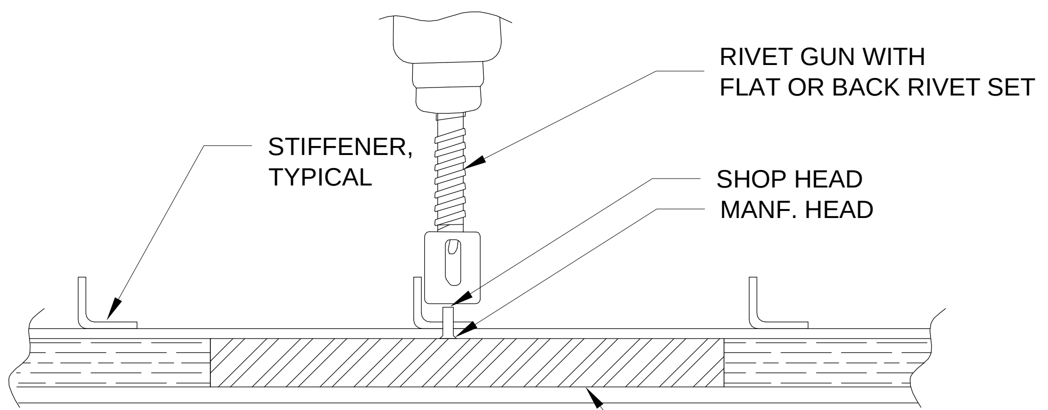


FIGURE 1: BACK RIVETING

5.7 FOLDED TRAILING EDGES

The shape of control surface trailing edges affects the "feel" and performance of the aircraft's controls. This cannot be over stressed. For proper handling qualities and trim, all surfaces should be checked and adjusted before the first flight. Many flying RVs have had bad roll trim or stability issues completely resolved just by using a straight edge to check and adjust all of the control surfaces.

On surfaces having folded trailing edges the skins are provided partially pre-bent. This allows room to install stiffeners and end ribs. Plans pages will have detail drawings depicting the proper radius for the final bend.

A homemade bender can be fabricated from a pair of 2X8 boards and a number of door hinges to achieve the final bend. See Figure 2.

Prior to final riveting, place a dab of RTV or tank sealant about the size of a wad of chewing gum at the inside of the skin where the two stiffeners overlap near the trailing edge. This will tie the stiffeners together and prevent the skins from cracking at this point due to vibration.

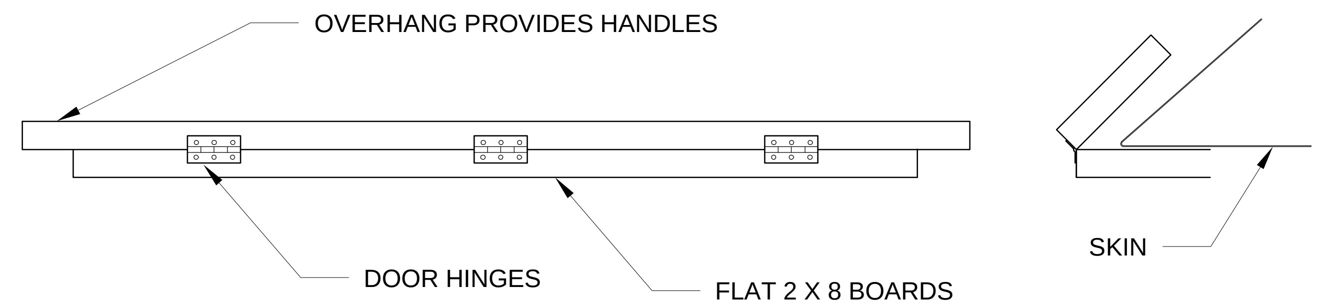


FIGURE 2: HOMEMADE BENDER

5.7 FOLDED TRAILING EDGES (continued)

After riveting the stiffeners in place and bending the skins, check that both sides of the skin are flat and form a straight line from the spar to the tangent point of the trailing edge radius. Avoid bulged or over-bent trailing edges. See Figures 1-3.

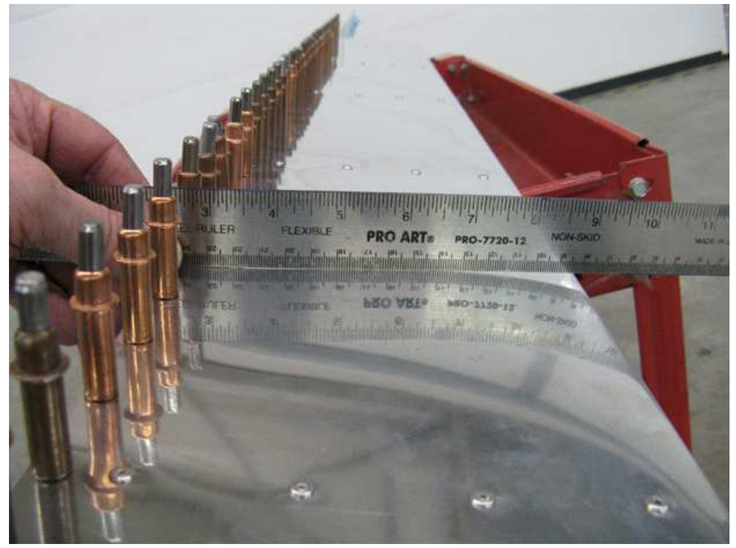


FIGURE 1: BULGED (UNDER BENT) TRAILING EDGE

For adjusting buldged trailing edges fabricate a squeezing tool like the one shown in Figure 4. Join two 1X2X6 hardwood blocks with wire springs made from welding rod or left over hinge pin. The wire will help maintain the block's alignment. Note the shallow radius formed at each end so that the sharp edge at the end of the block will not put a crease in the skin.

FIGURE 4: TRAILING EDGE TOOL

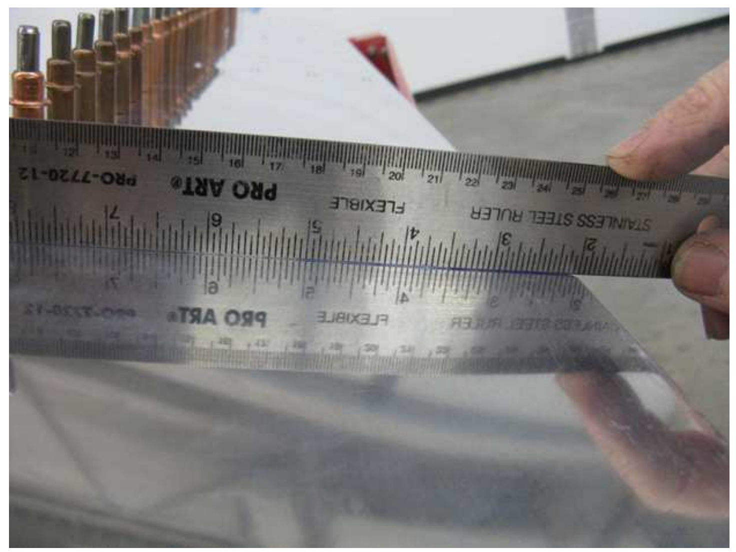


FIGURE 2: PROPERLY BENT TRAILING EDGE

To add additional bend (remove buldge), position the tool as shown in Figure 5 then squeeze the trailing edge (TE) using large channel-lock pliers. Large channel-locks provide a lot of leverage which allows for very fine control.

Apply many small squeezes moving the tool at least an inch or so after each one. Work back and forth along the TE checking the skin often with a straight edge and adjusting local areas as needed until the entire control surface is uniformly flat. Occasionally it is difficult to completely finish the bend in areas where stiffeners or ribs are located.

FIGURE 5: TRAILING EDGE TOOL APPLICATION

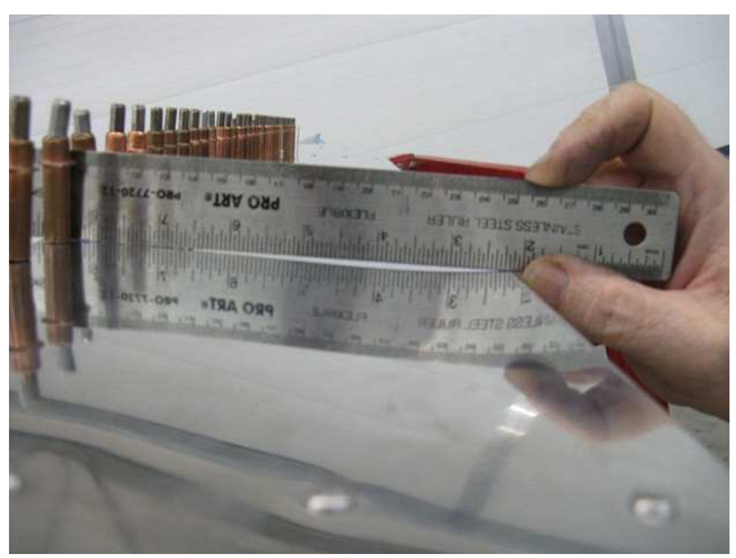


FIGURE 3: OVER BENT TRAILING EDGE

Correct, or "un-squeeze", an over-bent TE using another wood block as shown in Figure 6. Again, put a large radius taper on each end of the block as was done on the squeezing tool.

Move the tool back and forth along the TE of the over-squeezed area while lightly taping with a hammer. If no change results... tap a little bit harder.

It is best to do this adjusting before the control surfaces are painted because some paints are hard and can crack from the flexing. If adjustments are needed on surfaces that have been painted glue thin felt to the wood blocks to protect the paint finish.

FIGURE 6: "UN-SQUEEZING"

5.8 RIVETED TRAILING EDGES

Control surfaces with riveted trailing edges have a wedge shaped filler piece whose cross-section and degree of pre-fabrication may vary. Whether or not the part comes pre-drilled it will need holes and these holes will need machine countersinking in order to receive a dimpled skin. A simple method of accomplishing this is detailed below. Some set up time is required but with a little planning ahead a number of these pieces may be done at one sitting resulting in a big time savings.

To avoid confusion the wedge shaped filler piece will be referred to here as "wedge" and the trailing edge in general as "TE." Use scrap aluminum strips that are thinner than the max. thickness of the wedge to be countersunk. Cut a small V-shaped notch into one strip to prevent interference with the countersink cutter pilot. Position the strips so that the foot of the countersink cage contacts the top face of the wedge squarely (flush) and the countersink pilot aligns with the centerline of the hole pattern. Attach a piece of safety wire or string between the countersink cage and the post of the drill press so that the cage does not spin. Use a low speed setting on the drill press. See Figure 1.

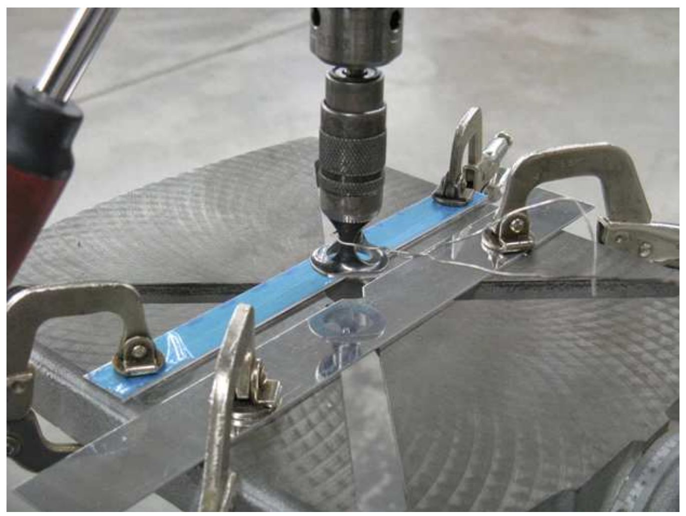


FIGURE 1: GUIDE AND CUTTER SETUP

FIGURE 2: COUNTERSINKING WEDGE

Building a truly straight TE is one of the more difficult things to do in aircraft construction. To help keep the TE straight we advise adhering or bonding the components together before setting the rivets. Use of double-sided adhesive tape makes it possible to keep the wedge aligned all the way through the TE build process. We recommend 3M tape product number F9460PC VHB for this purpose. In the past fuel tank sealant has been used on RVs for this application.

To apply the tape, prep all surfaces to be bonded with isopropyl alcohol, wipe them down and wait until the excess liquid has evaporated. Apply a continuous piece of tape to both sides of the wedge as shown in Figure 3. Avoid touching the adhesive since skin oils can degrade its effectiveness over time. Allow the tape to bond 15-20 minutes before proceeding further.

At this point there are several possible scenarios one may encounter involving the bonding of riveted TEs, but two predominate. They are (A) when one skin will be rolled into place onto another and (B) whenever both skins are already in place at the time the wedge is to be installed.

Scenario A: One skin rolled into place on another.
Once the adhesive on the wedge has had a chance to bond (see above) remove one protective strip from the surface of the tape and adhere the wedge first to the control surface skin that will remain flat. Insert a small number of clecos from the outer skin surface, poking them through both tapes and the remaining protective strip, to aid in aligning the wedge. Use finger pressure to compress the joint and bond the entire length of the wedge to the skin.

Lay the opposite skin onto the wedge using the clecos as a guide. Install enough clecos to the opposite skin to ensure the skin will maintain its correct alignment and then roll the skin back as described in the construction manual. Follow the process described in the manual for completing all of the internal structure riveting. Lower the upper skin when complete. Keep the control surface TE on a flat surface. Use a straight board and small weights to hold the TE straight. Lift the un-bounded skin slightly and begin progressively pulling the backing from the tape. Once the backing is started the skin can stay close to the wedge while pulling the backing out from between. As clecos are encountered remove them before pulling the backing past to avoid tearing. Once the backing is fully removed apply finger pressure along the entire length of the wedge to get a good bond to the second skin. Insert rivets into the TE holes with the manufactured heads oriented up (on a rudder it's builder's choice). The double-sided tape covering the holes should keep the rivets in place though it might be necessary to apply an additional strip of regular tape.

Scenario B: Both skins already in place:
With the skins and wedge prepared as described in scenario A, insert the wedge between the skins. Use several clecos to hold the wedge to one of the skins and maintain alignment. Peel the backing from the side that corresponds to the un-clecoed skin, clecoing and pressing the skin in place on down the length of the TE. See Scenario A for the remainder of the process for the second skin.

Now for the riveting. Trailing edges are riveted with "double-flush" rivets. These are standard rivets, but instead of setting the shop head on a flat surface, it is set in a dimple and ends up flush with the skin surface. However, a double flush rivet will not look the same on both sides. The factory flush head will set almost perfectly flat. The finished shop head will be flush with the skin, but it will not fill the dimple completely. This has been described as "an acorn sitting in a dimple." Do not fall into the trap of trying to use a longer rivet to "fill the hole." Rivets used in this manner will bend over instead of setting properly and the force involved in trying to drive more rivet material flush into the dimple will cause puckering and waviness.

Place blocks on either side of the back riveting plate, to allow the control surface to lie flat as it slides over the plate (Note, because RV rudders vary in cord and thickness from top to bottom, the skins are not entirely flat so they can not be laid flat on a table. Instead, position the rudder so that only the aft couple of inches are on the back riveting plate and spacers. Then place shims under the spar as needed.) Weight the control surface down to the work surface so it remains straight while riveting.

Starting at the **MIDDLE** of the control surface, to minimize pillowing, back rivet about every tenth rivet just enough to lock everything in place. Do not set the rivets all the way yet. Continue with the remaining rivets by doing one rivet midway between others that have already been done, and working back and forth along the trailing edge until all are initially set.

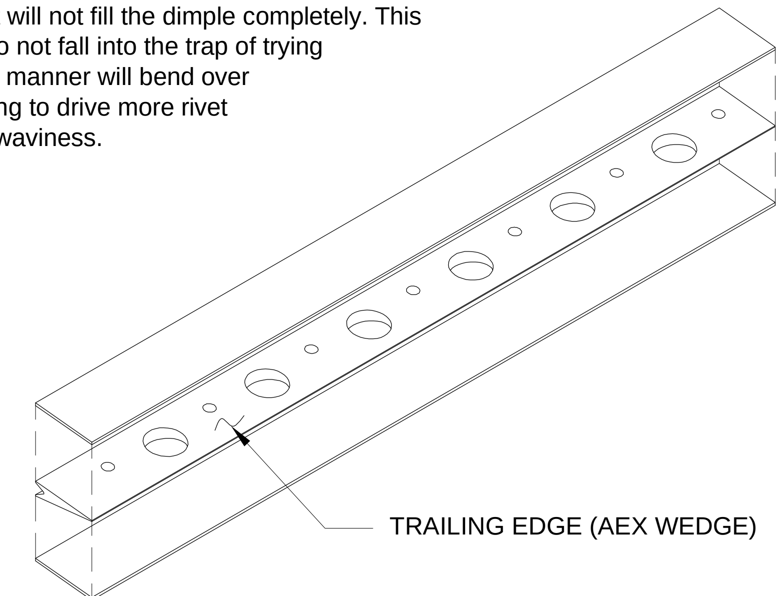


FIGURE 3: DOUBLE-SIDED TAPE

5.8 RIVETED TRAILING EDGES (continued)

Set the rivet gun pressure low (it should take about three seconds to fully set a rivet). This will allow time to vary the angle of the rivet gun while driving the rivet. Start with the rivet set parallel to the rivet shank and tilt it to set the rivet flush to the skin as the rivet sets. Repeat the initial pattern until the rivets are completely set. See Figures 1 and 2.

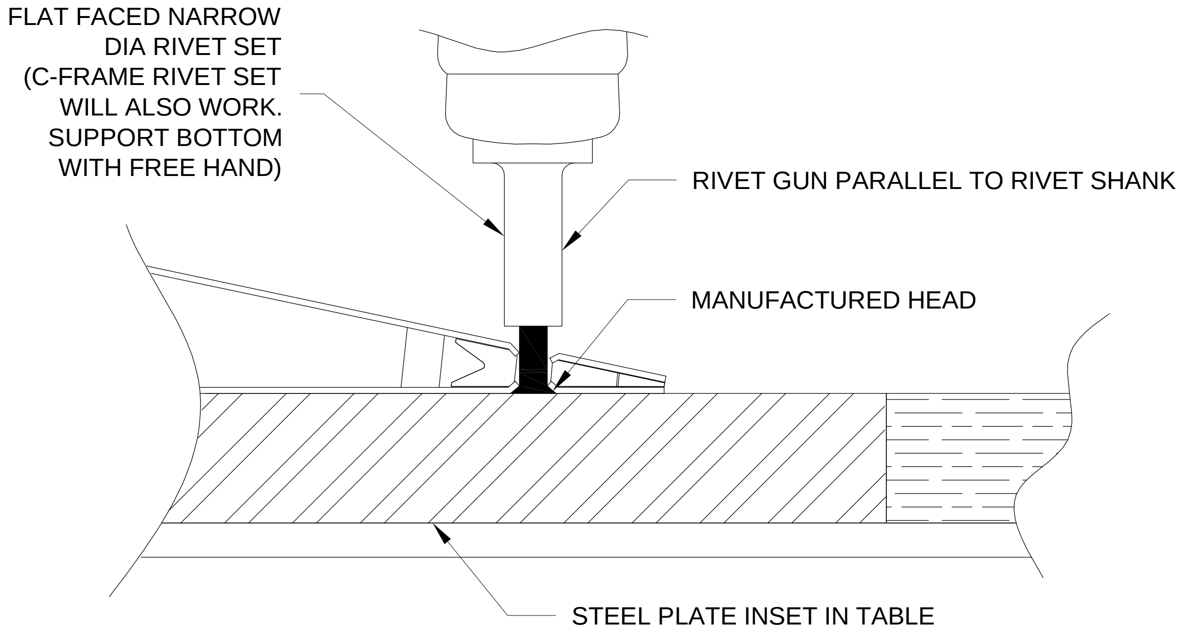


FIGURE 1: RIVETING THE TRAILING EDGE, INITIAL

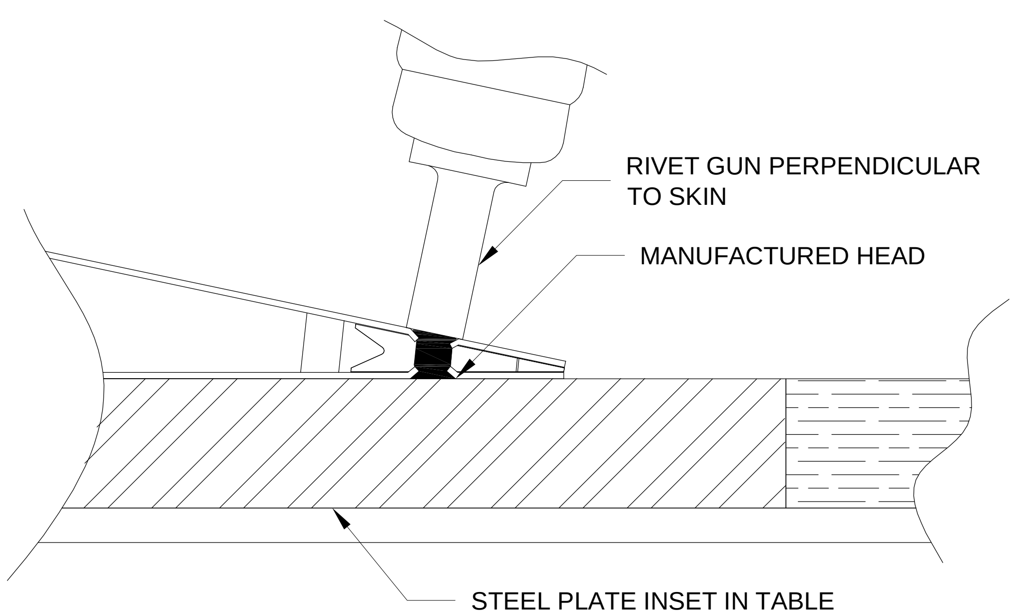


FIGURE 2: RIVETING THE TRAILING EDGE, CONTINUED

Check constantly for any deformation of the trailing edge. If deformation over 1-2 in. [2.5-5 cm] in length is observed place blocks near the curved area and lightly bend the trailing edge back down. Take your time and work as precisely as possible. An excessively wavy or bowed trailing edge will affect the flying qualities of the airplane. Strive to build a trailing edge that does not vary more than the dimension called out in Figure 3.

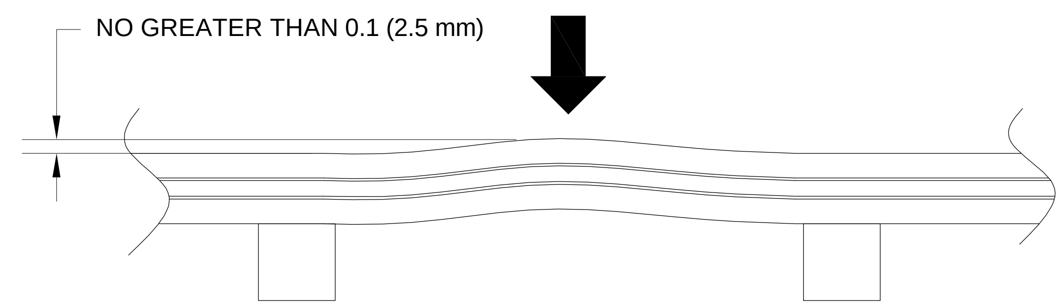


FIGURE 3: STRAIGHTENING THE TRAILING EDGE

5.9 ROLLED LEADING EDGES

Before the empennage control surfaces can be installed on the stabilizers, the leading edges must be formed. The object here is to achieve a smoothly curved surface that fits neatly between the skin overhang of the stabilizer.

Simply pulling the overhanging skins together results in an angle or crease where they cross the edge of the spar. To avoid creasing the skins the curve is started by rolling the edge of the skin. A piece of 3/4 or 1 inch diameter steel water pipe, a broomstick, or something of similar diameter about four inches longer than the skin will be needed.

Tape the edge of the skin to the pipe along its entire length. Use vise grips or a small pipe wrench clamped to the pipe as a handle and roll the skin around the pipe. Maintain pressure down toward the work surface and away from the spar to prevent the skin from bending right at the spar. This will not produce the final shape, but it will produce a curve in the skin that allows the skin to be closed with a minimum of spring-back. If working solo, it will be easier to use a shorter pipe and do each skin section individually.

NOTE: Not fully forming the skin, but instead just pulling the two halves together and riveting, causes a lot of pre-load on the skin and is a common cause of skin cracking at the forward end of the skin stiffeners.

Finish the bend by hand, squeezing the skin until the holes match. Drill the holes full size then clean up the holes (it is hard to get to the inside of the curved skin with a deburring tool, but in this case a quick rub along the holes with a scotchbrite pad is good enough) and rivet. Blind rivets are used here. They are simple to set with a hand pop-riveting tool, but difficult to drill out. Make sure that the heads of the rivets are firmly against the skin before squeezing. See the Leading Edge Detail on the appropriate drawing.

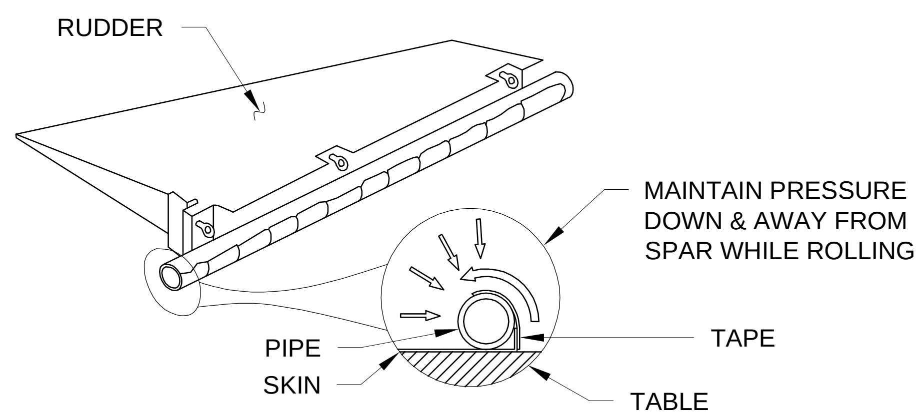


FIGURE 1: ROLLED LEADING EDGES

5.10 LAP JOINTS

When riveting a lap joint, the expansion of the aluminum caused by the setting pressure and the expansion of the rivet causes the overhanging edge of the sheet to bend upwards slightly. This creates a number of problems, like making the lap joint appear wider than it is, making painting more difficult, etc. One easy method of minimizing this effect is by pre-bending the last 1/4 inch of the skin downward just a small amount before it is clecoed and riveted. When the rivets are driven, the skin will be flattened and the pre-set in the skin edge will tend to hold it flush. Except for very rare circumstances, the amount of bend (break) is very small and when done properly is almost undetectable with your eye. The goal is to do just enough to keep the skin lying flat but not too much or it will be obvious that it was done.

There are several methods that may be used for making this slight edge bend. Using a hand seamer and moving progressively down the sheet, making a very light bend to avoid bend marks between succeeding grips with the seamer. On long thin pieces put the sheet on an even-edged table with about a 1/4 inch overhang and draw a block of hardwood or plastic along the edge with just enough downward pressure to cause the slight bend as the block moves. UHMW blocks with different depth slots to set the bend depth may also be used. Slip the slot over the skin, apply a bending force and pull the block towards you, sliding it along the edge of the skin. Do not try to form the bend all in one pass.

Some tool suppliers sell tools for this purpose, usually two small rollers mounted on a variety of different tools. The edge of the aluminum sheet is placed between the rollers and a bending pressure is held as the tool is drawn down the edge. Use these with caution as they may tend to stretch a long edge and make it wavy. Avoid over bending the edge and causing a worse visual effect than before. Experiment with scrap material first.

5.11 FORMING ALUMINUM PARTS FROM SHEET

Some of Van's kits require forming several ribs and bulkheads from flat aluminum sheet. This can be a useful skill in the Standard kits as well. Sheet metal press brakes are only capable of producing straight bends, so parts with flanges along curved edges must be bent over “formblocks.”

formblocks are made of hardwood or dense particle board. They are cut to the contour of the finished part with allowances for the thickness of the material. Edges are radiused so as the part is bent around the block, it does not bend too sharply and crack. A blank part, with the appropriate material for flanges, notches at the corners, etc., is cut from sheet stock and sandwiched between the formblock and a “tool cap”. This tool cap looks very much like a formblock, but does not have to be exact.

The tool cap functions to keep the part from bowing or distorting when the flanges are bent. The formblock, blank and tool cap are all aligned with tooling holes and clamped together with bolts. The protruding edge of the blank part is bent around the formblock with a mallet or lead bar. Final adjustments to the flange are made with a hand seamer and fluting pliers.

5.12 VINYL COATING

Many of the alclad parts are supplied with a thin (usually blue) vinyl coating to prevent scratching during the manufacturing of the parts. The vinyl may be left on during drilling but should be removed for dimpling, priming and final installation. It is possible to remove strips of vinyl along rivet lines with a soldering iron. Carefully round and smooth the tip of the iron so it will not scratch the aluminum. The time in labor required for this added protection during construction should only be considered of value if you intend to leave the airplane polished bare aluminum. If you intend to paint, the preparation process will include scuffing/deglossing all of the skin surfaces anyway to provide good paint adhesion.

The adhesive on the vinyl strengthens with age, so if the coating is left on for more than a few weeks, it may become very difficult to remove. Corrosion has been found under the vinyl in some instances. If vinyl covered parts must be stored for long periods remove the vinyl first.

5.13 FLUTING

There are some conventions when referring to parts of parts.Terms like "flange" and "web" have specific connotations and using them correctly makes the job of Van's Builders Support personnel much easier. See Figure 1.

Verify that the flanges on parts are perpendicular to the web (unless otherwise specified), so that they will mate correctly with the skins. Adjust flanges with hand seamers or small wood blocks with slots cut in them as necessary. A pair of duck bill pliers can also be very handy for adjusting small flanges.

The process used to manufacture parts with curved flanges will leave them slightly bowed and sometimes twisted. Before parts are installed the flanges must be straightened (any twist in the part can be ignored). This is done by "fluting", that is, putting small creases or "flutes" along the edge of the flange with special pliers. The flutes effectively shrink the flange material and pull the part into line.

Fluting diagrams are shown on the plans where required. Otherwise the flutes are simply centered between the pre-punched holes in the flanges. When making flutes, be sure they are formed towards the inside of the part so that the outer face of the flange remains flat for the skin to lie on.

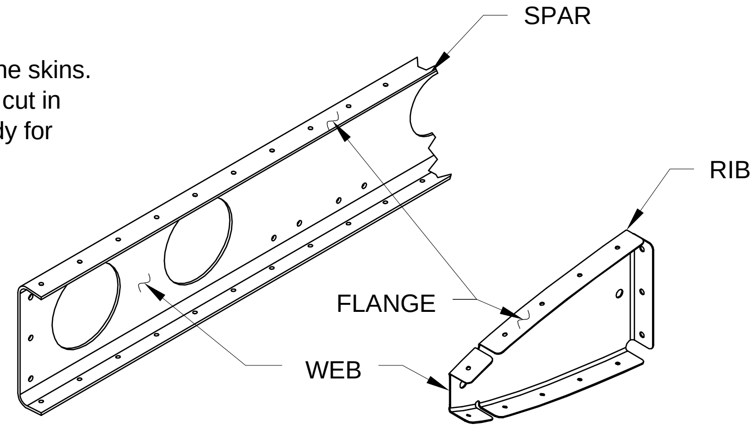


FIGURE 1: BASIC TERMINOLOGY

Straighten the ribs/bulkheads with fluting pliers and check for straightness by sighting down the web or by laying the part on a flat table top. On parts with prepunched holes, a straight edge can be used to check that the prepunched holes are aligned. The more curve that a flange has, the more fluting that will be required. On parts with a varying amount of curve (such as a wing rib), a different amount of fluting will be required in different areas of the part. Do a little at a time until reaching the desired flatness.

NOTE: Do not confuse the twist in a part with a curved flange. It is normal for light pressure to be required to hold a twisted part flat on a table. Fluting does not remove twist from a part.

If you have overdone the flutes and curved the rib or bulkhead the other way, gently squeeze the flutes with smooth pliers to straighten the ribs.

5.13.1 STRAIGHTENING THICK ALUMINUM PARTS

NOTE: Some thick (.125 [3.2 mm] or thicker) aluminum parts, such as the (F-01411C Horizontal Stabilizer Attachment Bars in the RV-14) may be bowed due to the punching operation used during their manufacture. Use the following process to straighten any other thick aluminum part prior to installation.

Clamp one end of the part in a padded vice (padded with wood, aluminum, etc).

Pre-load the free end of the attachment bar in the direction required to straighten it. Using a rubber mallet, firmly strike the part once near the vice.

Slide the part further into the vice, pre-load, and strike the bar again.

Repeat as necessary until the part is straight within 1/16 [1.6 mm] along its entire length. See Figure 2.

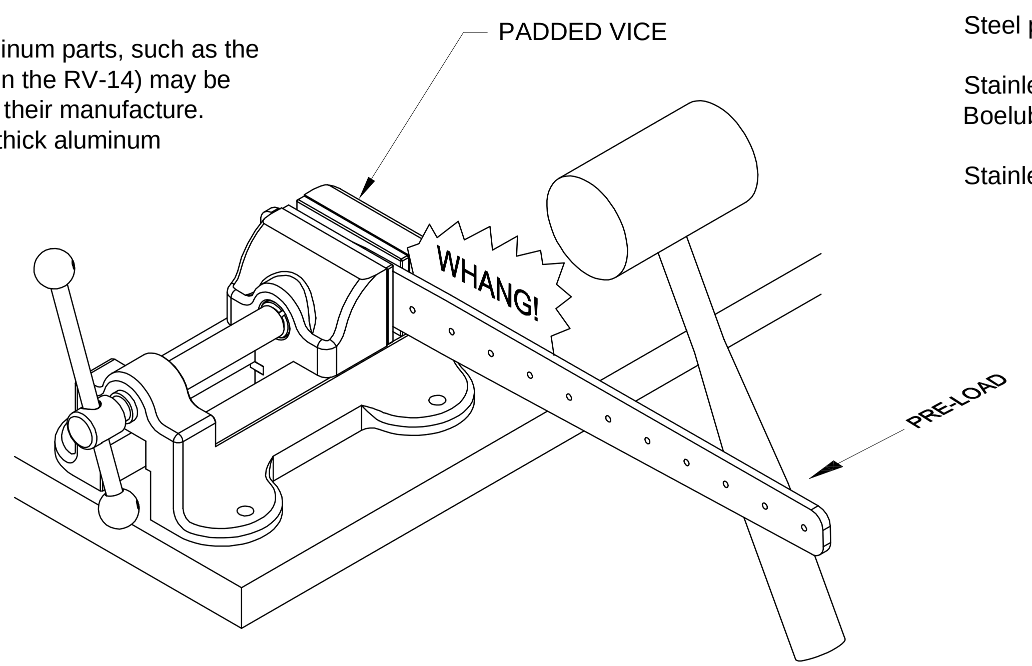


FIGURE 2: STRAIGHTENING A THICK ALUMINUM PART

5.14 ALUMINUM TUBING

In RVs, 3003 soft aluminum tubing is used for the fuel lines inside the cockpit and for the brake lines. These lines must be bent with a tube bender to avoid kinking and to get a professional looking installation. The flared ends of these lines are 37°, not the 45° found on automotive lines. A good quality flaring tool is a necessary tool to do the proper job. Properly installed, aluminum lines will last for many years. Here are a few tips on the "properly" part:

Preparing the tube: Soft aluminum tube should be cut with a tubing cutter - not a hacksaw. The resulting end will be square. After making the cut, deburr the interior edge of the tube end and polish the end of the tube with fine crocus cloth, emery paper, or a Scotchbrite wheel.

Mounting it in the flaring tool: First, put the AN-818 nut and AN-819 collar on the tube and push them out of the way. There is a tongue on most flaring tools that serves as a stop. Make sure you have selected the right diameter (Most RV's use 3/8 tubing for fuel lines and 1/4 tubing for brake lines), insert the tube from the far side of the tool until it hits the stop, then tighten the clamp.

Making the flare: Put a drop of light oil on the cone of the flaring tool. Spin the cone down into the tube and watch it make the flare. Do not over tighten, which can start thinning the material in the area of the flare. Turn the cone just enough to fully form the flare.

Inspect the flare: Take a good look at the stretched aluminum around the circumference of the flare. You will probably see some tiny stretch marks, but there should be no cracks or splits.

Install the tube on the flare fitting: Mate the flared end of the tube with the conical end of the AN fitting. Slide the AN-819 collar down the tube until it rests on the back of the flare. It must be square to the fitting. Any slight angle will make it difficult to start the nut, and if you do get it started, runs the risk of splitting the aluminum flare.

Slide the AN818 nut over the far end of the tube and engage the threads on the AN fitting. Tighten to the specified torque. You should have a Standard Aircraft Handbook with the torque tables for these things. (assuming aluminum fittings, for 1/4 tubing it is 40-65 inch-pounds, for 3/8 tubing it is 75-125 inch-pounds.) Later, you can leak test the system.

5.15 STEEL

Most of the steel used in RVs is 4130 normalized, mostly in the form of thin plate and thin wall seamless tubing. This 4130 high carbon steel is used extensively in the aircraft industry because of its high strength and relatively good workability.

Most steel parts supplied in RV kits are powder coated at the factory, meaning that there is little for the builder to do except install it. On a few parts, where the sequence of welding or forming operations makes powder coating at the factory impractical, the builder may paint the part. The best method of cleaning is bead-blasting, but some work with a stiff brush and solvent will do the job.

Steel parts should be primed and painted immediately after cleaning to prevent rust.

Stainless steel will quickly dull cutting tools (drills, deburring tools, reamers, etc.). Use plenty of lubricant (Van's Aircraft uses Boelube) and keep the cutting speed low. Use a step drill if creating holes over .250 [6.4 mm] in diameter.

Stainless steel edges can be very sharp. Handle with care!

5.16 INSTALLING NUTPLATES

Nutplates are almost always installed with flush rivets. When the structure is too thin to machine countersink there are two options. The first alternative is to dimple both structure and nutplate. In order to dimple the nutplate it is sometimes necessary to use a reduced diameter female dimple die so it will clear the threaded or countersunk portion of the nutplate. Simply grind away that portion of one side of the die that is in the way. If carefully modified the die will still give good service in dimpling other parts. Only the female half of the die needs to be modified. When installing single leg nutplates (MS21051, etc.), temporarily install a screw to insure it remains aligned while riveting.

The second alternative when attaching nutplates to thin material is to replace AN426 rivets with NAS1097 rivets which require a much shallower countersink and are still acceptable.

Nutplate mounting holes that are not prepunched must be match-drilled using a nutplate drill jig. Commercial nutplate jigs are quick to use but may be unusable in situations with limited access. A compact nutplate drill jig may be fabricated from an appropriately sized nut plate and screw. Insert the screw finger tight in the nutplate and then remove the head of the screw with a hacksaw or die grinder/cutting disk. See Figure 1. This also works well with single leg and corner nutplates.

For application, insert the screw in the screw hole and rotate to the desired alignment. Match drill one of the mounting holes and cleco. Match drill the other mounting hole. When the attach holes in the nutplate begin to get worn/enlarged, replace the nutplate with a new one.

FIGURE 1: NUTPLATE JIG

5.17 FUEL TANK SEALANT

The recommended sealant, MC-236-B2, (often called ProSeal) is available through the VAN'S ACCESSORIES CATALOG. Mixed, unused sealant may be kept in the freezer for up to 4 days.

Although the sealant used to seal the tanks is not particularly noxious, only use it and the solvents used in tank construction with adequate ventilation. Use a respirator, gloves (which also keep oil from your skin off the surfaces to be sealed), and protective cream when sealing the tanks. Why expose your skin and lungs if you can prevent it?

Working with tank sealant can be a messy proposition but it does not have to be. By taking care and thinking things through it can be painless. Handy things to have on hand: disposable surgical gloves, a box of Popsicle sticks, a supply of clean rags, paper towels, butcher paper (not newspaper) to cover the bench surface.

Rough all mating surfaces using a Scotchbrite pad. Don't be bashful; score the aluminum well so the sealing compound will have more surface to grip. After scoring thoroughly clean all parts (including rivets) with naphtha, MEK, or an etching acid like Alumiprep or Twin Etch. After cleaning, do not pollute the areas to be sealed. Don't even touch them. The oils from your skin will affect the bond of the sealant.

The tank sealant should be mixed as accurately as possible. This can be done by using a homemade balance scale, a hand loader's scale, a postal scale or nearly any of the small inexpensive digital scales that are available. Follow the instructions supplied with the sealant. When mixing sealant, do not mix too much at one time. A batch the size of four or five golf balls is usually enough for one work session. The sealant provides 45 to 90 minutes of working time (less in warmer temperatures). To use the sealant as soon as possible after mixing, have all the work well planned and tools all laid out. Have a container of acetone, MEK, or lacquer thinner nearby for the frequent tool cleanings necessary during riveting. You can peel away overflow on areas you want to keep clean by strategically applying plastic tape before spreading the sealant.

APPLYING SEALANT

Use plastic freezer bags. A small amount of sealant can be put in one, the corner of the bag cut off, and the bag squeezed like a cake decorator's pastry bag to apply sealant to parts.

Purchase some plastic disposable syringes from a farm supply store. Monoject 35cc syringes cost very little. Drill the end out a little larger for better flow of the thick sealant. After filling the syringe with sealant using a Popsicle stick and squeezing out the air, you now have a miniature caulking gun.

5.18 FIBERGLASS

Fiberglass Reinforced Plastic (FRP), or "Fiberglass" as it is more commonly known, is used in numerous places in RVs for non-structural parts. These include the cowl, spinner, and other fairings. The typical part consists of several layers of bidirectional fiberglass cloth and resin.

Fiberglass parts supplied with RVs come in two resin types, polyester and epoxy. Polyester parts can easily be identified by their white or gray gel-coat surface. The "wet layup" epoxy parts are translucent green. Some parts (typically large parts such as cowlings) are manufactured from epoxy pre-preg cloth which requires baking in an oven to cure. These parts can be gray exterior, opaque green or pink. They are easily identified by the honeycomb pattern visible on the inside surface of the part. Polyester resin is not compatible with epoxy and can only be used on polyester parts. However epoxy resin is OK to use on either epoxy or polyester parts. Many builders have had good results with West Systems epoxy resin.

Molded fiberglass can be cut, filed, and drilled with any tools used for metal working. Though it is softer than steel or aluminum, glass fiber is very abrasive and will quickly dull tools. Set aside some drill bits for use exclusively with fiberglass. Use sanding blocks and sandpaper rather than files.

Like welding, fiberglass molding is a specialty skill. Fiberglass parts lend themselves more to production methods than do most other parts. Thus, VAN'S AIRCRAFT offers most fiberglass parts pre-molded. To make the parts that are not supplied in the kit any fiberglass cloth of medium weight will do. Flocked cotton fiber and micro balloons are mixed with resin for building up and filling. Using Peel Ply will result in a very smooth finish that is also ready for glass to glass bonding without sanding. Most supplies can be obtained from a local marine/boat store or from one of the mail order supply houses like Aircraft Spruce.

NOTE: When setting solid rivets in fiberglass composites, use soft rivets or do not fully set normal rivets (shop head height approximately 1.2 X the hole diameter).

PREPPING THE COWLING FOR PAINT

Fit the cowling to the fuselage with all the hinges, retaining screw holes, and nut plates installed, but leave the oil door installation for later.

Van's recommends use of a Poly Fiber product called Smooth Prime. We follow the manufacturer's instructions EXCEPT that we apply the first coat straight-out-of-the-can and un-reduced, using a Bondo squeegee rather than a roller or spray gun. Using a squeegee to apply the first coat forces the filler into surface voids.

TIPS FOR FIBERGLASS FAIRINGS

When installing fiberglass tip fairings (especially wingtips), ensure that the trailing edge extension is aligned with the control surface trailing edge. On wingtips, this can lead to inconsistent gaps between the skins and the joggled edges formed into the parts at the factory. For instance, there may be a smaller gap on the bottom than on the top, differing along the length from leading to trailing edge. Once the part has been positioned to where the trailing edges align well and the part has been match drilled and clecoed into position, make sure the metal edges are not riding up onto a fiberglass edge radius as shown in Figure 1.

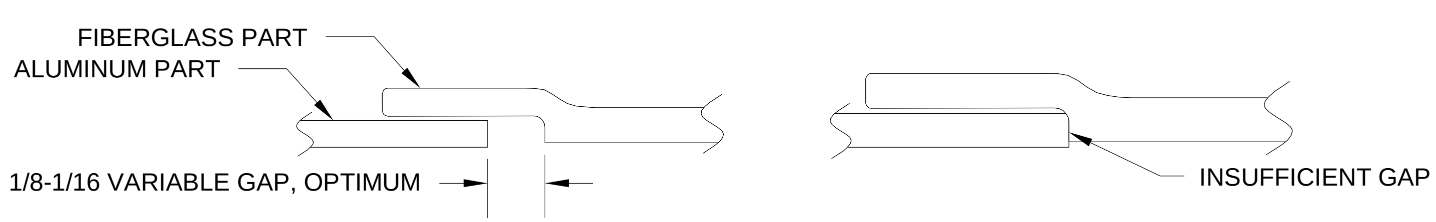


FIGURE 1: FIBERGLASS GAP

After the part is prepped for final installation, either with screws and nutplates or rivets, the gap can be filled using the following steps:

Step 1: Clean the part around the perimeter with solvent to remove any residual release agent.

Step 2: Scuff deeply with coarse sandpaper the recessed area that falls between the normal finished surface and the edge of the metal (through the gel coat will ensure the best possible bond). After scuffing, clean thoroughly.

Step 3: Wrap electrical tape or equivalent around the inside surface of the metal part. See Figure 2. Insert and secure the fiberglass tip with either screws or clecos as appropriate, then finish wrapping the tape snugly around the edge of the metal. The tape will act as a release agent for the next step.

Mix up a small batch of epoxy resin and add flox until it reaches the consistency of peanut butter. Fill in the groove between the tape and fiberglass with this mixture. Ensure that the thickened flox fills in the entire gap. The flox should come up to the level of the tape or slightly beyond so there is room to sand it back down after it has cured.

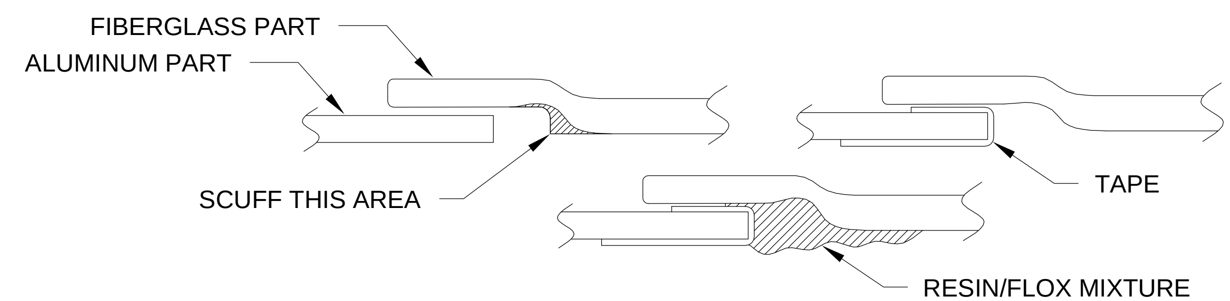


FIGURE 2: RESIN APPLICATION

When the resin has hardened overnight, lightly sand off any mixture that overlaps the tape as shown in Figure 3. Remove the tip and the tape. Complete installation of the tip per kit instructions. The interface can be sanded to leave a perfectly co-planar surface with a consistent gap.

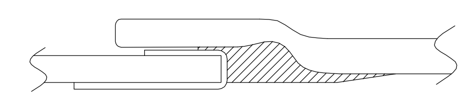


FIGURE 3: SANDING

MIXING COTTON FLOX WITH EPOXY RESIN

Mix cotton flox with epoxy resin. Gradually add flox until the mixture does not move when the mixing container is turned on its side.

The epoxy/flox mixture can be applied using plastic freezer bags in a similar fashion to fuel tank sealant (see 5.17).

5.19 ACRYLIC CANOPY AND LEXAN WINDOW HINTS

DEFINITIONS

Plexiglas or Poly(methyl methacrylate) (PMMA) is a transparent thermoplastic often used as a light or shatter-resistant alternative to glass. This material is specifically used for canopies and windows contained in RV Finish Kits. Beware of aftermarket canopies made of material other than Plexiglas that promise easy installation because of resistance to cracking yet may not break in a roll over accident and will be difficult to break by hand preventing egress from the aircraft. Lexan or polycarbonate resin thermoplastic is the brand name for polycarbonate sheet and resin in a wide range of grades. This material with a fuel resistant coating is used specifically for the RV-12 aft window. The Plexiglas canopy bubble and Lexan window are two of the most expensive and fragile components in the kit. Mishandling, scratching, or cracking them are some of the most disappointing and gumption-robbing experiences a homebuilder can have. Below are a few general Do's and Don'ts.

SAFETY

Most of us understand the importance of Shop Safety. Eye, ear, and respiratory protection are essential when fabricating Plexiglas and Lexan. Die grinders will cut fingers without a second thought, turn at very high rpm, and can throw chips and dust at un-dodgable velocities. Two hands are recommended to guide this tool. Drill bits can also break and become flying hazards. Eye protection is a must. Remember to support your work well and use gloves when it makes sense.

HANDLING

The canopy is most vulnerable to cracking when moved or flexed before edges or holes have been deburred. Be especially cautious when the canopy is in this state. Plexiglas and Lexan are dramatically less brittle when warm. Do not try to work on these materials in a cold shop. Cutting or drilling the acrylic transparencies in temperatures under 60º F is asking for trouble. Heat the shop to 75-80º -- it may be uncomfortable to you, but your canopy loves it. Many builders will put a small space heater under the canopy when trimming, just as insurance. Take care not to overheat the canopy. Too hot is when any part of the canopy is hotter than "warm to the touch". More than one builder has melted a canopy in an attempt to make sure it is "warm enough". Localized heat is as bad as no heat and can deform the canopy. Be cautious when fitting your canopy over small protrusions and/or transitions in canopy frame tubing diameters. You might elect to shim the tubing surfaces so that the acrylic is not pinched or bridged over any given area.

CUTTING

CAUTION: DO NOT use a saw of any kind. You might get away with it once or twice, but eventually you will crack the canopy.

Cutting discs, supplied with the kit, do an excellent job when used in a high-speed die grinder. If a die grinder is not available, an electric drill will work, but several passes will be necessary, going a little deeper each time to complete the cut. Practice on the flanges of the canopy for both the cutting and drilling operations. Work slowly at first pass to begin cutting an initial slot and to gain confidence with the procedure. Once the initial slot is made, continue cutting through the material. Once cut, the edges should be smoothed and rounded with a scraper. For a scraper use an edge from a pair of quality scissors. Do not leave the edges rough. Ensure that no edge has a sharp corner.

DRILLING

Special Plexiglas/Lexan drills are available from tool suppliers. Van's recommends two such tools; Diamond Dust drills and Unibits. Clamping a piece of wood behind the acrylic material and drilling through into the wood can eliminate chipping on the backside of drilled holes. Start drilling the warmed acrylic with slow speeds and light pressure. Increase speed and pressure as you progress. As the drill bit starts to go through the canopy, reduce speed and pressure so that the drill bit penetrates the opposite surface slowly. It is important to deburr both sides of the hole lightly with a machine countersink. No hole should have a sharp corner. Practice drilling holes in scrap pieces until you are familiar and confident with the process. It is worth remembering that excessive heat caused by machining and drilling *may* alter the acrylic's properties which may in turn allow even approved products to negatively affect the material. For this reason it is important to cut slowly and avoid overheating the acrylic. To enlarge holes the use of a step-drill (Unibit) or reamer is recommended.

CAUTION: DO NOT use a regular twist drill! A twist drill tends to fracture the acrylic due to its tip design. Using a regular twist or plexi drill to enlarge a pre-drilled hole is not recommended and will practically guarantee a cracked canopy as a result.

FIBERGLASS BONDING, CRACKS, ETC.

CAUTION: DO NOT use Polyester resin of any type, as it will cause crazing .

Be certain to use ONLY epoxy resins. Do *not* use the more common polyester or vinyl ester resins since they are not compatible with Plexiglas and cause crazing that will ruin the canopy. We have had excellent results with West Systems Epoxy products, available from boat yards and mail order houses.

The three keys to getting a good bond between fiberglass and acrylic canopies and windows are proper surface prep, proper surface prep, and proper surface prep. The bonding surface must be entirely de-glossed. Many builders think they have scuffed the surface well, when it is not nearly enough. Fully scuff the surface using 60 - 80 grit sandpaper. Use an overhead light source to inspect the surface carefully. Look between the scratches... there should be absolutely no sign of any shininess whatsoever. Just to be sure, go over the entire area once more, this time using a circular motion. Clean the area with a lint free cloth and denatured alcohol. To prevent contamination of the surface avoid touching it with your hands.

Cracks… Avoid jeopardizing or cracking the canopy at all costs. If the unthinkable happens and a crack appears it may sometimes be repaired using a solvent adhesive such as Plasti-Fix or Weld-On 3. Stop-drilling the crack is typically required to keep it from running.

CLEANING AND USE OF LIQUIDS

CAUTION: DO NOT use Loctite, aromatic solvents, acetone, benzene, ethyl acetate, carbon tetrachloride, lighter fluid, lacquer thinners, gasoline, toluene, window sprays, concentrated alcohols, ketones, scouring compounds, ammonia, or 409 cleaner on or around acrylic or Lexan canopy materials.

The adhesive used on some brands of electrical tape may be incompatible with acrylic or Lexan. Test the tape on a scrap of material before use. In all cases do not leave the tape on the canopy for extended periods of time (more than two days).

For general cleaning use Dawn dishwashing liquid or equivalent and water followed by a clear water rinse. To prevent water spots, blow-dry with compressed air or wipe dry with soft cotton flannel. Plexus, Sprayaway #848 Industrial Plastic Cleaner, or All Clear can also be used for day to day cleaning. Grease, oil, tape residue, etc. may best be removed with mineral spirits, refined kerosene, white gasoline, naphtha, or isopropyl alcohol. Wash approved solvents off the canopy with Dawn dishwashing liquid and water. It is best to avoid using products on your canopy that are not specifically formulated for acrylics such as Rain-X or Lemon Pledge.

SCRATCH REMOVAL

Small scratches can be buffed out with Meguiar's Mirror Glaze Plastic Cleaner #17. For deep scratch removal, use Scratch Off , Micro Mesh, or 3M Window Repair kits. Avoid removing scratches in critical areas where clear visibility is important, as the process will usually result in some degree of optical distortion.

CANOPY PROTECTION AND VENTILATION

If the aircraft is tied down outdoors and subject to weather elements for any length of time, then the use of an aircraft canopy cover is highly recommended. The cover will protect canopies and windows from abrasive dust, dirt, and sand kicked up by wind or prop wash. Before purchasing, verify that the canopy cover is NOT waterproof as the trapped moisture and heat from the sun can be deleterious. Acrylic subjected to this treatment over a period of time may turn slightly milky and eventually craze.

Keep your canopy ventilated or covered when your aircraft is parked in the hot sun. Cabin temperatures can easily reach 150-200 degrees F even on a mild day. The acrylic can generally take these temperature conditions multiple times without any apparent adverse effect. It is the cumulative affect that will cause shortened service life of your canopy. The use of a Van's Aircraft Canopy Cover will significantly reduce the internal temperatures inside your aircraft to just a few degrees above outside ambient temperatures. Additionally it will also protect your expensive avionics from heat and your upholstery/seat belt harnesses from harmful UV rays.

In winter conditions ensure that the cabin and canopy are warmed adequately prior to flight whenever possible. A heat lamp or small, low output ceramic space heater can raise the cabin temperature to warm the acrylic, keeping it free from ice or snow. It will also be less prone to cracking.

5.20 NUT AND BOLT TORQUES

The importance of correct torque application cannot be overemphasized. Under-torque can result in unnecessary wear of nuts and bolts, as well as the parts they secure. Over-torque can cause failure of a bolt or nut from over-stressing the threaded areas. Uneven or additional loads that are applied to the assembly may result in wear or premature failure. The following are a few simple, but important procedures, that should be followed to ensure that correct torque is applied.

NOTE: Insure that the torque to be applied is for the size of the bolt shank not the wrench size.

Use the standard torque table provided as a guide for tightening nuts, bolts and screws whenever specific torque values are not provided in the builders manual. These values are for clean and dry threads. Note that on the smaller bolts the torque is quite low and is in inch pounds. Do not use a foot pound torque wrench on these bolts, but instead use a torque wrench calibrated in inch pounds. The propeller manufacturer and the engine manufacturer have specific torque requirements for their equipment. Consult the appropriate manual for that information. Apply a smooth, even pull when applying torque. When using the 1/4 in. drive snap-over type torque wrench we recommend practicing with it off the aircraft first until you get the feel of the particular tool's snap-over feature since it can be rather light depending on the size of the fastener.

Apply the torque to the nut and not the bolt whenever possible. This will minimize rotation of the bolt in the hole and reduce wear. When the bolt is rotated for final torque the chart values must be modified. When applying torque to a bolt be sure to have a washer under the bolt head and lubricate the bolt shank. Add to the overall torque value the torque required to overcome the friction associated with turning the shank of the bolt within the assembly.

When tightening fasteners with self-locking nuts the chart values must be modified. Due to the friction of the locking device noticeable torque is required just to turn the nut onto the threads and does nothing to actually tighten the parts together and stretch the bolt (clamp load). This is called friction drag (or prevailing) torque. The friction drag torque must be determined and then added to the standard torque from the table. Run the nut down to where it nearly contacts the washer or bearing surface and check the friction drag torque required to turn the nut. (At least one thread should protrude from the nut). Add the friction drag torque to the standard torque. This sum is referred to as the final (or total) torque, which should register on the indicator or setting for a snap-over type torque wrench.

As an example illustrating the importance of determining the friction drag torque consider a new AN3 bolt and MS21042-3 all-metal lock nut. Our tests showed an average friction drag torque of 14 in-lbs (your results may vary). The standard torque for this nut/bolt combination from the table below is 28 in-lbs. This results in a final torque setting on our wrench of 14 plus 28 or 42 in-lbs. Though we exceeded the 28 in-lb value listed in the table by using a final torque of 42 in-lbs we are still well within the capability of the nut. (Incidentally this nut must meet a maximum torque test value of 60 in-lbs per the military standard spec sheet.) Now what if we completely ignore the friction drag torque and set our wrench to just 28 in-lbs? Recall that it requires about 14 in-lbs (friction drag torque) just to turn the nut. We subtract 14 from 28 and arrive at only 14 in-lbs of torque(torque being the measurement of friction, not tension) applied to induce preload (clamp load) in the bolt. Not a satisfactory result.

(Portions of this information has been adapted from AC 43.13-1B Section 7-40.)

AN Bolt Size	Bolt Size-Threads Per Inch	Standard Nuts AN310, AN315, AN365		Self Locking Nut MS21042-3, MS21042-4	
		INCH POUNDS	FOOT POUNDS	INCH POUNDS	FOOT POUNDS
AN3	*#10-32*	*20-25*	*1.6-2.0*	*28*	*2.3*
AN4	*1/4-28*	*50-70*	*4.2-5.8*	*85*	*7.0*
AN5	*5/16-24*	*100-140*	*8.3-11.6*		
AN6	*3/8-24*	*160-190*	*13.3-15.8*		
AN7	*7/16-20*	*450-500*	*37.5-41.7*		
AN8	*1/2-20*	*480-690*	*40.0-57.5*		
AN9	*9/16-18*	*800-1000*	*66.6-83.3*		
AN10	*5/8-18*	*1100-1500*	*91.6-125.0*		
MS21042-3	*10-32*	*28*	*2.3*		
MS21042-4	*1/4-28*	*85*	*7.0*		

FASTENERS AS PIVOT POINTS

In specific cases, bolts are intended to be used as axis of rotation. The most common example is the attachment of control system cables. Here, it is intended that the cable end fitting pivot on the bolt. In these instances, the nut must not be torqued to the standard torque value. Instead a castellated nut, safetied with a cotter pin, is used. Finger-tighten the nut, then install the cotter pin. The cable end fitting must pivot freely when the installation is complete.

MS NUTS

A common rule of thumb for evaluating whether an installed bolt is the proper length has always been that up to three thick washers are allowed (if more than three are needed the next shorter bolt should be used), and that at least one but no more than three full threads of the fastener are to be showing beyond the nut. This rule of thumb works for the AN365 nuts that have been commonly used on RVs for years.

Some of the newer RV kits use the all metal MS21042 self locking nut. The long standing rule of thumb will not work for these nuts because they are shorter in height than the AN365 nut. For these nuts, modify the rule of thumb to “at least three, but not more than five threads showing.” This rule of thumb will still allow for meeting the 'maximum use of three washers' rule.

You may have to educate any technical councilors or airworthiness inspectors that perform inspections on your project. Some inspectors are not familiar with these smaller sized nuts.

5.21 ELECTRICAL

ELECTRICITY

There are three primary units of measure or terms to know to successfully wire the aircraft: voltage, current and power. The battery we will be dealing with is known as a 12V battery. Batteries in good charge will have a terminal voltage between approximately 12.8 and 13 volts. When a battery is installed in an airframe and the alternator or generator is operating, the system voltage will be 14 to 14.5 volts. The second term is current which is measured in units of amps (A). Current is a value representing the flow of electrons through a wire. An analogy would be a measurement of the flow of fuel to the engine in gallons/hour. The amount of current (amps) flowing in a circuit will determine the size of the circuit breaker (or fuse), the type of switch to use and the size of wire to use. The last term we must understand is power, more specifically the power being consumed by a circuit, which is measured in units of Watts (W). Items such as lights are typically rated in watts.

WIRING

Stranded wire is preferred over a solid conductor. Solid conductor wire (a single strand of wire) is more susceptible to breakage from the normal vibrations of an aircraft. Automotive type wire can be used in most applications. The only exception would be where shielded wire is desired.

Wire should be supported such that it does not sag or swing freely. When passing through a bulkhead, use a grommet or support the wire in the center of the hole with clamps to prevent chaffing which could result in an in-flight electrical short. Bundling wires together is acceptable, except when a noisy wire is included with a sensitive circuit. An example of this would be including the transponder antenna lead or a strobe power lead in the same bundle with the mike wire or headset leads. The impulses created by either the transponder or the strobe could be picked up by the audio wiring.

WARNING: Antennas must be hooked up before turning on the transponder or radio or damage may result. Refer to the transponder, radio, and antenna manual/installation instructions for more information.

Wire colors are called out in the building plans as needed. Wire call outs are followed by their color in brackets.
(WIRE COLOR/STRIPE COLOR). Colors are abbreviated as follows: BLK = BLACK, BLU = BLUE, BRN = BROWN, GRN = GREEN, GRY = GRAY, ORN = ORANGE, PRP = PURPLE OR VIOLET, RED = RED, WHT = WHITE, YEL = YELLOW. Harnesses are supplied with multi-colored wire or white wire with a label.

D-SUBS

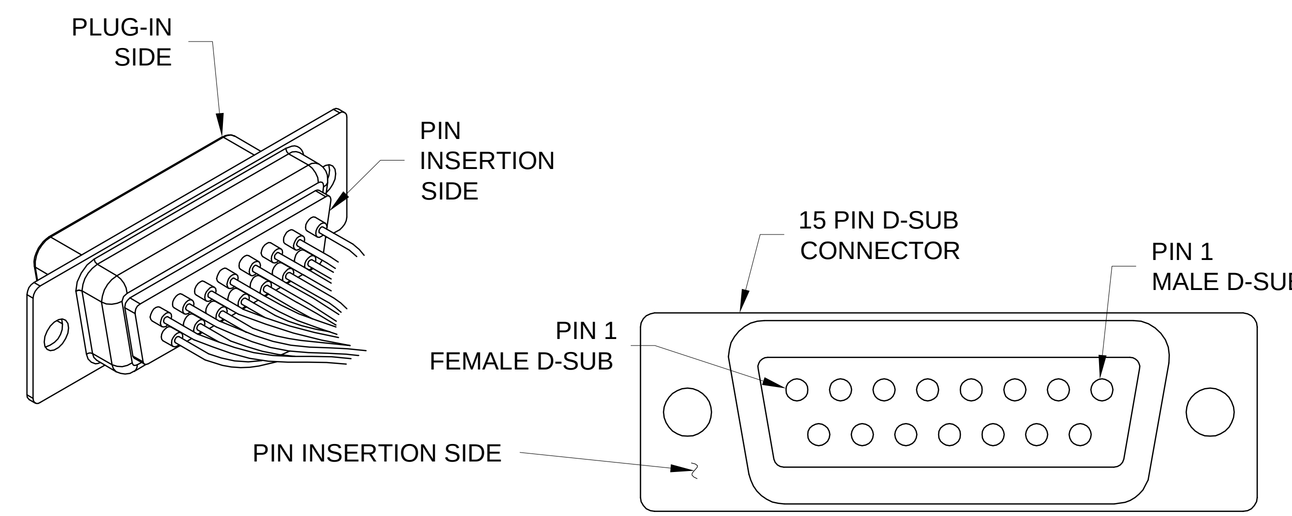


FIGURE 1: INSERTING D-SUB PINS

REPAIRING D-SUB PINS

If the proper crimping tool is unavailable, machined d-sub pins and sockets may be soldered on. If unfamiliar with soldering it may be prudent to practice this procedure on a sample wire before repairing the flight article wire.

Step 1: Strip wire back per the dimension in Figure 2.

Step 2: Tin the end of the stripped wire by heating up the wire as it exits the insulation while holding solder against the tip of the wire. When the solder wicks into the strands of the stripped wire remove the heat and solder. **It is very important to not let the solder wick beyond the end of the exposed wire under the insulation. This will make the wire brittle, fatigue and break where it exits the back of the pin.**

Step 3: Slide the tinned portion of the wire fully into the pin or socket. Use a soldering iron to heat the barrel of the pin or socket while inserting solder wire into the witness hole (This will require a solder wire of a small diameter). Melt solder into the witness hole, then remove the heat and solder. Be careful not to get excess solder on the barrel of the pin or socket

Step 4: Check that the wire is properly soldered to the pin by gently pulling on the pin or socket and the wire.

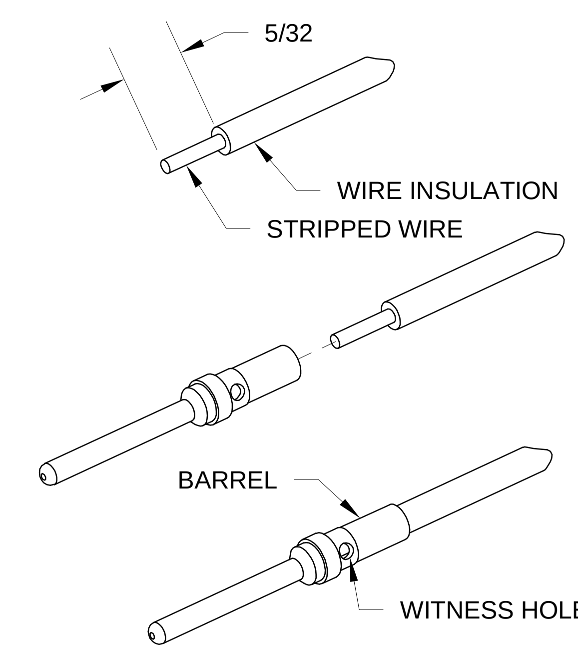


FIGURE 2: SOLDER WIRE TO PIN

5.21 ELECTRICAL (continued)

BACKSHELL ASSEMBLY

There are a number of connections which make use of d-sub assemblies sheathed with a backshell. There are a variety of backshell styles, two of which are discussed here and illustrated in Figure 1. For both styles of backshell, ensure that the wires are properly installed and heat shrink tubing is installed to secure the wire bundle.

The **two piece backshell** contains two metal strain reliefs. These are secured around the wire bundle with two screws. One screw is installed from the top, and one from the bottom as shown in Figure 1. Position the strain reliefs so that they will fit the recess in the backshell halves.

Install the d-sub assembly in the bottom half of the backshell. Loosely attach the top and bottom halves of the backshell with the hardware as shown in Figure 1. Note that one screw is installed from above, and one is installed from below. Pry the backshell halves apart to insert the jack screws through the aft side of the assembled backshell halves. The jack screw shoulder will be captured by the top and bottom backshell halves and extend through the corresponding hole in the d-sub assembly. With the jack screws and saddle washers captured, tighten the top and bottom screws to complete the assembly. See Figure 1.

The **clamshell style backshell** has a plastic strain relief that nests in the bottom half of the clamshell and the wire bundle is secured with a metal strain relief on the top as shown in Figure 1. Jack screws snap into molded receptacles in the bottom half of the clamshell and extend through the holes in the d-sub assembly. To complete assembly the top half of the clamshell is closed and snapped into place with the molded posts and integrated side latch.

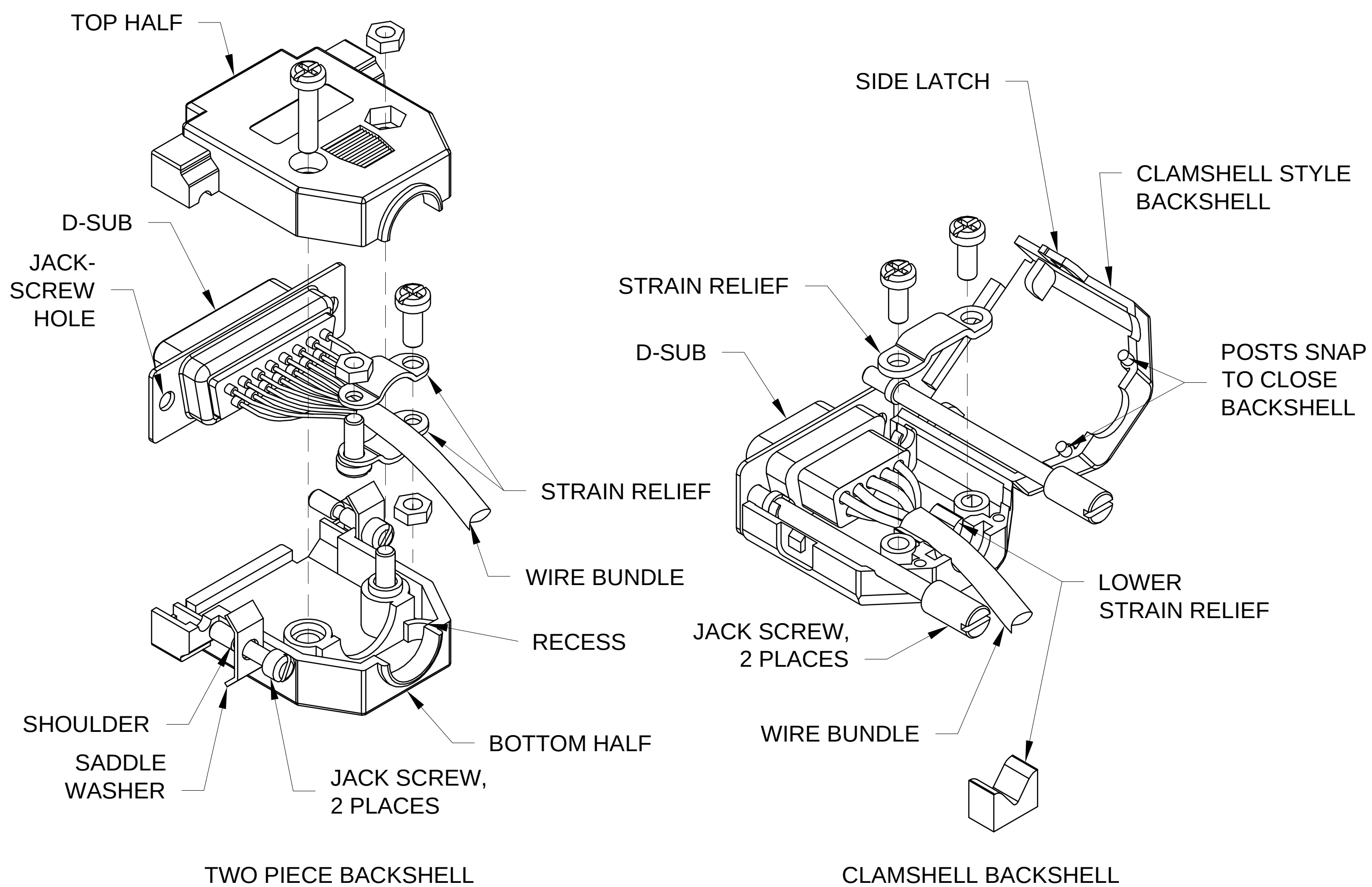


FIGURE 1: BACKSHELL ASSEMBLY

SHIELDED WIRES

Some wires included in the kit are shielded with braided wire surrounding the main conductor wire(s). Unless otherwise stated all shields are connected to ground at the d-sub connector that the wire is coming from. The shield on the device end of the wire should not be connected to ground.

When stripping the inner conductor wire(s) remove and discard the shield as shown in Figure 2. Cover the exposed shield with heat shrink. This will ensure that when the conductor wire is crimped to a connector there will be no possible electrical connection between the connector and the shield or between the shield and the fuselage structure.

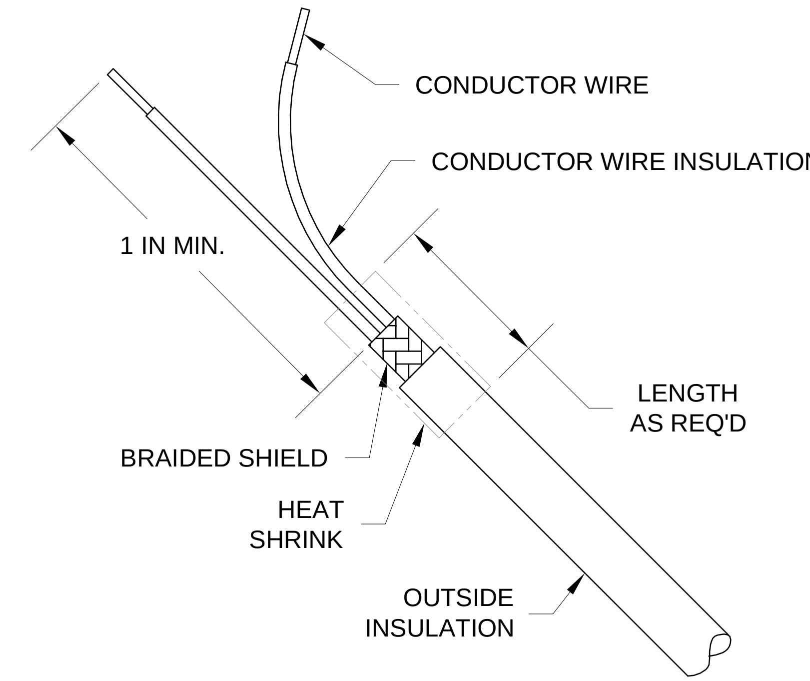


FIGURE 2: STRIPPING SHIELDED WIRES

MOLEX CONNECTORS

NOTE: When installing wire pins into Micro-Fit connectors, the pin will only fully insert and lock in one position. If it fails to insert, rotate 90 degrees and try again. Note the orientation when it properly inserts and position all subsequent pins the same. This also applies to sockets. Lightly pull test each wire after insertion to verify it has hooked into the connector body. If inserted incorrectly Micro-Fit pins and sockets may be removed by using a Micro-Fit Extractor.

When installing Molex sockets into Molex receptacles, the socket will only fully insert and lock in one orientation. To ensure proper orientation, always face the socket seam, which appears along its length, toward the receptacle's retaining lever as shown in Figure 3. This also applies to the pins.

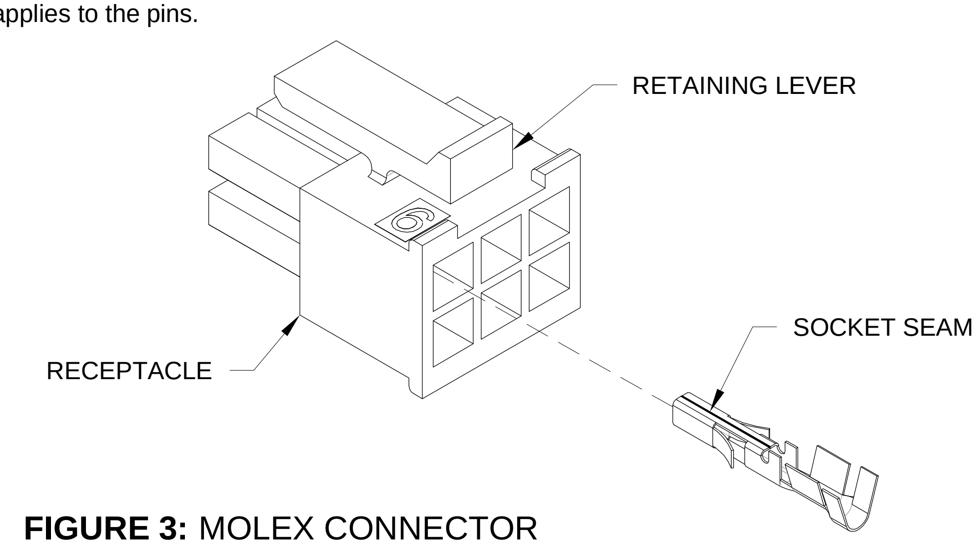


FIGURE 3: MOLEX CONNECTOR

5.21 ELECTRICAL (continued)

ELECTRICAL CONNECTIONS

NOTE: Terminals should be crimped, but not necessarily soldered. If a termination is soldered, the wire should be supported near the solder joint to ensure there is no movement of the wire at the solder joint. The point where the wire goes into the solder joint is subject to breakage if the wire is allowed to move freely (i.e. normal vibrations and flexing).

CLOSED BARREL TERMINALS

Closed Barrel Terminals include Ring Terminals, Spade Terminals, and Butt Splices as shown in Figure 1. While the exposed ends may be of a different configuration, the common feature of a closed barrel terminal is a precision-formed metal wire barrel and a copper sleeve encased in insulating material made of nylon, polyvinyl chloride (PVC) or polyvinyl flouride (PVF²). The insulation is color coded to correspond with a specific wire size or wire size range.

These terminals are crimped in two places: first where the wire is stripped and second where the wire insulation fits inside the terminal. The first crimp retains the wire and provides a good electrical connection between the wire conductors and the terminal. The second crimp supports the end of the insulation thus protecting the wire conductors at the end of the insulation where they would otherwise be likely to break.

The barrel comes in various sizes. The most common will be for wire sizes (AWG) 22-16, 16-14, 12-10, 8 for the alternator and the 2 gauge battery wires. Smaller barrels will accommodate more than one wire size, whereas the larger barrels are designed specifically for one wire size. Sometimes the barrel has insulation, which is the terminal type used in most of our applications. The larger terminals for 2 gauge wires are usually not insulated.

While some barrels are continuous or braised, the industrial quality barrel will be a folded or rolled barrel. When crimping it is important to note where the seam is to ensure that the crimp will not cause the barrel to spread open.

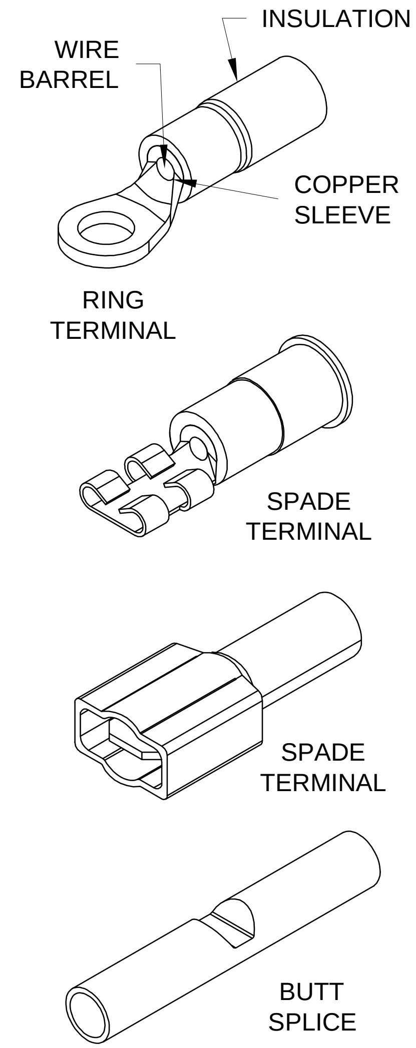


FIGURE 1: TYPES OF CLOSED BARREL TERMINALS

CRIMPING

There are several types of crimping pliers on the market. Most of them will flatten the barrel when the crimp is made (Figure 2 view "B") from its original round shape (view "A"), while others will form a crescent shape when crimped (view "C"). It is important when crimping to not squeeze the crimp so hard that the wire strands are broken or cut by the squeezed barrel, yet hard enough that the compressed barrel will securely hold the wire strands.

Most quality crimp style connectors require two crimping operations. The first crimps the conductor portion of the wire within the connector, and the second crimp clamps the insulation portion of the wire, providing a strain relief. If the wire flexes or vibrates, the movement is not occurring just on the wire strands.

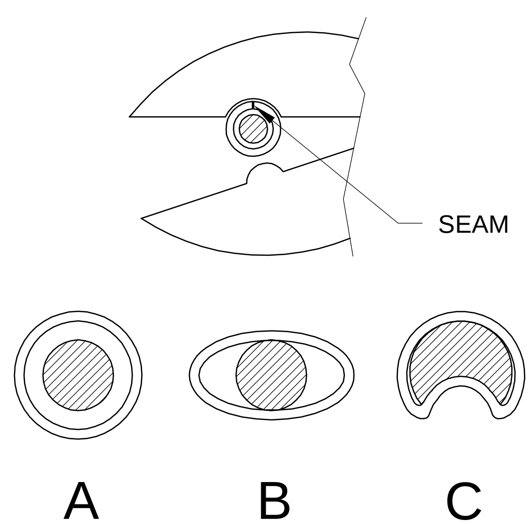


FIGURE 2: CRIMPING

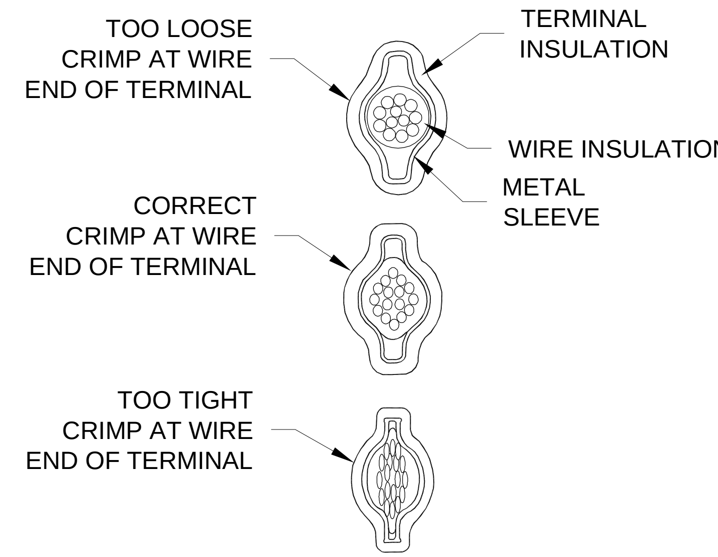


FIGURE 3: CORRECT & INCORRECT EXAMPLES

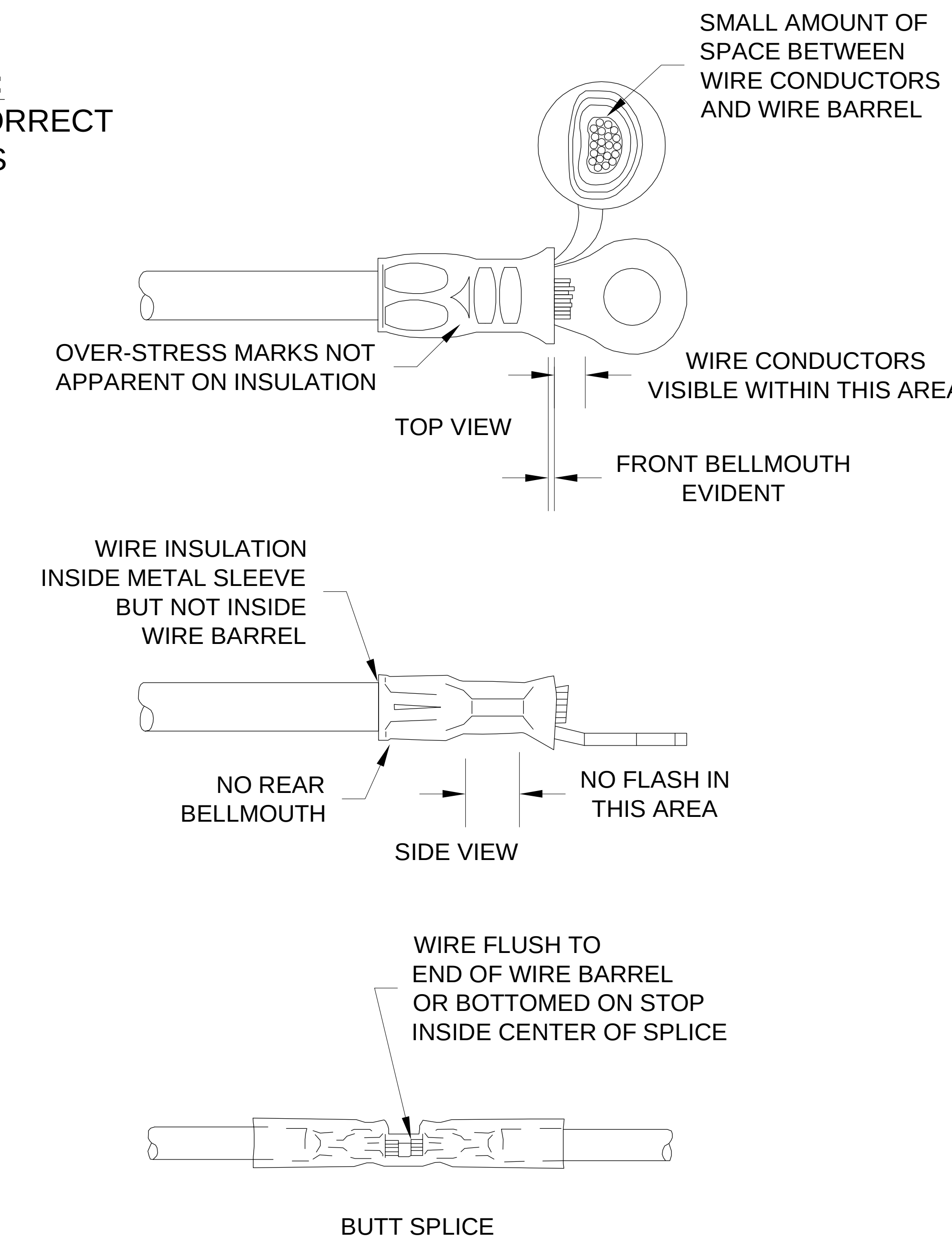


FIGURE 4: CRIMPING OF CLOSED BARREL TERMINALS

5.21 ELECTRICAL (continued)

Strip the wire according to the WIRE STRIP LENGTH found in Table 1, then use the crimp tool.

TERMINAL INSTALLATION TABLE

PART NUMBER	NOMENCLATURE	WIRE STRIP LENGTH	RECOMMENDED CRIMPING TOOL	TOOL USE NOTES
ES-00003	MOLEX PIN .093	.130 -.150	BCT-1	
ES-00004	MOLEX SOCKET .093	.130 -.150	BCT-1	
ES-00005	MOLEX PIN .093	.130 -.150	BCT-1	
ES-00006	MOLEX SOCKET .093	.130 -.150	BCT-1	
ES-00014	MOLEX PIN .093	.156 -.218	BCT-1	
ES-00015	MOLEX SOCKET .093	.156 -.218	BCT-1	
ES-00046	MOLEX MICRO-FIT SOCKET	.100 -.115	BCT-1	FOR 26 AWG WIRE DOUBLE STRIP LENGTH & FOLD OVER
ES-00047	MOLEX MICRO-FIT PIN	.100 -.115	BCT-1	FOR 26 AWG WIRE DOUBLE STRIP LENGTH & FOLD OVER
ES-00079	FLOATING CONNECTOR PIN	.150	BCT-1	
ES-00080	FLOATING CONNECTOR PIN	.150	BCT-1	
ES-31890	RING TERMINAL, #8	.203 -.234	TH-450	
ES-31906	RING TERMINAL, 1/4	.203 -.234	TH-450	
ES-320559	BUTT SPLICE	.250 -.281	TH-450	
ES-320562	BUTT SPLICE	.250 -.281	TH-450	
ES-320565	RING TERMINAL, #8	.203 -.234	TH-450	
ES-320571	RING TERMINAL, 1/4	.203 -.234	TH-450	
ES-320619	RING TERMINAL, #6	.203 -.234	TH-450	
ES-321045	RING TERMINAL, 1/4	.203 -.234	TH-450	
ES-323990	RING TERMINAL, #10	.188 -.219	TH-450	
ES-324043	RING TERMINAL, #10	.313 -.344	TH-450	
ES-324044	RING TERMINAL, 5/16	.313 -.344	TH-450	
ES-324082	RING TERMINAL, 1/4	.313 -.344	TH-450	
ES-36152	RING TERMINAL, #6	.203 -.234	TH-450	
ES-36154	RING TERMINAL, #10	.203 -.234	TH-450	
ES-421-0107	SPADE TERMINAL	.203 -.234	TH-450	
ES-421-0108	SPADE TERMINAL	.203 -.234	TH-450	
ES-640903-2	SPADE TERMINAL	.203 -.234	TH-450	
ES DV18-188-M	SPADE TERMINAL	.203 -.234	TH-450	

TABLE 1: WIRE TERMINAL INSTALLATION INFORMATION

5.21 ELECTRICAL (continued)

OPEN BARREL TERMINALS

The following text has been reproduced from "The AeroElectric Connection "http://aeroelectric.com/articles/matenlok/matenlok.html
Special thanks to Bob Nuckolls for allowing us to reproduce this information.

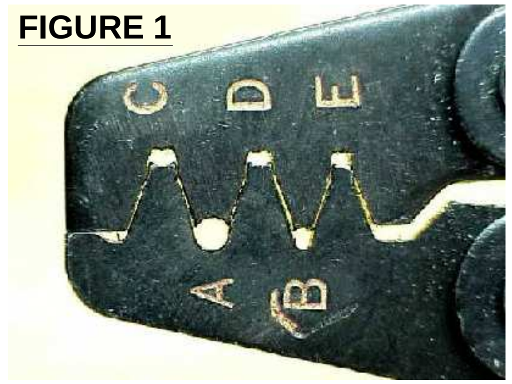


FIGURE 1

OBC-1 CRIMP TOOL FOR OPEN BARREL TERMINALS

Figure 1 is a closeup of the business end of our Open Barrel Terminal Crimp Tool. Note that pockets "C", "D" and "E" have "butt-cheeks" formed into the upper surface. These pockets cause the end of wire grip wings to curl over and dive into the approximate center of the wire strands. Pockets "A" and "B" have a smooth, circular shape used to shape the terminal's insulation-grips into a "bear hug."

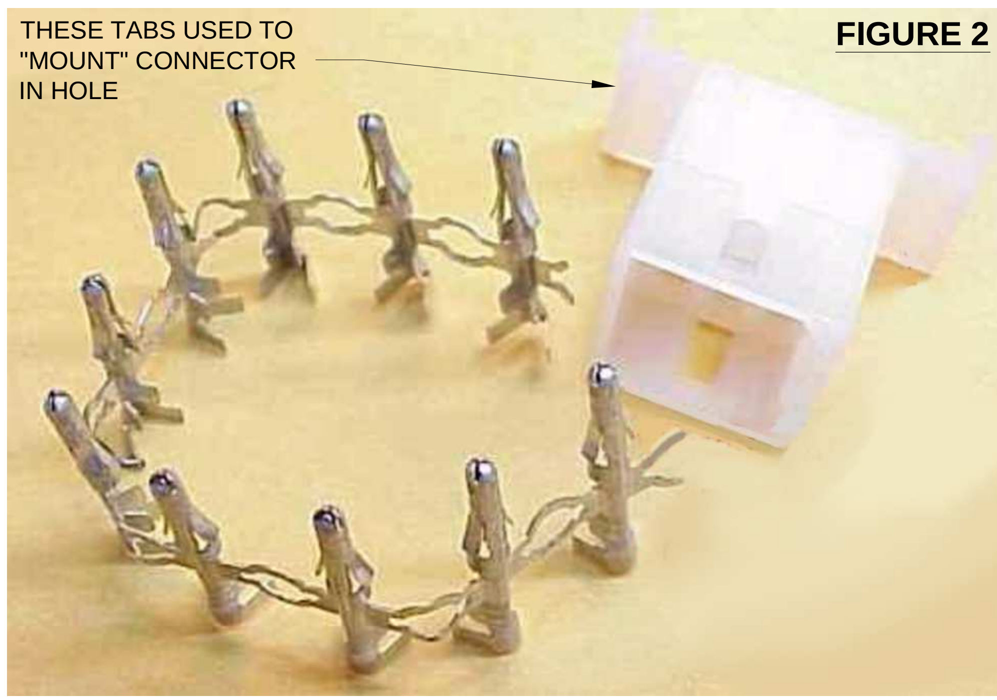


FIGURE 2

Figure 2 shows a typical nylon connector housing and a strip of open barrel pins. This particular connector is a Waldom/Molex product purchased in a blister-pak from Radio Shack. The techniques described here are typical for all connectors of this genre.

If you wish to mount the connector in a hole, the tabs visible at the rear of the connector housing can be folded flat against the side of the connector. Barbs molded into the wings will slip through the appropriate sized rectangular hole and hold the housing captive in the hole. Check the original manufacturer's data for recommended hole dimensions.

Pins supplied in strips are intended for application by automatic machine. The pins come in reels of perhaps 10,000 and feed into the side of an application machine like a belt of cartridges into a machine gun. For our use, we need to cut individual pins apart similar to what you see here in Figure 3. Note that part of the material that joins adjacent pins is left in place. It's too long in this view and will be snipped off again later.

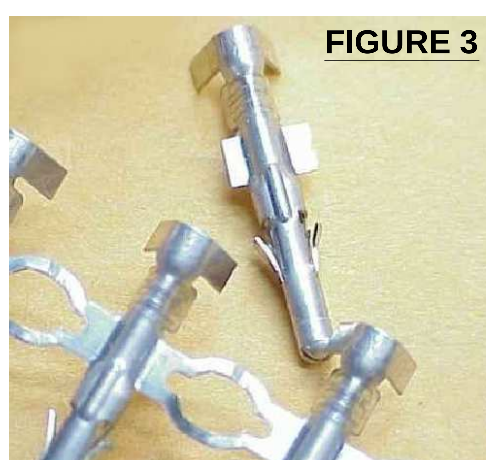


FIGURE 3

Strip the wire about 3/32". Note that I've shortened the insulation grip wings on this pin. These connectors are designed for automotive applications where wiring insulation is MUCH larger in diameter than for the same AWG size in aircraft wire. Left full length as supplied, it's difficult if not impossible to get a proper "bear hug" on the wire's insulation. See Figure 4.

Note shortened wire grip "wings". I've also shortened the stop tabs but they will prove to be too long.


FIGURE 4

If left in as-supplied shape, the wire-grip and insulation-grip wings tend to rotate the pin in the tool's dies as they close. This can result in a poorly shaped crimp or even broken wings. Use a pair of pliers to bend the wings into a "U" shape with sides parallel or even tilted inward toward each other slightly. See Figure 5.

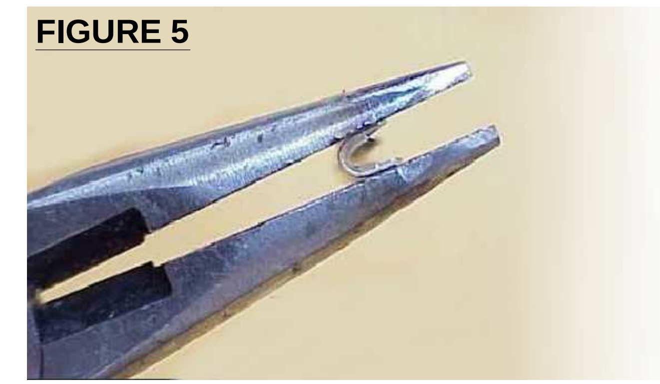


FIGURE 5

Now comes the fun part. Grip the pin loosely in pocket "D" with the ends of the wire grip wings pointing toward the pocket's "butt cheeks". Insert the stripped end of the wire so that exposed strands are inside the crimp area. Close the tool while being watchful of dreaded "pin-spin". If things go as they should, ends of wire grip wings will do a 180 degree turn and dive back into the center of the strands from both sides. You'll want to squeeze the tool with as much force as you can with one hand. When you've got a nice LOOKING crimp, put a 5-8 pound pull on the wire to make sure it doesn't pull out easily from under the wire grip. If it does, you need to squeeze harder next time.

Use tool pocket "A" to form the insulation-grip wings down onto the wire's insulation. You'll have to rotate the pin in the tool so that the ends of the wings are pushed into the circular bottom of the pocket. As the ends of insulation-grip wings collide in the bottom of the pocket - don't compress the tool any further. Take the pin out and use the end pincers of the tool to deflect the end of one insulation grip down against the insulation. Return the pin to pocket "A" and rotate the pin in the pocket as you form the insulation-grip wings down smoothly around the wire. The goal here is very different from the electrical connection. The conductor strands need to be held very tightly while the insulation gets a only snug "bear-hug" as shown here. If you look at similar pins installed on PVC insulated automotive wire, the fabricator may have turned the insulation-grip wings into the insulation not unlike the wire-grip. I DO NOT RECOMMEND this on the aircraft wire - the insulation is too thin. For airplanes we want a simple, snug support of the wire behind the wire-grip without penetrating the insulation.

Note also in Figure 6 how short the stop tabs are. Trim with caution as you learn how to deal with each style and size of pin. Cut the tabs off too short and the pin will not be properly retained when installed. If the tabs are too long, the pin will simply resist insertion into the back of the connector housing.


FIGURE 6

5.21 ELECTRICAL (continued)

OPEN BARREL TERMINALS (continued)

Now you can install the pin into the connector's housing. In Figure 1 you can see the barbs that snap out to keep the pin from being pulled backwards through the hole. The stop tabs will bottom out in the hole from behind to keep the pin from coming on through.

The technique I've just described is typical of the AMP Mate-n-Lock and the larger (.093" pins) sized Waldom/Molex connectors. The smaller Waldom/Molex connectors (.063") pins use pockets "E" for wire grip and "B" for insulation grip. Wires of up to 14AWG and carrying up to 10 Amps may be routed through this style of connector. The wire I illustrated here is 20AWG. Use pocket "C" to crimp 16 and 14AWG wire. 22AWG wire is somewhat dicey in .093" pins. Waldom/Molex connectors also come in a smaller size having a nominal pin diameter of .063". Use pockets "E" and "B" to install the smaller pins like D-subminiature pins found on many instruments and avionics products.

Some connectors may be supplied with loose pins. In this case, you will not have to trim the stop tabs - they will be the proper length as supplied. You may still have to shorten either wire grip or insulation grip wings to work well with your wire of choice. It's always a good idea to experiment with extra pins on scraps of wire to see what it takes to achieve the smooth and tight crimp/grip shown on Page 05-23, Figure 6. Each manufacturer of these connectors offers an extraction tool that will let you remove a pin without damage for re-use in the same or a different location on the connector. Female pins are installed the same way.

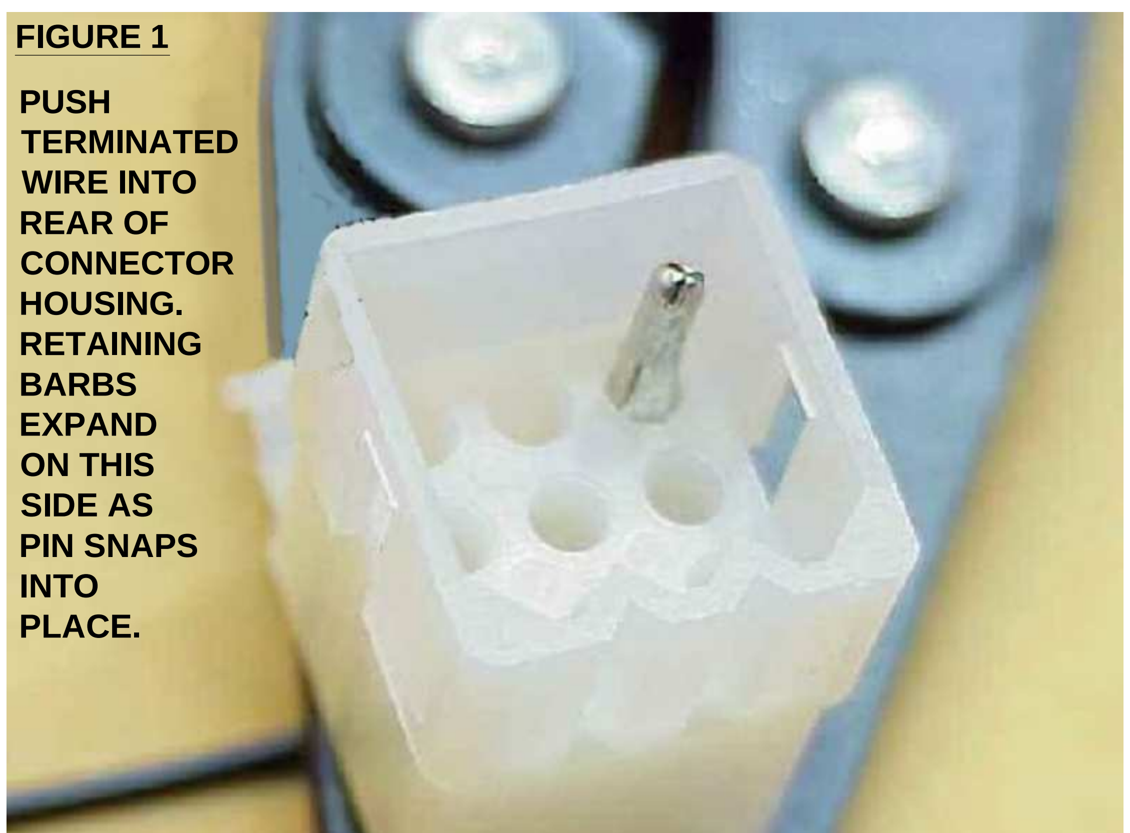


FIGURE 1

5.21 ELECTRICAL (continued)

ELECTRICAL TROUBLESHOOTING

NOTE: Van's Aircraft has tailored each avionics component for the combination of aircraft and avionics by supplying each component with a specific set of default presets. Although not supplied in the kit a list of these presets are available upon request.

WARNING: Never run an electrical system using power from a battery charger only. Always have a battery connected to the system. Always connect the battery charger on the battery side of the master relay so that if the relay is turned off the charger will not be left as the only device providing power to the system. Battery chargers alone may produce voltage levels that will damage components connected to the electrical system!

Control Module

CAUTION: The potentiometers used to control audio levels and trim speed etc. can easily be damaged by excessive force. Use only the supplied adjustment screwdriver tool (TOOL-00000) and use only light pressure to keep it engaged on the screw head.

Besides the control of the pitch trim, audio mixer, dimmer (flap, landing light pulse and roll trim as well for non-RV-12 installations) the control module makes connections between different avionics systems, sensors and electrical devices in the aircraft. For these circuits the control module is nothing more than a connecting wire between an input and output pin taking the place of many complex wiring harnesses. When troubleshooting a problem in the electrical system it is tempting to assume that the problem lies inside the control module or "unknown black box". Although it is possible that the control module could have a defect there is a very low probability since each unit is tested before shipment. Instead, in most instances the control module should be treated like a wire. Problems occurring with wiring rarely occur in the wire itself but more often at the connections between the wires or within the devices being connected. Some connections on the control module besides the circuits stated above do contain discrete components such as diodes and resistors. Such components are shown on the overall electrical schematic available from the downloads page of the Vans Aircraft web site.

Continuity Test

CAUTION: Checking the wrong pins is a common error made by even the professionals. Triple check you are checking for continuity on the correct pins.

One of the most useful troubleshooting steps is the continuity test. Many multi-meters today have a setting for performing a continuity test. Touch the leads coming from the tester to each end of a wire and if there is an electrical connection then the multimeter will generate a tone indicating a good electrical connection. If your multimeter did not include this setting use the resistance setting. If the resistance is a very large number in the Mega Ohm range then there is not continuity. If the resistance is zero or nearly zero then continuity exists.

If for example an EFIS is not receiving data from another device. Test for a connection between the end of the wire that connects to the EFIS and the end of the wire that connects to the device. This will by default also test the connection through the control module as well. If there is continuity the wiring is not the problem (hopefully you have already double checked for a proper setup within the menus of the EFIS and the device). If there is not continuity , then each portion of the wiring harness for that circuit path will need to be checked separately for continuity to find the problem (the control module itself, the harness from the control module to the device, the harness from the control module to the EFIS).

Audio

Basic Checks:

Always check that your headset is plugged in properly. Try a different headset or even a different headset type. Try one headset at a time or the same headset in different positions. Check that ANR headsets have fresh batteries.

Van's Aircraft audio systems are stereo not mono. *Double check that all headsets are set to stereo mode.* Setting some headsets to mono will short the left and right channels together resulting in no audio.

Check that the radio and transponder (if applicable) are properly (fully) inserted into their trays.

FIGURE 1: TYPICAL HEADSET SETTINGS

5.21 ELECTRICAL (continued)

Problem Isolation: There are several quick easy steps to isolate an audio noise problem. Try turning the intercom volume knob. If the problem is controlled by the intercom volume the problem is the intercom itself, wiring from the intercom to the headset jacks, the headset jacks or the headset. As stated above try different headsets in different jacks. Try turning off each device individually (EFIS, COM, transponder, ADS-B, GPS, unplug an aux music device such as an iPhone and any connecting cable, a car charger plugged into the 12V power outlet, etc…) to help isolate the source of the problem. Some circuits may only be controlled by removing a fuse. Remember to shut the master off before removing a fuse. When calling for tech help first isolate the problem, this will save time.

Problem: The Audio levels are much different using the same headset in the pilot and co-pilot positions.
Solution: If one side is different than the other the problem may be in the headset jacks. Inspect the wiring below the headset jack that is not receiving/transmitting properly to be sure that no wires are shorted out. Move the wires to check for a loose connection. If you can hear or transmit but very faintly then the problem could be a loose connection.

Problem: I can't hear myself when transmitting but can hear COM transmissions
Solution: Check the COM side tone setting. For more information see the manual supplied with your COM radio. Remember to check both sides of the aircraft for this condition. The COM side tone applies to both sides of the aircraft equally so using the same headset on both pilot and co-pilot headset positions should yield the same conditions.

Problem: Received COM transmissions are fine but my transmitted voice sounds distorted or there is a high level of background noise.
Solution: The setting of the COM side tone may be set to automatically adjust with the volume level. In some cases this works well but in most instances the side tone may need to be adjusted manually especially when using modern headsets that are more sensitive.

Problem: Only when the COM is turned on there are random loud bursts of noise.
Solution: The default setting of the COM squelch should be adjusted. See troubleshooting section on a random noise through the headset. If you hear Strobe noise only with the COM on read the problem/solution for strobe noise below.

Problem: Only a small portion of the control module volume adjustment potentiometer range is usable.
Solution: Check that all headsets are in stereo mode. If the left and right channels are shorted together with a mono headset it will be impossible to change the left or right volume level for any stereo item such as aux music or EFIS warnings.

The audio mixer was designed to give the most usable range of the volume setting potentiometers for the most common input impedances. If the impedance of the device you are trying to connect is significantly different than the most common impedances the circuit was designed around you may experience a loss of useful range of the volume adjustment potentiometer.

In most cases you may only find that 6 of the available 24 turns in a pot are usable. We still find this situation more pleasant than trying to use a small range of a single turn potentiometer. The usable range will always start at the full clockwise end of the potentiometer range.

A short note on the concept of an audio mixer: The mixer potentiometer is acting as a voltage divider, dividing the signal and sending part of that signal to ground and the rest to the audio amplifier. As you turn the potentiometer clockwise the resistance to ground becomes less and more of the signal is sent to ground thus reducing the volume of that signal. In short you are reducing the volume of each signal with the potentiometer to a desired level. The signals small in volume are then added together (for example Aux1 Left, Aux2 Left and EFIS Left) and amplified to a useable volume. The amplified signal is sent out of the control module on a single wire to the intercom or audio panel.

The volume range may also be dependent on the type of intercom in use. In recent years there has been an increased use of music players designed to drive small ear bud headphones. This results in low volume output from older intercom designs. To compensate, some intercom manufactures have increased the gain level (oversimplified they have turned up the internal output volume knob within the intercom as high as possible). As the mixer output is increased the high level of gain in the intercom causes the signal to become distorted (the top of the signal is being chopped off because the intercom cannot handle that high of input).

Problem: Constant background hiss noise when the aircraft engine is turned off.
Solution: It is normal to hear a faint ocean sounding noise with the engine turned off with the electrical system powered on. When the engine is running this noise will disappear. The noise will disappear not only because of the sound of the engine which is much greater in magnitude but also because the voltage regulators (especially 12V regulators) in the system will have a greater differential to regulate from when the engine driven alternator or generator brings the bus voltage up to 14V. The greater the difference between the bus voltage and the regulated voltage the better the voltage regulator will be able to maintain a steady voltage for a device such as an intercom. A fluctuating voltage can introduce noise into the system. Note for this reason adding a battery charger may introduce noise into the system.

Problem: Rhythmic jjgt jjgt noise or banjo noise in the background.
Solution: This noise can be caused if a battery charger has been placed on the battery. Temporarily remove the charger and see if the noise goes away.

The noise may also be caused by serial data transmission along a wire. Try turning off devices that transmit and receive serial data one at a time (for example autopilot, transponder, com radio, ADS-B, GPS, etc...) Although Van's Aircraft has done their best through the use of twisted wires, shielded wires and the use of ground planes this still can be a problem. Try removing tie-wraps from your harnesses and moving wires relative to each other and see if the sound changes. Using an alternate routing path for a noisy wire or shielding wires may be a solution. RS-232 data lines, especially GPS signals, using 9600 baud (9.6 kHz frequency) are particularly susceptible to this; the range of human hearing goes up to 20kHz. If possible use a higher baud rate for the offending RS-232 data line.

If the problem noise is not related to the solution above try the troubleshooting steps listed for a random static noise.

5.21 ELECTRICAL (continued)

Problem: A random static noise comes through the headset.
Solution: Adjust the volume and squelch on the intercom and determine if this will make the noise disappear. If the noise can be controlled with the intercom volume and squelch it means that most likely the noise is being generated by the headset microphone, mic jack, mic hi or mic lo wires. Unplug the headset. If the noise goes away try a different headset. If the noise still persists remove each mic pin from the wiring harness one location at a time and see if the noise goes away (checking the wires connected to the headset jack, wires connecting the headset jacks to the control module and the wires connecting the control module to the intercom). Check that d-sub pins and solder joints all make a proper connection and do not generate the noise when the wires are wiggled.

If the noise is not affected by the volume and squelch turn off your radio. If the noise goes away the sound is being generated by your COM. One of the most common issues is the COM receive squelch being broken. A COM radio has an internal squelch setting to control what level of input from the COM antenna will open the COM squelch, similar to how the squelch level is set for the mic on a headset using the squelch knob on an intercom. If set too low, bursts of noise picked up by the antenna may break the squelch. Consult the user manual supplied with your COM radio and turn the receive squelch up slowly until the noise disappears. Note setting the receive squelch too high will prevent your radio from receiving faint transmissions and therefore great care should be taken to set the squelch as low as possible while still eliminating any noise. Conduct this test outside and away from the source of any electronic signals that may be picked up on the antenna.

If the noise is not affected by the squelch or the radio, try the troubleshooting steps listed for a rhythmic noise.

If the problem still persists disconnect the mono and stereo inputs from the back of the intercom one at a time and determine if the noise goes away. This may help isolate where the noise is coming from.

Turn the audio level pots up or down in the control module. If the sound level of the noise problem changes the problem is between the device generating the audio and the control module. If the sound level does not change the problem is between the control module and the intercom, in the intercom or between the headset and the intercom.

If turning off a device removes the noise from the system check that the unit is properly grounded. First remove any wires that are dedicated to audio ground and run the device off its own primary ground. If this does not change the noise run an extra wire from the case of the device to the structure of the aircraft. If the noise still persists consider using a ground loop isolator (GLI) on the wires coming from the device.

When troubleshooting a stereo music input, first disconnect the ground from the music lo or music ground input. Noise coming into an audio system may be transmitted through ground connections to the audio system and most often the music ground/lo. By removing the music lo connection the music will have no connection to ground and the lo will be become a “floating ground”. Use an aux music device to determine if the music input is still useable. Since the ground is floating possibly higher, the magnitude of the signal will be smaller. A signal with less amplitude will result in less volume.

Problem: My EFIS warning tones are too quiet I can't change the sound levels using the audio mixer on the control module.
Solution: Check that your headsets are turned to *stereo* not *mono* mode. On some headsets this may be a small and hard to find switch see the manual that came with your headset to be absolutely sure you have the headset in *stereo* mode.

Problem: My EFIS is generating a high level of background noise when turned on.
Solution: See the troubleshooting section on a random noise comes through the headset.

Problem: Strobe noise in the headset.
Solution: There are multiple ways the strobe noise will enter the audio system. Try turning the COM radio off and see if the noise goes away. Is the noise only present while the radio squelch is open during receive or transmit? If so the noise is a high frequency RFI noise being picked up on the radio com antenna (some strobes use circuitry in this band, most light manufacturers are now aware of this and have changed their products to remove this issue). Add a choke (magnet that goes around a wire) around the wires coming from each strobe device. Add the choke as close to the device as practical. If all the wires will not go through the choke make sure to at least capture the power and ground wires.

Try also adding a capacitor to the power line. The larger the capacitor the more effective but at some point the inrush current (current filling the capacitor when the circuit is turned on) will blow the fuse on that circuit.

If the above options have not resolved the problem, try shielding the wires for nav/strobe if they have not been shielded already. If the noise is coming in on the mic line (volume of the noise increases when the intercom volume increases with the intercom squelch broken as would be the case if you were talking through the intercom) inspect how your mic line is configured. If the shield for the mic wire is used to provide the mic lo any noise picked up by the shield will be transmitted into the audio system. Older Van's kits were wired this way and in many cases there have been no problems. If this is deemed to be a problem replace the mic wire with a multi-conductor wire that will allow the mic ground to be a separate wire within the shielded bundle.

Dimming (when controlled by Van's control module)

Problem: Interior lights do not come on at all
Solution: Double check that your EFIS is emitting a pulsed dimming signal compatible with LED lighting. Check the EFIS manual or contact your EFIS manufacturer directly. Older EFIS's may output a constant voltage that varies in voltage level with the EFIS dimming level. This constant voltage will never reach ground. The interior lights will only turn on when the control signal goes to ground.

5.21 ELECTRICAL (continued)

EMS

Problem: My EMS display values randomly spike causing warnings.
Solution: If for example the value of an EGT is randomly going high enough to generate a warning on the EFIS, check the quality of all the harness connections. Check if wiggling the spade connector between the thermocouple wires and the wires going back through the firewall recreates the problem. Also move the harness back and forth that goes into any d-sub type connection. If the connection is severed some EFIS systems we default to an error value that is very high, which will in turn generate a warning. If you have a bad connection that intermittently becomes disconnected you will then be generating intermittent warnings.

Some values that spike can be fixed by changing the sampling rate of a signal or by changing how the data collected is averaged and over what amount of time the average takes place. Consult the instructions provided with your EFIS system or the EFIS manufacture.

Problem: My EMS values randomly spike during transmit.
Solution: RFI leakage from the com antenna may affect the EGT or MP wires. This is a common issue with the Van's gauges and has not been a major problem.

If using a Dynon Avionics SkyView system, and the CHT and EGT readings spike during COM transmit: This is a known issue with older SkyView SV-EMS-220 modules, which Dynon can fix. Contact Dynon Technical Support. Mention that you have a SkyView system and CHT/EGT is spiking during COM transmissions.

GPS

Problem: My EFIS is not detecting a GPS signal.
Solution: Check that the output format of the GPS signal is set correctly. You may have no control of the output format of a GPS puck but for a device like a Garmin handheld GPS etc. there will be a menu driven option allowing different formats.

Check that the wire carrying GPS data to the ELT has not been accidentally grounded by

a) crimping the shield to main wire conductor (Refer to Section 5 in your builder manual for the proper termination of shielded wires)

b) no connection to the ELT thus the wire is dangling and grounding out on aircraft structure. Cover the end of the conductor in heat shrink.

Trim

Problem: Trim motor does not move, or low voltage present at trim motor
Solution: The trim speed is controlled by a pulsed voltage (ie the power is turned on and off quickly - the longer it is off the slower the motor moves). Adjust the trim potentiometer CCW to increase the speed. Most voltmeters will average the pulsed voltage as something less than buss voltage (for example a pulsed voltage with a peak voltage of 12V off 50% of the time would be seen as 6V on a typical voltmeter).

Glossary of Electrical Terms

These definitions are not meant to be “scientifically” correct but rather a definition understandable to someone not technically familiar with electrical systems.

EMI and EMR (RFI): Electro Magnetic Interference. A magnetic field if oriented correctly near a wire will move electrons within the wire inducing a current and causing electrical “noise”. This is referred to as “near field” since the effect falls off rapidly. This is why moving wires relative to or away from a source may solve an EMI problem. A common source would be a wire carrying a fluctuating high current.

Electro Radiation Interference (or Radio Frequency Interference when in the radio frequency spectrum) is energy absorbed or emitted from a charged particle and will continue to travel through space away from the source. This is referred to as “far field” and in such cases a solution should if possible be applied to the source of the radiation. A common source would be a COM and the transmit wire / antenna.

With any electromagnetic radiation interference small signals such as audio are more likely to be affected.

Gain: Amplification of a signal (for the sake of this manual audio signal)

Impedance: The equivalent resistance of an electrical device.

Quiescent Current Consumption: Power consumed by a device in the idle state.

Side tone: Sound from a headset microphone fed back into the earpiece of that same headset or the level at which you hear your own voice in the head set when transmitting. For more information consult your COM radio installation and user manual.

Squelch: A level setting used to cancel background noise so that only signals above the set level will be heard. The term “breaking the squelch” means that an incoming signal has a level high enough to be above this level and will be heard.

5.22 COMPRESSION FITTINGS IN PLASTIC TUBING

Install compression fittings to plastic tubing using the following steps:

Step 1: Drill #29 the inside of the tube.

Step 2: Blow out the tube using compressed air from the end opposite the one which was drilled.

Step 3: Slide the nut and sleeve over the plastic tube, then locate the sleeve about 1/8 inch from the end. See Figure 1.

Step 4: Press the brass insert into the end of the plastic tube as far as possible by pushing it against some solid object. Place the end of the assembly in boiling water for one minute, then immediately press the insert in the rest of the way until it bottoms against the end of the plastic tube.

Step 5: Tighten the nut finger tight, then one full turn thereafter.

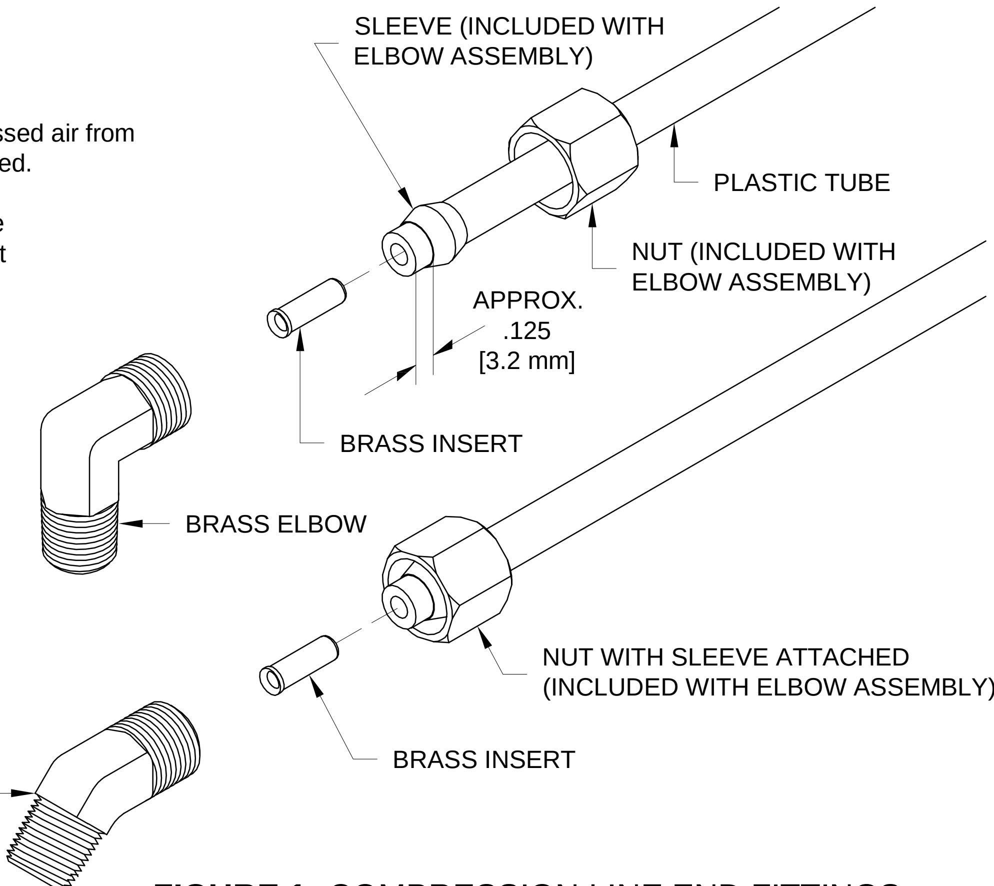


FIGURE 1: COMPRESSION LINE END FITTINGS

5.23 NYLON FLUID FITTINGS IN PLASTIC TUBING

Install nylon fittings to PT-062X1/4 Plastic Tube using the following steps:

Step 1: Cut tube squarely and remove any burrs.

Step 2: Place insertion mark .625 [15.9 mm] from end of tube. See Figure 2. Moisten marked end of tube with water.

NOTE: Nut, keeper, collar and O-ring are in place on the fitting at this point.

Step 3: Install plastic tube into nylon nut by pushing end of moistened tube straight into the nut until the tube bottoms on the tee's shoulder.

Step 4: Finger tighten nylon nuts. Additional tightening should not be necessary, but 1/4 additional turn may be added if desired. DO NOT OVER TIGHTEN nut or threads will strip and fitting will not function properly. A proper assembly will not show insertion mark extending beyond the nut. If insertion mark is visible, then repeat steps 3 and 4.

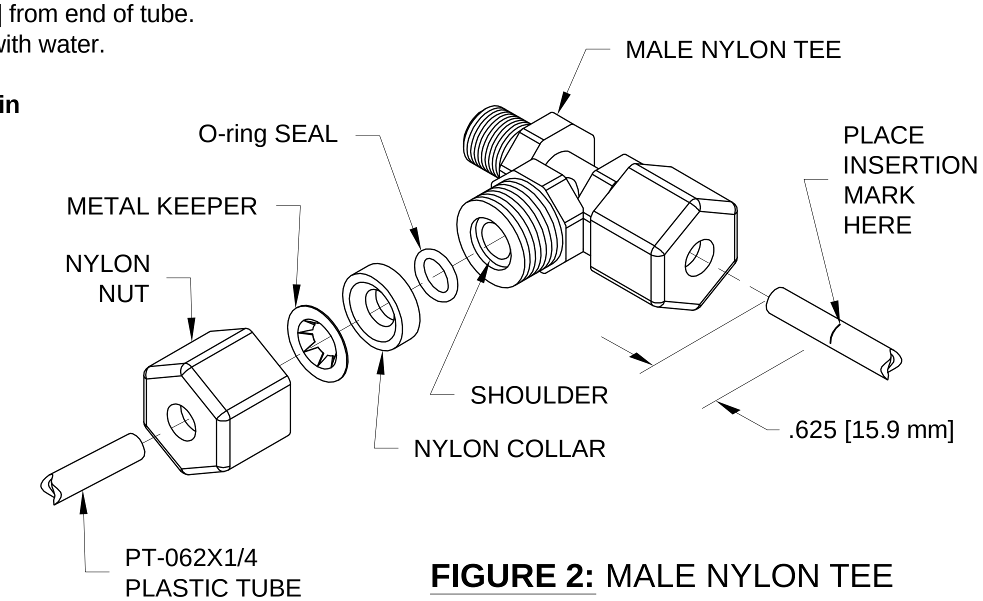


FIGURE 2: MALE NYLON TEE
EXPLODED VIEW

5.24 DRILLING, TAPS AND DIES

Material alloy and hardness, as well as the makeup of the cutting tool determine the speed at which metal is best drilled. For the purpose of this discussion, we assume that the drill used is High Speed Steel (HSS). Cutting speed is stated in surface feet per minute or abbreviated as FPM and is a measure of the peripheral speed of the drill. Softer materials can be cut at a higher speed than harder materials. Smaller drills have to turn faster than larger drills to achieve the same FPM cutting speed.

For the most part, the materials we are concerned with in RV construction are aluminum and steel. The aluminum is of various alloys, but we can use 200 FPM as a cutting speed for all of them. The steel is 4130 chrome molybdenum alloy. We can use a cutting speed of 60 FPM for 4130.

Drilling most of the aluminum in RV construction can be done dry, without any oils or cutting fluid. When drilling holes more than three diameters deep, a few drops of kerosene or Boelube helps. For holes larger than 1/4" in thin material a "Unibit" makes a cleaner hole.

Steel is best drilled with at least some oil. Practically any oil, WD-40 etc. can be used. There is no need to get sloppy. Use just enough oil to lubricate and carry off some heat. Drilling steel requires considerably more feed pressure, or thrust, than aluminum.

The chart below is general in nature. Interpolate speeds for sizes not listed. Notice the drill speeds for aluminum are higher than any of our hand held drills are likely to go. This is why air drills are superior to electric drills when drilling aluminum. It is also assumed that the drills are sharp and the setup is rigid, as in a drill press.

Drill RPM

Drill Size	*#40 0.098*	*#30 0.128*	*#12 0.189*	*0.250*	*0.375*	*0.500*
Material Aluminum (200 FPM)	*7796*	*5946*	*4198*	*3056*	*1748*	*1528*
Steel (60 FPM)	*2339*	*1784*	*1213*	*917*	*611*	*459*

When drilling with a hand drill it is advisable to start the drill turning slowly, then increase the RPM after the drill is centered and stabilized in the hole. Drill a straight hole by aligning the drill with its reflection in the shiny aluminum surface. The small drills that we use in RV building are of the split point style and need special equipment to sharpen. As many as a dozen each of #30 and #40 will be needed to complete the project. Do not skimp on drill bits; when they get dull replace them.

See Section 5.19 for tips on drilling Plexiglass.

DRILLING TERMINOLOGY

Fundamentally, and unless otherwise noted, "drilling" shall be understood as comprising the following basic sequence of procedures; having material(s) in hand, acquiring hole size and position from the drawing, transferring hole location to the part through measurement or other means, marking the hole location, center-punching hole location, drilling through the material or materials.

Match-drill refers to drilling a stack of two or more parts in which a hole is already located in the first part. Drilling through the existing hole in the first part results in a matching hole(s) in the other part(s) in the stack.

Final-drill refers to drilling one or more parts that already have a hole in the location to be drilled. A final pass is made through the existing hole with the specified size drill bit.

Deburr all drilled holes before dimpling or riveting.

5.24 DRILLING, TAPS AND DIES (continued)

SOME NOTES ON TAPS

A "tap" is a tool used for cutting internal threads into an existing hole. Taps come in several styles. The most common hardware store variety is a four-flute tap. The flute is the groove along the length of the tool. When using a tap on metal, some lubricant should be used. Common motor oil is OK for steel while kerosene works well on aluminum. Plastic needs no lubricant.

Starting the tap straight in the hole is very important. Most broken taps are due to hole misalignment. The best way to get the tap started straight is to use a drill press. Clamp the work in a vise and with the tap in the chuck, turn the chuck by hand.

When tapping a deep hole it is best to back the tap out about one turn to every two turns in. In this way the resulting chips are allowed to clear from the flutes. Do not allow the tap to get stuck by turning too many times without clearing; another cause of broken taps.

An 8-32 tap means that the screw size is #8 and it has 32 threads per inch (pitch). Fractional sizes like ¼-20 mean the screw is 1/4" and has 20 threads per inch.

5.25 DIMENSIONS

Dimensions in newer kits are depicted in English fractional form with a 1/32 inch accuracy where possible. Other dimensions, not lending themselves readily to a 1/32 of an inch conversion, are depicted in decimal form with a three decimal place accuracy. We realize that most tape measures do not have three decimal place accuracy, and so have provided a conversion table to facilitate conversion between fractions and decimals.

Holes as provided in the kit will be called out as decimals, but after drilling, they will be referred to by the drill bit size used to drill them. Example: "Drill #40 the .094 [2.4 mm] holes in the dingus. Dimple the #40 holes."

In many cases, use of the nearest fractional measurement to a decimal place dimension is sufficient, but use your best judgement, especially in areas that may require high precision to fit correctly.

All dimensions are also depicted in metric measurements.

FIGURE 1: **FRACTION TO DECIMAL CONVERSION**

1/32	0.032	17/32	0.531
1/16	0.063	9/16	0.563
3/32	0.094	19/32	0.594
1/8	0.125	5/8	0.625
5/32	0.156	21/32	0.656
3/16	0.188	11/16	0.688
7/32	0.219	23/32	0.719
1/4	0.250	3/4	0.750
9/32	0.281	25/32	0.781
5/16	0.313	13/16	0.813
11/32	0.344	27/32	0.844
3/8	0.375	7/8	0.875
13/32	0.406	29/32	0.906
7/16	0.438	15/16	0.938
15/32	0.469	31/32	0.969
1/2	0.500	1 1.000	1.000

5.26 HARDWARE REFERENCE

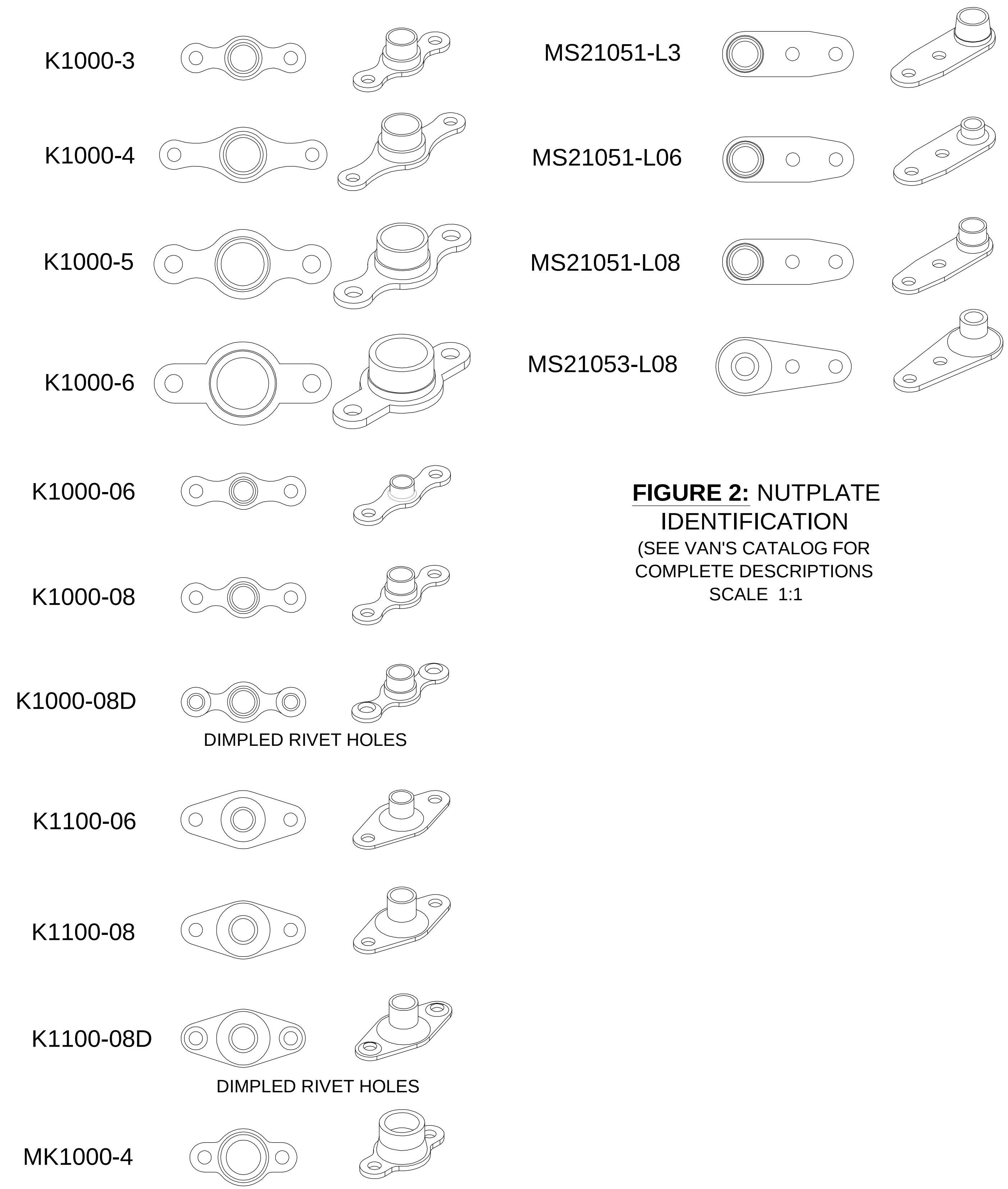


FIGURE 2: NUTPLATE IDENTIFICATION
(SEE VAN'S CATALOG FOR COMPLETE DESCRIPTIONS
SCALE 1:1

5.26 (continued)

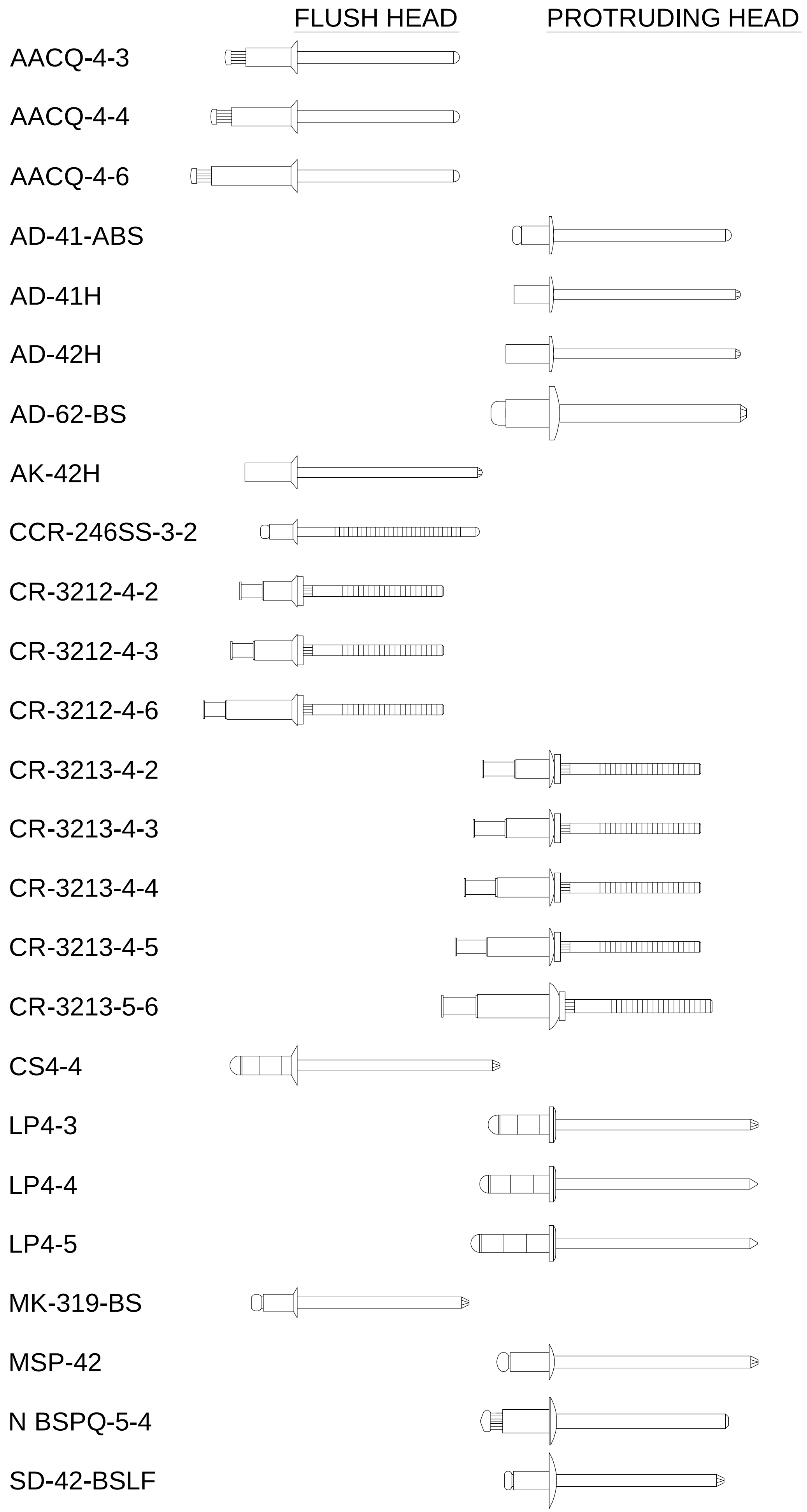


FIGURE 1: BLIND RIVET IDENTIFICATION
(SEE VAN'S CATALOG FOR COMPLETE DESCRIPTIONS)
SCALE 1:1

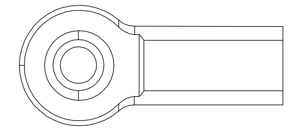
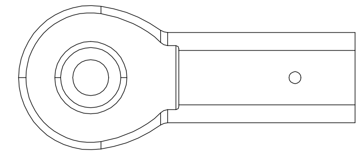
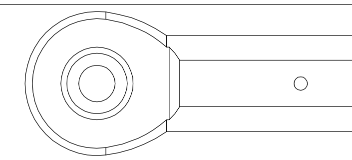
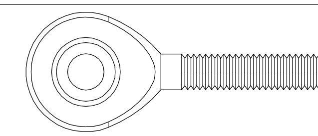
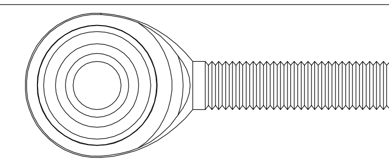
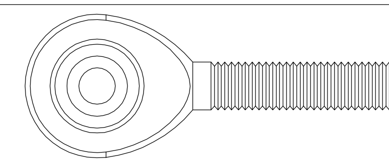
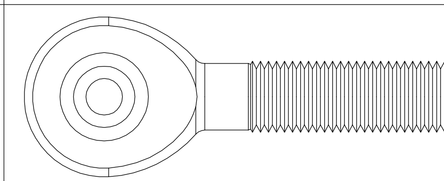
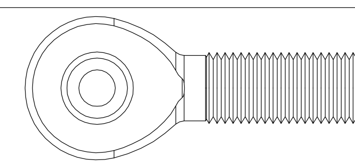
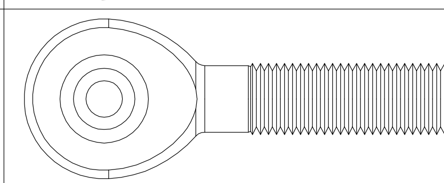
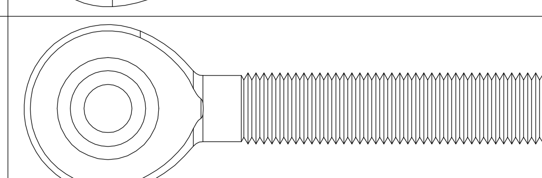
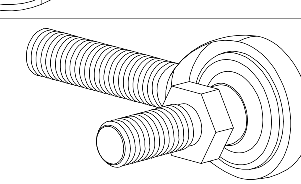
FIGURE 2: NAS1149 AND AN960 WASHER SUBSTITUTION

NAS1149 washers may be used anywhere a AN960 washer is called for. However, ***DO NOT*** use a AN960 washer where a NAS1149 washer is specified. Manufacturing tolerances for the NAS1149 washers are tighter than are those for the AN960 washers.

AN Part No.	NAS Part No.
AN960-4L	NAS1149FN416P
AN960-4	NAS1149FN432P
AN960-6	NAS1149FN632P
AN960-8	NAS1149FN832P
AN960-10L	NAS1149F0332P
AN960-10	NAS1149F0363P
AN960-416L	NAS1149F0432P
AN960-416	NAS1149F0463P
AN960-516L	NAS1149F0532P
AN960-516	NAS1149F0563P
AN960-616L	NAS1149F0632P
AN960-616	NAS1149F0663P
AN960-716	NAS1149F0763P
AN960-816L	NAS1149F0832P
AN960-816	NAS1149F0863P
AN960-916	NAS1149F0963P
AN960-1016	NAS1149F1063P
AN960-1216	NAS1149F1290P
AN960-2016	NAS1149F2090P

5.26 (continued)

FIGURE 1: ROD-END BEARING REFERENCE CHART

PART NO.	STUD	BEARING HOLE	LENGTH	THICKNESS	
MW-3M	3/16" FEMALE	3/16	1 3/8	0.31	
F3414M	1/4" FEMALE	3/16	1 3/4	7/16	
F3514M	5/16" FEMALE	3/16	1 3/4	7/16	
MM-3	1/8" MALE	3/16	1 1/4	5/16	
CM-4M	1/4" MALE	1/4	1.94	3/8	
M3414M	1/4" MALE	3/16	1.94	7/16	
MD3616M	3/8" MALE	3/16	2 1/4	1/2	
MD3614M	3/8" MALE	3/16	1 3/4	7/16	
MD3616M	3/8" MALE	3/16	2 1/4	1/2	
GMM-4M-675	3/8" MALE	1/4	2 3/4	1/2	
CM-4S	1/4" MALE	1/4 STUD	1.94		

5.27 FLUID FITTINGS

PIPE THREAD FITTINGS

Many fittings used in RV plumbing systems have tapered pipe threads. Tapered pipe threads have an outside diameter which decreases toward the opening. Therefore, as the fitting is threaded into a normally threaded hole, the clearance between the two diminishes until the fitting becomes tight. To a large degree this interference fit is what provides the high pressure seal. Some fittings have 45 or 90 degree angles which require positioning (clocking) in a specific direction and may prevent them from being turned to the fully seated point (though this should be done on all straight fittings that allow doing so).

NOTE: There are a few locations where the fittings used have straight threads (usually fittings or sensors installed on engines). In these cases, some type of crush gasket or O-ring is used to provide the seal (no paste or liquid sealant is used). One obvious indicator of a straight thread fitting/sensor is that it can easily be fully threaded in until it bottoms out in the hole.

All of the threaded fittings used in RVs are NPT (National Pipe Thread), which is a U.S. standard for tapered threads used on threaded pipe and fittings. There is often confusion regarding the size designations because it pertains to the nominal inside diameter of the fluid passage, not the outside diameter of the fitting.

Two methods are provided for tapered fitting identification. See Page 05-29, Figure 1 for full scale drawings or refer to Table 1 for use in identifying a fitting's designated size. To use the table measure the maximum outside diameter (OD) of the tapered thread, locate this value under the "Actual Size (OD)" column, and read the corresponding NPT fractional value from the "Designated Size" column.

Actual Size (OD)	Designated Size
0.405 in. [10.29 mm]	1/8
0.540 in. [13.72 mm]	1/4
0.675 in. [17.15 mm]	3/8

TABLE 1: NPT SIZES

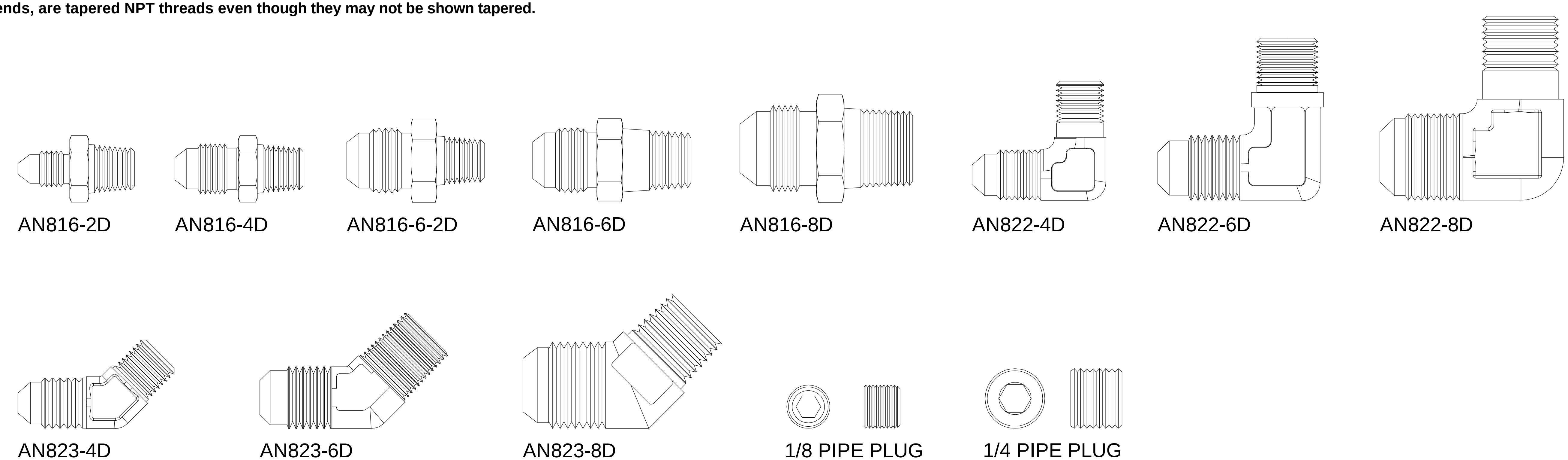
Because we cannot always fully tighten tapered thread fittings, and because even after fully tightening the fitting a small spiral leak path remains along the full length of threads, a thread sealant must be used during assembly. Two sealants popular for use on aircraft are Tite-seal and Permatex #2. Teflon based pipe dopes and sealants, and some of the anaerobic thread sealants are also used by some builders with success. Do not use Fuel Lube. It is not a sealant. It is meant for lubricating moving parts in fuel valves, etc. Teflon tape is also not recommended. Small pieces of this tape may be cut by the threads, become loose, and cause all kinds of problems in aircraft systems. Teflon tape has even been the cause of engine stoppages.

When installing the fitting, be sure the threads on both parts are clean and dry since most sealants will not tolerate any oil contamination. First determine what the clocking position needs to be by installing it finger tight and marking the desired clocking. Remove the fitting and apply a small amount of sealant to 2 - 3 threads but leave the first 2 bare to prevent contamination inside the fluid path. Remember, this is an interference fit so not much sealant is required.

Thread the fitting in with your fingers until you just begin to feel resistance and then an additional 1.5 - 2 turns. This is a general guideline… you must still use judgment to not over tighten and damage the threads, but a properly installed fitting is quite tight. If the installation requires a specific clocking, when approaching the correct position you must determine whether you will be able to make another full rotation and still be within the 1.5 - 2 turns stopping range. You must avoid turning the fitting backwards in the loosening direction because it will have a high probability of leaking. If you must do this, it is best to completely remove the fitting, clean up the threads on both parts, and try again.

5.27 FLUID FITTINGS (continued)

NOTE: Fitting depictions are intended for general identification purposes only. All threads, except for those at or adjacent to flared ends, are tapered NPT threads even though they may not be shown tapered.



10 9/16

FIGURE 1: FITTING IDENTIFICATION
(SEE VAN'S CATALOG FOR COMPLETE DESCRIPTIONS)
SCALE 1:1

FLARED FITTINGS

For identification see Figure 2 for a selection of flared fluid fittings.

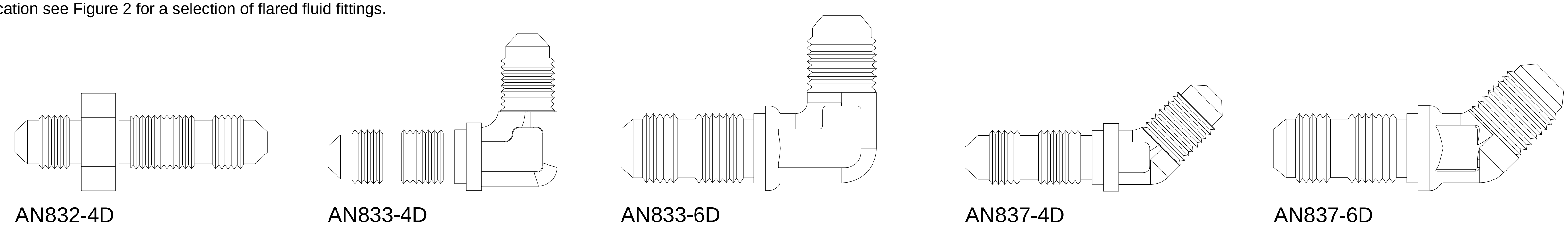


FIGURE 2: FITTING IDENTIFICATION
(SEE VAN'S CATALOG FOR COMPLETE DESCRIPTIONS)
SCALE 1:1

5.27 FLUID FITTINGS (continued)

STRAIGHT THREAD FLUID FITTINGS

Some fluid fittings (such as those installed in a typical Lycoming style Fuel Pump) are based on a straight thread and O-Ring arrangement. These threads do not taper like an NPT fitting.

To install fluid elbow-type fittings of this configuration, thread the ftting into the receptacle until the O-Ring is partially compressed into the chamfer, clock the fitting to the correct angle, then fully torque the nut.

NOTE: Torque values provided in Figure 1 and Figure 2 are for -6 (9/16 - 18 thread) fittings ONLY.

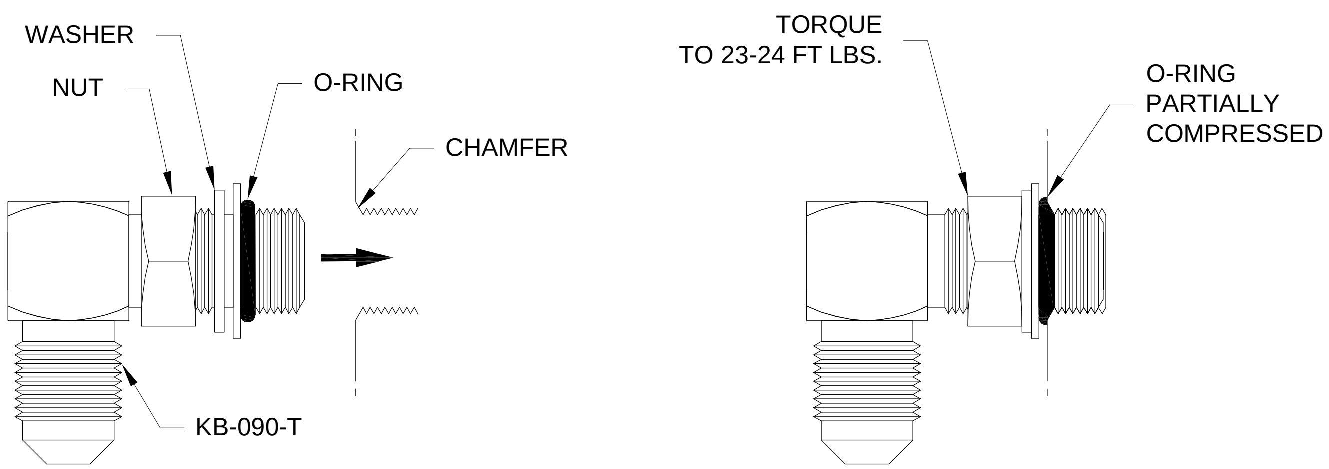


FIGURE 1: ELBOW-TYPE STRAIGHT THREAD FLUID FITTING

For straight-type fluid fittings of this configuration, thread the ftting into the receptacle until the O-Ring is partially compressed into the chamfer, then fully torque the fitting.

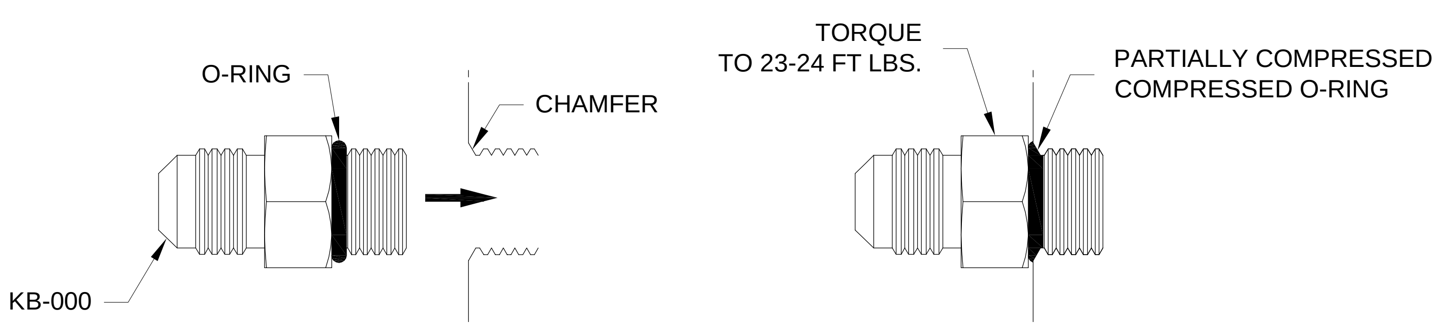


FIGURE 2: STRAIGHT-TYPE STRAIGHT THREAD FLUID FITTING

5.28 CONCLUSION

The manual now changes from general information to specific building instructions for your new airplane. The information is presented in logical, step-by-step order. This DOES NOT mean that the construction sequence given is the only way to do things; depending on factors such as available help, available space, or just personal preference, you might well alter some procedures with good results. Nor does it mean that you should simply follow the instructions blindly, one step at a time, without thinking ahead.

While the manual has been crafted in such a way as to minimize contradictions between the instructions provided by Van's and the instructions provided with a part/assembly that is included in the kit (wheels and brakes for example), **should there be an instance where the instructions from Van's contradict the instructions provided with a particular kit component, those of the component manufacturer shall take precedence over those provided by Van's.**

Successful use of this manual requires your active participation. Before you begin building, **READ THE ENTIRE SECTION**. Read it two or three times. Visualize the operations described, think about what might come next, consider what consequence your actions might have. **NEVER** do anything in a hurry. A great deal of a homebuilder's time is spent staring into space, making odd motions with the hands as he or she imagines how things might fit together. This is not wasted time! It is essential to forming a clear mental image of the task ahead.

Read Section 5 again and be familiar with the proper techniques needed for construction.

SECTION 6: EMPENNAGE

BUILDING THE HORIZONTAL STABILIZER

The assembly of the horizontal stab and following references are shown on DWG 3.

REAR SPAR ASSEMBLY

- ❑ Use a file or Scotchbrite wheel to "break" the edges of the HS-609PP (See Sec E-E). Lay the HS-609PP rear spar reinforcement bars inside the HS-603PP spar channels and check to see that the faces rest against one another when the holes are aligned. If the bend of the channel tends to lift the edge of the bar, use a coarse Vixen file to round the edge of HS-609PP to fit. Round the ends of the HS-609PP bars as shown in Rear View.
- ❑ Smooth the edges and surfaces of the HS-609PPs to a satin finish equivalent to that left by 400 grit wet/dry sandpaper, removing all the milling and file marks (See “Edge Finishing”, Section 5.2).
- ❑ The pre-punched holes used to attach HS-603PP to HS-609PP are slightly undersized, and must be "final drilled" to the correct size. Cleco and drill every second or third hole, drill #30, then move the clecos and drill #30 all the remaining holes.
- ❑ Carefully locate the holes that attach HS-708 to the rear spar assembly (it is the eighth hole from the end of HS-609PP) and enlarge it to #21 (See Rear View).
- ❑ Cleco the HS-412PP and HS-413PP elevator hinge brackets to the rear spar assembly and run a #30 drill through all the holes.
- ❑ There are two HS-411PP brackets, but only HS-411BPP is pre-punched for the VA-146 attach holes (See Exploded Iso View). Clamp HS-411APP and HS-411BPP around the VA-146 bearing and cleco the assembly to the spar.
- ❑ Using HS-411BPP as a drill guide match drill and cleco the aft four VA-146 attach holes.
- ❑ Remove the assembly from the spar and match drill the forward two VA-146 attach holes.
- ❑ Deburr the parts, prime VA-146 if desired, then rivet them together (the –5 rivet is the correct length, see Section 5.4). This sort of one at a time priming makes having a spray can self etching primer nice.
- ❑ Cleco the HS-411 assembly back to the spar. Drill/enlarge the bolt holes that will attach the HS-411 assembly to the spar to #12.
- ❑ Mark all the parts in the rear spar assembly so they can be returned to their previous positions. Use a "Sharpie" pen or equivalent for all marks on aluminum, but in this case the ink will be lost if you clean the parts for priming.

FRONT SPAR ASSEMBLY

- ❑ Separate the two HS-00001 spar doublers and draw the rivet lines as shown in the HS-00001 Detail View.
- ❑ Place the two HS-702 front spar channels on a work table, end to end, with the flanges facing down. Cleco HS-710 reinforcement angle, HS-714 splice angle to the two HS-702 spar channels.
- ❑ HS-702 has been designed for use on an RV-8 and will require extra trimming for use on an RV-7. In order for the spar to be bent to match the HS-710 and HS-714, the spar flanges inboard of the bend line must be removed.
- ❑ Lay the spar on the workbench with the flanges facing up and mark the bend line on the spar as shown in the HS-702 Front Spar Tab Detail.

- ❑ Drill a #30 relief hole 1/8” inboard of the bend line and centered on the bend radius of the flange (See HS-702 Front Spar Tab Detail and HS-702 Front Spar Tab Detail). Turn the spar over and enlarge this hole to 1/4" using a unibit.
- ❑ Trim the inboard ends of the HS-702 flanges as shown in the HS-702 Front Spar Tab Detail. Be sure to only trim the flanges down to about halfway along the bend. Flatten the remainder of the bend.
- ❑ Bend the tab as shown in HS-702 Front Spar Tab Detail using a hand seamer or blocks of wood.
- ❑ Clamp the HS-00001 spar doublers to the HS-702 spar channels. Position the top edge of the doublers flush with the top edge of the spar channels. Position the doublers left and right from the center line of the horizontal stab as shown in View B-B. Match-Drill #30 the inboard holes shown in Vew A-A. Cleco the doublers to the spar.
- ❑ Drill/match-drill all the holes inboard of the HS-00006/HS-00005 rib attach points (See View A-A). DO NOT drill the holes that will attach the HS-00006 and HS-00005 ribs or the holes outboard of the bend line. The holes outboard of the bends will be drilled later, after the bends are made. Also see Figure 6-6.
- ❑ Remove HS-710, HS-714 and HS-00001 from the two HS-702 spar channels. Taper the ends of HS-710 and HS-714 (See HS-710/HS-714 Taper Detail).
- ❑ Bend the outboard ends of HS-710, HS-714 (See View B-B). Clamp the aluminum angle between wood blocks in a vise and bend with a mallet. Use a simple cardboard template to check the angle.
- ❑ Refer to View A-A for the rivet pattern at the center of the front spar. Note that the center four rivets are AN426AD4 rivets with the flush heads aft. Dimple HS-702 and countersink HS-710 and HS-714 (See “Countersinking”, Section 5.5).

PREPARING THE RIBS

- ❑ Notch the aft end of the HS-00006 ribs to fit around HS-714 and HS-710 (See HS-00006 Trim Detail). Make sure to make one left and one right.
- ❑ Prepare the HS-00006, HS-00005, HS-706, HS-707 and HS-708 ribs (See “Fluting and Straightening Ribs and Bulkheads” and “Edge Finishing”, Section 5.13 & 5.2).

DRILLING THE HORIZONTAL STABILIZER

- ❑ Choose which ribs will be used on the right and which will be used on the left then mark them.
- ❑ Using the dimensions given in SEC D-D, mark the hole locations on the centerline of the aft side of the aft flange of HS-00006. These holes attach HS-00006 to the forward spar assembly and HS-00005. Make a light mark with a center punch to keep the drill bit from wandering then pilot drill the holes to #40.
- ❑ Draw a centerline on the forward side of the forward flange of HS-00005.
- ❑ Select the left side HS-702, HS-603PP, HS-706, HS-707 and HS-708 and cleco them together.
- ❑ Drill all HS-706, HS-707, HS-708 rib to spar attach holes to #30 (except the HS-708 and HS-603PP holes)
- ❑ Un-cleco, deburr holes, clean out chips and re-cleco.
- ❑ Cleco on the HS-601PP skin.
- ❑ Enlarge the HS-708 to HS-603PP holes to #21.
- ❑ Cleco HS-00001, HS-710 and HS-714 to HS-702.

- Slip the HS-00006 and HS-00005 ribs into place and mark the approximate hole locations on the top and bottom rib flanges with a pen using the holes in the skin as a guide.
- Remove the HS-00006 and HS-00005 ribs and flute as necessary between the rivet hole marks.
- Reinstall the HS-00006 and HS-00005 ribs. Clamp HS-00006 to the HS-601PP skin and spar assembly.
- Match Drill #30 and cleco the aft flange of HS-00005 rib to HS-603PP spar, using the holes in the spar as a drill guide. Remove HS-00005, clean out any chips.
- Match Drill #40 the holes in the aft flange of the HS-00006 rib to HS-702 and HS-00001.
- Mark and drill #40 the two holes common to the HS-00001, HS-702, HS-710 or HS-714 on the forward side of the spar bars, keeping the holes in line with the holes in the aft flange of the HS-00006. See SEC D-D.
- Reinstall HS-00005. Align the centerline line drawn on the forward flange to the previously drilled holes in the spar assembly and HS-00006 rib. Clamp the rib in place, making sure it fits tightly against HS-00001. Next, cleco the aft flange of the HS-00005 rib to the aft spar. Finally clamp the top and bottom flanges to the HS-601PP skin. Finally, Match-drill the holes in the forward flange of the HS-00005 rib.
- Cleco the ribs and spar assembly together.
- Beginning at the rear spar and working forward, match drill the holes in the HS-601PP skins to the HS-00005 rib.
- Be sure that the front flange of HS-00005, HS-702, HS-710 and HS-714, HS-00001 and the aft flange of HS-00006 are pulled up tight. Re-clamp the upper and lower flanges of HS-00006 to HS-601PP.
- Drill to final size or match drill all the remaining holes attaching the HS-601PP skin. The suggested drilling sequence begins at the intersection of the HS-708 center rib and the rear spar and proceeds both up along the rib and outward toward the tip. Put clecos in every second or third hole as you drill them.
- Remove the skin and drill the remaining holes in HS-714, HS-710 and HS-00001. Remove HS-710, HS-714 and HS-00001.
- Repeat the above steps for the right side.

PREPARING THE HORIZONTAL STABILIZER PARTS FOR ASSEMBLY

- Mark and disassemble all parts.
- Deburr all the holes in both the skin and the skeleton (See “Hole Deburring”, Section 5.2).
- Dimple the understructure using a pneumatic or hand squeezer. Dimple the rivet holes in the skins using a C-frame dimpling tool (See Section 3).
- Smooth the edges of the parts (See “Edge Finishing”, Section 5.2).
- Prime all parts as required (See “Priming”, Section 5.1). The HS-609PP rear spar reinforcement bars, HS-710 reinforcement angle and HS-714 splice angle are not made of Alclad material, so before riveting, they must be primed.

RIVETING THE HORIZONTAL STABILIZER

- Locate the rivet holes in the rear spar that will attach the HS-706, HS-708 and HS-00005 ribs and the HS-412PP hinge brackets. Put tape over them to prevent accidentally riveting these holes before the ribs are attached.

- Rivet the HS-609PP bars to the HS-603PP spar channels. The rivet callout is correct on the plans. See Section 5.4. This can be accomplished with either a gun, pneumatic or hand squeezer. You may find it takes a bit of "grunt" to set -4 rivets with a hand squeezer.
- Rivet the HS-412PP and HS-413PP hinge brackets to the spar.
- Bolt the HS-411PP center bearing to the spar (See Torque Value Chart, Section 5.20).
- Rivet HS-710 and HS-714 and HS-00001 to the HS-702 front spars. Remember the flush rivets in the center of the assembly (See View A-A and Section D-D.)
- Rivet HS-00006 and HS-00005 to the front spar assembly. The ribs may be gently flexed out of the way to allow better access during riveting.
- Lay the HS-601PP skin marked for the left side down on a clean surface. Use foam padding if desired.
- Cleco then rivet HS-707 to the top side of the skin.
- Cleco HS-706 to the skin. Temporarily cleco HS-708 to HS-601PP and the aft flange of HS-707 to help hold the skin tight against HS-707, then rivet the bottom side of HS-707 to HS-601PP. Remove HS-708.
- Cleco the forward spar assembly to HS-706, HS-707 and HS-601PP, then cleco on HS-708.
- Blind rivet HS-702 to HS-707 and HS-708.
- Rivet HS-702 to HS-706.
- Rivet HS-702 and HS-708 to HS-601PP.
- Repeat the above steps for the right side then cleco on the rear spar assembly
- Rivet the rear spar assembly, HS-00006, HS-00005 and HS-706 to HS-601PP. These holes can all be reached by a hand squeezer.
- Blind rivet the rear spar assembly to HS-708.

Congratulations! You've finished the first major sub-assembly on your new airplane.

BUILDING THE VERTICAL STABILIZER

The assembly of the vertical stab and following references can be found on DWG 6. Construction of the vertical stabilizer is very similar to the horizontal stabilizer.

DRILLING THE VERTICAL STABILIZER

- Cleco the VS-808PP spar doubler to the VS-803PP rear spar. Then cleco on the hinge brackets VS-410PP, VS-411PP and VS-412PP (See Exploded Iso View).
- The VS-410PP hinge brackets have two holes missing from the pattern. Use the holes in the spar channel and spar doubler as drill guides and back-drill the entire six-hole pattern through the upper VS-410PP only. The corner holes in the lower VS-410PP will be drilled for bolts later, in assembly with the fuselage (See DWG 27/27A).
- Prepare the ribs VS-704, VS-705, VS-706 and VS-707 (See “Edge Finishing”, “Fluting and Straightening Ribs and Bulkheads”, Section 5.2 & 5.13).

- Cleco the ribs to the front and rear spars.
- Final drill #30 VS-808PP, VS-410PP, VS-411PP and VS 412PP to VS-803PP.
- Drill all rib to spar attach holes to #30.
- Cleco on the VS-801PP / VS-901 skin.
- Drill / match drill to final size all the holes attaching the VS-801PP / VS-901 skin.
- Mark the location and orientation of VS-803PP, VS-411PP and VS-412PP. Disassemble, de-burr, dimple, machine countersink and prime parts as desired (See “Countersinking”, “Dimpling”, “Hole Deburring” and “Priming”, Section 5.1, 5.2, & 5.5).
- Note as shown on DWG 27/27A the lower portion of the rear spar must lay flush against the F-712/812 bulkhead assembly. Therefore the rivets in this region must be flush on the forward side of the rear spar that mates to the F-712/812 bulkhead (See Rear View, SEC A-A and “Countersinking and Dimpling”, Section 5.5).

FINISHING THE VERTICAL STABILIZER

- Cleco VS-803PP to VS-808PP, VS-410PP, VS-411PP and VS-412PP together. Then tape over the holes that will attach VS-704, VS-706 and VS-707.
- Rivet the rear spar together remembering the flush rivets on the lower rear spar.
- Rivet VS-704, VS-705, VS-706 and VS-707 ribs to the front spar.
- Cleco on the VS-801PP / VS-901 skin.
- Rivet on the skin. Begin at the intersection of VS-707 and VS-702 and work towards the tip, then restart at the same place and rivet along the front spar toward the root and along the VS-707 rib starting at the front and riveting toward the rear spar.
- Cleco on the rear spar assembly and install the remaining rivets along the rear spar and end ribs with a squeezer.
- Blind rivet the rear spar assembly to VS-707.

BUILDING THE RUDDER

FITTING THE STIFFENERS TO THE RUDDER SKIN

- Pre-punched holes in the R-915 rudder stiffeners match corresponding pre-punched holes in the R-901-L and R -901-R rudder skins.
- Trim individual stiffeners from strips consisting of two stiffeners. See diagram on DWG 7. Shorten all the stiffeners (except the lowest) by trimming the excess from the forward end. Use the pre-punched hole pattern in the rudder skins to determine the correct amount of trim. See note on DWG 7.
- Before you begin actually drilling stiffeners and skins, be sure that you are placing the stiffeners on the inside surfaces of the right and left rudder skins. Study the exploded isometric view on DWG 7.
- Match drill the stiffeners to the rudder skins. Having a tabletop you don’t mind drilling into will make the job easier. You can drill through the part right into the table. A cleco run into the hole in the table will not hold the part up off the surface.
- Disassemble and debur the holes. BE VERY CAREFUL deburring the thin R-901 rudder skins -- it doesn't take much pressure or over-enthusiasm (one turn is usually plenty) to ruin a hole in 0.016 aluminum. You do not want to be left with a knife-edged hole when you are done.
- Because 0.016 is too thin to machine countersink, it must be dimple countersunk. Use a C-frame deep-throat dimpler/riveter as shown in Section 3. Remember that the pressure needed to dimple 0.016 is quite low.

- Dimple the stiffeners and skin, and prime the parts if you choose. Now you are ready to rivet the skin and stiffeners together. BACK-RIVETING is the best technique here. See Section 5.6. Be sure you fully set the aft rivet in each stiffener…if you leave these standing too tall, they will interfere with the opposite skin when the rudder is assembled.
- When back-riveting, the flush head rivets are taped in place with Van’s Special Riveting tape (See VAN'S ACCESSORIES CATALOG), Mylar, or Scotch 811 tape (masking or regular Scotch tape does not work well.) The flush heads are placed on a flat, smooth plate of steel or hard aluminum. A small flat, cupped, or special sliding-sleeve set is used to make the shop head. If you are careful to keep the bucking surface clean, this method almost ensures clean, well-set rivets.

BUILDING THE RUDDER SKELETON

- Cleco R-904 Bottom Rib to the R-902 Spar. Enlarge the 0.125 hole in the center of the forward flange of R-904 to 3/8 using the hole in R-902 as a drill guide.
- Fabricate R-917 Shim per DWG 7.
- Use a 3/8 bolt to fasten the R-405PD rudder horn squarely on the rudder spar and final drill the four holes through the upper edge of the rudder horn to #30 using the pre-punched holes in the spar as a drill guide.
- Cleco the rudder horn to the R-904 bottom rib to check the fit. If necessary radius the top of the rudder horn so it nests nicely in the radius of the rib flange.
- Cleco the R-904 bottom rib and R-405PD rudder horn to the R-902 rudder spar. Slide the R-917 shim into place between the rudder spar and rudder horn and drill to #30. Use the pre-punched holes in the spar as a guide.
- Cleco the R-606PP, R-607PP, and R-608PP reinforcement plates to the R-902 rudder spar. NOTE that the R-606PP lower reinforcement plate goes on the forward (flange side) of the spar web, while the R-607PP and R-608PP plates go on the rear.
- Flute the R-903 tip rib and R-912 counterbalance rib. Use a ruler along the holes to make sure they are straight. Use a hand seamer to adjust the flanges square to the web.
- Cleco the tip rib and the counterbalance rib to the top of the spar and drill to #30.
- Cleco the R-913 counterbalance skin to the R-903 tip rib and R-912 counterbalance rib. Match drill #40 the counterbalance skin to the ribs using the pre-punched holes in the R-913 counterbalance skin as a drill guide.
- Cleco the R-901R&L rudder skins to the ribs and spar. Fit the R-916 rudder trailing edge and cleco it in place. Drill all remaining holes in the rudder to final size.
- Trim the excess material from R-710 rudder brace. Fit the R-710 between R-405PD and R-904. Cleco the aft edge of R-710 to the bottom of R-904 and drill #30. Match drill through the forward edge of R-710 using the holes in R-405PD as a drill guide.
- Make the R-918 rudder bottom attachment strips shown on DWG 7 and clamp them in place. Drill them to the skeleton, using the existing holes as drill guides.
- Disassemble the rudder and deburr all the holes. Dimple the skin, spar and ribs.
- The aft three 3/32 holes in the upper edge of R-901-L and R-901-R should be drilled to #30 and dimpled. These holes will later be used to attach the R-909 rudder tip. While the holes could be opened up to #30 when drilling the tip to the rudder, it would be nearly impossible to dimple the skins because the rudder is so narrow at that location.
- Drill the E-614-020 counterweight to the R-912 counterbalance rib. The forward tooling hole on the R-912 rib matches with the forward hole on the counterweight. Use the aft hole in the counterweight to match drill into R-912. Remove the counterweight and machine countersink the holes for a #10 countersunk screw. De burr the holes in the counterbalance rib and dimple for a #10 countersunk screw.
- Although the rudder and elevator spars are 0.032 and could technically be machine countersunk, we strongly recommend that these parts be dimpled. Be careful that the dimple dies do not drag along the web of the spar and gouge it. It may be necessary to grind a flat side on the dies to obtain the necessary clearance.
- The trailing edges of both the left and right R-901 skins are dimple countersunk and both sides of the R-916 rudder trailing edge are machine countersunk. These rivets will be double flush. The shop head actually turns out looking pretty nice when it is driven into a dimple. Prime all the components desired.

RIVETING THE RUDDER

- Install the reinforcement plates and platenuts on the spar.
- Rivet the R-904 rib and associated parts.
- Rivet the R-912 counterbalance rib to the R-902 spar. Then rivet the R-913 counterbalance skin to the

counterbalance rib, but not the spar. Install the E-614-020 counterweight (see exploded view on DWG 7).

- ❑ Cleco both skins to the spar.

- ❑ There are six rivets on each side that join the R-901 skins and the R-913 counterbalance skin and three that join the rib, counterbalance skin and spar. The aft end of the R-913 counterbalance skin will lay *under* the R-901 rudder skin. Set these, then rivet on the R-903 tip rib. Blind rivets are used for the first time here. They are simple to set with a hand pop-riveting tool, but they are difficult to drill out. Make sure that the heads of the rivets are firmly against the rib before setting.
- ❑ Rivet the skin to the skeleton. A rivet squeezer will reach almost all the rivets, depending on the throat depth. In the narrow spaces at the end of the ribs a narrow bucking bar will be necessary. If one isn't available, these holes may be enlarged to 7/64" and MK-319-BS blind rivets may be substituted for the last one or two AN rivets. Both rivets have heads that fit the same dimple.
- ❑ The trailing edge is the last in the sequence. Building a truly straight trailing edge is one of the more difficult things to do in the empennage kit. Take your time and work as precisely as possible. A wavy or bowed trailing edge doesn't look good, and in more extreme cases will affect the flying qualities of the airplane. Strive to build a trailing edge that does not vary more than 0.100" from a straight line.
- ❑ One way to help keep the trailing edge straight is to bond the components together before setting the rivets. The bonding agent can be fuel tank sealant or any good epoxy with a 30 minute working time.
- ❑ Trailing edges are riveted with "double-flush" rivets. These are standard rivets, but instead of setting the shop head on a flat surface, it is set in a dimple and ends up flush with the skin surface. However, a double flush rivet will not look the same on both sides. The factory flush head will set almost perfectly flat. The finished shop head will be flush with the skin, but it will not fill the dimple completely...it's been described as "an acorn sitting in a dimple." Do not fall in the trap of trying to use a longer rivet and "fill the hole." The rivet will bend over instead of setting properly.
- ❑ Begin by using one of the skins as a guide and drill the trailing edge pattern of holes into a rigid, straight piece of aluminum angle. Cleco the trailing edge together, with both skins and the AEX wedge clecoed to the angle and check the alignment. The angle should hold the trailing edge straight. Because the rudder tapers in thickness, the trailing edge cannot simply be clamped to the table. Lay the rudder with the trailing edge and clecoed angle off the edge of the table so it can remain straight.
- ❑ Disassemble the trailing edge and clean the surface completely, using the directions for cleaning the fuel tank components in Section 7. Mix (follow the mixing directions on the can) and apply tank sealant thinly and evenly to both surfaces of the AEX wedge and cleco the trailing edge together, including the alignment angle. Wipe away any sealant that squeezes out and make sure that the parts fit tightly. There should be no globs of sealant holding the skin and wedge apart, for instance.
- ❑ Check the alignment once more, and set the assembly aside. Let the sealant cure for a couple of days. After curing, remove the angle and the clecos.
- ❑ Insert rivets into the trailing edge holes with the manufactured head on the top side. Tape all the rivets in place and flip the rudder over. Put blocks on either side of the back-riveting plate, so the rudder can stay flat as it slides over the plate. Weight the rudder down to the worksurface so it remains straight while riveting.
- ❑ Back-rivet about every tenth rivet just enough to to lock everything in place…don't set the rivets all the way just yet.
- ❑ Back-rivet the rest of the trailing edge rivets, but for now, set the rivets only about halfway. Set every fifth or sixth rivet and check constantly to see that the trailing edge is not bending one way or the other. If the rivets are set fully in only one direction it can leave a "hook" in the trailing edge. Start with the rivet set parallel to the rivet and tilt it to set the rivet flush to the skin as the rivet sets.
- ❑ Flip the rudder over and set the trailing edge rivets to the final size with a mushroom set, again checking constantly.
- ❑ A little finesse will produce a nice double flush joint, but you must constantly guard against bowing the trailing edge.

COMPLETING THE LEADING EDGE OF THE RUDDER

- ❑ Before the rudder can be installed on the vertical stabilizer, its leading edge must be formed. The object here is to achieve a smoothly curved surface that fits neatly between the skin overhang of the stabilizer. Simply pulling the overhanging skins together results in an angle or crease where they cross the edge of the spar (See Rolled Leading Edges", Section 5.9)

- ❑ Rivet the leading edge together. Blind rivets are used here. They are simple to set with a hand pop-riveting tool, but they are difficult to drill out. Make sure that the heads of the rivets are firmly against the rudder skin before squeezing. See the Rudder Leading Edge Detail on DWG 7.

BUILDING THE ELEVATORS

The assembly of the left elevator is shown on DWG 4. The assembly of the right elevator is shown on DWG 5. The elevators are built much like the rudder. The elevators are balanced surfaces, having lead weights forward of the hinge lines to counteract the weight of the structure behind it. This improves the control "feel" and helps prevent flutter. The major difference between elevators and the rudder is the installation of a trim tab in the left elevator. This need not be an especially difficult task, but it does require careful attention to detail. The majority of builder mistakes on the empennage are made on the left elevator and trim tab. Fair warning! Because of the complication of the trim tab, we'll leave it to last and start with the right elevator.

PREPARING THE ELEVATOR SKINS

TRIMMING THE STIFFENERS

- ❑ The E-701-L/R elevator skins and E-720 (A-L) elevator skin stiffeners are provided with pre-punched holes. The various E-720 stiffeners are snipped from the pre-punched lengths of aluminum angle. The double notch in the edge denotes the overall length of the stiffener. Use aviation snips to cut from center to center of the guide holes (See E-720 Trim Detail, DWG 5).
- ❑ Trim the flange of the stiffener (surface perpendicular to the skin) to fit inside the tapered elevator. Single notches on the edge of the stiffener note the beginning points of these trim cuts. Trim the stiffeners and clean up the edges with a file and the Scotchbrite wheel (See E-720 Trim Detail, DWG 5).
- ❑ Make stiffeners E-720J, E-720K and E-720L from the existing E-720D, E-720E and E-720F (See E-720 Trim Detail and Note 1, DWG 5). Set aside stiffeners for use in the left elevator assembly.
- ❑ Drill the stiffeners to the E-701-L/R skins. Drill E-615PP to E-701-L. Disassemble parts then, deburr, dimple and prime as desired (See "Edge Finishing", "Hole Deburring", "Dimpling" and "Priming", Section 5.2, 5.5 & 5.1). Dimple the #6 screw holes and rivet the K-1100-06 platenuts to the E-615PP.
- ❑ Back rivet the stiffeners to the E-701-L/R skins (See "Back Riveting", Section 5.6).
- ❑ Back rivet E-615PP to E-701-L.
- ❑ Bend the trailing edge of the elevator (See "Folded Trailing Edges", Section 5.7). Remember do not add the sealant to the trailing edge until just prior to assembly.

PREPARING THE RIGHT ELEVATOR

- ❑ Separate the E-00001A & B hinge doublers.
- ❑ Use a file to radius the top and bottom edges of the E-00001A outboard hinge doubler to nest against the spar radii.
- ❑ Cleco and drill the E-610PP and E-611PP reinforcement plates, E-00001A & B hinge doublers and corresponding platenuts to the E-702 spar.
- ❑ Prepare the E-703 end ribs and E-704 counterbalance ribs (See "Edge Finishing" and "Fluting", Section 5.2 & 5.13).

- ❑ Cleco and drill the E-703 end rib to the E-704 counterbalance rib then cleco and drill them to E-702. Remove the ribs from the spar.

- ❑ Place the E-714 counterweight on the forward end of E-703 and E-704 as shown (See View F-F, DWG 5).
- ❑ Cleco the E-713 counterbalance skin to E-703 and E-704, overtop of E-714. The step in the front face of E-714 should butt against the outboard edge of E-713.

- ❑ Use the two holes in the forward face of E-713 as a guide and drill #12 the holes for the screws that will hold E-714 in place. Use a drilling lubricant when drilling the lead E-714's.

- ❑ Un-cleco E-713, remove and set aside E-714, re-cleco on E-713 to E-703 and E-704. Then cleco the E-703, E-704, E-713 subassembly to E-702.

- ❑ Cleco the E-709 root rib right to E-702.

- ❑ Final drill #40, E-709 to E-702.

- ❑ Cleco E-701-R to the understructure. Note that E-701-R lays on top of E-713.

- ❑ Remove the clecos connecting E-709 to the E-702 then cleco and drill the WD-605-1-R elevator horn to E-702 and E-709.

- ❑ Drill the E-701-R skin to the understructure.

- ❑ Disassemble the elevator.

- ❑ Dimple E-713 for the screw heads that will attach E-714 (See "Dimpling", Section 5.5).

- ❑ Machine countersink E-714 for the dimples in E-713 (See "Countersinking", Section 5.5).

- ❑ Machine countersink the E-709 attach holes on the forward face of E-702 (See "Countersinking", Section 5.5). E-709 and E-702 will be riveted together with flush head rivets, so that the WD-605-1-R elevator horn can be mounted flush with the forward face of the E-702 spar.

- ❑ Bevel the inboard and aft edges of E-713 locally where E-713 overlaps the spar and rib flanges to provide a smooth transition between the counterbalance skin and the E-701-R elevator skin.

- ❑ Deburr, dimple and prime the parts as desired (See "Deburring", "Dimpling" and "Priming", Section 5.2, 5.5 & 5.1).

RIVETING THE RIGHT ELEVATOR (See "Riveting", Section 5.4)

- ❑ Rivet E-703 to E-704.

- ❑ Rivet E-610PP, E-611PP, E-00001A & B and platenuts to E-702.

- ❑ Rivet E-709 to E-702 (flush heads forward).

- ❑ Rivet E-703/E-704 to E-702.

- ❑ Rivet WD-605-1-R to E-702 and E-709.

- ❑ Rivet E-713 to E-701, two rivets on the top and two rivets on the bottom (assembling this way eliminates the need for blind rivets).

- ❑ Loosely place E-714 in place nested inside E-713 with screws partially inserted.

- ❑ Insert the elevator skeleton into E-701-R/E-713 beginning at the front end of E-703/E-704 and then rotating the root end aft into proper position.

- ❑ Cleco and rivet E-701-R and E-713 to the understructure.

- ❑ Finish attaching E-714.

PREPARING THE LEFT ELEVATOR

The left elevator is similar to the right elevator, the only difference is the use of the E-615PP trim access reinforcing plate, supporting the trim cable or servo, and the E-606PP trim spar.

- ❑ Use a file to radius the top and bottom edges of the E-00001A outboard hinge doubler to nest against the spar radius.

- ❑ Cleco and drill the E-610PP and E-611PP reinforcement plates, E-00001A & B hinge doublers and corresponding platenuts to the E-702 spar.

- ❑ E-704 counterbalance rib then cleco and drill them to E-702. Remove the ribs from the spar.

- ❑ Place the E-714 counterweight on the forward end of E-703 and E-704 as shown (See View F-F, DWG 5). Cleco the E-713 counterbalance skin to E-703 and E-704, overtop of E-714. The step in the front face of E-714 should butt against the outboard edge of E-713.

- ❑ Use the two holes in the forward face of E-713 as a guide and drill #12 the holes for the screws that will hold E-714 in place. Use a drilling lubricant when drilling the lead E-714's.

- ❑ Un-cleco E-713, remove and set aside E-714, re-cleco on E-713 to E-703 and E-704. Then cleco the E-703, E-704, E-713 subassembly to E-702.

- ❑ Cleco the E-705 root rib left to E-702.

- ❑ Final drill #40, E-705 to E-702.

- ❑ Cleco E-701-L to the understructure. Note that E-701-L lays on top of E-713.

- ❑ Remove the clecos connecting E-705 to the E-702 then cleco and drill the WD-605-1-L elevator horn to E-702 and E-705.

- ❑ Cleco and final drill E-606PP to E-705 (at the root end of the E-606PP spar).

- ❑ Drill the E-701-L skin to the understructure.

- ❑ Disassemble the elevator. Deburr, dimple and prime the parts as desired (See "Deburring", "Dimpling" and "Priming", Section 5.2, 5.5 & 5.1).

- ❑ Dimple E-713 for the screw heads that will attach E-714 (See "Dimpling", Section 5.5).

- ❑ Machine countersink E-714 for the dimples in E-713 (See "Countersinking", Section 5.5).

- ❑ Machine countersink the top flange of E-606PP to accept the dimples in the E-701-L skin (See "Countersinking", Section 5.5). Dimple the bottom flange of E-606PP.

- ❑ Machine countersink for the rivets that attach E-705 to E-606PP, the flush head can go on either the forward face of E-705 or aft face of E-606PP.

- ❑ Machine countersink the E-705 attach holes on the forward face of E-702 (See "Countersinking", Section 5.5).

E-705 and E-702 will be riveted together with flush head rivets, so that the WD-605-1-L elevator horn can be mounted flush with the forward face of the E-702 spar.

- ❑ Bevel the inboard and aft edges of E-713 locally where E-713 overlaps the spar and rib flanges to provide a smooth transition between the counterbalance skin and the E-701-L elevator skin.
- ❑ See DWG 4 for details of the trim system you have chosen. It is easier to install the necessary parts while access is still available to the inside of the skin. Note that the WD-415 trim cable anchor, related snap bushings and the manual trim cable will be sent in the finish kit.

BENDING THE LEFT ELEVATOR TABS

- ❑ Before the elevator is riveted together, the tabs that close the elevator at the trim tab cutout must be bent. Begin by removing any vinyl from the tabs and outboard of the tabs where the bending blocks will touch the skin surface (the vinyl allows the blocks to shift while bending the tabs).
- ❑ Lay a square reference along the trailing edge of E-701-L in the trim tab cutout (where E-606PP attaches). Mark the bend line perpendicular to the aft edge of the E-701-L trim tab cutout. While bending the tabs the bending blocks will move away from the bend line (outboard). Compensate for this by offsetting the bend line approx. 1/32 inboard from the desired bend location.
- ❑ Fabricate a set of bending blocks from particleboard or wood. The taper of the inside block should approximate the completed bend angle of the E-701-L elevator skin. Clamp the skin and blocks to the edge of a table (See Figure 6-1). Use double-sided tape between the mating surfaces of the bending blocks and the E-701-L skin, to prevent the wedge shaped blocks from slipping.
- ❑ Note that the upper tab overlaps the lower one so the joint sheds water. Bend the bottom tab down using the face of a block of wood, working progressively back and forth across the tab (See Figure 6-2). Finish the bend by using a flush set and a rivet gun turned down low (See Figure 6-3). Work the rivet gun across the entire tab without stopping.
- ❑ With the block still clamped in place repeat the above steps to bend the upper tab up and over the bottom tab.

RIVETING THE LEFT ELEVATOR (See “Riveting”, Section 5.4)

- ❑ Rivet E-703 to E-704.
- ❑ Rivet E-610PP, E-611PP, E-00001A & B and platenuts to E-702.
- ❑ Rivet E-705 to E-702 (flush heads forward).
- ❑ Rivet E-703/E-704 to E-702.
- ❑ Rivet WD-605-1-L to E-702 and E-705.
- ❑ Rivet E-713 to E-701, two rivets on the top and two rivets on the bottom (assembling this way eliminates the need for blind rivets).
- ❑ Loosely place E-714 in place nested inside E-713 with screws partially inserted.
- ❑ Insert the elevator skeleton into E-701-L/E-713 beginning at the front end of E-703/E-704 and then rotating the root end aft into proper position.
- ❑ Cleco and rivet E-701-L and E-713 to the understructure.
- ❑ Rivet E-606PP to E-701-L along the bottom flange only. Leave the top flange unriveted at this point for

installation of the trim tab hinge. Rivet E-606PP to E-705.

- ❑ Finish attaching E-714.

BUILDING THE TRIM TAB

- ❑ Complete the trailing edge bend of the E-619-1-020 trim tab skin (See “Folded Trailing Edges”, Section 5.7).
- ❑ Fabricate a set of bending blocks from wood or particleboard (See Figure 6-1,6-2,6-3 and 6-4). Note that the upper block hooks over the lower block to prevent the wedge shaped blocks from slipping. The taper of the inside block should approximate the completed bend angle of the trim tab skin.
- ❑ Remove the vinyl from the ends of the trim tab and mark bend lines on the tab (See Trim Tab Bend Detail, DWG 4). While bending the tabs the bending blocks will move away from the bend line (toward the center of the trim tab). Compensate for this by offsetting the bend line approx. 1/32 from the desired bend location.
- ❑ Clamp the inboard end of the tab with the bending blocks to the edge of a table (See Figure 6-1) Use double-sided tape between the mating surfaces of the bending blocks and the trim tab skin to help prevent the wedge shaped blocks from slipping.
- ❑ Bend the bottom tab down using the face of a block of wood, working progressively back and forth across the tab (See Figure 6-2). Finish the bend by using a flush set and a rivet gun turned down low (See Figure 6-3). Work the rivet gun across the entire tab without stopping.
- ❑ With the block still clamped in place repeat the above steps to bend the upper tab up and over the bottom tab (See Figure 6-4).
- ❑ Repeat the above steps for the outboard tabs.
- ❑ Cleco E-607PP to the inside bottom surface of E-619PP-1-020.
- ❑ Clamp E-718 to E-717 and run a clevis pin through the clevis pin attach hole for alignment. Cleco the E-717 outboard horn to the trim tab skin. Using the holes in E-718 as a drill guide, match drill E-718 to E-619-1-020 and E-607PP.
- ❑ Use the dimensions given on DWG 4 to position and clamp E-721 to the top flange of E-607PP. Mark the inboard edge of E-619PP-1-020 and E-607PP on E-721.
- ❑ Drill the remaining holes attaching E-619PP-1-020 to the bottom flange of E-607PP. Drill the holes attaching E-619PP-1-020 to the top flange of E-607PP and E-721.
- ❑ Disassemble the trim tab.
- ❑ Machine countersink the top of the E-607PP trim tab spar to accept the dimples in the trim tab skin (See “Countersinking”, Section 5.5). Dimple the bottom flange of E-607PP.
- ❑ Trim off the excess material from the E-717 outboard trim tab horn and the E-718 inboard trim tab horn depending on the type of trim system used (See Manual Trim Assembly or Electric Trim Assembly, DWG 4).
- ❑ Trim the inboard edge of the aft portion of the E-721 trim tab hinge.
- ❑ Prepare the parts (See “Edge Finishing”, “Deburring”, “Dimpling” and “Priming”, Section 5.2, 5.5 & 5.1).
- ❑ Cleco the trim tab back together.

- ❑ Rivet the bottom of E-619-1-020 to the bottom flange of E-607PP, E-717 and E-718.
- ❑ Remove the clecos along the top flange of E-606PP and clamp E-721 to the upper flange of E-606PP and the aft edge of E-701-L.
- ❑ Adjust the position of the hinge on the elevator so that the inboard and trailing edges of the trim tab are aligned with the corresponding edges on the elevator (The trailing edge being more critical than the inboard edge). Use a long straight edge to aid in aligning the trailing edge.
- ❑ Match drill and cleco the forward portion of E-721 #40 using the holes in E-701-L and E-606PP as a drill guide.
- ❑ Mark the inboard edge of the E-701-L skin on E-721.
- ❑ Remove E-721 and trim the inboard end to match the inboard edge of the E-701-L skin.
- ❑ Re-cleco the tab hinge and trim tab assembly onto the elevator.
- ❑ Sight down the trailing edge of the elevator, with the trim tab in trail. If the tab has any twist and does not continue the straight line of the elevator trailing edge, now is the time to correct it. Even with the clecos installed, there is enough play in the holes to gently twist the tab as necessary to align it perfectly. When the tab fits, use tape or a second pair of hands to hold it, and drill the folded ends of the inboard tabs.
- ❑ With a pair of clecos in the inboard tabs, and a couple of reference marks for alignment, remove the trim tab from the elevator.
- ❑ Carefully maintaining the alignment, set the rivets on the top of the trim tab.
- ❑ Set the blind rivets in the ends of the trim tab, making sure they don't interfere with the rivets in the inboard tabs of the elevator.
- ❑ Rivet the forward (elevator) half of E-721 to the elevator.
- ❑ Install and bend the trim tab hinge-pin and secure as shown on DWG 4, View A-A. The hinge pin supplied is too short to do this now. You will receive longer pins with the fuselage kit.

FINISHING THE ELEVATORS

- ❑ Roll and rivet the leading edges (See “Rolled Leading Edges”, Section 5.9).
- ❑ Install the rod end bearings as shown (See Detail D, DWG 5).
- ❑ Make a preliminary check to see that the elevator will swing through its full up and down travel without any interference’s (See “Flight Controls”, Section 15). Travel is best measured with a protractor or an electronic "smart level". It will probably be necessary to remove the bottom flange of HS-603PP to allow the elevator horns enough swing. DO NOT remove any of the HS-609PP bar!
- ❑ Align the trailing edge on the extended chord line of the stabilizer: "in trail." The counterbalance arm should align evenly with the stabilizer. Secure the elevator in this position.
- ❑ Fabricate a “drill bushing” with an outside diameter of 1/4" and an 3/32" inside diameter. Any small metal tube can be used. The bushing will protect the VA-146 hinge bearing from the drill bit and act as a drill guide to locate and drill the hole in WD-605-1-R for the bolt that attaches the horn to the center bracket.
- ❑ Insert the drill bushing into the HS-411PP hinge bracket/bearing assembly. Using the drill bushing as a drill guide, pilot drill WD-605-1-R to #40.
- ❑ Remove the elevator from the horizontal stabilizer and carefully drill the hole in the WD-605-1-R horn to final

size.

- ❑ Repeat the above steps for the left elevator assembly.
- ❑ At this point the E-714 counterweights will overbalance the elevators. Final adjustments are made after the elevators are complete and painted. It is impossible to make the elevator balance exactly until is finished. The best approach is probably to leave the counterweights a little heavy, then drill the inboard side of the counterweight with a series of small holes until the elevator balances. A correctly balanced elevator will remain "in trail".
- ❑ Install the elevators on the horizontal stabilizer and make a check for alignment. There should be no binding in the hinge line.

INSTALLING FIBERGLASS TIPS

You can add the fiberglass tips to the completed empennage now or you may chose to wait and do all the fiberglass work at a later stage. Fiberglass is abrasive and will dull your countersink.

After dimpling the skins and machine countersinking the fiberglass, the tips are attached with CS4-4 “pop” rivets. Installing the rudder and elevator tips first will make it easier to fit and trim the tips of the horizontal and vertical.

Figure 6-5 details ideas on closing the open ended tips.

Note: On the RV-7 only, wait to install the fiberglass rudder bottom until the rudder is fit to the fuselage. It may need to be modified to clear the tail spring.

Figure 6-1

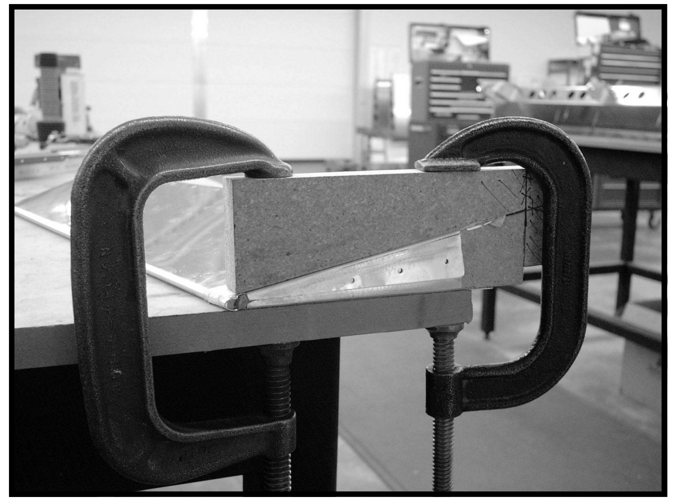


Figure 6-4

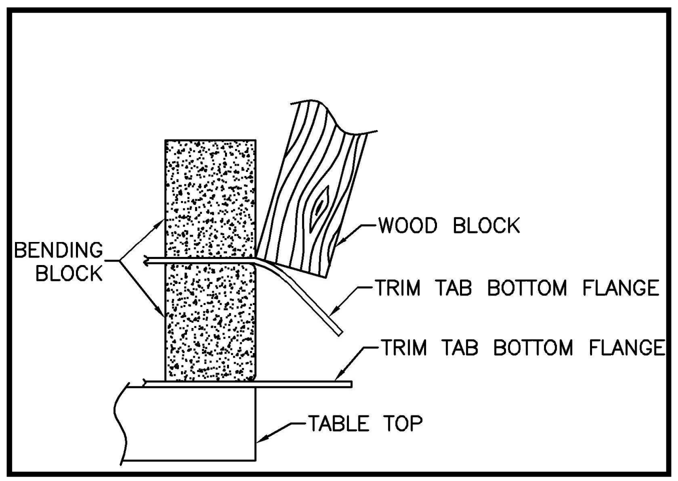


Figure 6-2

Figure 6-3

FIGURE 6-5

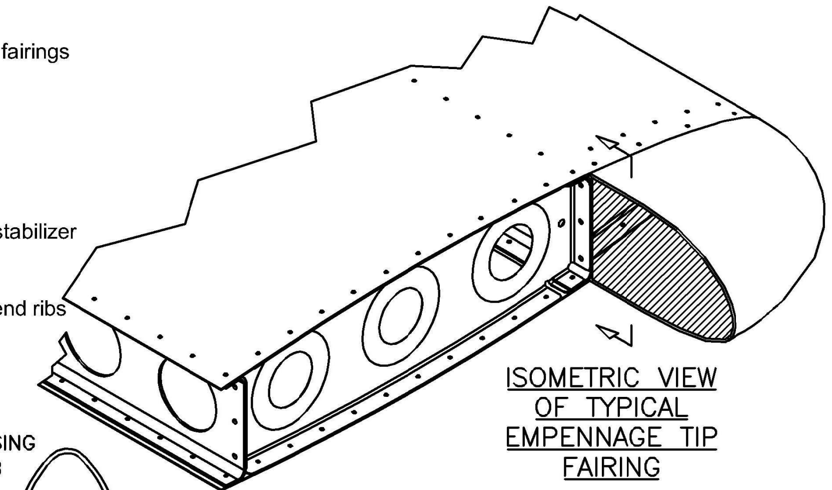
The open ends of the following empennage tip fairings must be closed:

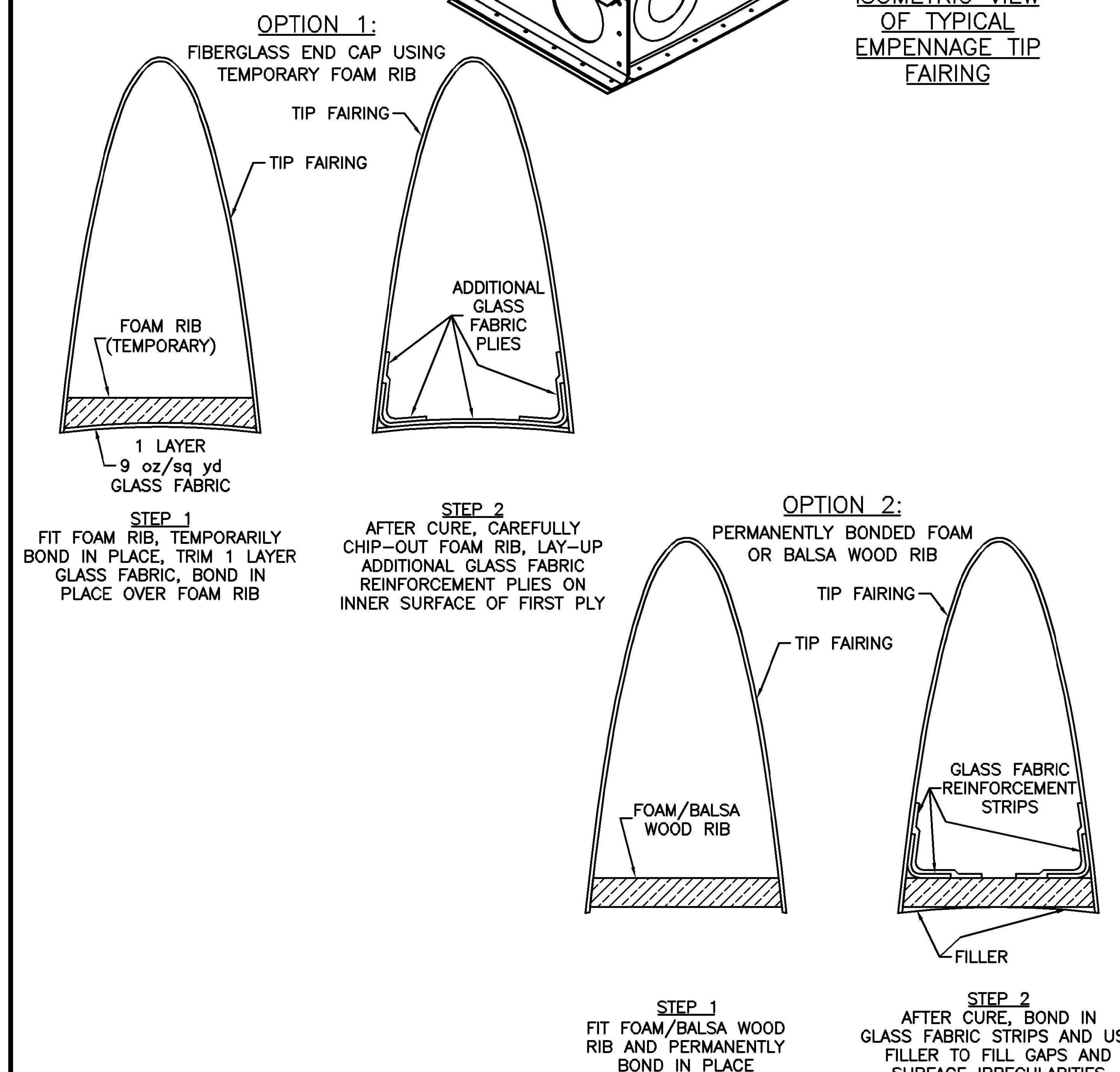
RV-7 & RV-8: Elevator and rudder

RV-9: Horizontal and Vertical stabilizers

The open ends of the RV-7 & RV-8 horizontal stabilizer tip fairings may be closed if desired.

A couple of possibilities for creating tip fairing end ribs are presented here.





SECTION 7: BUILDING THE WING

FIRST, A NOTE TO QUICKBUILDERS

All information necessary to complete the RV-7/7A QuickBuild Kit is contained in the standard Builder's Manual. The empennage, built from the Standard Kit, should be completed before starting the wings and fuselage. The skills learned during empennage construction are necessary during the rest of the project.

After completing the empennage, we suggest finishing the wings. They will not take long, and are relatively easy to store. The jig shown in the Builder's Manual is not required to align QuickBuild wings, but you may find it a convenient way to hold the wing while fitting and riveting.

Obviously, not all the information needed to build wings from the Standard Kit is necessary for wings built from the QuickBuild Kit. However, we still recommend reading the entire chapter to gain the "big picture." Once you understand the basics of wing building, you can extract the relevant information for the QuickBuild Kit.

Use the following sequence as a place to start.

- Install Wd-421L&R-PC bellcranks. See Builder's Manual section ATTACHING AILERONS TO THE WING and DWG 15A. Remove the top bracket to facilitate installing the bolt.
- Make the W-818 and W-716 pushrods. See Builder's Manual section ATTACHING AILERONS TO THE WING and DWG 15A.
- Install W-413L&R and W-414L&R aileron brackets on rear spar. See Builder's Manual section INSTALLING THE AILERON BRACKETS in the RIVETING THE WING SKIN Section and DWG 13A.
- Be sure lighting, wiring, and pitot line provisions are complete.
- Prepare and rivet the W-705 outboard bottom skin. See Builder's Manual sections RIVETING THE WING SKINS and FINISHING THE WING and DWG 12.
- Install the W-715 wingtip. See Builder's Manual section WING TIP INSTALLATION and DWG 12.
- Complete details of access panel in W-705. See DWG 12.
- Install the ailerons and flaps on the wing. See Builder's Manual sections FLAPS, ATTACHING AILERONS TO THE WING and DWGS 13A, 14A, 15A.

OVERVIEW

The wing assembly sequence begins with the construction of the main and rear spars. Leading edge and tank assemblies are then fitted to the main spar. The wing main ribs are then prepared and installed to the spars. The skeleton is placed in a holding fixture where the main skins are fitted. The wing is then checked for overall dimensions and twist. The leading edge and main skins are then taken off for dimpling, priming, and subassembly prior to final riveting on the wing. The bottom skins are left off until last. The internal parts of the wing (aileron and flap hangers, aileron and flap braces etc.) are installed. Riveting the lower outboard skin closes the wing.

GETTING READY

Before construction begins, spend some time building a few simple fixtures. Make a wing assembly stand by adding arms and supports to a vertical pair of 4X4s as shown on DWG 12A. Also on DWG 12A is a simple tool for aligning the ailerons and flaps.

The biggest fixture project is the wing stand shown on DWG 12A. If you take the time to build this before starting wing construction, you will have a convenient, safe place to store the finished wing panel. Some builders add custom details, like swiveling casters, to make the wing stand even more useful.

PREPARING THE MAIN SPAR

The main wing spar is supplied completely assembled and anodized for corrosion resistance. Carefully inspect the spar for shipping damage. Use a large marking pen to mark the orientation of the spar ("right top", "forward", "left bottom", etc.) and study the plans until you understand how the spars are installed. You do NOT want to build a wing upside down!

To begin wing construction, rivet the tank skin attach platenuts to the spar as shown in DWG 16A, Detail A.

Machine countersink (trying to dimple the 0.063 thick spar flange will result in severe distortion!) the platenut attach holes in the W-706A spar flange. See Section 5E. Use a microstop countersink with a #30 pilot to countersink the screw holes in the spar to the proper depth for the #8 screw. The pilot will center in the countersunk platenut well enough to keep the hole round and concentric. (Tip: cut a #8 screw short so that it enters the K1100 nutplate easily and use it to gage the depth.)

Attach the K1000-06 platenuts for the W-822 access plate to the W-706A flange (note that the access plate uses #6 screws on the spar flange and #8 screws around the perimeter.) See DWG 12. Dimple the access plate for a #6 screw, then machine countersink the spar flange to fit the dimples. Use a #40 piloted countersink cutter to center in the platenut. See section 5E to determine the depth adjustment of the countersink.

Attach the two K1000-4 center section attach nutplates to the forward side of the spar. Countersink the W-706C doubler plate to allow the flush heads of the rivets to rest on the aft side of spar. This allows the doubler plate to fit flush against the F-704G vertical bars (DWG 11).

Spot prime all countersunk holes where the anodizing has been removed.

Fabricate the tie-down assembly (DWG 15A). Make the two W-726 spacers, but leave them un-drilled. Cut the W-731 Tie-down bar to length from the AEX stock provided and drill the match hole at the dimensions shown. Clamp the W-731 and W-726 spacers to the spar and slip a bolt through the location hole and the hole in the spar. Align the W-731 and back drill all the bolt holes through the spar.

Remove the tie-down and spacers from the spar, cleco or bolt them together and drill the holes for the platenut rivets. Use a platenut as a drill guide. Machine countersink the W-726 spacers, rivet the plate nuts, spacers and tie-down together and bolt the assembly to the spar. Note that the plate nuts are NOT riveted to the spar web. If a platenut must be replaced, the tiedown assembly can be removed and the repair made out on the bench, without drilling rivets out of the spar.

Remove the assembly, deburr and prime. Install the tiedown assembly and the W-823PP bellcrank brackets on the spar. The tie-down rings are not supplied in the kit, as they are simply 3/8 inch eyebolts available from most hardware stores. Weld the eyes closed to add strength. If you prefer you can order forged tiedown rings (p/n Bolt Eye 3/8x16TD in Van's Accessories Catalog.)

Drill the W-706-L spar for the stall warning system wire run. See OP46-02 Step 8 and OP46-02 Figure 3.

ASSEMBLING THE REAR SPAR

The W-707 rear spar assembly, shown on DWG 10A, is a "Z" section channel, reinforced where it joins the fuselage and at the aileron brackets.

Deburr the edges of the W-707A rear spar channel, and the W-707E and W-707F doubler plates. Trim the ends and deburr the edges of W-707G & D as shown on DWG 10A & DWG 38.

Begin rear spar assembly by clamping the W-707E and W-707F doubler plates to the spar. Vertical placement is correct when the flanges of the spar and the reinforcement plates are tight. Lateral placement for W-707F is determined by aligning the outboard edges of W-707F and the W-707A spar channel. To place W-707E measure the distance between the outboard edges of W-707E and W-707A (See DWG 10A).

Using the spar as a template, clamp, drill and cleco W-707E/F to the W-707A spar channel. Mark and cut out the holes for the aileron pushrods. You can use a Unibit to remove a major portion of the area, and then use a round file or a rotary cutter in a die grinder to remove the remaining portion. Carefully smooth and deburr the inside of the holes.

Cleco the W-707G reinforcement fork and the W-707D rear spar doubler plate to the W-707A spar channel and drill the rivet holes to full size. Note: this part bends during punching and can be straightened easily by hand.

Deburr, prime and prepare the rear spar components for riveting. Note that some of the holes in the W-707F are machine countersunk for flush rivets (DWG 10A, Detail A).

Once the reinforcement fork is riveted to the spar, it is difficult to dimple some of the holes in the upper flange of the spar. On the inboard top flange, for the length of the W-707G, drill the holes for the main wing skin to final size (#40) and dimple them before attaching W-707G.

Some rivets in the rear spar reinforcements also attach ribs, aileron brackets, aileron gap fairings and the flap braces. Tape over these holes so you do not inadvertently put a rivet in one.

Rivet the components of the rear spar together.

PREPARING THE WING RIBS

You will save time if you set up and prepare all the ribs for both wings at the same time.

Begin preparing the ribs by deburring the edges of the flanges and lightening holes. A small Scotchbrite wheel mounted in a die grinder prepares the inside edges of the holes quickly and easily. Pay particular attention to the forward parts of the leading edge ribs. Remove all bumps around the notches to insure that the skin fits well.

Wing ribs come in seven flavors. Part numbers are marked on the ribs at the factory, but if you cleaned them off by mistake, they may still be identified:

- There are three types of main ribs, W-710, W-711 and W-712. At first glance they look identical, but they are not. W-710 is 0.032" thick. W-711 and W-712 are 0.025" thick. W-712 is slightly longer than W-711 and the 7/16" dia. hole near the front flange for the pitot tube line is omitted.
- There are two different leading edge ribs: W-408-1 and W-709. The W-408-1 rib is slightly (0.032") undersized around the perimeter to accommodate the W-423 joint plate, is 0.032" thick, and does not have holes in the curved flange.
- Tank ribs differ in thickness and hole pattern. T-703 ribs, used on the ends of the tanks, are 0.032" thick. The internal T-704 ribs are 0.025" and have a pattern of large holes to allow the fuel to run from one bay to another. The holes in the upper side are for venting air, and are located at the high point of the tank in a three-point attitude and in cruise flight. DON'T CONFUSE LEADING EDGE AND TANK RIBS. They look much the same, but the tank ribs are shorter.

Ribs may be either "left" (suffix L, i.e.: W-709-L) or "right" (suffix R, i.e.: W-709-R). You may identify the "hand" of a rib by holding it with the leading edge away from you with the flange closest to the tooling holes toward the floor. If the flange is on your left, the rib is an "-L", if it is on the right, it is an "-R".

Adjust rib flanges 90° to the web using hand seamers.

The forming process leaves ribs bowed, particularly the leading edge ribs. Straighten the webs with fluting pliers. Place the center of each flute at the midpoint between the prepunched holes. Use a straightedge or holes in a wing skin to check for straightness of the line of rivet holes. The straighter the parts, the better they will fit.

Make provisions for running stall warning system wires (left wing only) and, if you intend to install them, wingtip position lights, strobes or landing lights. Drill holes in the ribs for grommets, or conduit sold in VAN'S ACCESSORIES CATALOG. Opening up the tooling holes works well. Be careful not to interfere with the pitot line or control systems. Leave the tooling hole in the outboard tip rib undrilled for now. The smaller hole is useful for aligning the aileron. The 7/16" hole in the inboard ribs of the left wing get plastic grommets for routing the pitot tube line.

ASSEMBLING THE WING SKELETON

MAIN RIB/SPAR ASSEMBLY

Cleco the W-710, W-711 and W-712 ribs to the main and rear spars. Be sure the proper ribs are in the right locations and that wire and pitot tube routings are aligned. The ribs do not have all their flanges facing the same way.

Drill the holes attaching the ribs to the spars to full size. Most of the ribs simply fit to the spar without modification. However, two W-709 ribs just outboard of the tiedown require two new rivet holes (one near the top, the other near the bottom). Drill these, using the holes in the spar as guides. The two holes left unused in the rib are simply abandoned. A similar situation applies to W-711-L & R in the wing walk, use the top & bottom holes at the rear spar and drill new holes using the rear spar as a guide.

Remove the ribs and do the necessary deburring and priming.

Reassemble the ribs and spars with clecoes.

Put protective tape on the W-706B/D spar flange bars to prevent bucking bar damage when installing the top and bottom most rivets. Rivet the main ribs to the front and rear spar, EXCEPT for the outboard W-712 rib, which is riveted to the rear spar, but not the main spar. Place the manufactured head of the rivet on the rib flange (side with thinnest material), to prevent distorting the parts.

WING STAND

Although the matched-hole process eliminates the need for the traditional wing jig, mounting the wing in a stand will make it easier to build. A stand allows access to both sides of the wing and makes it easy to take measurements and assure the wing is straight. The wing has no washout, twist or taper.

The stand (shown on DWG 12A) is simple; two vertical posts run from floor to ceiling. Horizontal arms of steel angle or wood, bolted to the posts, support the main spar. The size of the posts and arms is not important, but they must be sufficiently strong and rigid to support the wing.

Clamp or bolt the wing skeleton to the horizontal arms of the jig. To provide a mounting point on the outboard end of the wing, drill and bolt a temporary 5" long piece of aluminum angle, parallel to the spar web, to the outboard rib with 3/16" bolts. The small additional holes in the ribs will not compromise strength.

The center of the skeleton will sag toward the floor when it is mounted in the stand. To make installing and removing the skins easier, support the skeleton in the middle. Run a fishing line along the rivet holes in the main spar. Then adjust the middle of the skeleton with a 4x4 wood block and shims, screw jack, etc., (almost anything that will remain stable works) placed under a rib. Raise the skeleton just enough to bring the rivet holes even with the fishing line along the length of the spar.

FITTING THE WING SKINS

Wing skins are pre-punched with pilot holes for the ribs and spars. The vinyl can be left in place when fitting and drilling the main wing skins to prevent scratches (except on the inside of the leading edge and tank skins, where the vinyl should be removed before fitting.) Remove the vinyl before dimpling to prevent pounding trapped drill shavings into the skin with the dimple die.

FITTING THE WING WALK DOUBLERS

The wings have doublers under the main skin next to the cabin sidewall to add strength and help support the loads imposed by people entering and leaving the airplane. Make the wing walk doubler (DWG 12) from AS3-025x9 3/8x26. Lay W-702 on a bench and slip the doubler underneath it. The doubler nearly butts against the aft edge of the main spar channel and overhangs the rear spar by about an inch. Align the inboard edges and set the forward edge of the doubler 9/16" aft of the forward edge of the skin. Using the skin as a guide, drill all the holes for each rib in the wing-walk doubler.

FITTING THE MAIN SKINS

Cleco the forward row of holes in W-702 and W-703 skins to the matching holes in the main spar. Cleco the W702 and W-703 skins to the ribs using a cleco in every fourth hole.

Don't forget to insert the doubler between the ribs and the W-702 skin. The main skins overlap at the eighth rib from the root. The outboard skin should fit on top of the inboard one.

Gently pull ribs into position if the matched holes do not align with the skin holes. Drill all the holes to final size.

Start drilling in the upper middle of the panel and work down and out toward the edges, work out any slack as you go.

Move the clecoes down one hole (into the drilled holes) and drill all the remaining holes.

Repeat the procedure for the W-704 and W-705 bottom skins.

Draw a couple of lines on the main skins that intersect at the center of the hole for the tiedown eye.

Remove the bottom main skins before fitting the leading edge and tank skins. Leave the top skins clecoed.

LEADING EDGE ASSEMBLY

BUILDING THE CRADLE

Construct a cradle as shown on DWG 12A to hold the tank and leading edge during construction. Don't waste time making the cradle perfect, since it simply holds the leading edge, and has no bearing on alignment. Use a W-709 rib to trace the shape. Pad the surfaces of the cradle with something soft to prevent skin scratches.

FITTING THE LEADING EDGE

Remove the vinyl from the inside surface of the W-701 leading edge skin.

Modify the W-701-L leading edge skin for the stall warning assembly. Complete OP46-02 Steps 1-4 and OP46-03 Steps 1-5.

Place the W-701 leading edge skin in the cradle. The ribs are much easier to install with it pre-bent to shape in the cradle.

Cleco the W-709 ribs into the W-701 Leading Edge Skin. Install the clecoes on the top first; working from the front to the rear. Then cleco the bottom, also working from the front to the rear. Cleco the VA-195F mount bracket to the W-701-L leading edge skin (OP46-04 Step 8). The most inboard rib (W-408-1 Leading Edge Rib) is not pre-punched with holes and will be installed later. Mark the ribs so they may be reinstalled in the same location.

Remove the leading edge assembly from the cradle and place it on the spar. Put clecoes through the spar into the ribs. Also cleco the W-701 Leading Edge Skin to the wing spar through about every third hole.

Slide the W-408-I Leading Edge Rib in place starting at the lower aft edges of the Leading edge skin. Back drill the rear flange from the spar and cleco in place. Mark a line on the W-423 Joint Plate 1/2" (with the vinyl removed) from the edge. This line will match up to the holes in the skin, leaving 11/16" exposed to support the tank skin. You can pre-bend the W-423 to make it fit better around the leading edge.

Work the W-423 Joint Plate into place between the W-701 Leading Edge Skin and W-408-1 Leading edge rib. You can gently tap the rib or strip with a soft hammer to coax things into place. When the strip is in position you will see the line through the pre-punched holes in the skin. Re-check the position of the W-408-1 rib by measuring from the edge of the joint plate to the web of the rib.

Drill all the ribs and the joint plate through the pre-punched holes in the leading edge skin.

Extend the lines for the tiedown eye onto the leading edge. They should intersect at the pre-punched hole but variations will occur. If necessary, file the hole in the correct direction to center it over the tiedown hole, then drill it full size with a Unibit.

Leave all of the clecoes in place and move on to the tank.

ASSEMBLING THE FUEL TANKS

The fuel tanks are also the inboard leading edge of the wing, so they are constructed in a manner similar to the outboard leading edge. However, the tank is removable so the tank ribs can not be permanently attached to the spar. The tank is attached to the wing two ways. Flush machine screws fasten the skin to the spar flanges and bolts hold the T-712 fuel tank attach brackets (mounted on the rear tank baffle) to the spar web. The tank is also held to the fuselage by the T-405 attach angle.

Fuel tank construction and details are on DWG 16A.

FITTING THE ATTACH ANGLES TO THE SPAR AND REAR TANK BAFFLE

Mark a vertical centerline on the forward and aft flanges of all the T-712 attach angles.

Find the exact lengthwise center of each flange. Drill a 1/8" hole in one flange of each angle. Set one T-712 aside and drill a #12 hole in the center of the other flange on the remaining six. When you are done, six of the attach angles will have a 1/8" hole in one flange and a #12 in the other. The seventh attach angle will have one 1/8" hole in one of the flanges and the other flange will be blank.

Cleco the six drilled T-712 Attach Angles to the aft side of the pre-punched main wing spar so you have good access with the drill. Position them so the centerline is centered in the pre-punched holes in the spar. Clamp the angles in place and drill the remaining holes using the spar as a guide.

Remove the angles and drill & rivet the nutplates to them, then bolt them in place on the front of the main wing spar.

Cleco the T-702 Baffle to the forward side of the T-712 Attach Angles. Check to see that the centerlines on the angles are visible through the holes in the baffle.

Cleco the seventh attach angle to the tank baffle between the baffle and the spar. Verify that you can see the centerline on the angle through the holes in the baffle and the spar. Back drill through the spar for the three AN3 bolts that attach the angle to the spar. Do not drill the other four holes through the baffle to the angles yet.

Install the three nutplates on the aft side of the spar.

FITTING THE TANK SKINS TO THE RIBS AND REAR BAFFLE

Complete any remaining rib preparation details. Bend flanges 90° and flute ribs. Use a square to check the flanges and a straight edge and/or skin to check the ribs for rivet hole alignment.

Make all T-711 A through D stiffeners as shown on DWG 16A. Round all stiffener corners, deburr edges, then cleco and final drill them to the T-701 skin.

Cleco the tank skin to the baffle (still fastened to the spar) and the wing spar. The fit between the spar, baffle, tank skin and leading edge should be perfect. If not, elongate the holes in the baffle inboard or outboard as necessary to allow the baffle holes to align with the T-701 holes when T-701 is clecoed to the spar.

Remove the T-701 skin and cleco all the tank ribs to the baffle. Drill the rib/baffle/attach bracket holes full size. Use a drill stop to prevent damaging the spar.

Remove the vinyl from the inside of the tank skin and cleco the skin to the ribs, baffle and spar.

Match drill T-701 to W-423.

Remove the clecoed tank assembly from the wing, and drill all rivet holes to final size. (Doing so off the wing prevents accidentally drilling into the spar).

Machine countersink the spanwise rows of holes in the T-701 tank skin (not the baffle) that attach the skin to the T-702 baffle. Have the baffle in place so that the pilot has a good hole to guide the countersink. This makes it easier to slide the baffle into position on final assembly.

Drill the spar attachment screw holes and the W-423 screw holes to final size using a #19 drill.

Disassemble the tank, marking all parts so they may be easily returned to the same location.

Fabricate the T-405 tank attach angle and pre drill with the rivet holes per DWG 16A.

Clamp the T-405 and T-410 reinforcing plates in place on the end ribs and drill the attach holes.

If you plan to use the capacitive fuel gauge senders offered in the VAN'S AIRCRAFT ACCESSORIES CATALOG you should complete their installation at this point using the instructions supplied in the sender kit.

FINAL PREPARATIONS

Modify the inboard end ribs as shown in the right side view of DWG 16A. The large hole for the access cover is best cut using a flycutter on a drill press.

Stiffener ring T-407 and access plate T-708 are supplied pre-punched. (The T-708 access plate is designed to mount the Stewart-Warner float-type sender offered in VAN'S ACCESSORIES CATALOG. If you wish to install a different sender, the T-411 plate is available without the sender mounting provisions).

Clamp the T-708 cover plate on the rib with the flat forward edge aligned with the stiffener bead, and an equal distance to the top and bottom rib flanges. Drill all of the screw holes, clecoing as you go (be sure the hole for the fuel pick-up tube is oriented toward the top of the tank). Remove the T-708 and cleco the T-407 in place.

Drill all of the platenut rivet attach holes. Remove the T-407, deburr all holes, dimple the rivet holes in the rib, and machine countersink the rivet holes in the T-407 for the dimples. Rivet the T-407 and the platenuts in place. The gasket under the T-708 cover plate will seal these rivets, so they do not have to be set with tank sealant.

Fit and drill the T-406B fuel cap flange. Use the cap (installed in the cap flange) as a guide for centering the flange in the tank skin opening. Note that the cap flange has two slight bends in it to help it to conform to the curve of the tank skin. Make the T-714 clip from a scrap piece of aluminum and drill it for installation sharing one of the cap flange rivets. Countersink the top of the T-406B to accept the dimples in the tank skin.

Center the VA-112 drain flange on the prepunched hole and drill it to the tank skin. Machine countersink the holes for the attach rivets.

Dimple the skins and ribs. Dimple the holes for screws with the C-frame tool and a hammer, instead of trying to form them with a rivet squeezer. It looks nicer.

Do not prime any area that will be on the inside of the tank. Fuel could have an adverse effect on the primer, or (worse) vice versa. At this point, all parts of the tank should be deburred, dimpled, and primed as necessary.

ASSEMBLING AND SEALING THE TANK

Plan on two or three work sessions to seal a tank. Working on both tanks at once will help to speed things up. See section 5S for more information. The tank is riveted together just like any other structure with one very important difference. Apply sealant between the parts to any seam through which fuel could conceivably leak. This includes every rivet. The recommended sealant, MC-236-B2 is available through VAN'S ACCESSORIES CATALOG.

Although the sealant used to seal the tanks is not particularly noxious, only use it and the solvents used in tank construction with adequate ventilation. Use a respirator, gloves (which also keep oil from your skin off the surfaces to be sealed) and protective cream when sealing the tanks. Why expose your skin and lungs if you can prevent it?

Roughen all mating surfaces using a scotchbrite pad. Don't be bashful; score the aluminum well, so the sealing compound will have more surface to grip.

Clean the manufacturing residues and oils off all the rivets by sloshing them in a jar of solvent and drying them on a clean rag. Clean the mating surfaces of the skin, stiffeners and ribs. Clean every surface that the sealer is applied to. Recommended cleaners include naphtha or MEK. Builders have also reported excellent results with etching using a light phosphoric acid (brand names include AlumaPrep or Twin Etch).

It is essential that the surface of the aluminum be clean when the sealer is applied. Not just kind-of-clean or clean enough. Clean.

After cleaning, do not pollute the areas to be sealed. Don't even touch them. Oils from your skin will affect the bond of the sealant.

The tank sealant should be mixed as accurately as possible. This is done by weight. Follow the instructions supplied with the sealant. When mixing sealant, do not mix too much at one time. A batch the size of four or five golf balls is usually enough for one work session. The sealant provides 45 to 90 minutes of working time (less in warmer temperatures). Measure by volume or weight as accurately as possible and mix thoroughly before applying. To use the sealant as soon a possible, have all the work well planned and tools all laid out. Have a container of acetone, MEK, or lacquer thinner nearby for the frequent tool cleanings necessary during riveting. You can peel away overflow on areas you want to keep clean by strategically applying plastic tape before spreading the sealant (such as along any areas of the skin that have to mate flush with the wing spar or W-423 splice plate).

After thoroughly mixing the sealant, use Popsicle sticks to apply an approximately 1/16" thick layer to the parts being riveted. In the first work session rivet on the T-711 stiffeners. Back-riveting works well here, so spread a thin layer of sealant on the inside of the skin, covering the area the stiffener will contact, then insert the rivets into the skin from the outside and tape them in. Press the stiffener into place. Sealant will ooze out around all the stiffener edges. When the stiffener is firmly seated, back rivet it permanently into place. Even more sealant will squeeze out as the rivets set. Clean this away, making neat fillets around all the edges of the stiffener with the curved end of the Popsicle stick. Dab a bit of sealant over every rivet head.

Rivet the VA-112 drain flange, T-406B fuel cap flange and T-714 clip to the skin, using sealant in the same way. Cover the aft tooling holes in the outboard T-703 end ribs by riveting on a small plate, or by filling the hole with an AN470AD6 rivet. (See Figs. 7-8, 7-11.) After each session clean everything that you do not want to have a permanent coat of sealant. It is much easier to clean up before the sealant sets.

For the next session, rivet all the interior ribs to the skin (if you can only do a few ribs at a time, that's fine.) Work in the “cradle." When assembling the tank, cleco all ribs to the skin. This keeps the assembly straight. You may want to start riveting with the rib next to the outboard one. After this rib is clecoed in place with sealant you can remove the outer end rib for easy riveting access. Remove the ribs one at a time, apply sealant, and rivet. When riveting the ribs to the skin work from the leading edge to the trailing edge.

Insert the rivets and set them with a squeezer or a rivet gun, as appropriate. Use the Popsicle sticks to form the squeezed-out sealant into fillets in the rib/skin joint. Apply extra sealant to the rivet heads.

Next, install the inboard end rib. After the rivets joining this rib to the skin are squeezed, install the T-405 and the T-410 (fitted to the inside contour of the skin as shown on DWG 16A) on the leading edge. Put a thin layer of sealant on the sealing surfaces. (If T-405 were installed on the rib before riveting the rib to the skin, the skin rivets around the leading edge would be very difficult to set.)

Seal and rivet the other T-410 to the outboard end rib. Three or four AN470 rivets is sufficient.

Apply a generous fillet of sealant around the inside of the end ribs where they join the skin, particularly at the very leading edge. Also make sure the outboard end rib aft tooling hole has been sealed. Finally, clean any excess sealant from the rear of the ribs and skin where the baffle will later rest and clean any sealant smeared on the outer surfaces. Once cured, it is difficult to remove.

CLOSING AND FINISHING THE TANK

If you are using a float type fuel sender, adjust and check it before closing the tank. Dimensions for the float arm of the IE F-385 B/C sender in VAN'S ACCESSORIES CATALOG are shown on DWG 16A. Make an electrical check with a 12-volt battery and a fuel gauge, or a multimeter should show about 32 ohms when the sender is in the "full" position and about 240 ohms in the “empty” position.

Install the fuel pick-up tube and position it so it lies on the bottom of the tank. Use a small amount of sealant to seal the rivet holes.

Check all final details before installing the baffle and closing the tank. Check that the tank vent line is in, and its outlet is at the tank high-point. Check the vent line bulkhead fitting to see that it is tight and that it has been installed with sealant.

Assured that everything is in order, apply sealant to the tank skin from the rivet holes forward. Upon installation the baffle acts as a squeegee and the bead of sealant will be pushed ahead as the baffle is moved forward. Use a

maximum of 3/16' bead of sealant. Too much, and the thickness can start to build up, making the tank difficult to install on the wing. Put a bead of sealant along the inside edge of the flange on each end rib. Put a heavy glob of sealant where each corner of the baffle will meet the end ribs (this is one of the most common locations for leaks).

Put a very thin smear of sealant around each of the rivet holes on the back flanges of the T-703/4 ribs.

Important: You may have noticed that the tank ribs have a larger notch in the lower corner than in the top corner at the rear flange. This is to allow any water that may condense in the tank to run to the low point and be drained. Be careful not to allow the tank sealant to block off this path.

With the tank sitting in the cradle, install the T-702 rear baffle assembly by dropping it straight down onto the rear flanges of the ribs.

Put a cleco in every hole of the T-701 skin to T-702 baffle joint. After clecoing, inspect the skin to see if it is pillowed out between the clecoes. The contact surface of the tank baffle flange may require pressure to force out excess sealant. The easiest method is to apply a c-clamp or strong spring clamp between each set of rivets and squeeze out the excess. If you are unsure, clamp the flange in a couple of spots and see if it makes a difference.

Twirl the AD-41 H closed end blind rivets in sealant and set them in the top and bottom baffle-to-rear rib-flange holes. The T-712 brackets are installed last. Check to be sure the platenuts have been installed on them because it is much more difficult to do once they are riveted to the tank. Put a very light smear of sealant over each hole for mounting the T-712 brackets. Note that the brackets on each end of the tank use solid rivets, not blind rivets. While double-checking with DWGs 16A and 10A, cleco each T-712 bracket in place. Be sure you get them oriented correctly because they will shortly be very difficult to change. Install the AD-42H blind rivets in the T-712 brackets after twirling them in sealant. This may require modifying a blind rivet tool by grinding enough of the puller “nozzle” away to get into the corner of the Z angle.

Finish all riveting and clean any excess sealant off the tank.

To mount the T-708 cover plate use an 1/8” inch thick bead of fuel tank sealant between the cover plate and the inboard rib. Dab a small blob of sealant on threads of each attach screw, insert into the holes, and tighten them sequentially until sealant bulges evenly about 1/32” from underneath the perimeter of the sender plate. Some builders may optionally seal the T-407 gasket to the tank with sealant as well, viewing the cork ring as sacrificial if the cover is removed. The sealant will also form a small gasket around each screw head.

Install the IE F-385 Sending Units with sealant using the appropriate hardware. DO NOT install the rubber gasket supplied by the manufacturer. Use the same procedure for sealing the sending unit as was accomplished above.

A continuous electrical path is necessary between the airframe and the sender plate so be sure that at least one of the screw heads is making metal to metal contact with the outside of the sender plate. Conduct a final electrical continuity test for the sender units with an Ohm Meter by probing the tank body and the sender center screw to ensure proper operation.

Wait at least 24-48 hours and then conduct a fuel tank leak check using the FUEL TANK TEST KIT available in the VAN'S ACCESSORIES CATALOG.

RIVETING THE WING SKINS

There is a definite order in installing the wing skins. First, the leading edge (built off the wing) is installed. Then the top main skins are installed. The wing is then rigid enough to remove from the stand and install the ailerons, flaps and work on the internal details. After that is complete, the wing is laid, top down, on a large table and the bottom skins are riveted.

WING SKIN PREPARATION AND ASSEMBLY

Remove the skins, deburr and dimple them. Complete OP46-02 Steps 5-6 deburring and dimpling (rivet parts when riveting skins).

Prepare the skeleton while it is still fastened to the stand. Drill a 7/16" hole in the left W-701 outboard leading edge skin and the left main spar flange for the pitot tube fitting (see DWG 15A.)

Dimple the ribs with a hand squeezer. The 0.063 main spar channel is too thick to dimple so it is machine countersunk per section 5E.

Dimple the 0.040 rear spar and “touch up" the dimpled holes slightly with a sharp deburring bit or microstop countersink. This "touch up" operation removes just a small amount of metal to make the skin dimple fit better and is not critical, so it can be done by eye. The usual tendency is to remove too much metal, so use a light touch.

Drill the W-423 splice plates for installation of the platenuts. Deburr all holes. Dimple the screw holes and the rivet holes for the rib and the platenut attachment. The holes for attaching to the rib and skin can be slightly touched up (like the rear spar) to gain a better fit between the skin, the splice plate, and the rib.

Cleco the main skins to the wing skeleton. The skins overlap, outboard skin over inboard. This means that the doubled skins will protrude above the aft edge of the tank skin at the spar. File the corners of these skins, starting at a point 3 or 4 inches from the corner, making each of them progressively thinner toward the edge. This will form a sort of "scarf joint" and lower the forward edge, making a clean joint with the tank skin. It is NOT necessary to scarf the whole width of the skin, just the corner.

This is the point of no return; the point where things start going together permanently. Make a close inspection to assure everything is clean and proper before continuing.

ASSEMBLING THE WING LEADING EDGE

Rivet the Leading Edge Assembly by fitting the skin into the cradle and then clecoing in the ribs and the W-423 splice plate. After making sure that the holes at the aft end of the ribs are exactly aligned, rivet the aft most rivets on the top and bottom using a rivet squeezer. Finish the riveting by working from the rear towards the L.E. one hole at a time.

INSTALLING THE LEADING EDGE

Install the leading edge assembly on the wing skeleton. While the main skins are off, there is room to reach in and rivet the rib flanges to the spar web. This will require an offset rivet set. Remember the outboard W-709 and W-712 ribs are both riveted together in assembly with the W-706A spar web. After riveting the ribs to the spar, rivet the spanwise row of rivets, top and bottom, along the main spar web, using a rivet squeezer.

Install the fuel tank on the wing, with screws in every other hole, top, bottom and around the leading edge. Install about half the bolts in the Z-brackets.

RIVETING THE TOP SKINS

With the outboard leading edge riveted in place and the tank installed it is time to rivet the top main skins. While it is possible for one person to install the first set of main skins, it is much easier with two. Rivet the W-702 inboard skins first, because the outboard skins overlap them.

Begin by clecoing the inboard skin in position (wing walk doublers, too) and start riveting. To assure maximum skin tightness, rivet from the center rib of each skin outward towards the root and tip. Do this on both the inboard and outboard skins, saving the double row of rivets at the lap joint until last.

Many builders find that they can get a nicer skin finish (especially when they are using less experienced helpers) if they back-rivet the wing skins. Use a large bucking bar laid over the rivet on the outside of the skin, and drive the head on the rivet from the inside using an extended back-rivet set available from some suppliers.

When the top main and leading edge skins are riveted on, remove the wing from the stand and put it on a padded worktable, top down. Block the wing so it doesn't rock around on the table.

If you are installing leading edge landing lights (p/n LL DW-01 in Van's Accessories Catalog) it is easiest to do it now, before the bottom skins are permanently installed.

INSTALLING THE AILERON BRACKETS

Assemble the W-413 and W-414 Aileron bracket assemblies as shown on DWG 10A. Install them on the rear spar by lining up the matched holes, drilling, deburring, and riveting.

INSTALLING THE FLAP BRACE AND AILERON GAP FAIRINGS

Drill, deburr, dimple where required, and rivet the W-721 flap brace (DWG 14A) to the rear spar.

QUICKBUILDER'S NOTE: *The W-721 must be attached to the rear spar with blind rivets. See the note on DWG 14A, Section B-B'.*

Drill the W-724 aileron gap fairing (DWG 13A) to the rear spar. Drill, deburr, and dimple where required, and rivet the W-724 aileron gap fairing to the rear spar.

RIVETING THE BOTTOM SKINS

The bottom skins are riveted while the wing lies top down on the bench. Begin with the inboard skin and rivet it to the rear spar, between the inboard wing walk ribs. This means pulling the skin back until you can reach the rear spar with a bucking bar. While it is possible for one person to rivet the bottom skins working solo if they use some sort of tape/rope/clamp system to peel the skin back, many builders find the job easier with a helper.

Be careful when pulling the skin back. If you try to bend it too sharply, you will get an unsightly, and irreparable, kink.

Work in an "L" pattern, riveting toward the tip along the rear spar, then about halfway up the wing rib. Before the skin is riveted all the way to the main spar, move to the next bay and repeat the process. After the second bay is partially riveted, complete the first. Riveting gets much easier as you move forward, because of the improved access through the larger holes in the ribs and the inspection openings. Once the inboard skin is riveted, the outboard is installed the same way, beginning on the inboard rib and working toward the tip.

Lay the skin back down after every bay or so and check to see that all the holes in the skin and the skeleton still align and that the skin is not "creeping" outboard.

AILERONS

The construction technique for RV-7/7A ailerons (DWG 13A) is similar to that of the elevators. The aileron uses ribs at the ends only; light angle stiffeners support the rest of the skin. The A-710 skin stiffeners are provided with the rivet holes pre-punched but not cut to length. The aileron skin is punched to match. These are match-drilled much like the stiffeners in the empennage. Cut and trim the stiffeners as shown on the drawing. Locate the stiffeners on the inside of the A-801-1PP rear aileron skin and drill.

Dimple the stiffener angles and skin. After priming (if desired), rivet the stiffeners onto the skin, preferably using the backriveting method described in Section . Following this, complete the trailing edge bend using the homemade bending brake used on the empennage. The bent skins must be straight up to the radius and the radius must be between 3/32" to 1/8". Match the degree of bend to the full size end view drawings. The upper and lower skin should just touch the spar when placed in position.

The A-403PP aileron spar is not symmetrical; the top and bottom flanges are bent to different angles. Check and label each spar for top, bottom, inboard and outboard. Make the A-408 aileron spar reinforcement brackets from supplied .040" material. Match-drill using spar holes as a guide and cleco as you go. Cleco the A-406-1 and A-407 aileron brackets in place and drill #12 for attach bolts. Label the parts, disassemble, deburr & prime as desired. Making sure that you leave the holes that will later attach the ribs empty, rivet the A-408 aileron spar reinforcement brackets on the spar along with the K1000-3 plate nut.

The wide tabs on the top of the A-704 nose ribs have no pre-punched holes, they will be match drilled from the nose skin. Flute the center of the tab slightly to remove any distortion from the manufacturing process. Use the nose skin holes as a check for straightness. Cleco and match drill the nose ribs to the spar.

Look closely! The A-705 aileron ribs are NOT symmetrical, so be sure you have them installed correctly. The tooling holes are nearer the bottom of the aileron. Cleco and match drill the A-705 main ribs to the spar.

Cleco the A-802PP leading edge skin and the A-801-1PP trailing edge skin to the spar with the A-409 counterbalance pipe in place. Match drill the skins to the skeleton including the #30 holes in the counterbalance pipe. The holes along the bottom of the spar are opened to #30 for the CS4-4 blind rivets. Remove the trailing edge portion and re-cleco the leading edge in place with the counterbalance pipe in position. Using a long 1/8" drill, go through the lower hole that attaches the A-704 nose rib to the spar and drill through the tab on the rib into the counterbalance pipe.

Disassemble the parts, deburr, dimple and prime as needed. Machine countersink the holes in the counterbalance pipe. The countersink need not be 120° to match that of the rivet heads. The .020" skin and the aluminum blind rivet will deform sufficiently to contour to a 100° countersunk hole.

Attach the nose ribs to the counterbalance with blind rivets. Bend the tab on the nose rib juse enough to clear the rivet tool.

Cleco the leading edge skin to the counterbalance/rib assembly, rivet the nose ribs to the to the spar. Cleco the aft skin to the spar. Leave out the main ribs and the clecos along the bottom of the spar to allow access to the inside. Rivet the leading edge skin and tariling edge skin to the top of the spar. Rivet the nose ribs to the the top half of the nose skin only. Insert the main ribs and rivet them to the spar and top of the aft skin. Install the A-406-1 and A-407 brackets.

Flip the assembly over , cleco it together and weight it down on a flat work surface. Blind rivet the counterbalance pipe to the leading edge skin. Keep checking that the aileron is flat. Rivet the bottom side of the nose rib to the skin. Rivet the bottom side of the main ribs to the aft skin. Last, blind rivet the leading edge and aft skins to the spar.

FLAPS

Flap details are shown on DWG 14A. The flaps are the easiest control surfaces on the RV-7/7A to build. The only jigging required is a level, flat surface at least 5' long and 1' wide. Easy or not, it is possible to build in an unacceptable twist, so work with care.

Prepare the FL-703 flap spars by deburring the lightening holes and polishing the edges.

Drill and cleco the FL-704 and FL-705 ribs to the spar then cleco the assemly to the FL-702 bottom skin. Make the FL-708 spacers that go between the end ribs and the bottom of the top skin. The aft edge of the ribs should contact the "rear spar" bent into the bottom skin. Thin shims between the aft end of rib and the rear spar are acceptable.

After making any necessary shims, drill the ribs to the rear spar.

Drill the ribs to the bottom skin. The line of rivets along the bottom of the spar holds the hinge that will connect the flap to the wing. Drill and cleco on the hinge as well. Pinning the two halves of hinge together while drilling will help hold the hinge straight.

Instead of dimpling the bottom of the spar, dimple the skin and machine countersink the spar, with the hinge clecoed on to serve as a guide for the countersink pilot. The soft hinge does not have to be countersunk or dimpled.

Fit the FL-701 top skin to the assembly. Cleco the top skin to the spar, align the holes along the ribs and drill these before drilling the line along the bottom of the flap.

Fabricate the FL-706A. Fit the FL-706A and FL-706B to the inboard rib and inboard end of the spar. Rivet the FL-706A to the spar with the AN rivets only, leaving the holes that will attach the rib open.

After the necessary dimpling, priming, etc., begin riveting the flap together. A cradle, made with simple V-blocks like those used in the empennage, is a useful aid. Put the flap in the cradle and remove the spar to gain access to the rear row of rivets that join the top and bottom skins. Rivet the interior ribs to the skins, but leave the end ribs clecoed.

Rivet FL-706B and the platenut to the inboard FL-704 rib, then rivet the rib to the skins...you must set these rivets before "closing the door" by putting the spar in place.

When all the ribs are riveted to the skins, rivet the spar to the ribs with blind rivets, then rivet the spanwise lines that join the spar and hinge to the skins. Finish riveting the end ribs.

Expect to trim the upper skin of the flap slightly when the wing is mated to the fuselage, but for now, leave it untouched.

NOTE: The bearing CM-4MS, shown on DWG 14A, is supplied in the fuselage kit, not in the wing kit.

ATTACHING AILERONS TO THE WING

Completely finish the flaps and ailerons before mounting them to the wing.

Set the wing, with the leading edge and the top main skins riveted on, on a workbench, topside down.

Assemble the W-716 and W-818 pushrods as shown in DWG 15A. Prime both pushrods inside and out. Cover the inside by pouring a small quantity of primer inside the rod and slowly swirling it around or by spraying into each end. Rivet the AN49OHT8P or VA-111 rod ends to the pushrod.

Make sure the primer is fully cured, then thread the rod-end bearings and jam nuts on. Temporarily tape the pushrod where it passes through the rear spar, so when aileron is removed the primer won't be scraped away.

Install the WD-421 bellcrank as shown on DWG 15A. The bushing in the WD-421 needs to be drilled to final size for the slip fit on the AN4 bolt. The bushing should be slightly longer than the WD-421 aileron bellcrank. It is held firmly between the bellcrank brackets with the bolt. The bellcrank rotates around the bushing, not the bolt. This is the same way that the stick assembly is done also. Lubricate the bushing with your favorite grease when assembling for the final time.

Connect the W-716 and W-818 pushrods to the WD-421 bellcrank. Use the W-730 bellcrank jig provided to set the bellcrank in the correct neutral position. Use the alignment tool you built at the beginning of the wing construction to

position the aileron in the neutral position. Clamp the aileron in this position and adjust the rod end bearings on the W-818 push rod until the pivot bolts at the bellcrank slip in smoothly. Tighten the jam nuts and label the push rod right or left as appropriate. Final adjustments will be made to the W-716 push rod later, when the wing is installed on the fuselage.

ATTACHING FLAPS TO THE WING

There are two good methods of installing the flap hinge pin. The choice is yours.

Drill a small hole in the W-413 aileron hinge bracket assembly for the flap hinge pin to just go through. You will not be able to get this hole exactly in line with the flap hinge line, but this is a good thing. Drill the hole in the approximate position and when you insert the hinge pin for the flap, the pin will spring into position after being pushed all the way through and not be able to come out on its own. You may have to disconnect the aileron pushrod in the wing to remove this pin after the aircraft is fully assembled. This will allow you to swing the aileron out of the way for pin removal.

An alternative method is to remove one hinge eye at the center of the flap hinge and two hinge eyes at the center of the wing hinge. This will allow you to get two hinge pins in from the center of the flap, one in each direction. Bend a small portion of the hinge pin at a right angle to grasp with pliers as you slide the pin into place. With the flap hanging down the hinge is accessible from the opening at the top. Push the bent portion of the pins forward to lie on the inside of the skin. Drill two small holes in the skin and safety the hinge pins in place.

FINISHING THE WING

INSTALLING THE PITOT LINE AND WIRES

Install the pitot line and fittings shown on DWG 15A. Install SB437-4 snap bushings in the 7/16" holes for the Pilot line in W-710 and W-711. Put the low profile face of the bushing on the flange side of the rib, to ease access to the skin rivets later.

Complete the stall warning assembly instructions OP46-04 Steps 1-7 and OP46-05 Steps 1-6. Complete Op46-06 Steps 1-8 when installing the electrical system.

Double check that you have done everything else inside the wing that you wish to do such as installing wiring for wing tip lights, installing a wing leveler servo, etc., before closing up the wing. If you have not decided on some of these items, riveting the bottom skins can wait until much later in the project.

WING TIP INSTALLATION

Delay wing tip installation until late in the construction process, preferably until the aircraft is nearing final assembly. This prevents the possibility of damage from handling and gives every opportunity for the installation of lights, wing tip antennae, etc.

The tips may be installed with the wing lying down on a table or with a wing positioned in a cradle style storage fixture. See DWG 12A.

The aileron control system is used to neutrally position the aileron, which helps to position the wingtip. Use the W-730 Adjustment Fixture to locate the aileron in its neutral position and hold them in place with a bungee cord.

Sand or file the flange on the W-715 tip so it is an even depth and width all around.

Portions of the aft end of the W-715 tip must be trimmed away to provide clearance from the aileron and W-414 Aileron Hinge Bracket. Leave a gap between the aileron and the tip as shown on DWG 9.

Slip the W-715 tip into place. Push it forward so it is tight in the wing leading edge and align the trailing edge with the trailing edge of the aileron. An assistant is helpful.

Drill the W-715 tip using a #40 drill. Begin at the leading edge and work to the back. Alternate holes from the top to the bottom. If you are unhappy with the placement of the tip, adjust it slightly when the holes are drilled to full size.

Swing the aileron out of the way and slip the W-412 tip rib (DWG 12) into place. Mark the location of the rib trailing edge on the tip.

Remove the tip and lay out the rivet lines (top and bottom) 5/16" from the edge. Cleco the W-715 tip back on the wing and slip the W-412 tip rib back in place. The flange edge must be flush with the tip edge.

Locate the rib chordwise so it fits without distorting the tip.

Drill and cleco the W-412 tip rib to the W-715 tip. Remove the tip and machine countersink it. Rivet the rib in place.

The W-715 tip may be riveted or screwed to the wing (DWG 12.) The choice usually depends on what kind of access is necessary to service lights, power supplies, etc.

If you decide to use the rivets the tip must be reinforced with a strip of aluminum to keep the rivets from cracking the fiberglass. Drill (#40) the aluminum reinforcement strips to the W-715 tip using the existing holes.

Scuff the aluminum reinforcement strip and W-715 tip with some 80-100 grit sandpaper. Bond the strip to the tip with resin (polyester or epoxy). Hold the strip in place with clecoes. Remove the clecoes before the resin is fully hardened.

When cured, cleco the W-715 tips back on the wing and drill out to full size. Remove the tips and machine countersink the fiberglass to accept a 1/8" dimple.

Dimple the skins on the wing and blind rivet the W-715 tip on. This step may be postponed until later to permit easier access.

If you are using screws and platenuts the platenuts may be riveted directly to the fiberglass. You may delete the reinforcement strip. Screws and platenuts for this installation are not provided in the kit.

BULKHEAD ASSEMBLY

NOTE: *Although the F-704 bulkhead shown on DWG 11 is a fuselage part, it is provided in the wing kit so that it will remain with the correct wing spars. We recommend delaying construction until work on the fuselage begins.*

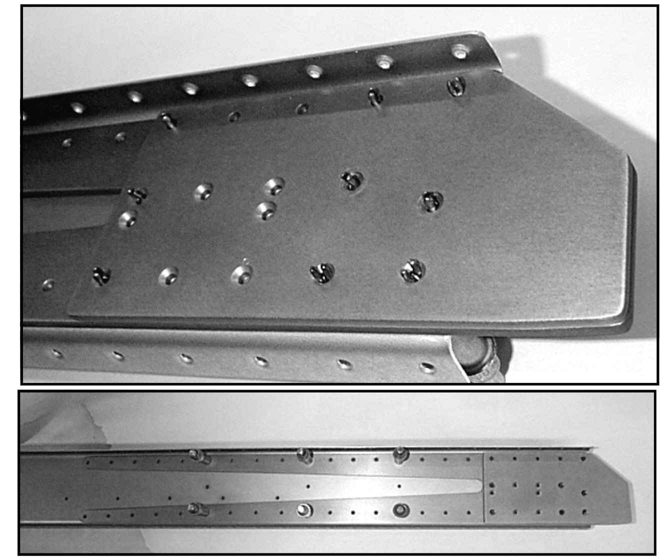


Fig. 7-1. The root end of the rear spar. Note that the flanges are already dimpled...it is hard to get a squeezer on them if the doublers are already installed. (RV-9/9A spar shown)

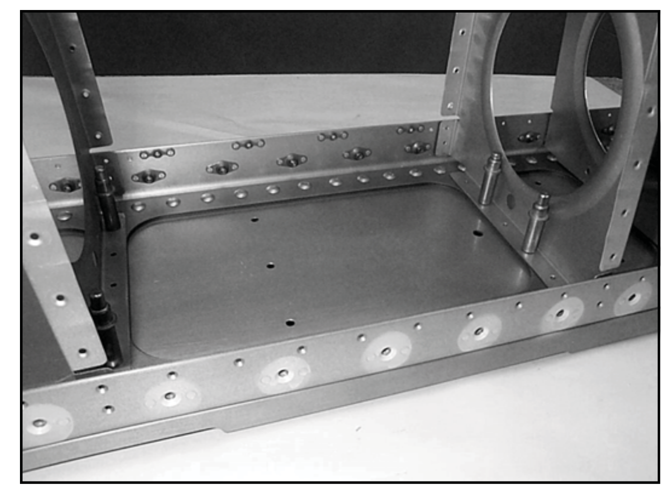


Fig. 7-2. Main ribs are fitted and drilled to the main spar.

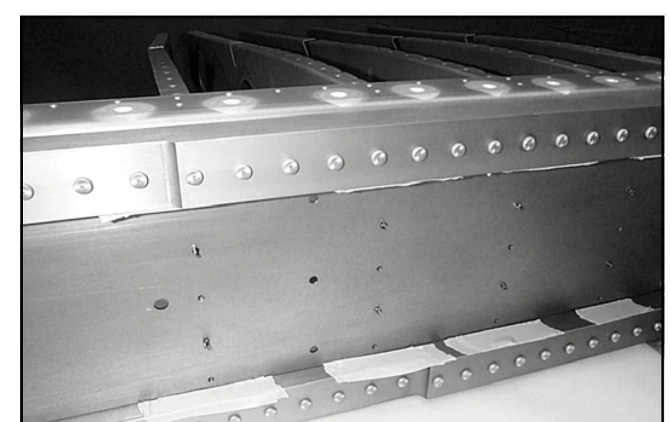


Fig. 7-3. Tape protects the main spar bars from damage when the ribs are riveted.

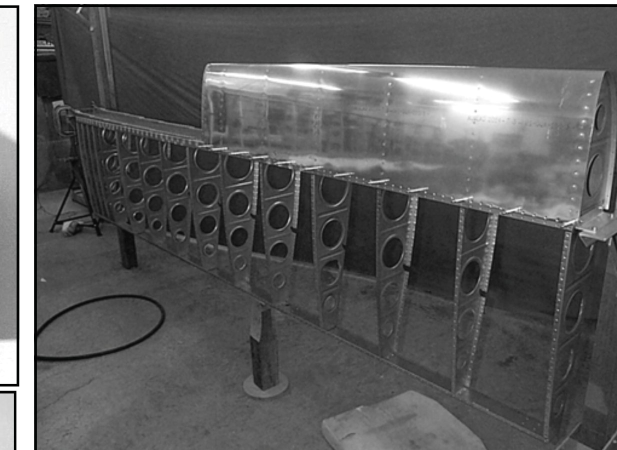


Fig. 7-4. A pair of posts and brackets hold the wing in a convenient position. The posts under the rear spar keep the structure from sagging. Here the leading edge is fitted to the wing skeleton.

Fig. 7-5: The tank and top main skins are fitted.

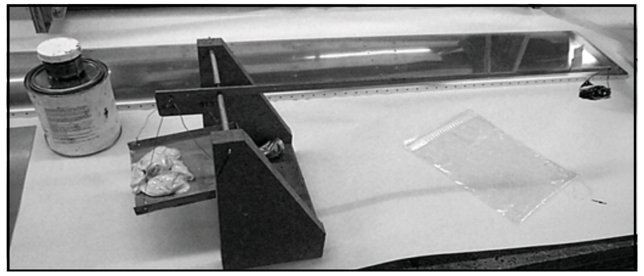


Fig. 7-7. Tank sealant is mixed in a shopbuilt 10:1 balance.

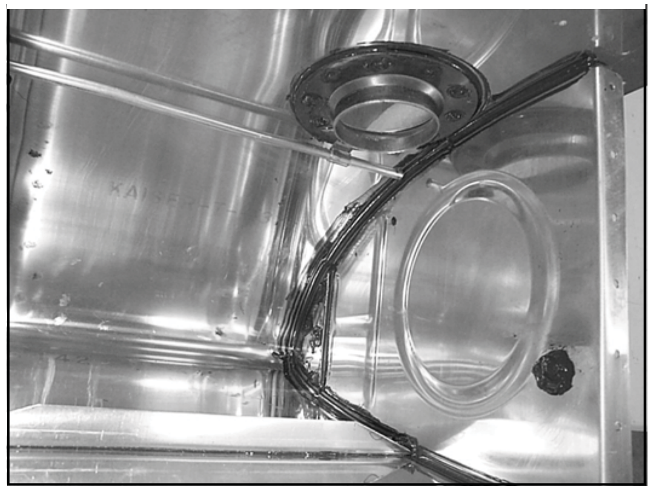


Fig. 7-8. The interior of the tank at the outboard end. The T-410 reinforcement helps seal around the nose. The blob on the rib is a 316" rivet set in the tooling hole and covered with sealant. The filler neck and vent line are also visible.

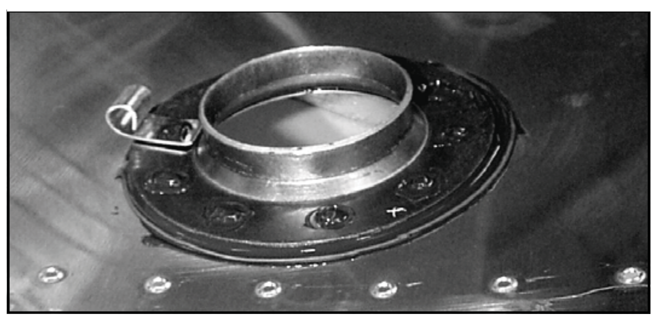


Fig 7-9. The filler neck riveted to the inside of the tank skin. A common rivet holds the T-914 clip to secure the vent line.

Fig 7-10. A bead of sealant for the rear baffle is squeezed out of a plastic bag.

Fig.7-11. The VA-112 drain flange riveted to the outside of the tank skin.

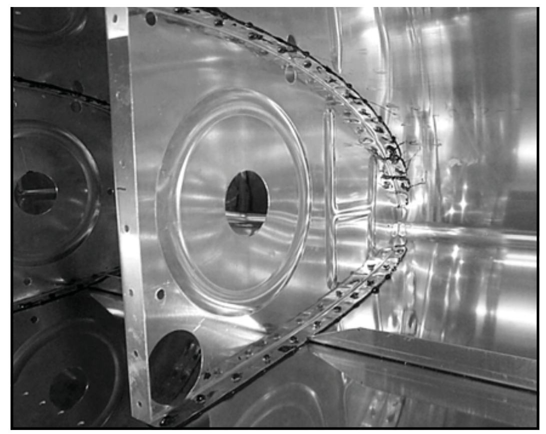
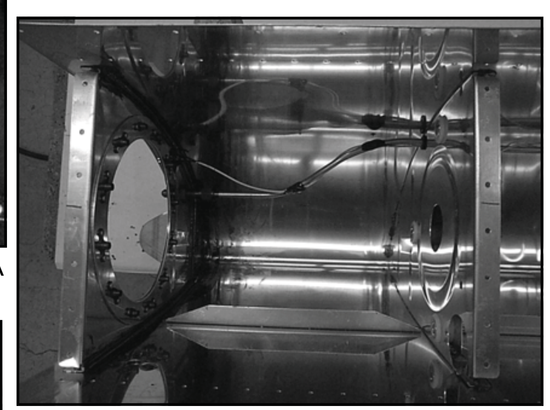


Fig. 7-12. An interior fuel tank rib, riveted and sealed.



Above: Fig 7-13. Details of the inboard bay. The access cover with the fuel sender attached will cover the large hole on the inboard rib. The vent line is looped forward to clear the sender float.

NOTES

SECTION 8. BUILDING THE FUSELAGE

INTRODUCTION

The RV-7 fuselage is a semi-monocoque structure. The skins carry a majority of the load and they are held in place with a combination of bulkheads and longerons (also called stringers).

All the ribs, bulkheads and skins are pre-punched at Van's factory. No jigs or alignment fixtures are required ... when the holes align, the fuselage must be straight. All that is required is three sturdy sawhorses to support the fuselage as it is assembled and a clean, level table used to assemble the bulkheads.

A NOTE TO QUICKBUILDERS

Obviously, not all the information needed to build the fuselage from the Standard Kit is necessary for a fuselage built from the QuickBuild Kit. However, we still recommend reading the entire chapter to gain the “big picture.” Once you understand the basics of fuselage building, you can extract the relevant information for the QuickBuild Kit.

STRAIGHTENING, FLUTING AND PRIMING

Seam and flute the flanges of the ribs and bulkheads. If you are the kind of person who eats their vegetables first, you can finish all the ribs and bulkheads now. Otherwise, you may finish them as you need them.

Not all flanges are seamed to exactly 90°. The aft end of the fuselage is a cone, so the bulkhead flanges should match the angle of the skin. It is hard to get the perfect angle unless the bulkheads are in place and you can sight down them. For now, get them as close as possible. The perfect adjustment can be applied later when the bulkheads are all in place.

From here on we will assume that you know enough to deburr, dimple/countersink, and prime everything as necessary before assembly. We will only mention these chores if there is a special order or technique that should be used.

PREPARING THE BULKHEADS

ASSEMBLING THE F-601 FIREWALL

The firewall is a stainless steel bulkhead, reinforced by aluminum angle. Steel brackets, fitted on each corner, provide a means of attaching the longerons and supporting the engine mount.

Stainless steel has a couple of nasty qualities. First, edges can be very sharp. Second, it will quickly dull your drills, unibits, and deburring tools. When drilling stainless, use regular twist drills for holes 1/8" or smaller. Use a unibit on all larger holes. Use plenty of lubricant (we like Boelube) with either, and keep the drill speed low. Paying attention to the best drill/feed speeds, combined with Boelube, will allow your cutters to last the life of the project. Without them, you will be buying a new cutter every 5 to 10 holes.

Begin the firewall by making the F-601J angles from AA6-187x2x2 1/2 stock, as shown on DWG 19.

Position and cleco all pre-punched or drilled stiffeners, spacers, gussets and weldments to the matching holes in the F-601A-2 firewall. Drill and cleco the remaining holes, using F-601A-2 as a guide.

Fabricate the F-601P spacers and F-601E stiffener and install them per DWG 19. Note that you need to round some edges of F-601J and the ends of F-601N-L&R to fit the inside radius of the aluminum angle they rest upon. There is no need to make this curve exact -- just remove enough of the corner to allow the edges of the brackets to rest on the flanges of the angle.

Square F-601J-L&R with the F-601N and F-601M stiffeners. Align F-601J-L/R horizontally by nesting their inboard face with the outboard face of F-601N-L/R. Use the dimension given on DWG 19 for vertical alignment. Clamp F-601J-L&R and underlying shims F-601H-1 and F-601G-1 lightly in place and align the pre-punched holes. Then tighten the clamps and back-drill F-601J through the firewall.

The brake lines require an F-6122-1 bracket (RV-7A) or F-601TD plate (RV-7) riveted to the firewall. This bracket holds the fittings that connect the flexible brake hoses from the master cylinders to the solid brake lines leading to the wheels. Drill F-6122-1 or F-601TD to F-601A-2 as shown on DWG 19, Firewall Bulkhead Rear View.

Cleco the firewall recess (necessary to provide room for the oil filter and prop governor) F-601K-1 in the square hole centered in the F-601A-2 bulkhead. Drill all holes to full size.

Fit and drill the F-601Z Fuel Pump Doubler to the lower firewall. Rivet it to the firewall. Note that the nutplates are on the forward side of the firewall and the rivets holding them penetrate both the F-601A-2 stainless firewall and the F-601Z doubler.

Disassemble the firewall, dimple F-601A-2 and F-601K-1, then machine countersink the underlying stiffeners and spacers. The firewall is built using flush head rivets, with the flush heads on the forward side. This gives a smooth surface, making the firewall easy to clean and easy to fit brackets, etc.

Rivet all the components of the firewall together, except the F-601K-1 recess. Leaving the recess out will allow a good access through the firewall and make installing the rudder pedal brace much easier.

The firewall keeps fumes and liquids in the engine compartment from entering the cabin. Some of bent corners have unavoidable openings, especially around the firewall recess and the lower corners of the firewall. Seal all openings with fuel tank sealant after skinning the fuselage.

ASSEMBLING THE F-704 BULKHEAD

The F-704 bulkhead is a massive assembly and there's a reason: it is the heart of the fuselage. It transfers most of the loads carried by the airplane. Deburr and prime all of the pieces that need it. The F-704 was drilled in a fixture, in assembly with the wing spars to ensure an exact fit. Important pieces are marked so they may be returned to their proper location.

The F-704 bulkhead is shown on DWG 11.

Drill the holes that will receive snap bushings in F-704A/B/C/D to full size.

Attach the F-704C-L&R Center Sections to the F-704A forward bulkhead and the F-704D-L&R Center Sections to the F-704B aft bulkhead. Assemble the components with clecos and put a NAS1307 bolt through at least one hole on both top and bottom to align the parts exactly. On the aft F-704B, locate the F-704G shear bars with bolts and clamp them in place. Drill the rivet holes to final size, then disassemble, debur and dimple as necessary. Note that the rivets attaching the F-704G bars have flush heads on the forward side.

Fabricate the F-633 Control Column Mounts. Drill the first bolt to hole to the dimensions shown, then bolt the F-633 to the aft F-704. Square it carefully and back-drill the second hole through the pre-punched hole in the bulkhead. After the holes are drilled, you may trim away the area shown (on the bolted leg of the angle, not the leg with the bearing in it!) to save weight.

Now is a good time, while the bulkhead is wide open, to fit the Wd-610 control column and Wd-611/612 control stick bases. These are bolted together as shown on DWG 38. Once the control stick assembly is fitted it may be removed as a unit, leaving the mounts bolted to the bulkhead, and stored.

Countersink all the nutplate rivet holes on the top flanges of F-704A/B. Rivet on all nutplates.

Prepare the F-782B-L&R and F-783B-L&R Cover Support Ribs. Drill them to the bulkhead, then remove them and install the nutplates. Drill the snap bushing holes to full size.

Fabricate the F-704M Web Stiffeners and drill them to the F-704A.

Rivet the Cover Support Ribs and Web Stiffeners to F-704A.

Make the F-904J Center Section Spacers from the rigid aluminum tube provided. The ends are squared by chucking them in a drill press and spinning them gently against a piece of sandpaper or fine file held flat on the drill press table.

Make some spacer blocks from dense wood or particleboard to hold the halves of the center bulkhead assemblies the correct distance apart. The thickness of these spacers must be 1.438” (1 7/16”) to match the thickness of the spar. Drill the blocks (the holes may be oversize) to allow the bolts to run through the spacers.

Bolt the two center bulkhead assemblies together around the spacers for a trial fit. Do not rivet the F-704H side plates on now. They will be riveted to the center section after being riveted to the side skins. It is a strange order but it allows some potentially difficult rivets to be set easily.

When you are assured everything fits correctly, remove the bolts and spacers so the bulkhead is once again two separate halves, fore and aft. Store all the bolts and spacers in a bag and tape the bag to the bulkhead.

ASSEMBLING THE F-705 BULKHEAD

The F-705 bulkhead serves several purposes. It supports the seat backs, strengthens the open cockpit and provides the attachment for the rear wing spar. Details are shown on DWG 20.

Mark a lengthwise centerline on the rear face of the bar. Locate and clamp the F-705B, the F-605C Bar Doublers and the F-705H Spacers to the F-705A Rear Spar Attach Bulkhead. Drill the assembly using the prepunched holes in the F-705A as a guide.

Drill the F-634 seat belt anchors to the F-705 lower bulkhead assembly. One of each pair of anchors should be drilled first. Bolt it to the F-705A, then put a 3/16" shim between it and the other anchor and clamp the three pieces together. Clamp the flange of the unbolted anchor to the bulkhead. Drill the anchor using the prepunched hole in the bulkhead as a guide. In some cases, the flange of the seat belt anchor comes close to an adjoining rivet or bolt hole. Grind or file the flange of the seat belt anchor to allow for bolt or rivet heads as necessary. Be careful to preserve a 2 diameter edge allowance from the center of the anchor bolt hole to the edge of the anchor flange.

Disassemble and prepare the F-705A lower bulkhead for riveting. Fabricate the F-705G angles (for the tip -up canopy only) and drill the snap bushing holes to full size. **Quick builders, remove the F-705G for the slider canopy.**

Drill and rivet the F-705J Angle, the F-705K Plate and the F-705-L seat adjustment supports to the F-705F Channel.

Drill the snap bushing holes and install the nutplates on F-705D. Cleco the F-705A, D and F bulkhead components together.

If you are planning a tip up canopy, cut a slot into the F-705G angle, using the slot in F-705D&F as a guide. These slots provide room for the canopy latch fingers when the canopy is closed.

Before riveting the F-705 bulkhead assembly together, see the NOTES on DWG 20 for the various holes that must be left open so other pieces may be attached later. Cover these holes with tape. Also note the holes that must have flush rivets installed and be sure they are machine countersunk.

Rivet the F-705 bulkhead together.

Fit and drill the F-661EF flap actuator bearing blocks. You may drill out the bearing blocks with a #10 drill if necessary to fit the bolts. Once the blocks are fitted, remove and store them. They will interfere with skin riveting, so they will be bolted on permanently when the flaps are installed.

Bolt the seat belt anchors and F-705H spacer to the lower bulkhead.

ASSEMBLING THE F-706 BULKHEAD AND BELLCRANK SUPPORT RIBS

Bulkhead details are shown on DWG 21. The F-706 ring bulkhead is made of three pieces. The F-729 bellcrank rib, F-728 Bellcrank Channel, F-730 Plate and F-729C Angle all attach to the aft side of the F-706B Bulkhead Bottom (see DWG 26.)

Use a unibit to enlarge the rudder cable holes on all these bulkheads..

Make the F-729C angle shown on DWG 26.

Drill and rivet the F-729A bellcrank rib and F-729B angle together. Be sure to drill the 1/4" hole for the bellcrank pivot bolt.

Drill the F-728A Bellcrank Channel to the F-728B angle, but do not rivet them together yet. Be sure to drill the ¼" hole for the bellcrank pivot bolt.

Begin assembling the bulkhead by drilling the F-730 plate, F-728, F-729C and F-729 rib to the F-706B Bulkhead Bottom. After deburring, rivet the assembly shown in Detail A of DWG 26 together, except for the F-728 channel. Leave that clecoed for now.

Fit and rivet the F-706A-L&R bulkhead halves to the F-706B bulkhead bottom. Leave the top joined with clecos. Drill and cleco the F-728 channel to the pre-punched location hole on the top of the F-706A bulkhead.

ASSEMBLING THE F-707, F-708, 709, and 710 BULKHEADS

See DWG 21. The F-707 and 708 bulkheads are simple two piece bulkheads. Align the tooling holes and rivet them together.

F-711 BULKHEAD

The F-711 is a double bulkhead. The front half is F-711A and the back half is F-711B.

The protruding F-711C bars will attach to the horizontal stabilizer. The F-711C bars may be tapered as shown on drawing 21 if you are building an RV-7A. Mark the centerline of the F-711C bars. Cleco the F-711A&B bulkheads together, using the holes that are not common with the bars. Clamp the bars against the F-711A forward bulkhead, with the lines showing in all the pre-punched holes, then drill using the prepunched holes as a guide.

Both F-711 Bulkheads must have the upper portions trimmed away to allow the elevator pushrod to pass through. Trim to the marks on the bulkheads.

After the usual preparation, rivet the bulkheads and bars together to form the finished F-711 Bulkhead. See drawing 21 for rivet call-outs and other assembly details.

F-712 BULKHEAD

The F-712 is also a double bulkhead and again F-712A is the front and F-712B is the rear. They must be riveted together before the fuselage is assembled. Note that flush rivets are used with the flush side aft. The aft surface must be smooth so the vertical stabilizer spar will fit. For RV-7A builders, the aft tiedown will be fitted later, in

assembly with the vertical stabilizer.

BENDING THE LONGERONS

This section will require more of an artist's touch and a little finesse. The F-718 longerons (see DWG 18) must curve, bend, and twist to form the necessary shape of the fuselage. Aluminum angle can do maddening things when you try to bend it. If you bend it in one dimension, it will also move in another. You must persevere. Correctly bent longerons are fundamental to an accurate fuselage.

Begin by finding the AA6-125 longeron angles (shipped in your wing spar box). Measure and trim them to the correct length - see Note 2, DWG 18. Triple check before you cut! Trim the horizontal face on the aft end of the angle as shown on Detail C, DWG 18.

You will obviously be bending a left and right version of the F-718 longeron. It is easy to get confused and bend one incorrectly, so mark the longerons plainly for front, rear, top and side.

Lay the longerons side-by-side on the floor with the ends matching. Mark the starting and ending point of the shallow curve, looking down. This bend follows a line 0.032” inside the outside edge of the F-721B Aft Canopy Deck. Mark the location of the sharp downward bend, in side view. This bend occurs at the front end of the F-721 B.

BENDING THE SHALLOW CURVE

Bend the F-718 longeron angle in a sturdy vise mounted to a solid, stationary table. Pad the jaws to protect the longerons from gouges and scratches.

The general idea is to hold the angle in the vise, pull on the free end and establish a small "pre-load" on the angle and then give it a small-to-medium whack with a rubber hammer to produce the bend. Several small, progressive bends will form the curve.

Cut the template from DWG 17 and glue it to a piece of stiff cardboard or aluminum. This serves as your guide while bending the longeron. Make both sides useable so it will work on both a left and a right longeron.

Clamp the angle in the vise so the end of the jaw is one inch aft of the aft mark. Start bending at the mark. Push the forward end of the longeron in the correct direction, hold it there, and hit it right at the end of the vise jaw with the rubber mallet until it bends a few degrees. Move it an inch and repeat the process until you get to the other mark. Check it often against the template to prevent overbending.

Keep coaxing the angle until it matches the curve of the template. You can clamp the angle in a six-inch vise without removing any of the bend, so it is easy to add more bend.

Remember to check that the angle has not bent out of plane (up or down) as you were applying the sideways load - it is quite common to get vertical bow while you're bending a horizontal curve. If this happens, rotate the longeron 90°, clamp it in the vise and bend it back straight with your hands. You can call it a night when the curve of the F-718 longeron matches the curve on the template within a 1/16" all around and the angle sits flat on the table within a 1/16".

Tape a piece of 0.032” aluminum to the outboard surface of the longeron and fit the F-721B aft deck to the top of the longeron. Carefully establish the fore/aft position. The shim will simulate the F-770 side skin. When the outside edge of the side rail matches the outboard surface of the shim, drill the F-721B to the longeron. Leave it clecoed for now.

MAKING THE SHARP DOWNWARD BEND

The front of the F-718 longeron needs the sharp bend and twist applied. The bend is done using the same method as the curve; you just don't move the longeron. The angle will really want to curve off axis on this bend. Check this bend by using the F-770 forward side skin as a template. The angle should match the upper portion of the skin within about a quarter of an inch.

TWISTING THE FORWARD END OF THE LONGERON

The twist is applied with a big crescent wrench. Clamp the longeron in the vise, with the point of the downward bend at the end of the vice jaw. Grab the end of the angle and give it a twist. Keep going until you have the twist shown on View A-A', DWG 18.

FINISHING THE J-CHANNEL

Cut the F-786A, B, & C J-channel to length and prepare the ends as shown on DWG 18. A cutting disk in a die grinder works well here too.

AFT FUSELAGE ASSEMBLY

Now for the fun part: putting some of the big assemblies together.

Set up three sawhorses so they are all at the same height and level.

Begin the assembly by clecoing the F-779 Tailcone Skin to the F-711 and F-712 bulkheads (DWG 26).

If you are building an RV-7, the WD-409 tail spring mount must be fitted between F-711 and F-712. Also, the F-779 skin must be relieved to allow the tail spring mount tube to protrude aft and down. See drawing 27 for WD-409 installation details. The “mouse-hole” in the bottom of F-712 may be enlarged as necessary to allow the tube and weld fillet of WD-409 to fit. The single hole in the forward part of the F-779 centerline is for access to the tail spring nut. Ignore this hole on the RV-7A and open the hole for a socket on the RV-7.

The WD-409 forward plate upper edge should be used to square the tail spring mount with the F-711 bulkhead assembly. Drill through F-711 and WD-409 for the AN4 bolts using the pre-punched holes in F-711 as drill guides. Drill through F-712 and WD-409 for the two “keeper” rivets only; the three bolt holes will be match-drilled later while attaching the vertical stabilizer. If there are any gaps between WD-409 and the two bulkheads, a shim should be installed between F-711 and WD-409. After fitting and match-drilling WD-409 to F-711 and F-712, remove WD-409.

Lay the F-778 Aft Bottom Skin across two of the sawhorses, with the outside surface down. Reach underneath and cleco the F-707 and F-708 bulkheads to the inside of the skin.

Mark the outside face of the lower 4 J-channels with a lengthwise centerline. Slide the lower 4 J-channels into the slots in the bulkheads, leaving them loose for now.

Slide the assembly to the edge of the sawhorses and cleco the F-773 side skins to the bulkheads.

Cleco the F-706 bulkhead to the assembly.

Cleco the F-729A bellcrank rib to the bottom skin.

Now add the F-711/F-712/F-779 assembly and cleco in the F-710 bulkhead.

With all the skins in place check to make sure there is no twist in the fuselage by hanging a plumb bob on bulkheads on each end. The tooling holes are on center, so if the plumb line falls past the center of the top and bottom holes, on both bulkheads, the fuselage is straight. Check before you drill!

Double check the J channels for proper position and drill them to the skins. It works best to drill every fourth or fifth hole and cleco. Work from one end to the other. When the J-channel is located, drill the remaining holes.

Drill all of the remaining holes (except the ones for the F-706 bulkhead and the F-718 longerons) to final size.

NOTE: see DWG 27A for the position of the F-792 rudder stop. One hole must be left open to match with the drilled hole in the rudder stop. Mark this hole or tape over it so that it will not be riveted or dimpled.

When drilling is complete, remove the skins. Debur the structure and skins, dimple as required, and cleco the rear fuselage back together.

Rivet F-712 bulkhead to F-779.

RV-7 Only: Attach WD-409 to the F-712 assembly using keeper rivets previously drilled.

Rivet the F-711 bulkhead assembly to F-779 and bolt WD-409 (RV-7 Only) to the F-711 assembly.

Rivet the F-779 and F-778 bottom skins to the bulkheads and J-channel.

Rivet the F-773 skins to the bulkheads up to the upper J-channel, and to the J-channel itself, but no higher. The top of the skins must be able to bend away from the upper sections of the bulkheads so the main longerons can be inserted later.

PREPARING THE CENTER FUSELAGE

The center fuselage is shown on DWG 22. Skins are shown on DWG 28.

Make four F-916C spacers from aluminum plate as shown on DWG 22.

Modify one F-716-L and one F-716-R Seat Rib by adding the F-716B Seat Rib Access Plate and cutting the rib. The top of the ribs must be removable to install the control system.

Modify one F-716-R and F-716-L Seat Access Rib by enlarging the lightening hole in the forward portion as shown. The extra space is needed to allow the controls to move.

Install the nutplates on all the seat ribs. Screws generally fit quite tight in nutplates, and because there isn’t much room for a screwdriver on the outboard edges of the floor skins, it is acceptable to run an 8-32 tap through the nutplates. This will make it easier to install the screws. Be careful and use a lubricant on the tap.

Attach the rear half of F-704 center section bulkhead to the F-716 and F-715 seat ribs. Be sure you have the modified ribs in the proper place. F-716 ribs may be clecoed, but the F-715 seat ribs are not drilled to the center section until later, so hold them in place with clamps for now.

If you are going to install the optional step(s) cut the F-725 baggage ribs with a 1 5/8" hole saw using the prepunched hole as a guide.

Cleco the F-725, 726, and 727 baggage ribs to the F-705 rear spar bulkhead.

Cleco the F-705 bulkhead and ribs to the aft ends of the F-715/716 seat ribs. Insert the F-916C spacers at the necessary stations.

Cleco the F-776 center bottom skin to the center fuselage assembly. The skin holds the F-715 and F-716 seat ribs in correct alignment.

Drill everything to final size except for the aft two rows (spanwise) on the F-776 center bottom skin. Fit and drill the F-623 corner ribs. Flute the F-623 as necessary to fit the skins, and if you are installing steps, trim the flange to clear the step tube. Make the F-623A forward and aft attach straps.

Once again, fit the front half of the F-704 bulkhead to the rear half. Use the pre-fit bolts and spacers you made earlier to hold the bulkhead together.

Now, drill the holes on the forward edge of F-776 to size.

NOTE. See DWG 28. Rivets at the intersection of the spanwise row across the forward F-704 bulkhead and the fore-and-aft lines along the stiffener are shown as AN426AD3-6. Machine countersink these holes through the F-776 skin and into the bulkhead. Rivets through these holes will later attach the floor stiffeners and a smooth inside surface will help fit the stiffeners property.

Once the bottom skin is clecoed on, fit and drill the F-704H side doublers to the center section.

Remove the clecos and prepare the parts for riveting. Do not dimple the holes in the aft edge of the F-776 bottom center skin. They will match up with the F-706 bulkhead and F-778 bottom aft skin later when the two fuselage halves are brought together.

Dimple the holes (in the skin and the ribs) that will later match up with the lower aft tabs on the F-725, 726, and 727 baggage ribs.

ASSEMBLING THE CENTER FUSELAGE

After all the preparation, it's time to rivet and bolt the skeleton of center fuselage together. Details are shown on DWG 25.

Draw a centerline on the bottom flange of the F-715 ribs.

Start at the aft face of the F-704 bulkhead and install the F-716-L&R ribs. Use bolts and rivets as shown on DWG 22.

Turn the center fuselage upside down and rivet on the F-776 center bottom skin on the skeleton. Remember to leave the holes for rivets common to the F-772 Forward Bottom Skin open.

Do not rivet the F-623 corner ribs on yet.

Turn the assembly upright and cleco in the F-742-L&R, F-747-L&R, F-739, and F-740 baggage and seat skins. See DWGs 25 and 29. Drill all of the holes, except for those through the F-715 outer seat rib, to final size.

Drill the F-715 outer seat rib to the F-704 bulkhead. Also drill it to the F-776 centering the centerline on the bottom flange in the holes in the bottom skin. Position the top of the rib so the distance between the outside of the web and the outer edge of the seat skin is 0.032” (use a bit of scrap for a spacer.) This means a thin strip of flange will be visible past the edge of the seat skin when viewed from the top.

The seat and baggage skins should be left clecoed in place to help keep the fuselage stiff and straight during the assembly.

JOINING THE REAR AND CENTER FUSELAGE ASSEMBLIES

It's time to join the aft and center sections of the fuselage. Place the tailcone assembly upside down on a couple of sawhorses. Add another sawhorse on the forward side of the tailcone assembly approximately where the F-704 bulkhead will rest.

Set the F-718 longeron assemblies on either side of the aft fuselage. Remove just enough clecoes from the F-773 side skins to allow the longeron to be slipped into the notches in the bulkheads. Align the vertical leg of aft end of the longeron with the aft end of the flange of F-712.

The longerons must be notched to fit around the F-711C bars as shown on DWG 18.

NOTE: *NOTCH THE LONGERONS, NOT THE F-711C BARS!*

With the longerons in place re-cleco the side skins to the bulkheads. Add a few clamps to keep the longerons aligned with the top of the side skin.

Place the center fuselage in position. Place the top of the F-704Cs so they rest on the third sawhorse. Slip the F-725, 726, and 727 baggage ribs and the F-776 center bottom skin into place over the F-706 bulkhead and F-778 aft bottom skin.

Cleco the F-725, 726, and 727 baggage ribs to the F-706 bulkhead from the rear. Cleco the F-776 center bottom skin to the F-706 and the F-778 aft bottom skin.

The F-770 forward side skins are fitted next. (If you are going to install a step, use the holesaw to drill the F-770 where the tube of the step will pass though. Pilot holes show the location. If you are not installing a step, dimple these holes and fill them with 'rivets to nowhere'). Cleco the F-770 forward side skins to the F-704, F-705, and F-706 bulkheads, and the F-773 aft side skins. It may be necessary to raise or lower the tailcone slightly to align the holes.

Use a straight edge to mark the flanges of the F-623 corner ribs where the step comes through. Use the F-770 forward side skin and F-725 baggage rib as a guide. Remove the ribs and trim them on the table.

Check the forward ends of the main longerons. The longerons should follow the top edge of the F-770 side skin. If they do not, adjust the bend/twist in the longeron until they do.

Fit and drill the F-720 armrests. You may flute lightly between the holes in the armrest to make it match the holes in the fuselage side skin. After drilling, remove and store the armrests. They are installed after the side skins are riveted on and the seat floors are installed. Do not install the LP4-3 blind rivet until the F-704Ks are installed.

Remove the F-770 forward side skins.

The conical bend at the lower aft end of the F-770 skin must to be rolled to fit the aft fuselage. Clamp the F-770 to the table with a couple of C-clamps and a length of angle. Arrange the skin so the bend line rests between the edge of the angle and the edge of the table.

Drill a piece of scrap AA6-125 angle to match the lower edge of the skin and cleco it to the skin, using clecoes in every hole. The bend of the skin is very tight -a sharp 90° bend - on the forward end, and opens to a gentle curve at the aft end. Clamp visegrips to the aft end of the angle and use a twisting, rolling motion to start the curve. At the same time, use a strong push with the thumb of the other hand to form the tight bend at the forward end. It may take several tries and trial fits to form a bend that makes a smooth transition to the rear fuselage. Be patient and take the work in small steps.

Make and install the F-623A Rib Attach Strips that fasten F-623 to F-705. See View C-C', DWG 22.

Cleco the F-770 skins back on the fuselage.

At this point all the skins below the main longerons and aft of F-704 should be clecoed to the fuselage skeleton. Clamp the skins aft of F-704 to the longerons, being sure to that the corner of the longeron is flush with the edge of the skins. Begin drilling all the holes through the skins and the longerons, starting at the tail and working forward.

NOTE on the F-773 side skins that there is a "rivet between rivets" several places along the main longerons. These rivets are used to fasten the skin and longeron during construction. The rest of the holes are left open and used when the top fuselage skins are installed.

ADDING THE FORWARD FUSELAGE

At F-704, clamp the longerons even with the upper edge of the F-770 skin. Now check the forward edge of the F-770 ... the skins should extend 3/4" past the forward edge of the longerons. If the longerons are slightly short, there is no problem, but if they are closer than 3/4", trim them back with a die grinder and cutting disc.

Drill the remaining holes connecting the longerons to the F-770 skin.

Make the four F-704-L straps shown in Detail D, DWG 23.

Remove the forward six or seven clecos from the longerons and set the firewall in place. The rear facing "fingers" of the WD-602 brackets rest on the inside of the longeron angles. Clamp the firewall to the longeron.

Draw a centerline on the flange of the aluminum firewall angle. Cleco the F-772 Forward Bottom Skin to the F-704 bulkhead. Clamp the skin to the firewall with the line centered in the 2nd row from the front edge. Drill a hole on each side of the fuselage, through the skin and angle. This will set the distance between the firewall and the F-704 bulkhead.

Slip some AN470AD4 rivets into all the holes in the skin and longeron between the firewall and the aft end of the WD-602. At this point, these holes have not been drilled through the steel brackets and the firewall is heavy enough to cause some sag in the longerons and make the holes mis-align.

Now, take a break for a few minutes. When you return recheck that:

1. The forward face of the firewall is 5/8" aft of the forward edge of the F-770 skin.
2. The webs of the longeron angles are clamped tightly to the Wd-602 brackets.
3. The 1/8" holes in the F-770 skin and longerons are still aligned -in other words, 1/8" rivets slip easily into the holes.

When all these things have come to pass, drill the F-770 skin to the flanges of the firewall, starting at the top longeron and working toward the bottom.

Add another clamp or two to the longeron/bracket assembly and continue the holes already in the longeron and skin through the steel brackets. Put a cleco in each hole as you drill it.

If you are building an RV-7A, remove the F-772 lower skin and use the template shown on DWG 34A to locate the holes for the landing gear sockets and brake lines. Enlarge these holes as shown. Some of the forward flange of the F-704 must also be removed for gear leg socket clearance.

INSTALLING THE AUXILARY LONGERONS AND FORWARD BULKHEADS

Draw lengthwise centerlines on Auxiliary Longerons F-713-R&L. Trial fit the longerons between the firewall brackets and the F-704 bulkhead. To fit properly, the longeron must be twisted slightly and the aft end must be filed at an angle to butt against the F-704.

Clamp the forward end of the F-713 and wiggle the aft end until the centerline appears in the pre-punched holes in the F-770 side skin. Drill and cleco.

Make the two F-719B Angle Clips shown on DWG 23. Use them to help fit the F-719R&L Forward Skin Stiffeners to the skin in the same manner as the F-713 longerons. Note that the joggled end of the F-719 goes aft and laps over the edge of the F-704 bulkhead as shown in Sect H-H'.

Make the F-717-R&L Lower Longerons. These are simply lengths of AA6-125 x 1 x 1¼ angle. The aft end is cut at an angle to butt against the vertical side of F-704, and 4 1/8" of one leg of the angle is removed as shown on the plans. This is for clearance of the F-7114 gusset (RV-7) or the WD-721 landing gear mount (RV-7A). See DWG 34 or 34A. To mate with the curving forward fuselage, this longeron must have a bit of twist. Clamp the longeron in a sturdy vise with the forward 3-7/8" captured between the jaws.

Use a large padded crescent wrench on the vertical leg of the angle to twist it outboard. Work in small steps and fit the longeron to the fuselage until it "nests" well with the Wd-603 bracket (see Section K-K') and butts against the forward edge of the F-704 bulkhead (see Section N-N'.) The vertex of the longeron should parallel the lower edge of the F-770 side skin. About 1/8" of the longeron will be visible, extending below the edge of the skin.

When the longeron fits in Wd-603, clamp the assembly and drill the four vertical bolts shown in Detail L, Detail A and the Side View of DWG 23.

Clamp the aft end of the longeron to the F-704 bulkhead for now.

Before drilling holes for the rivets that join the lower longerons and auxiliary longerons to the Wd-603 brackets, the F-684 gussets must be fitted. These require some careful edge filing to fit really well, but this is an important juncture, so make sure all the parts fit before riveting. The forward edge of F-684 should be 1/8" aft of the firewall bulkhead and the lower edge should align with the lower edge of the F-713 Aux. Longeron. Adjust the bend angle if necessary to make the gusset lie flat inside the Wd-603 bracket and the vertical firewall angle. See Section K-K', DWG 23.

Clamp the assembly, drill as shown on Detail A, and cleco. The holes in the skin will act as guides.

INSTALLING THE FORWARD BULKHEADS

Adjust the flanges of the F-902-L&R Forward Bulkheads until the web is perpendicular to the aircraft centerline. Check by using a straightedge between the two bulkhead webs to see that they are parallel. Straighten the bulkheads as necessary with flutes between the rivet holes. Open the hole for the rudder cable to 5/8"

Rivet the nutplates to the aft side of the F-902 bulkhead. These will later hold clamps securing the fuel vent line.

Cleco the F-7101 Gear Attach Web to the F-704 bulkhead. This should rest the web of the F-902 against the forward flange of the F-7101. Make any small adjustments necessary, then drill and cleco the F-902 to the F-7101 and the skin.

Adjust the top and bottom tabs of F-902 as necessary to fit the longerons, drill and cleco.

Make the F-796C & D Spacers as shown on DWG 38. Drill the top 3/32" hole in the spacers at the dimensions shown, but leave the other holes undrilled for now.

Make the F-796B reinforcement angle (DWG 38) and drill only the top hole. Drill the 3/16" hole to #30 for now.

Study drawing 38, Detail F to understand the fit of the spacers and angle with the bulkhead flange and longerons.

Put a centerline on the outboard face of the F-796B angle and cleco it on the inside of the longerons using the upper pilot hole drilled in the angle. When the centerline on the angle is visible through the lowest hole in the side skin, drill and cleco it to the fuselage. Match-drill the remaining holes through the angle using the holes in the skin as guides. Drill as straight as possible so as to minimize any hole position error due to the gap between the skin and angle.

Remove the F-796B. Cleco the F-796C & D spacers to the F-796B angle. Align part edges and match-drill all the holes through F-796C & D using the holes in F-796B as guides.

Cleco the angle and spacers back in the fuselage. Small hole misalignments may be cleaned-up by running a #40 drill through the part stack-up. Large hole misalignment may be cleaned-up by running a #30 drill through the stack-up and installing 1/8 inch rivets instead of 3/32 inch rivets. Remove the parts and set aside for later installation.

INSTALLING THE RUDDER AND BRAKE PEDALS

DWG 37 shows details of installing the rudder and brake pedal assemblies. This is best done while access is still available.

Assemble the F-6117-L&R Brake Pedals.

The Wd-655R&L Rudder Pedal Assemblies are assembled with the brake and master cylinders bolted on as shown on the Exploded View of DWG 37. The F-6116 Side Bearing Blocks are slipped over the end of the rudder pedal tubes and the assemblies are dropped into the fuselage from above. Note that the right side pedal assembly is forward of the left side.

The exact fore-and-aft location of the F-6116 bearing blocks is left to the builder. We recommend drilling several attachment hole patterns so the location can be changed easily if it becomes necessary. Remember to maintain at least two hole diameters between the edges of the holes.

Bolt the rudder pedal assemblies to the longerons with bolts through the side bearing blocks. Trim the F-6118 Rudder Pedal Brace as shown. The extra length of the notch in the bottom flange will accommodate the F601K Firewall Recess. Fit the F-6115 Center Bearing Block around the Wd-655 rudder pedal tubes and bolt it to the brace. Clamp the brace against F-601 upright firewall stiffener and drill. You may find it easier to drill from the inboard face of the F-601, reaching through the open hole for the F-601K recess. Plan your holes so the rivets don't interfere with rivets that attach the recess coming through the other leg of F-601N.

Remove and store the rudder pedal/brake pedal assemblies.

INSTALLING THE FLOOR STIFFENERS

The floor stiffeners are shown on DWG 23.

Cleco the F-772 forward bottom skin back on the fuselage.

Draw centerlines on the back of the F-772B-R&L Floor Stiffeners. These must be fitted to the inside surface of the F-772 skin, so it helps to have a helper to shift the stiffeners while you watch for the centerlines through the holes in the skin.

When the floor stiffeners are located, drill them to the skin, firewall, and center section bulkhead.

The center floor stiffeners are also drilled to the bottom of the F-783B-L&R Cover Support Ribs and F-601J angles on the firewall. Make sure the stiffener is firmly against the floor and bulkheads before using an angle drill to make these holes.

THE CABIN

FRAMING THE BAGGAGE AREA

See DWGs 25 and 29. The inside of the baggage area sidewall is partially covered with two panels. The aft is permanent, but the forward panel must be removable to give access to the flap mechanism. These panels are supported by two ribs, one vertical, one horizontal.

Fit the F-724 vertical rib by clecoing it to the F-770 side skin.

Install the nutplates on the F-722 horizontal ribs then drill and cleco them to the side skins.

Cleco the F-750 aft baggage side covers to the F-722 and F-724 ribs.

Adjust the top and bottom flanges of F-724 to the longeron and the F-623 rib, and drill them.

RIVETING THE FORWARD SIDE SKINS

Before the F-770 forward side skins can be riveted to the fuselage framework, there is a laundry list of small tasks that must be completed. You may have done some already. If not, complete them now.

Remove the skin.

Rivet the F-684 Gussets to the vertical firewall angles as shown on DWG 23, Detail A.

Rivet the F-7101 Gear Attach Web to the F-902 bulkhead (DWG 23, Sect G-G'.)

Rivet the F-719 and F-719B Stiffener and Angle Clip to the vertical angle of the firewall.

'Pre-rivet' the F-704H Center Section Side Plate (DWG 11) to the F-770 skin. A few key rivets are set at this time, because they will be very difficult to reach when the skin is installed on the fuselage. These rivets are right next to the spar entry cut-out. Set the upper five rivets forward of the spar cut-out, leaving the lowest one open ... it will be riveted when the skin goes on. Set the six rivets aft of the spar cut-out.

Complete the necessary dimpling or countersinking on the F-770 skin and underlying structure. (See Section 5E and Figure 5-4.) NOTE that the outboard five rivets holding the F-772 and F-776 Bottom Skins to the F-704A Forward Bulkhead must be installed “double-flush”. See drawing 28. The flush heads rest on the inside of the F-704 flange are necessary to provide clearance for the RV-7A main gear leg mounts that will be bolted into this location later. It is recommended that RV-7 builders install rivets the same way to retain the possibility of taildragger to tri-gear conversion.

When preparations are complete, rivet the F-770 side skins to the fuselage. We recommend starting at the F-704 bulkhead and working fore and aft. Finish riveting the F-772 skins.

Complete any riveting on the aft fuselage that has not been finished yet. Remember to rivet the skins to the main longerons with only the rivets specified! The rest of the holes must be left open to attach the top skins.

ROLLING OVER THE 'CANOE'

After the all the skins are riveted on, roll the fuselage right side up and set it at a convenient working height on a pair of sawhorses. Level the fuselage at the center section, both lengthwise, along the longerons, and sideways, across the longerons. Secure the fuselage so that it stays that way.

See DWG 26. Clamp the F-714 aft deck to the longerons, using clamps through the forward lightening holes and rear rectangular opening. Place a level across the rear deck, near F-710. It should read level ... if it doesn't, loosen the clamps and twist the fuselage slightly until it does. Take your time with this step. Once the aft deck is riveted to the longerons, the fuselage is torsionally rigid, and any twist built into it will be there forever.

When the fuselage is straight, re-clamp the aft deck and drill it to the longerons.

After deburring, etc., rivet aft deck to the fuselage.

FINISHING THE FORWARD FUSELAGE AND LONGERON DETAILS

INSTALLING THE SIDE RAILS and GUSSETS.

See DWG 25. The F-721B side rails have already been drilled to the longerons. Trim the F-757 gussets to the shape required by your canopy and try them for fit by sliding them into the slot in F-721B. File and radius the outside edge until the pre-punched holes in the F-757 match the holes in the F-705 bulkhead. Remove as little metal as possible.

Drill and cleco the pre-punched holes to fix the F-757 in position, then drill the holes through the longeron and the outboard portion of F-757.

Rivet both side rails, canopy decks and gussets to the longerons. Carefully file the decks and rails to fit the contour of the side skin.

INSTALLING THE F-695 FORWARD FUSELAGE GUSSETS

The F-695 gussets attach the main longerons to the angle frame of the firewall. They are shown on DWG 23.

Drill the holes in the gussets, then clamp the gussets to the longeron and horizontal angle of the firewall. Drill the gusset to the firewall and the longeron.

After final preparations, rivet the gussets to the fuselage.

INSTALLING THE SHOULDER HARNESS ANCHORS

RV-7/7A shoulder harnesses are secured to the aft fuselage longerons by a stainless steel cable. This provides a direct load path. Fit and drill the F-636 shoulder harness anchors as shown on DWG 26, detail D. Do not bolt them in just yet, because they will interfere with riveting the top fuselage skins to the longerons.

FINISHING THE BELLCRANK SUPPORT

See DWG 26. Drill the F-728A vertical channel to the F-706 bulkhead, then remove the channel. Fit, drill and rivet the F-728B angle to the channel, then re-install the channel permanently in the fuselage. It will require a narrow or notched bucking bar to set the rivets attaching it to the top of the bulkhead. If you don't have one that will work, you may use blind rivets as shown.

Fabricate the F-635 Bellcrank by riveting the components around the VA-146 flange bearing. Make the tubular F-635C spacers and fit the bellcrank in the fuselage. Square the ends of the spacers and fit them precisely between the area washers on each side of the bellcrank and the support ribs on either side. The bellcrank should be centered between the ribs and rotate smoothly, with no side-to-side play.

Remove the bellcrank, washers and spacers and store.

FITTING THE TOP FUSELAGE SKINS

INSTALLING THE GUSSET PLATES

The F-656-L&R gusset plates tie the F-706 and F-707 bulkheads to the main longerons. See DWG 26. Clamp the gussets to the longeron. Cleco the gussets to the bulkhead and use the pre-punched holes to drill them to both the bulkhead and the longeron.

Rivet them any time.

FITTING THE AFT TOP SKIN

The aft fuselage is shown on DWG 26. Adjust and check the flanges of the bulkheads to an angle that will lie smoothly against the skin. You can simulate the skin with a straightedge or tight thread.

Make the two F-786A Top Fuselage J-Stringers. Draw a centerline on the upper faces and tape them to the F-706, 707 and 708 bulkheads.

Cleco the F-775 Rear Top Skin to the F-707 and F-708 bulkheads and to the main longerons. The longeron holes were drilled already, when the lower side skins were installed.

Drill and cleco the skin to the bulkheads, starting with the intersections of the J-stringers and the bulkheads.

FITTING THE FORWARD TOP SKIN

Cleco the F-787 Stiffener Rib between the F-706 and F-707 Bulkheads.

Cleco the F-774 Forward Top Skin (tip-up canopy) or the F-7112 Forward Top Skin (sliding canopy) to the F-707 and F-706 bulkheads. As you move to the forward part of the skin, slip F-788 between the skin and the bulkhead and rib and continue clecoing.

There are four holes in the F-774 Forward Top Skin that are not in the F-706 bulkhead or the F-788 gusset. Match-drill the gusset and the bulkhead using the holes in the skin as a drill guide.

Drill the skin to the bulkheads, F-787/788 and J-stringers.

Now that both skins are on and clecoed to both bulkheads and longerons, fit the F-709 Bulkhead. Insert the bulkhead underneath the aft top skin and press it firmly against the inside of the skin. Cleco it to the F-714 aft deck, then drill it to the skin.

Remove the clecoes on the right side of the F-774 (7112) and F-775 skins and lift them up to expose the F-787 stiffener rib. Fabricate the F-707B clip shown on DWG 26. Clamp it to the F-707 bulkhead and F-787 rib. Drill it to the F-707 bulkhead using the pre-punched holes as a guide. When it is clecoed to the bulkhead, drill it to the rib. You may rivet F-707B to F-787, but do not rivet F-707 until the aft top skins are riveted – F-787/F-707B blocks access to one of the skin rivets.

Rivet the F-787 to the F-707B clip, but not to the F-707 bulkhead.

FITTING THE F-6111 RIBS (SLIDER ONLY)

Cleco the F-7112 skin in place. Trim the F-6111 ribs to length. The ribs are not attached to the longeron at the bottom and have one rivet common to the F-705 bulkhead at the top. The rib must be twisted and possibly fluted to achieve the proper shape. See DWG 41.

FINISHING THE INSIDE OF THE CABIN.

THE BAGGAGE COMPARTMENT

See DWG 29. Drill and rivet the F-750-L&R Aft Baggage Side Covers to the inside of the fuselage.

Now is the time to install the steps if you are building a -7A. See the separate instructions shipped with the steps.

If the F-747 baggage floors have been removed, cleco them back in. After drilling, deburring, and dimpling for the inboard nutplates, rivet them in place. Don't forget to rivet the nutplates as well. Leave the forward row of rivets out for now, as these are common to the F-742 Aft Seat Floors which will be installed shortly.

While the top skins are still clecoed to the fuselage, fit and drill the F-751 and F-652 corrugated baggage bulkheads to the F-706 bulkhead. The lower F-751 bulkhead has pre-punched holes across the bottom that can be used as guides, but the holes up the sides must be located and drilled in assembly. The upper F-652 bulkhead must be trimmed as shown on DWG 29 and drilled in assembly with F-706.

Remove the baggage bulkheads and install the nutplates on F-706. Notch F-652 and install the F-6114B&C cable wear blocks.

Temporarily install the baggage bulkheads on F-706. If any of the screws are particularly difficult to get into the nutplates, especially along the bottom where they are a bit difficult to reach, you can run an 8/32 tap through the nutplate.

Fit the F-748 Baggage Tunnel Cover.

Fit the F-749 Forward Baggage Side Covers. This will require twisting it into position with the horizontal flange under the baggage floor. (Yes, it can be done.) This cover must be removable to allow access to the flap links, so it is held to the fuselage frame with screws. We find the optional tie-down ring holders shown in Detail D, DWG 29, to be useful.

Adjust the flanges until F-749 fits correctly, match drill the necessary holes and rivet on the nutplates. Remove the aft top skins for deburring and dimpling. There is no particular rush to rivet these skins on ... in fact, having them off simplifies several operations in the rear fuselage, so store them carefully away.

AFT SEAT FLOORS

See DWG 30. The seats attach to the aft seat floors with piano hinges. The seat back position is changed by simply pulling the pin and repositioning the back in another hinge segment.

Prepare the F-742-L&R Aft Seat Floors by drilling them to the floor ribs and fitting the F-637E hinges as shown in DWG 30. Note that the F-637E hinges have eyelets on both ends and two eyelets trimmed away in the middle. The aft edge of F-742 may go on top of the baggage floor, or between the baggage floor and the F-705 bulkhead.

Rivet the aft seat floor assemblies to the floor ribs.

FORWARD SEAT FLOORS and CONTROL ROD TUNNEL

See DWGS 25 and 30. Fit and drill the F-739 and F-740 Forward Seat Floors to the seat ribs. These floors must be removable to gain access to the control system, so they attach to the ribs with screws. The left floor (F-740) goes on first, with the wider right floor (F-739) on top.

Make the F-741A-L&R Tunnel support covers and the F-741B from material as shown on DWG 30. Drill holes in the lower flanges of the support only. These holes must match the holes in the floors, so measure carefully.

Cleco the supports securely to the floor and clamp the F-741B Tunnel Cover to the top flanges of the supports. Slide the cover forward until it contacts the slanted floor. Drill and cleco the single forward hole to the floor. Check to see that the edges of the cover and the support flanges are even, then drill the holes connecting the cover to the supports.

Rivet the tunnel cover to the supports.

Remove the tunnel cover and forward seat floors. Install the nutplates in the seat ribs and around the stick cut-outs in the floors. Don't forget the nutplate for the tunnel cover.

Re-install the floors with enough screws to hold them securely.

SEAT BACKS

The seat backs are made as shown on DWG 30. The upright angle supports are made from 0.125 angle material (not 0.063!). The seat backs are very simple, but once the hinges are mounted on the bottom, they become “right” and “left.” Be sure to make one of each.

The F-638 Seat Back Braces are trimmed on the ends and the optional lightening holes cut on the drill press with a hole saw or flycutter.

FORWARD COVERS

Several covers are installed in the forward fuselage to protect fuel lines, cover the electric fuel boost pump and direct cabin heat. See drawing 34. These are removable for maintenance.

Fit the F-982E Access Plate and F-982D Heat Baffle to the F-782C Center Cabin Cover. Rivet the baffle and necessary nutplates to F-782C.

Insert the F-782C between the center floor reinforcement angles and the F-601N vertical angles on the firewall. Check to see that an even amount of the horizontal section of F-782C is exposed above the floor angles. Don't force it down too far…the flanges will be forced inboard by the radius of the angles and a poor fit will result. You may wish to put a simple wood spacer between the cabin floor and the center cabin cover to ensure that this won't happen.

Rivet the nutplates to the F-983A Fuel Valve Plate and screw it to the F-704 bulkhead. Slide the F-983C Fuel Valve Cover underneath the plate and fasten it to the F-783B cover support ribs and the fuel valve plate.

Adjust the F-782C fore/aft until it mates with the bottom of the F-983C, Fuel Valve Cover. Cleco the two parts together.

Fit the forward section of the F-782C to the firewall and F-601K-1 firewall recess. Recheck the height of the F-782C and drill it to the floor stiffener angles. Finish drilling it to the firewall as well.

Remove the fuel valve cover and center cabin cover components and install the necessary nutplates. If you are installing electric elevator trim, the triangular flange on top of the F-983A may be trimmed away. Leave it if you are installing manual trim…it will be needed to hold the trim cable.

THE ELECTRIC FLAPS

Electric flap actuation is standard on the RV-7/7A. The power comes from a sealed motor/gear drive assembly between the seat backs, driving the flaps through a welded steel actuator and pushrods connected to the inboard end of the flaps. The flap mechanism is shown on DWG 33.

Begin by drilling the holes in the clevis ends of WD-613-EF flap actuator to ¼".

Drill the holes in the F-680 block and saw it in half.

Drill the safety wire hole shown in Detail E. Install the rod end bearing and jam nut on the end of the ES-85615-157 flap motor shaft.

Install the flap actuator in the baggage compartment using bearing blocks F-661-EF on the F-705 uprights and F-680 in the center. The forward corner of the F-748 cover must be notched to clear the F-680 block, so it can be removed without removing the block. Use the holes in the F-680 block as a template to drill the floor.

Make the F-766C plate, but drill only the indicated index hole in it for now.

Make the F-766B angle, the F-785B attach angle, the F-766D Spacer and F-767 Attach Plate. Pre-drill the angles, but don't drill the attach plate.

Fit and rivet the F-758 bracket to the bottom end of the F-766A channel and install the nutplates along the sides.

Note: The F-758 and F-767 brackets replace the EF-603 and EF-604 brackets that are contained in the electric flap kit parts bag for the RV-7/7A.

Centerline the F-766C plate and match drill it to the F-766A channel. Rivet the pieces together and drill the bolt hole full size.

Fit and rivet the F-785B attach angle to the bottom of the F-785A backrest brace.

Temporarily screw the F-758/766A assembly to the floor and clamp the F-767 attach plate to the top of the channel. Clamp the attach plate to the crosspiece of the F-705 bulkhead and adjust it until it aligns with the pre-punched holes in the bulkhead. Drill the F-767 to both the F-766A and the bulkhead.

Remove the channel and finish F-767 by fitting the nutplates and riveting it to the top of F-766A.

Install the F-766 assembly in the fuselage.

Slide a bolt through the F-766B angle, the flap motor, the washer and the F-766D spacer. See Section B-B'. Use a 12v battery to run the motor until the shaft is half way between its travel stops. Reversing the leads to the terminals will make the motor run the other way.

When the shaft is stopped at half travel, bolt the motor to the Wd-613-EF actuator arm, using the washers shown to center it in the clevis. Safety wire as shown in Detail E. Rotate the arm and bracket until it rests against the inside of the F-766A channel. Bolt the assembly to the channel. Clamp the F-766B bracket to the channel and drill it,

using the holes in the channel as guides.

Remove the bracket from the motor and rivet it to the channel. Re-install the motor, using the spacer, etc. on top as shown in Section A-A'. Don't forget the cotter pin!

Install the F-785A backrest brace and begin fitting the F-760 Flap Actuator Covers. Match the holes with nutplates in the F-766 channel, cleco, and drill the rear row of holes. You can enlarge the hole around the bolt head with a unibit if necessary. Drill the backrest, using the side cover as a guide. Remove the backrest, install the nutplates and re-install it in the fuselage.

The final details of wiring and adjusting the F-759 pushrods are left until the wings and fuselage are joined.

INSTALLING THE LANDING GEAR MOUNTS (RV-7A ONLY)

The main landing gear mount installation is shown on DWG 34A.

Before fitting and bolting the mount to the fuselage, the upper gear leg alignment bolt hole must be completed. Make sure that the inside of the mount tube and the knob on upper end of the gear leg are clean and have no burrs around the holes.

Slide the gear leg into the mount and align the hole. Match drill the leg to the mount using a 0.311" drill bit. Remove the leg and clean up any burrs.

Install the WD-721 landing gear supports to the forward side of F-704. It is acceptable to slightly enlarge the elliptical openings if/as required for the landing gear weldments to pass through the floor as well as the flange of the main spar. Also, it is acceptable to slightly adjust the angle of the WD-721 flange that mates-up to the vertical leg of the lower longeron at its aft end. One other area of possible adjustment is the forward pointing brace tube of the WD-721 weldment.

It is acceptable to open holes in the WD-721 that don't line up with the main spar holes. **Do not drill through the spar,** but mark the holes, remove the weldment and use a round file to remove just the area of interference.

Don't forget the additional washer between the mount and the lower part of the spar as called out on the plans.

If you have a gap of 1/16" of less it is acceptable to pull it tight to the longeron with the bolts. If more than 1/16", use a spacer made from aluminum scrap or rebend the brace tube slightly as required.

Drill 3/16" diameter holes through F-770 and F-7101, 7 places per side using pre-punched holes in WD 721 as drill guides.

WING/FUSELAGE ASSEMBLY

During this phase of construction it is necessary to assemble the wings to the fuselage for a number of reasons including drilling the rear spar/center section attach, finishing the aileron and flap control mechanisms, installing the wing tank/fuselage attach brackets, fabricating and fitting fuel & vent lines, and installation of wing root fairings. If you are working in a small shop it is acceptable to install, then remove, one wing at a time.

Before installing the wing, mark on the W-704 the screw locations at each unused rivet space on the bottom flange of the W-710 root rib. Then mark a straight line from the hole location toward the wing tip and make a measured mark 3" outboard from the intended screw location. This will allow you to measure back to the same point on the overlapping F-776 fuselage skin.

If your wing tips have been permanently attached to the wings and/or your shop dimensions are such that the aileron pushrods cannot be inserted from the tips of the wings, the W-716 pushrods must be loosely placed in the wing lightening holes from the root before the wing panels are "plugged-in" to the fuselage.

Actual installation of the wing panels should be very simple, as the spars have been fitted and drilled at the factory. It is helpful to file a slight bevel on the root ends of the spar to assist getting it started sliding through the slot in the fuselage bulkhead, and to prevent it from scratching and galling the bulkhead bars as it slides through. Support the inboard ends of the wings when inserting to prevent the bottom of the spar from dragging along the inside of the fuselage bottom skin. As the wings are pushed in near center, be sure that the fuselage center bottom skin (which overhangs the fuselage) doesn't catch on the wing skin. When bringing the spar into its exact position, lining up the bolt holes in the bulkhead and spar, it is often helpful to use drift pins. This could be a disposable hardware store bolt with the end rounded or tapered on a grinder. Gently driving this lubricated pin into a nearly aligned hole will center the bulkhead/spar hole so that the bolts can be installed without excessive force It is recommended that 7/16" and ¼" hardware store bolts be used for test fitting to prevent damage to the holes and NAS bolts. Install the bolts as called-out on DWG 11. For fitting purposes, it is only necessary to install four 7/16" bolts, one top and one bottom for each wing panel. Of course, when permanently installing the wings all the bolts called-out on DWG 11 must be installed.

NOTE: When installing the wing for the last time, lubricate the NAS bolts with LPS #1,2 or 3 (available in a spray can). In lieu of that a light coat of ordinary motor oil will do. Do not lubricate the threaded portion of the bolt as this will influence the torque wrench reading.

SETTING THE WING INCIDENCE

With the main spar bolted in place, the next step is the attachment of the rear spars. Level the fuselage, both laterally and longitudinally, using the top surface of the F-718 longerons between F-704 and F-705 as a datum surface. Then square the wing with the fuselage. This is done by measuring from corresponding points on the wing tips to a common centerline point of the aft fuselage. Equate these distances at the same time checking that the wings have no forward or aft sweep. This can be done by dropping 4 plumb lines from the wing leading edges (2 on each wing at inboard and outboard points) to see that they all fall in a straight line. Mark this position with a vertical line at the rear spar attach, on both rear spar and center section.

Now the very important incidence angle must be measured and set. This is done by using a level and spacer blocks as shown in DWG 38. Verify that the fuselage is level. Rest one end of a level on the forward spar just forward of the skin butt joint and the other end on a spacer placed directly over the rear spar web. Shift the rear of the wing up or down to center the level. The spacer size has been calculated to provide the desired 1° positive incidence angle. Check several points along the span of the wing to verify the level reading. Clamp the root in place and check the other side in the same manner. See DWG 38, Section H-H.

It is extremely important that there is at least 5/8" from fastener center to the edge of the part, in both the rear spar and F-705. If unable to maintain proper edge distance, call Van's Aircraft for assistance before proceeding further.

Initially drill an undersize hole starting with no more than a 1/4" drill. Then progressively enlarge the hole to 5/16" which should provide a close fit for an AN5 bolt. Drilling with a long stiff drill bit is a good idea because it can be held straighter for a truer hole.

The overlapping portions of the F-776 bottom skin are screwed to the bottom of the wing when the wings are installed to stay. Holes for these screws must be drilled now. Use the reference lines to locate the hole positions. When the wing is removed, these holes are dimpled for #8 screws. K1100-08 platenuts are riveted to the inside flange of the root rib.

The F-796A Fuel Tank Attach Brackets are fitted to the fuselage as shown on DWG 38, Detail F. The bracket should have the main web adjusted by bending so that it mates flush to the fuselage side and to the T-405 angle bracket on the fuel tank. See DWG 38, Section E-E. Clamp the F-796A angle firmly to the T-405 bracket on the fuel tank. Check to see that it rests firmly against the fuselage and drill the attach holes.

After the F-796A is bolted, at least temporarily, to the fuselage, the clamp can be removed. Locate the center of the 1/4" hole on the flange of the angle. Double check to be sure you have sufficient edge distance on both T-405 and F-796A. Drill the 1/4" hole through T-405.

Finish the bracket installation after the wings are removed by installing the nutplate on T-405 as shown in DWG 38 Detail F and Section E-E. Note the orientation of the platenut. It is important.

Assemble F-759 flap pushrods as shown on DWG 33. Bolt the F-759 to both the flaps and the Wd-605EF flap control weldment. Rob a battery from your car or lawn tractor and connect it to the flap motor. Run the motor up and down while checking for any possible interference in the flap linkage. The hole in the fuselage skin may be enlarged as necessary to avoid interfering with the pushrod.

Install the F-799 wing root fairing as shown on DWG 38, Wing Root Fairing Installation Detail, and Section G-G.

Install the WD-610 control column, WD-611/WD-612 control sticks, and F-665 control column pushrod as shown on DWG 38. Use the W-730 bellcrank jig to hold the WD-421 bellcrank in its neutral position as shown on DWG 15A. Install and adjust the W-818 aileron-to-bellcrank pushrod such that the aileron is in the neutral position when the bellcrank is held in its neutral position. Install and adjust the W-716 bellcrank-to-stick pushrod such that the sticks are in their neutral positions (vertical) when the bellcrank is held in its neutral position.

INSTALLING CABIN SYSTEMS

Installing the brake, fuel tank vent, and fuel systems inside the cabin is much easier when the forward fuselage is still open. The brake and rudder pedals have already been fitted, but the brake lines and hoses must still be finished and installed. The fuel lines are made from aluminum tubing, flared on the ends to mate with AN fittings. Details of these systems are shown on DWG 36 for the RV-7 and on DWG 36A for the RV-7A.

- The routings and fitting details are so well depicted on DWG 36/36A that step-by-step instructions would be redundant. Here are a few general hints, however:
- Install the fuel and fuel vent lines before putting the rudder/brake system in to stay.
- Study the Standard Aircraft Handbook or a similar publication to learn the correct method of cutting and flaring the ends of aluminum tube. A tubing cutter and flaring tool will be necessary. Flares on aircraft fittings are typically 37°. Do NOT use automotive 45° flaring tools or fittings!
- A lever type tubing bender makes neat bends without collapsing the tube. It takes a little practice to learn the bend allowances and techniques, but the results are better than trying to hand-bend tight corners.

- Remember to put the bushings/grommets, sleeves, and nuts on the aluminum tube before you flare the ends. The sleeves particularly will not go around any but the gentlest curves. If you forget, you will usually have to cut the flared end off to get the fittings on.
- A drop of oil on the flaring and bending tools makes the operation much smoother and easier.
- Use Fuel Lube (a sealing paste available in supply catalogs) when installing AN fittings with pipe threads. Do not use Teflon tape!

After the fuel vent and fuel supply line installations are complete, the wings can be removed from the fuselage, the rib flanges, skins, and fairings dimpled, and nutplates installed.

FITTING THE EMPENNAGE

DRILLING THE ELEVATOR HORNS

The elevators were fitted to the horizontal stabilizer during construction, but the lower bolt hole in the elevator horns (to which the pushrod attaches) has not been drilled yet. These holes are best drilled with the elevators mounted to the stabilizer. This hole must be exactly perpendicular to the horns. If it isn't, when the bolt installing the pushrod is tightened, one horn will be pulled forward and the other aft, mis-aligning the counterbalance arms.

Clamp the horizontal stabilizer to the bench with the hinges hanging over the edge. Mount the elevators on the stabilizer. Align the elevator counterweight arms to the stabilizer tips and clamp them so they will not move. Measure the distance between the inside faces of the elevator horns.

The horns are individually welded and seldom does one side match the other exactly. Usually the mis-match is slight. Determine which horn is aft, then remove that elevator and drill a #30 pilot hole in the horn at the dimensions shown on DWG 27A, Side View.

Make an aluminum or hard wood block that fits exactly between inside faces of the horns. The exact size of the block is unimportant, but the two outside faces must be parallel. Use a drill press to make a #30 hole perpendicular to the faces of the block.

Remount the elevator and fix the counterweight arm to the stabilizer. Clamp the block between the horns and align the hole in the block with the hole in the one horn. Use the block as a guide to drill the other horn. Once pilot holes have been drilled in both horns, enlarge them to full size. This can be done one horn at a time.

FITTING THE HORIZONTAL STABILIZER

Clamp the horizontal stabilizer to the aft fuselage. The stabilizer must be perpendicular to the longitudinal centerline of the fuselage. Pre-position the inboard edges of the skins parallel to the longerons. Check by running a tape measure from the outboard end of the stab to the corner of the firewall. Use similar points on both sides of the airplane and adjust the stabilizer until the measurements are equal.

Once the stabilizer is located, it is time to drill the holes though the HS-714 attach angle on the forward spar.

The outboard holes must go through the fuselage longerons, the F-710C spacer and F-710B angle (see Detail B, DWG 27A). These parts are underneath the F-714 deck and invisible. Take careful measurements and locate these bolts as accurately as possible. Remember: the vertical leg of the longeron is 1/8" thick and the bolt must center in the available 5/8" of the horizontal leg.

When the HS-714 angle has been drilled, make the F-798 shims, slip them between the deck and the angle and use the holes as guides to drill the shims.

Temporarily bolt the forward spar and shims to the fuselage. Use a 3/16" spacer and slide it between the rear spar of the stabilizer and the aft deck. This will set the spacing necessary to obtain the desired 0° incidence. Check this by measuring from the deck to the tooling holes in the inboard stabilizer ribs. The measurements should be the same, fore and aft.

When the stabilizer is located, drill the bolt holes though the F-711C bars and the rear spar of the stabilizer.

INSTALLING THE PUSHROD

While the stabilizer is still bolted to the fuselage, pin the elevators in place and clamp the counterbalance arms to the stabilizer.

Install the F-635 Bellcrank and spacer assembly between the F-728 and F-729 ribs (DWG 26).

Make the F-790 Pushrod as shown on DWG 38. Because the pushrod effectively becomes an enclosed unit with no practical possibility of internal inspection, we recommend priming the inside of the tube. Pour liquid primer into one end and swirl it toward the other, coating the entire inside of the tube. An alternative method is to spray primer into one end of the tube, then turn the tube around and spray into the other end. Let the primer cure thoroughly, then rivet the primed VA-101 pushrod ends in the tube with the MSP-42 high strength blind rivets. The primer must be dry before installing the rod end bearings. We have seen wet primer migrate into the rod end bearing and freeze the bearing. You can make a simple pattern out of a strip of stiff paper. Wrap it around the outside of the tube, trim it until the ends just meet, then flatten it out and mark the pattern of 8 evenly spaced holes. Wrap it around the tube again and transfer the spacing to the tube.

Thread the jam nuts onto the rod-end bearing shanks, then thread the rod-end bearings into both ends of the pushrod.

Temporarily bolt the pushrod to the F-635 bellcrank and the elevator horns. Put the F-635 bellcrank in the neutral position, i.e., with the bolt holes for the pushrods vertical. You can come very close by inserting a 3/8" socket through the hole in the F-728 rib and fitting it over the head of the lower bolt, but because socket wall thicknesses are not standardized, there may still be some error, so double check.

With the F-635 in its neutral position and the elevator in trail, the length of F-790 should allow some adjustment both ways in the rod ends.

NOTE: In the final installation, both rod-ends must have over half the thread engaged, making it impossible for a bearing to back off the push-rod if both ends are pinned.

Adjust the pushrod length and tighten the jam nuts against the pushrod ends. Remove the pushrod and store.

MANUAL TRIM CABLE INSTALLATION

The RV manual trim control is a functional, though unconventional, vernier control. A vernier is a control cable that rotates for fine adjustment, but has a button that “unlocks” the threads and allows rapid push-pull movement. Most of us have encountered verniers in other airplanes where they are commonly used as throttle, prop, or mixture controls. Because the trim is very effective, it is conceivable that rapid trim application while the airplane is traveling at high speed could produce high G loads, possibly even destructive loads. Because of this remote possibility, the rapid push-pull action of the cable should be disabled, leaving the rotational vernier action as the only way to move the trim tab.

Pry up the rubber button with a small screwdriver. Work carefully because the button is held with and adhesive and it is possible to damage the handle. When the rubber button is out, remove the plunger shaft. Without this shaft, the vernier control cannot be released and all action will be limited to the twist screw function.

Replace the rubber button with a 1” chrome snap-in hole plug from the local hardware store.

The trim cable is installed from the cabin end, starting through the center console and then routing it aft through the fairlead holes in the bulkheads. See DWG 32 or 32A.

NOTE: If you are planning on a fuel injected engine, order the longer 191” length cable for clearance around the high pressure fuel pump and filter. (7/7A F.I. PUMP INSTAL KIT)

Snap-in bushings of 7/16 I.D. are used as fairleads in all of the bulkheads and webs through which the trim cable passes, except at the root rib and rear spar of the horizontal stabilizer. The hole through the root rib is at an acute angle not suited for a bushing, and the holes through the rear spar must be of minimum size, not large enough for a bushing. Use RTV Silicone Rubber to form a protective gasket around the trim cable in these passages.

Feed the cable through the fuselage and horizontal stabilizer and then through the elevator spar and out through the opening in the elevator bottom skin.

Drill the Wd-415 to the E-616PP cover plate. When the cable is completely in with its aft end hanging free under the elevator, the Wd-415 Anchor Nut is threaded onto the cable. With this anchor clecoed in place, the clevis end is threaded onto the shaft (just over half depth) and trim tab travel can be tested. Desired down travel of the tab (nose up trim) is 35 degrees, and up travel is 25 degrees.

The two inch travel of the control cable is sufficient for this total travel, but it may be necessary to adjust the position of the cable by threading the Wd-415 anchor in or out before it is finally riveted on. Even then, a little adjustment is available in the clevis end fitting.

ELECTRIC TRIM INSTALLATION

The installation of the Electric Elevator Trim (option ordered on the Empennage Kit) and Electric Aileron Trim (option ordered on the Fuselage Kit) systems are covered in those specific subkit instructions.

FITTING THE VERTICAL STABILIZER

Temporarily clamp the F-781 attach plate to the forward spar of the horizontal stabilizer.

Trim the VS-702 front spar as shown on DWG 27A.

Clamp the rear spar of the vertical stabilizer to the back of the F-712 bulkhead, centering it in the bulkhead. Set the height using the dimension shown between the longeron and the hinge bracket.

Take measurements from the tip of the vertical stabilizer to both tips of the horizontal. Adjust the vertical stabilizer until the measurements are equal and the stabilizer is truly vertical.

Drill the bolt holes through the stabilizer and the F-712D Up Elevator Stop. Install bolts temporarily.

Place a straight edge along the back of the vertical stabilizer hinge brackets. The hingeline must remain straight, so hold the straight edge there and double check while clamping the vertical stabilizer front spar to the F-781 attach plate. If the rear spar bends aft at the top when the front spar is clamped, the vertical spar may be mounted on the rear of the F-781 plate. If necessary, you can make a shim to put between the F-781 and the vertical stabilizer spar. If the rear spar bends forward, make a shim to go between the F-781 and the front spar of the vertical stabilizer. Note that the F-781 has a joggle built into it that will offset the front of the vertical stabilizer slightly to the left. Proper offset places the bottom of the leading edge of the vertical stabilizer ¼ inch to the left of the fuselage centerline.

When the vertical stabilizer is properly aligned, drill the front spar to the F-781, using the pre-punched holes as guides.

NOTE that because the stabilizer is offset, the rear spar no longer fits flush against the F-712D angle. Use a single washer, superglued to the forward face of the spar, as a spacer. See View A-A, DWG 27A.

Drill the bottom of the rear spar to the F-712 bulkhead. See DWG 27 for RV-7, see DWG 27A for RV-7A. For now, drill #30.

RV-7A Only: Make the F-712E Tie-down bar shown on DWG 21.

Remove the vertical stabilizer.

RV-7A Only: Drill the tie-down hole in the F-779 skin to 5/8”. Mark and drill the rivets that will attach the F-712E tie-down bar to the bulkhead.

Draw centerlines on the aft surface of the F-712E tie-down bar and insert the tiedown into the fuselage. Adjust the centerlines until they fall in the center of the holes drilled in the bulkhead. Clamp and drill the tie-down bar, using the drilled holes as guides.

Countersink the rear bulkhead and rivet the tie-down bar to the bulkhead.

Re-install the vertical stabilizer and drill the bolt holes to full size.

Temporarily bolt the vertical stabilizer to the horizontal stabilizer and rear bulkhead.

FITTING THE RUDDER

The rudder must swing freely. The gap between the counterbalance arm and the top of the vertical stabilizer should be even. If the rod end bearings were not installed and adjusted during empennage construction, do it now.

Thread the rod end bearings and jam nuts into the rudder spar. Measure from the center of the pivot bolt hole to the forward face of the spar. As a starting point you may use these measurements:

- Top: 51/64”
- Middle 63/64’
- Bottom 1 3/64”

Adjust these measurements as necessary to make the rudder swing without binding.

Make the F-792 L&R rudder stops shown on DWG 27A. Align the drilled hole with the pre-punched hole in the fuselage skin that was left open when the rear fuselage was riveted. Once the stop is clecoed and clamped, the rest of the holes may be drilled in assembly.

Measure the rudder deflection. The proper 35° degree swing is attained when the clearance between the inboard trailing edge of the elevator skin and rudder skin is 1 1/8” when measured perpendicular to the rudder skin with the elevator in the neutral position. File the rudder stops if necessary to achieve this dimension.

Rivet the rudder stops to the fuselage.

Now that the vertical stabilizer, horizontal stabilizer, elevators, and rudder have been installed now is a good time to install the empennage fairing. See drawing 44 for the empennage fairing installation details.

FINISHING THE FORWARD FUSELAGE

SOME THINGS TO THINK ABOUT

At this point, the cabin area is open to the sky. Except for the cross bar of the F-705 bulkhead, no permanently installed part crosses the cabin area. Before you begin upper fuselage construction, consider how the interior will be finished. All Van's demonstrator airplanes are simply painted with a high quality semi-gloss paint on the floor and sides. The only upholstered surfaces are the seat cushions. This rather spartan approach may not be for you. If you plan carpets and sidewall upholstery, now is the time to make and store patterns. It will be much easier than crawling around under the canopy and between the rudder pedals.

If you intend to paint the interior, it is still the time. Remove all the removable covers and panels and paint them separately. Mask and paint the interior as desired. Paint adds weight of course, so carefully consider what surfaces will be visible…do the seatbacks need to be painted, for instance, if they are always covered with cushions?

CONSTRUCTING THE CABIN FRAME (TIP-UP CANOPY ONLY)

The cabin frame serves as a join between the movable canopy and fixed windows over the baggage compartment. More importantly, it provides roll-over protection to the occupants. It is built from thick aluminum channels, formed in curves and riveted into a bow. The cabin frame is shown on DWG 39.

Cut the access holes in the aft F-631A channels, using a hole saw or fly-cutter in a drill press.

Make the various mounting angles shown on DWG 39. Remember to make lefts and rights when required!

Make the F-631E Plates.

Carefully study the cross section drawing, Section A-A'. Clamp the two aft F-631 channels (the ones with the big holes) to a flat surface and check both the width and height dimensions. Double check the width by measuring the fuselage…remember to allow for the thickness of the F-631C brackets. The forward edge of the frame assembly, including these brackets, should match the width of the fuselage as shown in View C-C', DWG 40. The butt ends of the channels can separate slightly to achieve the correct width.

Center F-631E on the center joint and drill the plate to the channels.

While the rear channels are clecoed and clamped to the bench, prepare, fit and clamp the lower F-631B inner strap to the lower flange of the channels. Begin drilling from the center and work toward both ends. The strap will try to rise out of position as it goes around the curve, so check often to see that it is still held firmly against the web of the channel.

Repeat the process with the upper F-631B strap.

Clamp the other pair of F-631 channels to the assembly on the bench and drill the holes through the straps. When the entire bow is clecoed together, drill the second F-631E plate at the joint. Although this will be installed inside the channel, it can be drilled from the outside.

Stand the bow on a table and measure the height at the center as shown on DWG 39, Rear View. File the ends of the bow if necessary.

Disassemble the frame for deburring, and while it is apart, fit and drill the F-732D Angle to the rear half.

Rivet the frame together, including the F-732D angle.

INSTALLING THE CABIN FRAME

Place the cabin frame flat on the table, with the large holes up.

Clamp the F-631C angles to the outside surface of the frame.

Clamp the F-631D angles inside the frame.

Clamp the two sets of angles together and drill the keeper rivet holes, using the holes drilled when F-631D was made as guides. Remove the angles, deburr and rivet them together to form channels with a offset bottoms.

Locate the F-631C/D channels on the fuselage at the F-705 bulkhead as shown in the Side View of DWG 40. Drill and bolt the channels to the fuselage, through F-705F and F-705G. This will leave the aft end of F-631C protruding outside the contour of the fuselage. Trim and file the projecting part of the bracket away as shown in View C-C', DWG 40. The skin must fit smoothly on the outside face of the bracket.

If it isn't already, cleco the F-774 skin and F-788 gusset to the fuselage.

Clamp the cabin frame assembly to the brackets on the fuselage. Cleco the F-732A Channel and F-732F spacer between the frame and the F-706 bulkhead as a brace. Match-drill #30 and cleco through the F-774 skin, F-788 gusset, F-706 bulkhead, F-732F spacer and F-732A channel.

Match-drill #30 through the two tabs on the F-732A into the F-706 Bulkhead. Match-drill the forward end of F-732A to the F-732D angles.

Use the two pre-punched holes in the forward "tongue" of the F-774 skin to locate the forward screw holes that join the F-774 skin, the F-631C bracket and the cabin frame. See Note 1 on DWG 40 for the sequence of drilling these holes.

Leave them at #30 for now, so that clecos will hold.

Peel back the skin, cleco the bracket to the frame through the holes you just drilled, then drill the aft screw holes, using the holes in F-631C as guides. In the finished airplane, the forward holes will be visible from the outside, but the skin will hide the aft screws.

Remove the skin and finish drilling the screw and bolt holes at the base of the cabin frame. Tap the frame as shown and temporarily install the screws and bolts attaching the frame to the fuselage. Match-drill #30 through the forward row of holes in the F-732 spacer and through the F-732A channel.

Because it is easier to work on many things in the cabin and fuselage if the rear skins and cabin frame are not in the way, once these components are fitted and ready to install, they may be removed and stored.

INSTALLING THE FRONT DECK (TIP-UP CANOPY ONLY)

The structure between the instrument panel and the firewall, above the main longerons, differs, depending on which canopy has been chosen. Be sure you are reading the directions for the canopy on your airplane.

Details of the upper forward fuselage for the tip-up canopy are shown on DWG 24A.

Begin by making the F-721C, F-743B, F-768C and F-703C angle brackets. Be careful to make left and right pairs when necessary.

Make the F-703B Angle and fit it, along with the F-703C angles, to the F-703 instrument panel. You can either rivet the angles to the panel now, or leave it until later…. the decision may rest on exactly how you plan to cut the holes for the instruments. If you are sending the panel out for custom work, perhaps involving machine or laser cutting, it will probably be better to leave the angle clecoed, so the flat panel is available to the cutting machine.

Assemble the components of the center F-768 subpanel. Locate and drill the hat-section F-697 Channel to the aft face of the F-768A Center Subpanel. Pre-punched holes in the subpanel serve as guides. The upper two rivets on the right hand flange also hold the F-643-1 Forward Fuselage Channel, so fit that as well.

Drill the F-644R&L forward fuselage channel to the flanges of the F-768A.

Drill the F-746 engine cable control bracket to the bottom of the F-768A.

Drill the F-768C seal support to the F-768A. Note that the flange of the seal support is lower than the flange of the subpanel (see Detail D) to allow for the thickness of the seal.

Prepare and rivet the forward fuselage channel, center sub panel and hat-section together. Note that flush head rivets are used (flush heads outboard) to join the F-644 stub ribs to the F-768A subpanel. Leave the F-746 engine control bracket clecoed for now…you may want to vary the spacing between the clamps holding the engine control cables, and it is much easier to install these nutplates out on the bench. See Note 1, DWG 24A.

Install the platenuts on the aft flange of the F-745-L&R Forward Fuselage Ribs.

Fit and rivet the F-768D Seal Support Angles to the F-768-L&R Outboard Subpanels.

Drill each F-768B outboard subpanel to the appropriate F-745 rib. Note that the two upper rivets are flush, with the flush heads inboard. Dimple the subpanel and rib and rivet them together with the flush rivets only. This will form two rather floppy subassemblies.

Insert the outboard subassemblies into the fuselage, with the notch in F-768 fitting around the longeron. Cleco the outboard subpanels to the forward flange of the F-721A deck and the F-902 bulkhead. Slip the center subassembly between them and cleco the structure together. Cleco the ribs to the firewall.

Fit and drill the F-743B bracket (connecting the F-643-1 to the firewall) to the channel only.

Mark centerlines on the F-643-1 and firewall flange.

Fit and drill the F-771 Forward Top Skin (DWG 28) to the firewall, ribs and subpanel. When the F-643-1 is clecoed to the skin, drill the F-743B angle through the firewall. Also fit the F-721A Forward Canopy Decks to the longerons. These will require some gentle hand twisting to fit well. Cleco them to the subpanels and align them with the longerons. The aft ends must be filed to fit the F-721B canopy decks. When the F-721A is removed for de-burring, bend the flange on the leading edge of the F-721B inboard to rest against the inside of the F-721A. Drill these components together.

Fit and drill the F-721C and F-721D attach angles to the panel and the F-721A deck. Rivet the nutplates to the angles and then remove the panel and install the angles to the deck.

Temporarily screw the instrument panel to the aft flanges of the ribs.

Fit and drill the F-793-L&R Vent Brackets to the fuselage, and fit the SV-2 Adapter and SV-5 Ventilator to the panel.

Depending on which task you intend to do next, you may either leave the structure clecoed in place or remove it all. You will probably want to at least "rough-in" avionic and instrument installations before riveting the entire upper forward fuselage assembly permanently.

INSTALLING THE FRONT DECK (SLIDING CANOPY ONLY)

The structure between the instrument panel and the firewall, above the main longerons, differs, depending on which canopy has been chosen. Be sure you are reading the directions for the canopy on your airplane.

Details of the upper forward fuselage for the sliding canopy are shown on DWG 24.

Make the F-7103C-L&R Attach Angles that go on the back of the F-7103 Instrument Panel. See View B-B, DWG 24. Leave the angles clecoed to the panel.

Make the F-7109 Plate, the F-7108B Angle, F-7108C and F-721D Attach Angle.

Drill and rivet the F-7109 plate and F-7108B angle to the F-7108A Center Forward Fuselage Rib.

Drill the F-746 engine control bracket to the F-7105A subpanel, but leave it clecoed for now…you may want to vary the spacing between the clamps holding the engine control cables, and it is much easier to install these nutplates out on the bench. See Note 1, DWG 24.

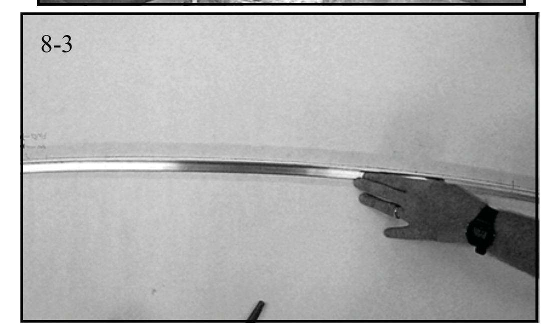
Twist the F-7105A subpanel and fit the F-7108 rib through the center of it…the guy who designed it swears it is possible. Cleco the rib to the firewall.

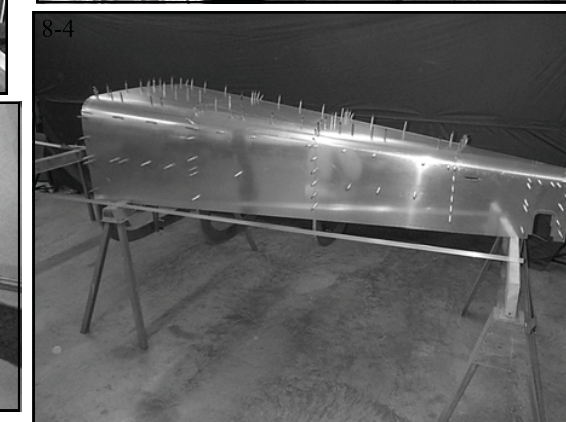
Cleco the F-7107-L&R Ribs to the firewall and F-7105. Add the F-7105B Outboard Subpanels and the instrument panel, so the entire structure between the panel and firewall is clecoed in place.

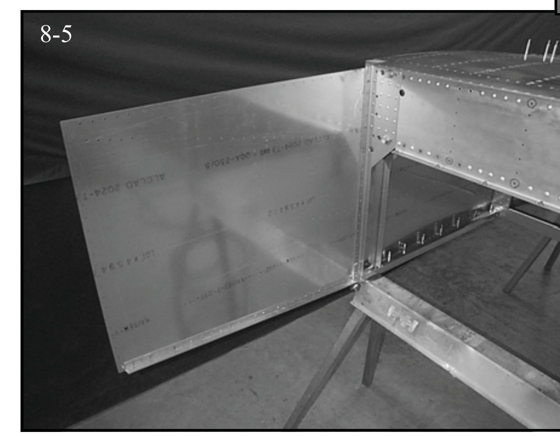
Fit and drill the F-7106 Forward Top Skin to the forward fuselage. Also fit the F-721A Forward Canopy Decks to the longerons. These will require some gently hand twisting to fit well. Cleco them to the subpanels and align them with the longerons. The aft ends must be filed to fit the F-721B canopy decks. When the F-721A is removed for de-burring, bend the flange on the leading edge of the F-721B inboard to rest against the inside of the F-721A. Drill these components together.

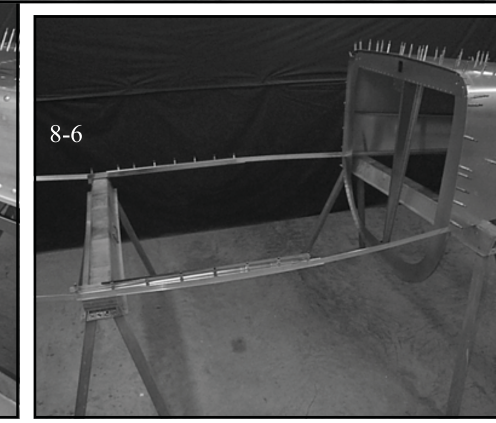
Fit and drill the F-721C and F-721D attach angles to the panel and the F-721A deck. Rivet the nutplates to the angles and then remove the panel and install the angles to the deck.

Fit and drill the F-793-L&R Vent Brackets to the fuselage, and, if you have them, fit the SV-2 Adapter and SV-5 Ventilator to the panel.









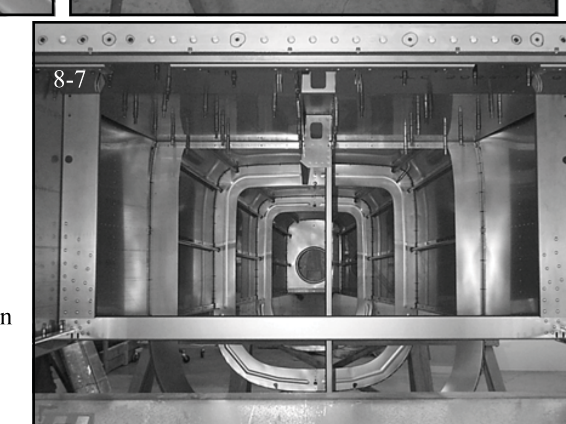
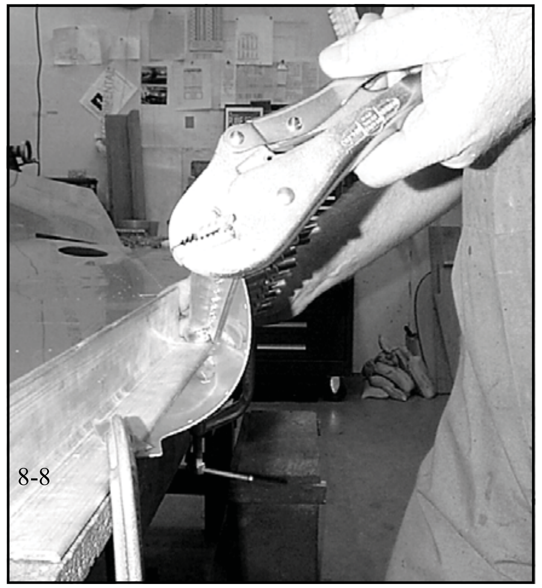
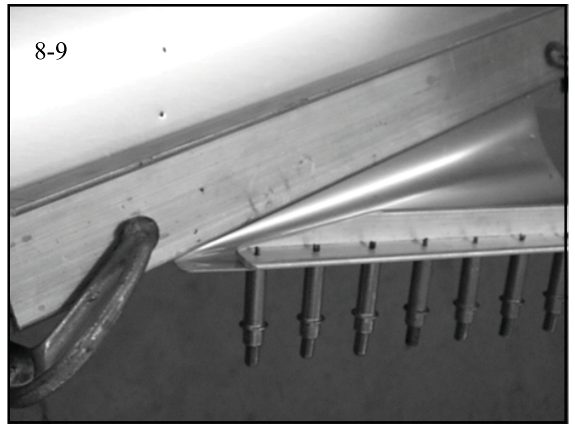
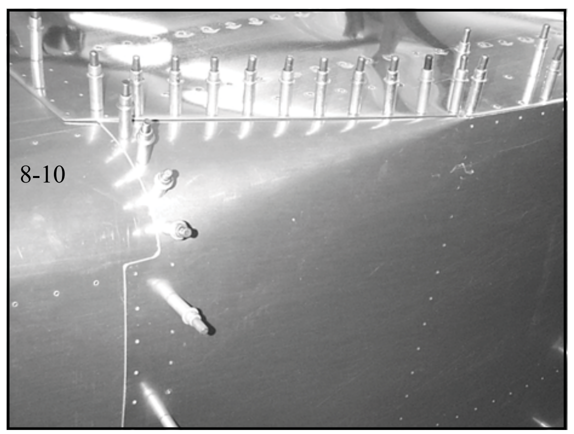


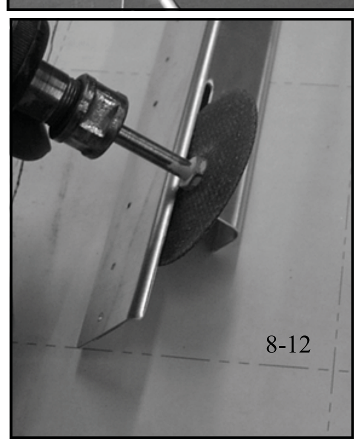
Fig 8-1. Bending the longeron in a vise.
Fig 8-2. Twisting the longeron.
Fig 8-3. Checking the longeron against the template.
Fig 8-4. The aft fuselage bulkheads and skins riveted together.
Fig 8-5. The forward side skin attached to the forward fuselage.
Fig 8-6. The longerons inserted.
Fig 8-7. Interior of the tailcone with floor ribs clecoed in place.







Figs 8-8-11: Various stages of the conical bend on the F-970 side skin. The forward end is bent almost to a sharp corner, but be cautious...if you try to do too much it will crack.



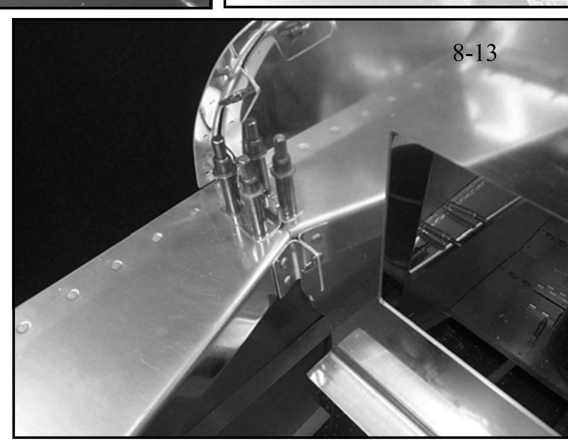
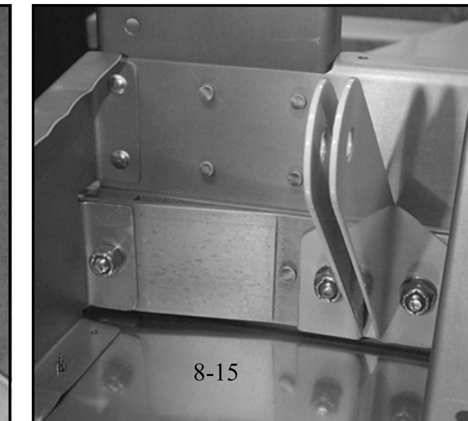
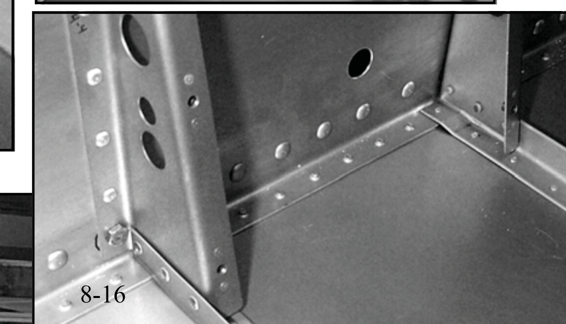
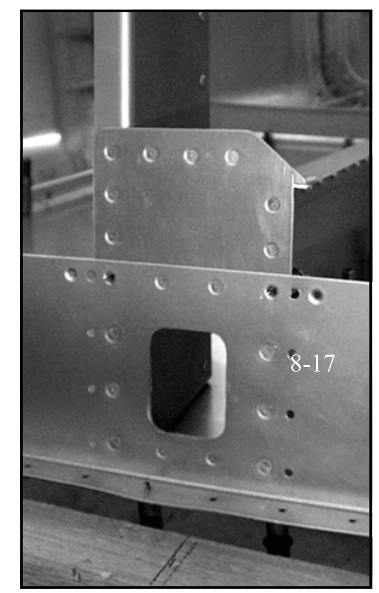


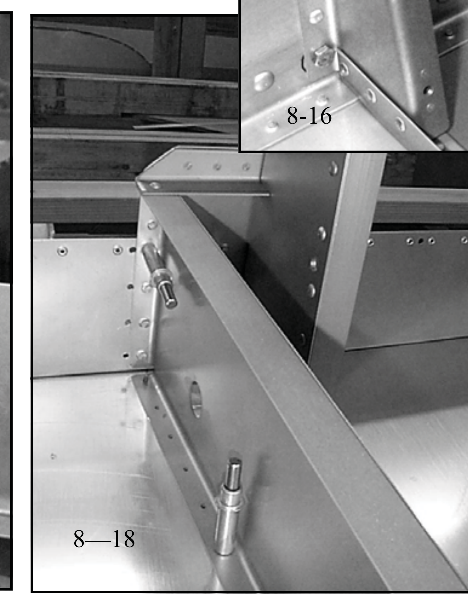
Fig 8-12. Slotting the aft end of the F-721B canopy deck.

Fig 8-13. The forward end of F-721B butted against F-721A









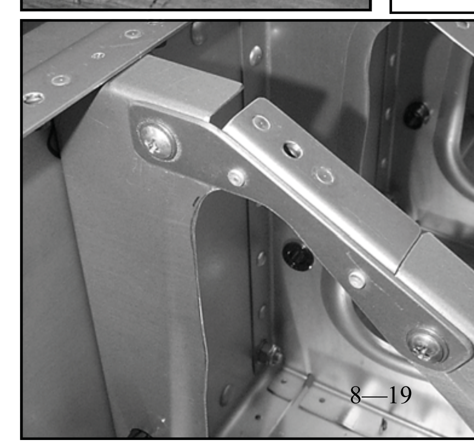


Fig 8-14. The F-656 gusset.
Fig 8-15. The F-634 seat belt anchor.
Fig 8-16. The F-838B cover support rib.
Fig 8-17/18. Details of the F-729/730/705 junction.
Fig 8-19. The modified F-916 floor rib

SECTION 9: FITTING THE CANOPY

OVERVIEW

The RV-7/7A has been designed to accept either a forward hinged, tip-up canopy bubble or a sliding canopy with a fixed windshield. The fuselage structure differs slightly between the two styles. Be sure you are following the directions for the proper canopy.

Fitting the canopy is one of the most demanding construction jobs in building an airplane -- any airplane. The big plexiglass bubble is fragile and difficult to handle. The geometry is not always obvious. The fit must be correct to prevent aggravating air and water leaks.

Take your time and work with patience and persistence.

PLEXIGLASS TIPS

The plexiglass canopy bubble is one of the most expensive and fragile components in the kit. Mis-handling and cracking it is one of the most disappointing, gumption-robbing experiences a homebuilder can have. Here are a few plexiglass tips.

Plexiglass is dramatically less brittle when it is warm. Do not try and work on the canopy in a cold shop. Cutting or drilling Plexiglass in temperatures under 60º F is asking for trouble. Heat the shop to 75-80º -- it may be uncomfortable to you, but your canopy loves it.

Regular twist drills have tips that tend to fracture Plexiglass. Special Plexiglass drills are available from tool suppliers. We have also found that a small Unibit makes excellent holes in warm Plexi. Using a regular twist drill to enlarge a pre-drilled hole is almost guaranteed to crack a canopy.

Do NOT try and use a saw of any kind. You might get away with it once or twice, but eventually you will crack the bubble. Cutting discs, supplied with the kit, do an excellent job when used in a high-speed die grinder. They will also cut fingers without a second thought, so support your work well and use two hands to guide the grinder. Die grinders turn at very high rpm and can throw chips and dust at un-dodgable velocities. Eye, ear, and respiratory protection is essential!

TIP-UP CANOPY INSTALLATION (slider instructions start on page 8)

INSTALLING THE FORWARD FUSELAGE RIBS & CANOPY RELEASE MECHANISM

DRILLING THE CANOPY HINGE BLOCKS TO THE RIBS

Making the canopy fit the fuselage precisely is easier if the canopy frame is fitted before the rotation points are drilled in curved hinges. The rotation points are located on the fuselage first, then transferred to the hinges themselves. To locate the hinge points on the fuselage, the spacers and bearing blocks that will receive the canopy hinges must be fitted and drilled in place.

Make the C-617, C-618, and C-619 spacers as shown on DWG 47.

Temporarily remove the F-644 ribs. Clamp the C-617 block to the F-745 rib with the aft surface of the block flush to the aft edge of the rib and the top surface of the block just low enough to clear the skin when it is installed. Drill two shallow #12 pilot holes into the block using the two pre-punched 3/16" holes in F-745 as a guide. Drill only about 1/16" deep into the block.

Remove the block and finish drilling the holes in a drill press using a #10 drill. (Be sure the drill press table is level and square). UHMW plastic tends to expand when drilling and then shrink back after the drill is removed. A #10 bit will produce a hole that will be a slip fit for an AN3 bolt.

Clamp the C-617 and C-618 blocks together, with the forward and top edges flush. Use the holes in C-617 to drill C-618.

While the two blocks are joined, carefully measure the location of the ¼" hole for the canopy hinge pivot bolt and drill it through both blocks.

Repeat the procedure with the other C-617/C-618 blocks.

Reinstall the C-617 blocks on the F-745 ribs with temporary bolts.

Drill the ¼" holes in the F-745 ribs, using the holes in the C-617 as a guide.

Pull a .251" reamer backwards through the block and rib a few times to get a nice slip fit on the modified AN43B pins.

Drill the upper hole in the C-619 spacer to the measurements shown on DWG 47. Be sure to maintain the bolt hole edge distance because this spacer will be used later as a guide/stop for positioning the canopy frame. Clamp the C-619 spacer to the C-617 block, insert a bolt through the hole and drill the second bolt hole.

The F-644 ribs were drilled but not riveted to the F-768 bulkhead during fuselage construction. Now they must be match drilled to the block assembly. Cleco the F-644 ribs to the F-768 bulkhead. Insert the C-617/618/619 assembly between F-644 and F-745 and slide bolts through the holes until they contact the face of F-644. Clamp the ribs and blocks together, using just enough pressure to hold the clamp in place.

Cleco the F-771 front top skin in place to maintain the proper position of the F-644 ribs. Do not cleco the portion of skin that is outboard of the F-745 ribs so the skin may be lifted to provide access for drilling.

If the holes in F-771 skin and F-644 ribs don't align, insert thin aluminum shims between the inboard face of C-617 and F-644 until they do. When the assembly comes apart later, you can make a full size shim of the correct thickness.

When the F-771 is clecoed to the F-644 rib, tighten the clamp. Peel up the outboard portion of the skin, remove one bolt from the assembly and drill F-644 through the hole. Reinsert the bolt, all the way through F-644 this time, and continue until all the holes are drilled.

INSTALLING THE CANOPY RELEASE

Make the C-620 bearing block shown on DWG 47. Drill the bolt holes to the dimensions shown.

Fabricate and/or install the canopy release mechanism components C-620, C-621, C-622, Wd-618, Wd-619, Wd-620, and the modified AN43B-16 bolts. See DWG 47. The entire pushrod/bellcrank assembly can be pre-assembled on the bench, with all its clevis pins, thin washers, and cotter pins. This will allow you to install it in one piece without having to lie on your back installing cotter pins, etc. Experiment with installing the assembly with the top skin removed so it will be familiar when it is time to install it after the skin is riveted on.

When drilling the Wd-618 to the Wd-619 be sure the arm on the Wd-619 is "clocked" to the correct position (with the ears on the Wd-619 pointed outboard) and that the elevation is correct. It must center vertically as it swings through the pre-punched cutout in the F-768 bulkhead.

Fit the mechanism to the forward fuselage and align the C-620 bearing block on the F-697 channel. The horizontal position is determined by the side-to-side pushrods. The vertical position is determined by the fore-and-aft pushrod. Clamp the block to the channel and work the mechanism. Adjust the block position if necessary to align the pushrods and eliminate any binding. When the block position is correct, drill the C-620 to the F-697 using the holes pre-drilled in the block as guides.

Note: If you intend to have in-flight canopy jettison capability you must notch a portion of the F-771 skin above each hinge slot to allow the canopy frame to be pushed up and away from the fuselage. See DWG 28, Detail F. These notches can then be covered with a sacrificial cover plate bonded in place lightly enough that it will not exceed your (probably adrenaline-enhanced) ability to break the bond should you ever have to push it open.

RIVETING THE UPPER FORWARD FUSELAGE

Once the above work is completed the upper forward fuselage structure can be riveted at any time, though we recommend that you delay it as long as possible. This will provide much better access to the cockpit area for all of the systems installation, wiring, instrument panel work, etc.

When you are ready to assemble the forward fuselage structure, first rivet the F-768C seal strips to the F-768A and F-768B sub-panel (leave open any rivet holes that share other parts). Rivet the plate nuts to the F-697 and then rivet the F-697 and the F-643-1 to the F-768A.

Rivet the F-745 ribs to each F-768B sub-panel (only at the 2 top holes requiring AN426 rivets). An F-768B with its associated F-745 rib (your choice, left or right) can now be riveted to the F-768A. Now before riveting the other F-768B you must fit the whole assembly into the fuselage and cleco it in place. See DWG 24A. You can now finish all of the other riveting in any order you choose, though it is easier to rivet the F-721C & D attach angles to the F-721A before it is riveted to the fuselage. If you are using the optional map box kit, now is a good time to complete the installation.

INSTALLING THE PRIMARY CANOPY LATCH

INSTALLING THE SIDE HANDLE

Use the Tip-Up Canopy Latch Hole Pattern template on DWG 48, Detail D to locate and drill holes in the forward side skin for the latch handle. Use a small file to slot between the holes…this will be visible, so work carefully.

Use a straight edge and check the C-607 Latch Handle for straightness. The 1/8" thick material often distorts slightly in the punching process. Clamp it in a vise and lightly tap in the appropriate locations to get it as straight as possible.

File/deburr the edges of C-607 and C-609. Finish the interior of the hooks with a small jeweler's file.

Fabricate the lower C-712 angle as shown on DWG 48. Use particular care to accurately locate the two 3/16" diameter holes in C-712.

Temporarily bolt C-607 and C-609 to the lower C-712 angle. The aft outboard portion of C-607 has two straight, parallel edges offset .032 from each other. C-607 should mate to the lower C-712 so one of the edges is flush with the outboard face of C-712 and the other edge is protruding by .032. C-609 should mate to the C-712 angle so it rotates enough to disengage before interfering with the forward surface of C-607.

Fabricate the upper C-712 angle. Clamp the angles together and ensure that the outer faces of the two angles are flush before drilling the 3/16" diameter holes.

Temporarily bolt the C-607 and C-609 between the two C-712 angles. We use UHMW tape applied to the upper/ lower faces of the C-712 angles to prevent C-607 & C-609 from scraping the angles as they rotate. Use an .016 spacer and a piece of heavy paper (to allow for the of UHMW tape) between the inside faces of angles and C-607 and C-609. This will provide some clearance and prevent binding.

Position and drill the C-712/C-607/C-609 sub-assembly to the forward side skin. Use the C-607 to align the sub-assembly with the slots in the skin.

Machine countersink the C-712 rivet holes, dimple the forward fuselage skin and rivet the angles to the skin.

Follow the instructions supplied with the VA-104 knob and install it on the C-607.

Bolt the C-607 to the C-712 angles. Drill a hole in C-609 and in the main spar bulkhead for C-616 wire core.

Install the C-607/C-609 latch handle, then insert the C-616 wire core into the C-615 spring and hook it into the holes on the fuselage and latch.

INSTALLING THE AFT CANOPY LATCH

The Wd-617 Canopy Latch spans the cockpit behind the seats and operates canopy latch fingers on each side of the canopy frame. It is shown on DWGs 48 and 49.

Bend the latch hooks (if necessary) until they fit through the oval holes in the F-705 bulkhead.

Mark lines on each C-611 block for the vertical position of the bolt holes. Fit a C-611 block to each end of the Wd-617 and install it into the fuselage. Fit the hooks in the F-705 oval holes and clamp the blocks in position so that the bolt position lines are visible through the pre-punched holes in F-705 (see DWG 20).

Using the holes in the bulkhead as guides, drill holes in the C-611 blocks about 1/16" deep with a #30 drill to mark its location. Remove the blocks and finish drilling the holes in a drill press. Then enlarge the holes in the blocks with a #10 drill bit. Enlarge the bolt holes in the F-705 bulkhead with a #12 drill. Bolt the Wd-617 and the two C-611 blocks into the fuselage.

Install the two VS-411 brackets to the F-705 bulkhead.

Install the C-605 and the two C-606 links. The links will require a slight twist and small bends on the ends to make them align with the angular difference between the arm on the Wd-617 and the C-605.

This all sounds complicated but it should be readily apparent when you begin bolting the parts together.

Finally make the C-710 push rod assembly as shown in DWG 48. Drill the ends of the tube with a #3 drill and tap them with 1/4 - 28 threads at each end to accept the rod ends.

FITTING THE CANOPY FRAME TO THE FUSELAGE

PREPARING THE FRAME AND FITTING THE CANOPY SKIN

If the instrument panel and avionics are installed, remove them for safekeeping while the frame is fitted.

Install the C-617, C-618, & C-619 blocks.

Draw a black pen center line on the aft tube of the Wd-716 fwd canopy frame weldment.

Use a ¼" to ½"wide strip of UHMW tape (not in the kit, available from Van's catalog) along the inner surface of the forward edge of the C-702 skin to prevent it and the F-768 sub-panel flanges from rubbing on each other when opening and closing. The tape should be attached flush with the forward edge of the skin before beginning the

installation process.

When the forward ribs of the Wd-716 canopy frame assembly are manufactured, the flanges do not form to the necessary 90 degrees. Use a file or belt sander to remove some material on the aft edge of the upper flange so it is 90º when checked with a square. Only the portion from the center to about 3" outboard of each hinge bracket should be modified. Outboard of that, the fuselage widens and the flange should be a little under-bent.

Cleco the C-702 forward top skin to the Wd-716 fwd canopy frame weldment. Verify that you can see the pen line on the Wd-716 aft tube through the aft row of holes, then begin drilling and clecoing from the center out to each side with a #40 bit (they will be opened up to #30 later on).

Double check that there are no bumps around the notches in the F-768A or F-768B flanges that would prevent the skin from smoothly laying down. File as necessary to make the skin fit smoothly.

Fit the forward canopy frame/canopy skin assembly on the fuselage (you might want to protect the fuselage side rails with paper/tape from now on if they are already painted) and check the fit. The frame width at the aft tube may need to be adjusted slightly to match the fuselage width. This can be done by adding more curve to the aft tube at the ends (bend it around something round) or straightening them slightly (push it against a table top).

Tape the canopy frame/canopy skin assembly back on the fuselage, pulling it down tight on the fuselage. Butt the forward edge of the C-702 canopy skin up to the aft edge of the F-771 forward fuselage top skin. Then slide the canopy skin slightly aft and slip some .020 or .032 spacers between the skins. When the canopy frame is in the correct position, the two skin edges will have a slight gap across the full width of the fuselage.

Pre-drill the hole pattern into the C-614 center splice plate using #40 holes. See DWG 47. Fit C-614 to the Wd-716 canopy frame and drill the holes to the two frame ribs (only use a # 40 bit at this time to allow for slight adjustments later if required).

Drill two rows of #40 holes through Wd-716 that run aft from each hinge point using the pre-punched holes in the C-702 skin as a guide.

Remove all chips from between canopy skin and canopy frame and re-cleco.

Now drill #30 through the pre-punched holes in the tabs on each hinge bracket into the fwd canopy frame ribs. Remove the frame. Remove the skin.

Deburr all holes. Re-cleco the skin to the frame and put it back on the fuselage.

Retape with duct tape to pull everything back down tight.

Double check that you are happy with the fit and if so drill the holes in the C-614 splice plate to #30.

Disassemble deburr and rivet the 1/8" rivets in the frame splice plate and hinge angles. Note that some of the rivets are AN426 flush on the fwd side. See DWG 47, View D-D.

Re-cleco the canopy skin to the frame and fit the frame back to the fuselage.

DRILLING THE HINGE BRACKETS

Be sure you have installed the second of two AN3 bolts through F-745, C-617, C-618, C-619, and F-644 after riveting on the F-771 skin. Use a ¼" drill bit in an angle drill to back drill through the C-617 block and into the Wd-716 hinge brackets to mark the hinge pin location. You do not have to drill all the way through the Wd-716 hinge brackets. Drill just deep enough to make the full diameter of the drill bit. Remove the frame from the fuselage and finish drilling the ¼" holes all the way through the brackets as straight as you can.

With the hole finished to 1/4 " enlarge it for the bushing. This is most accurately done by carefully drilling the hole to 23/64" and then reaming to .375 with a straight reamer. A sharp new 3/8 drill bit can also be used to take the hole to final size if a reamer isn't available. Deburr the holes and then press in the bushings using flush set in a rivet squeezer.

Reinstall the previously made release mechanism in the fuselage.

Attach the Wd-620 handle temporarily to make it easier to engage the pins when installing and removing the frame the 100 or so times you will do it while fitting the canopy.

FITTING THE CANOPY FRAME TO THE FUSELAGE AND CABIN FRAME

Reinstall the canopy frame on the fuselage (without the canopy skin clecoed on) and engage the release pins.

The canopy installation is designed with a very tight clearance between the Wd-716 frame and the F-768C seal support angle. See DWG 24A. Trim the seal support angle just enough to allow the frame to pivot without scraping.

Cleco the C-702 canopy skin to the Wd-716 canopy frame using clecos in all the holes.

Make four spacers 7/8" thick and four 1/8" thick. They can be made of what ever material you like (we used aluminum bar for the thin ones and blocks of wood cut on the band saw for the thick ones) but they should be accurate for thickness. The 1/8" spacers should be approx. 1" X 2", and the 7/8" spacers should be approx. 2” X 4". The 1/8" spacers will be used under the Wd-725 canopy side rails, and the 7/8" spacers will be used between the F-631A ribs and the F-631 roll bar.

The F-631A ribs must have the flange angles re-adjusted to about 92.5 degrees (as formed they are only about 88 degrees) and then fluted to make them straight. Adjust the flute spacing to allow for the eventual screw pattern that will attach the canopy.

Fit and drill the C-704 splice plate (DWG 49) to one (for now) of the F-631As. Later the splice plate will be clecoed to the front of the frame to locate the holes in the other half.

Lay the Wd-725 canopy side rails in place on the fuselage to check the fit. The goal is to have the curve of Wd-725 exactly match the longitudinal curve of the fuselage and align vertically with the fuselage side when checked with a straight edge. As supplied, the curve is usually very close along the bottom but more curve will probably be required along the joggle at the top. This is improved by lightly bending the rail across any heavy round object.

The fwd ends of the Wd-725 canopy side rails may need to be adjusted/modified where they mate to the Wd-716. Squeeze the upper bend with flush sets in a rivet squeezer and then finish the adjustment with a hand seamer. The goal is to get a smooth transition from the Wd-725, rolling inboard to the Wd-716.

Lay out and pre-drill the rivet pattern in the C-613 splice plates using a #40 drill. See DWG 48.

Layout and pre-drill the rivet pattern in the angle bracket welded to the aft end of each Wd-725, using a #40 drill.

Tape the 7/8" spacers to the aft side of the F-631A ribs. Clamp the ribs to the forward side of the F-631 cabin frame.

Clamp each Wd-725 to the fuselage sides using the 1/8” spacers between the bottom of Wd-725 and the F-721 aft canopy deck. The aft surface of Wd-725 mates to the forward surface of the F-631A ribs. Use a piece of .032 scrap to simulate the C-603 canopy skirt thickness. The correct position of the Wd-725 is with the C-603 skin flush with the side of the fuselage (see DWG 48, Sect B-B and C-C). Drill the welded angle to the F-631A ribs.

Clamp the C-613 splice plates to the Wd-716 and the Wd-725 with the bottom flanges of Wd-716 and Wd-725 aligned (see DWG 48.) The lower flange on the C-613 nests tightly to the lower flange of the Wd-725. The forward portion of the flange that angles away from the Wd-716 will be later filled with a wedge shaped spacer.

FINISHING THE FRAME

When you are happy with the alignment of the frame sides to the fuselage, drill the holes from the C-613 through the Wd-725 and the Wd-716. Do not drill the two holes through the Wd-725 upper flange and Wd-716 aft tab at this time. Drill the holes only through Wd-725/Wd-716 and C-613. While drilling, be sure to peel back the C-702 skin slightly where it overlaps the splice plate holes so you don't drill into it.

Remove the C-613s and Wd-725s from the Wd-716 and remove the Wd-716 from the fuselage.

Un-cleco the C-702 skin from Wd-716.

Re-cleco the C-613’s to the Wd-725's and the Wd-716.

Make the C-723 spacer wedges. See DWG 48.

Clamp a piece of scrap angle along the bottom edge of the side of the frame to make sure it is straight and then drill the 2 holes through the Wd-716, C-613, and the C-723 wedge.

Disassemble, deburr, and machine countersink for the AN426 rivets.

Re-cleco and reclamp with the angle to be sure it is straight, and rivet the canopy frame together, except at the joint of the F-631As. This will be final drilled and riveted a little later.

Reinstall the frame on the fuselage and cleco on the C-702 skin.

FITTING THE PLEXIGLASS CANOPY

It is now time to start cutting the canopy. Put away the prayer beads…this isn’t as bad as you may have feared.

Keep the vinyl plastic on the canopy for as long as possible to protect it from any accumulation of dirt and grit that can cause scratches during installation. It is very difficult to remove this without causing scratches. If you get to a point where you have to remove the vinyl, replace it with some stretch-on plastic wrap from the kitchen. This will help keep it protected until the airplane is ready to fly.

Before doing any cutting, mark a centerline on the vinyl down the middle of the canopy from front to back. This will aid in aligning to the fuselage and keeping the two parts aligned with each other once the canopy is cut.

The initial trim removes just the excess flange around the front, and the clamping areas along the sides and the back. Use this cutting on unused portions of the canopy as an opportunity to practice making clean straight lines. Go ahead and mark lines with a straight edge and practice following them as well as you can.

Before the canopy is moved/handled you must finish on the edges at least to the point of removing any nicks and rounding the sharp edges. These are all stress risers that can be the origin of a crack.

Put some masking tape on the roll bar and the F-631 rib flanges to prevent scratching the canopy. Mark a center line around the circumference of the cabin frame. This will be the eventual split line between the front and back portions of the canopy.

Set the canopy in place on the fuselage to check the fit. The canopy will eventually go behind the “ears” on the C-702 skin but for now, put some tape on the ears to prevent scratching and let them rest inside the canopy.

You now should be able to see what the frame shape has to be at the fwd end of the Wd-725 side rails where they intersect the Wd-716. The joggled flange on the Wd-725 and the tab on the Wd-716 need to begin rolling inboard to allow for the shape of the canopy at this point. Remove the canopy and adjust as necessary, then refit the canopy.

The initial trimming should work towards a flush fit of the windscreen portion at the front to the C-702 skin. WHEN CHECKING THE FIT OF THE CANOPY TO THE FRAME, THE CANOPY MUST BE (AS MUCH AS POSSIBLE) CLAMPED/HELD WHERE IT WILL BE IN WHEN IT IS FINALLY SCREWED ON TO THE FRAME.

Pull the canopy sides in to the frame when checking the overall fit. The goal is to get the canopy to fit nicely to the C-702 skin while it is pulled in to the Wd-725 side channels, is touching around the sides of the roll bar, and contacts the F-632A approx. 1.5 " forward of the F-606 bulkhead. In final position the base of the windscreen will be approximately 1.75" aft of the forward edge of C-702.

Do not attempt to do any trimming to final size, other than around the base of the windscreen, until after you have split it the canopy at the roll bar. The molded shape of the canopy results in a slight duck tail upturn at the very back (trimmed off later) and a curve in the top where it goes over the roll bar. This will prevent it from laying down flush on the top of the cabin frame and canopy frame until it is separated into two pieces.

When you have gotten the fit to be somewhat close (it doesn't need to be perfect: it actually becomes much easier to deal with once the canopy is split) it is time to mark the split line. The split point goes right down the middle of the F-631 roll bar. Don’t forget to pull the canopy in tight on the sides when marking the line.

At this time you should also temporarily cleco on the F-774 aft top skin and mark the window cutout on the canopy. Immediately mark "do not cut at this line". The line is useful for repositioning the canopy, but you must remember to leave an extra flange for attaching the window to the skin. Mark a line about 1.25" outside of the “do not cut” line for doing a rough cut to final size.

Remove the canopy from the fuselage. Attach (nail, screw, etc.) blocks to the table top or edges to hold the canopy and keep it from spreading as it rests on the table. By restraining its sides in this manner will hold its shape and you can be work on it safely.

It is a very good idea to have a helper with this step to help manage the progressively floppier canopy.

Cut the canopy into the front and back pieces. You may begin cutting at any point comfortable for you. However, if the cut begins on the bottom edge, we suggest that before the cut progresses more than a foot, the edge be taped or clamped back together in order to hold the shape as well as possible while continuing the cut. Similarly, the top center should either be the last portion cut, or should be taped together before completing the side cuts. The object here is to prevent the rear of the canopy from sagging down and damaging the last part of the cut. Finish these edges before moving/handling the pieces.

Put the fwd portion back on the fuselage and mark for the final trimming. Because it is more flexible now it should lay down flush all around the roll bar. It will probably not match up exactly to the center split line on the roll bar but don't worry, this will be taken care of with a little bit of final trim adjustment. You can also double-check the fit once more at the fwd end of the Wd-725. Remove the canopy, make any other adjustments necessary, then drill and rivet the tabs on the Wd-716 to the Wd-725s.

DRILLING THE CANOPY TO THE CANOPY FRAME

Reinstall the canopy on the frame.

With the canopy at its final position, lightly clamp it to the roll bar. Now unclamp the F-631 frame ribs and move them so that they make contact with the interior of the canopy and then re-clamp them to the roll bar.

Using a helper, carefully remove the canopy so as not to disturb the position of the F-631 ribs.

Carefully drill the remaining holes through the F-631 rib and the C-704 splice plate.

With everything clecoed, refit the canopy, tape it with duct tape at the front, clamp or tape it to the roll bar at the back. Mark the final trim along the Wd-725 joggle, and note any small adjustments that you want to make where the base of the windscreen mates with the C-702 skin.

Remove the canopy and do the final trim along the sides and front. Once again, finish the edges before handling or moving.

Locate and mark all the screw hole locations on the canopy frame. When drilling the canopy you can pre-drill all of the holes in the frame #40 and then drill through the canopy to them with a plexi bit. The canopy is transparent of course, and it is relatively easy to hit the holes already in the frame. Alternatively, you can drill the hole in the canopy (using a special 1/8" plexiglass bit) until the tip of the bit makes a mark on the frame. The holes in the frame will be drilled with a regular bit when the plexiglass is removed.

Either way, it is very important that you have the canopy pulled down tight when you drill the first few holes, at least on the side you are drilling. These holes will "lock in" the canopy position, so you must have the canopy in the correct position.

With the canopy taped at the front and clamped or taped at the back, begin by drilling 3 or 4 holes at the top center of the F-631 rib bow to help lock-in the position. Now with a helper pulling the canopy tight on one entire side drill some holes 6 - 8 " apart around the rear bow and the sides to lock it down. Do the same on the other side. Finish drilling all remaining holes.

Mark the aft edge of the canopy for final trimming to match the split line on the roll bar. Remove the canopy and frame as an assembly from the fuselage.

Do the final trimming on the back edge of the canopy. Note: more may be required later to provide clearance from the aft portion, and to allow for it to swing opened and closed.

FITTING THE REAR WINDOW

Trim the aft canopy window portion to the line previously marked and finish the edge.

Mark all of the screw holes on the aft top skin and the roll bar. Be sure that you make the screw pattern fit within the rivet pattern already in the roll bar.

The aft window should be now put in place and positioned so that it reaches the split line on the roll bar (be sure that you are pushing it fully tight to the aft top skin (remember the shape change). You will probably have excess on the roll bar over the top but that will be trimmed/adjusted later.

Lightly clamp the window to the cabin frame. Make sure that it is pushed tightly to the inside of the aft top skin.

Begin drilling at the top middle of the aft top skin and the top middle of the roll bar. Alternating back and forth, clecoing as you go to pull the window tight to the roll bar and skin as you work your way down.

Repeat on the other side.

Mark the window along the split line on the roll bar for final trimming.

Remove the window, trim the forward edge along the split line, and finish the edge.

The holes in the roll bar should be enlarged with a #35 drill and tapped for a 6-32 screw.

Remove the aft top skin. Lay it flat on some scrap .025 material and trace the window shape to cutout the backing strip for the screws.

The window screw holes in the aft top skin should be enlarged with a #27 drill and dimpled for a #6 screw.

Because of the expansion rate of plexiglass, it is good practice to make fastener holes in plexiglass canopy slightly larger than the diameter of the fasteners themselves. Remove the canopy from the frame and machine countersink all the holes for either #6 screw heads or a #6 dimple (Use a piece of .032 or .025 aluminum, as appropriate, dimpled for 6-32 screw to test the fit.) Check the drawing and mark the holes for the correct countersinking depth before you start cutting. After countersinking, enlarge all the holes in the plexi with a 5/32" plexi drill or the 5/32" step on a Unibit. Countersinking before enlarging the holes permits you to use a standard countersinking bit with a #30 pilot. Immediately debur all holes to prevent cracks.

Enlarge all screw holes in the frame with a #27 drill and then debur.

All holes in the aft window that screw to the roll bar should be machine countersunk for a 6-32 screw head, then enlarged as described for the canopy. All holes in the aft window that match with holes in the aft top skin should be machine countersunk, using piece of .025 dimpled for 6-32 screw to test the fit, then enlarged.

FITTING THE SIDE SKIRTS

It is time to fit and drill the C-603 canopy side skirts. Replace the frame on the fuselage, tape it down and attach the canopy bubble with three screws evenly spaced along each side of the frame. The screws are installed through the canopy bubble and Wd-725 only. This allows the final canopy bubble and frame shape to be held without clecos

interfering with the side skirts.

The bottom edge of the C-603 side skirts butts to the top of the fuselage side skin and the top edge is trimmed even with the top edge of Wd-725. The front edge butts up to the aft edge of the C-702 canopy skin, and the aft edge fits to the forward edge of F-774 with an approximately 1/16" gap.

Lay out the hole pattern for the AN426AD3 rivets that attach C-603 and Wd-725. Drill and cleco C-603 to the canopy frame. Remove the canopy and frame from the fuselage, and back-drill the row of screw holes through the canopy frame, canopy, and into the C-603 side skirt. See DWG 48, Section C-C.

Remove the C-603 side skirts, remove the screws holding the canopy to the frame, remove the canopy, and remove the C-702 canopy skin.

Debur, dimple/machine countersink all holes, and rivet the skins to the frame. Now is a good time to paint the canopy frame with whatever interior finish paint you have chosen.

Place the canopy bubble on the frame assembly and install all screws, washers, and nuts.

FITTING THE LATCH FINGERS AND SAFETY LATCH TO THE FRAME

Now that the canopy has been fitted and attached to the canopy frame, it is time to complete the canopy latch mechanism by attaching the Wd-622 canopy lugs to the bottom of the aft surface of the frame.

Re-install the canopy/frame assembly on the fuselage.

You will need to work from inside the cabin. Clamp the Wd-622 canopy lug to the aft end of the canopy frame as shown in DWG 48, View D-D. Lower the canopy and engage the lug with the latch fingers by moving the canopy latch mechanism to the closed and latched position. The lug is held in position inside the "hook" portion of Wd-617 from the bottom. Mart its position using the holes that pre-drilled in the aft ends of the Wd-725 canopy side rails. The Wd-622 canopy lugs should be clecoed to the frame initially using #30 holes, and the canopy latch functionality checked before enlarging the holes to 3/16 and installing bolts, washers, and nuts. The Wd-622 lug placement can be "cheated" up when the holes are enlarged if the canopy did not latch as tightly as desired. The "hooks" of the Wd-617 can be deepened slightly, or the lugs can be "cheated" down if the canopy latches too tightly. You should be able to feel the latch engage the lug when you work the latch handle, but you should not have to force the handle closed.

The Wd-621 Aft Canopy Handle is installed next. Insert the shaft of the canopy handle into mount block C-608. Position the handle/block assembly on the forward face of the C-631A frame as shown in DWG 49, View A-A. Mark, drill, and countersink the four holes as shown. Bolt the block to frame C-631A with AN509 flush head bolts. Install the 3/8" washer and cotter pin to hold the handle in the block.

The canopy handle serves several purposes. The primary one is as a convenient handle for raising and lowering the canopy. It also functions as a safety hold-down latch, and to hold the canopy partially open in a "Taxi" position. To function as a safety latch, the handle is turned fore and aft as shown on DWG 48. If the pilot forgets to latch the canopy before take-off, this handle will restrain the canopy from lifting open, at least at low flying speeds. When the canopy is opened about 3 1/2 inches, and the handle rotated fore-and-aft with the tip end aft, this tip will rest on top of the F-631 cabin frame, thus holding the canopy slightly open and providing cabin ventilation while taxiing.

INSTALLING THE SLIDING CANOPY

After the empennage, the sliding canopy probably raises more questions than any other installation. Fitting a structure of welded steel spaghetti to a hand-built fuselage is an exercise in patience and perseverance. Given the inevitable variations between individual frames, roll-bars and fuselages, it is not possible to give dimensions that will work every time. Instead, we caution builders to slow down and work carefully from "first principles." The amount of effort and time you spend on preliminary positioning and alignment, adjusting both the canopy frame and the canopy skirts, makes a big difference to the quality of the final fit of the canopy.

The RV-6/6A Sliding Canopy Assembly consists of two main components; the Windscreen/roll bar assembly which is fixed to the fuselage, and the Sliding Canopy Frame/Plexiglass canopy which moves fore and aft.

The windshield frame also serves as an overturn structure or "roll bar". It consists of a formed steel tube weldment with a flanged base which is bolted to the fuselage upper longerons and cockpit rails. The roll bar also includes a center brace which attaches to the upper forward fuselage. The windscreen is screwed to the roll bar and bonded to the top fuselage skin with an epoxy/fiberglass base molding.

The sliding canopy frame of is made of welded steel tubing and moves on nylon rollers and slide blocks. The canopy is trimmed and attached to the steel tube frame with blind rivets and machine screws. Aluminum skirts are used to fair the bottom and rear of the canopy to the fuselage.

The canopy has three contact points with the fuselage; two rollers at the lower forward corners of the canopy frame, and one slider block at the rear top of the canopy frame. The rollers move in extruded aluminum tracks and the rear slider block moves on a builder-fabricated guide track.

The sliding canopy is held closed with an over-center spring-loaded hook latch operated by an internal/external handle. This handle is also used for sliding the canopy open or closed. There are two pins at the rear base of the canopy just aft of the canopy tracks which engage nylon blocks mounted on the fuselage. The front of the sliding canopy is held down by a molded fiberglass lip on the windscreen. The pins and lip serve as passive hold-downs, so operating the sliding canopy requires just one latch and one hand.

INSTALLING THE ROLL BAR

Lay out and drill #40 pilot holes for the 3/16" and ¼" bolts through the F-721B Aft Canopy Decks shown on DWG 42, Detail A. Drill the aft pilot hole through both the upper surface of F-721B and the lower flange of F-721B.

The C-668 spacers are needed to provide a flat surface for the nuts and bolts that attach the roll bar to the longerons. See DWG 42, Section D-D. Modify the C-668 spacers provided in the kit as shown on DWG 42, C-668 Detail Views. When done, you should have a forward left, forward right, aft left, and aft right spacer. Mark centerlines on the upper surface of each spacer. Hold the spacers, one at a time, in place against the bottom surface of F-721B and nested tightly against the inboard edge of the longeron with the fastener centerline mark visible through the #40 pilot holes drilled earlier. Drill #40 through the pilot holes just enough (about 3/32" deep) to make a good center point for finish drilling the holes through the spacers off of the fuselage. Remove the spacers. Use a drill press to drill the #40 holes all the way through the spacers. Then finish-drill the holes to final size. Make sure you put the correct size hole in the correct spacer! #12 for the forward two spacers, ¼" for the aft two spacers.

Place the Wd-641 Roll Bar on the fuselage in the position shown on DWG 42, View C-C. The roll bar should have 7/32" gap between the fuselage sides and the outer edges of the bar. If the gap is within 1/16" of desired, you can push or pull it into position, otherwise you should bend it slightly to make it fit within 1/16". It can be adjusted quite easily by hooking one end behind something and pulling (to make it wider) or by putting one end on the floor and leaning on the other (to make it narrower). Go sloooowly. It is easy to do too much.

Once you have the width close, clamp the roll bar in the proper position of the fuselage (vise grips work well) and using a #40 bit, back-drill the 4 bolt holes up from the bottom using the pre-drilled pilot holes in F-721B as guides. The aft two holes are back-drilled using the holes in the F-721B flanges as well as the holes through the upper surfaces.

Remove the roll bar. Drill the holes up to final size in both the roll bar and in the aft canopy decks. Remember, #12 for the forward holes, ¼" for the aft holes. Use a unibit for the F-721B holes to keep the holes from wandering. De-burr all holes.

Install bolts/nuts/washers to hold the roll bar in place for further fitting. With the nuts tightened, double-check that the roll bar is square to the fuselage longerons. See DWG 42, View C-C. Use shims if/as required.

Insert the forward end of the Wd-643-SS Roll Bar Brace through the pre-punched slot in the F-7106 forward top skin. The tab of the roll bar brace fits between the F-7108A Rib and the F-7108B Angle. Carefully use a screwdriver to pry the rib and angle apart when inserting the tab. See DWG 24.

Trim the upper/aft end of Wd-643-SS as required to mate with the receptacle in Wd-641. Clamp the tube in place and drill a 1/4" hole through its upper end joining the roll bar. See DWG 43, Detail B. Using the pre-punched holes in the F-7108 rib as guides, drill two 3/16" holes through the plate in the Wd-643-SS lower end. Remove Wd-643-SS, de-burr holes, and trim the bottom of the roll bar brace to leave 3/8" edge distance. See DWG 42, View E-E. Install bolts/nuts/washers to hold the roll bar brace in place for further fitting.

FITTING THE SLIDER FRAME

Assemble the Wd-644/C-658 roller assemblies (see DWG 41, Detail A) and insert them into the tubes of the Wd-640 Canopy Frame. Light clamping pressure with a small C-clamp will hold them in -- do not drill them to the frame until all canopy fitting adjustment have been made.

Cut the C-657 Canopy Tracks to length as shown on DWG 41. Lay-out and pre-drill screw holes using a #40 bit. See DWG 42, Sliding Canopy Top View for screw hole spacing. Clamp the C-657 canopy tracks onto the F-721B Aft Canopy Decks.

Drill the hole through C-661 per DWG 43, C-661 Detail View. Position the C-661 rear slider block under the receptacle on the rear center of the canopy frame weldment. Drill through C-661 and the canopy frame and insert the bolt. See DWG 43, Detail J. Remove C-661 and de-burr holes.

Check the shape of the C-763 Slide Spacer against the full-scale template on DWG 41. The part supplied in your kit may vary slightly, so carefully adjust your C-763 to match the template. Complete the rear slider track assembly by positioning, drilling, and riveting the C-762 and C-763 parts together per DWG 43, Section H-H. Make sure that you are not changing the shape of C-763 as you are attaching C-762 to it. Lay the track assembly in place approximately centered on the rear fuselage top skin. Bend the tab in the F-7112 skin down to allow the track

assembly to rest on the skin. See DWG 43, Detail J. Slide the C-661 block onto the track. For the time being, hold the track in place on the fuselage with duct tape.

Install the Wd-640 Canopy frame on the fuselage by inserting the rollers in the tracks through their open aft ends and inserting the bolt through the C-661. Slide the frame forward until it meets the roll bar. The flanges of the Wd-644 roller brackets will be the first part of the frame assembly to touch the roll bar.

Check the following points to insure the proper fit of the canopy frame to the fuselage:

The canopy frame side bows match the shape of the fuselage, but are inset 1/16". See DWG 43, Section F-F. The vertical distance from the canopy frame side bows to the F-721B canopy deck should vary by no more than 1/8" from front to back.

The rear bows of the canopy frame closely match the contour of the F-7112 skin but are inset about 1/16". (when the plexiglass is fitted, it will bring the level up above the contour of the skin.)

When viewed from the front, the roll bar should look centered on, and symmetrical to the canopy frame forward bow with the canopy frame top center bow centered on the latch pin on the roll bar. The canopy frame forward bow should be slightly higher at the center than the roll bar, see DWG 43, Detail B.

The canopy frame forward bow is slightly wider at the sides than the roll bar. The roll bar to canopy frame width difference is a fall-out of having the canopy frame side bows at the proper inset from the fuselage sides and is necessary because the fuselage widens going aft from the roll bar.

Make any adjustments to the frame shape that may be necessary to achieve these parameters. Use large, heavy objects of similar radius to add more curvature. Use your feet to push it against the floor on areas to reduce the curvature. Because the canopy bubble must be pulled down from its natural shape to conform to the canopy frame, the canopy frame will expand as much as ½" in width when the plexiglass canopy is attached. This will be compensated for during later stages of canopy fitting.

With the canopy frame moved fully forward, re-adjust and re-clamp the tracks so that the canopy frame side bows are inset 1/16" from both fuselage sides when the rollers are centered laterally in the tracks. This should position the tracks approximately 40 13/16" apart when measuring between roller track inboard vertical surfaces. When you are happy with the track positions, drill #40 through the forward most screw hole in each track into the fuselage and cleco. Align the two tracks and measure to be sure that they are exactly parallel. Clamp the tracks firmly in place, drill the remaining holes #40, and cleco to the fuselage.

The C-762/C-763 Rear Track assembly is still free to move both side-to-side and fore-and-aft. Moving the rear track fore and aft raises and lowers the rear of the canopy frame. Use this feature to achieve the proper relationship between the canopy rear bows and the F-7112 skin. A straight edge placed on the F-7112 skin is used to extend the contour forward enough to check the measurement to the canopy frame rear bow. When you have adjusted the rear track position so that the rear canopy bow/skin relationship is correct, match-drill the rear track to the fuselage using a #40 drill at two locations, one aft and one forward. These holes must center on the upper flange of the F-787 channel as shown on DWG 43, Section H-H.

Install the C-664 threaded rod brace under the forward end of the rear track as shown on DWG 42, Detail H and DWG 43, Detail J. This brace is adjustable in length and serves to stabilize the overhanging end of the track. Leave the brace full length during fitting. It can be removed and shortened later, after the canopy has been positioned.

Do not worry at this point about the vertical relationship between the canopy frame forward bow and the roll bar. This will be adjusted when the canopy bubble is being fitted to the frame.

Now that you have all the canopy frame shape initial checks and adjustments complete, it is now time to start cutting the canopy.

CAUTION: You now have the canopy frame formed to the proper shape. Do not try to bend or reshape it after the Plexiglass is drilled to the frame, the frame will break at one of the attach holes.

TRIMMING THE PLEXIGLASS CANOPY

Lay the "as-delivered" canopy on a work table. The first step is to mark a fore/aft centerline on the outside of the canopy. This is done by measuring side-to-side along the outer surface of the canopy from bottom molding flange to bottom molding flange then dividing the distance by two (or simply running a string across and folding it in half.) Do this at two locations on the canopy, one forward and one aft. Finally, use a straight edge or snap line to connect the forward and aft center locations and draw the centerline.

Lay the canopy upside down on a padded work table.

Cut the bottom molding flange off of the canopy using a cutting disk in a die grinder. Use these early trim cuts to build your canopy cutting skills by marking straight lines on the canopy and cutting as close to the lines as possible. Whenever you trim plexiglass, take the time to sand and finish the edges to a rounded smooth surface.

Stick a couple of layers of tape over the top of the canopy frame latch handle tube to keep from scratching the inside of the canopy while the frame is being fitted to the bubble.

Lay the canopy frame inside the canopy bubble. Move the frame fore and aft to find the point of best fit between the shape of the canopy frame center tube and the shape of the canopy bubble.

Mark the fore and aft position of the canopy latch handle tube on the inside of the canopy at the previously marked centerline. Remove the frame from the canopy.

Use a unibit to drill a 5/8" diameter hole in the canopy bubble for the latch handle tube. Immediately de-burr the hole and sand the edges of the hole smooth initially with 220 grit, then 400 grit sandpaper.

Lay the canopy frame back into the canopy bubble. The latch handle hole in the canopy can be elongated fore and aft if necessary to fine-tune the frame to canopy fit. A cover strip will hide the elongated hole in the canopy.

Use the frame as a guide to mark the canopy for trimming. Initially, trim the canopy even with the bottom of the canopy frame side bows, so the plexi can be clamped to the frame. Trim conservatively as you might later want to shift the canopy around slightly to enhance the fit.

Place the canopy frame back into the canopy bubble and use spring clamps to tightly clamp the frame to the canopy along both sides and the rear. Clamp the frame into the canopy so its center is indeed on the centerline of the canopy and so the forward bow of the canopy frame fits the inside of the canopy with as few gaps as possible.

Mark the canopy split line dividing the bubble into the sliding canopy and the fixed windscreen. The ideal canopy split location is 1/16" to 3/32" forward of the most forward surface of the forward bow of the frame. See DWG 43, Detail B. Also mark the trim line just above the canopy frame side bows as shown on DWG 43, Section F-F.

Remove the frame from the canopy and make the cuts. The canopy is VERY floppy now and must be well supported when it is set down. One method of providing support is to run a strip of duct tape from side-to-side across the bottom of the canopy at two locations. Another, perhaps more dangerous method of keeping stress off the canopy to minimum is to carefully set the canopy down on its forward edge. The extra flexibility, however, will allow the canopy to fit the steel frame with little stress.

Clean the edges of the well supported plexi, sanding them smooth.

Place the canopy frame back onto the fuselage and slide it all the way closed.

Place the canopy bubble onto the canopy frame.

FITTING THE PLEXIGLASS CANOPY

FITTING THE SLIDING FRAME TO THE CANOPY

Secure the canopy to the canopy frame with duct tape and clamps. Initially drill #40 holes through the canopy into the sliding canopy frame at 2 inch intervals. (The holes will later be enlarged to 5/32" with a Unibit or special Plexi drill --remember, don't use a twist drill to enlarge holes in plexiglass!) Start at the top center and work aft and outward alternating from right to left. Be very careful when locating the holes so that they are directly centered on the canopy frame tubes. One good procedure for determining the center is to put a strip of masking tape on the bow. When the plexiglass is pushed against it, the contact line will show in the tape, indicating the exact center of the tube. After drilling a hole, cleco the plexiglass in place as drilling progresses.

When the canopy has been drilled and clecoed to the canopy frame, re-check the fit of the canopy and frame to the fuselage. The fitting of the canopy to the frame has probably pulled the frame so that it is a bit wider than is ideal. Note the amount of adjustment required and remove the canopy from the frame.

Take the opportunity to install C-653 Cover Strip while the canopy is off of the frame by placing the cover strip on the canopy and back-drilling from the canopy into the cover strip. See DWG 43, Section D-D.

Before you do anything else, determine and mark which holes will receive rivets directly, and which will contact dimpled aluminum…along the side skirts, for instance. Countersink these holes to the proper depth. Use a rivet or a dimpled scrap of .032 or .025 aluminum to test the depth of the countersink.

After countersinking and deburring the plexiglass, enlarge the holes to 5/32" using a plexiglass bit or small Unibit. By countersinking before enlarging the holes, you can use a countersinking bit with a standard pilot.

Moving back to the canopy frame, enlarge all of the #40 holes to #30. Adjust the frame, re-cleco the canopy to the frame, and re-fit the frame and canopy to the fuselage. Repeat the frame adjustments as necessary to achieve a perfect fit.

FITTING THE WINDSCREEN

Place the windscreen on the roll bar and fuselage. Use duct tape and/or clamps to hold it in place. Trim the front of the windscreen to fit the forward fuselage skin contours. Again, trim conservatively and carefully. The aft edge of the windscreen may also be trimmed slightly if/as required to allow the windscreen to better fit the forward fuselage and to allow the windscreen aft edge to mate nicely with the sliding canopy forward edge. The fit of the windscreen to the fuselage front deck has more leeway than any other part of the canopy, because the molding strip that will be installed here can bridge gaps up to 3/8".

With the canopy clecoed to the canopy frame and the windscreen taped/clamped to the fuselage and roll bar, it is time to make the final height adjustment of the canopy frame to the roll bar. While shims may be placed under the canopy on either the roll bar or the canopy frame, it is far preferable to place the shims on the roll bar. Shims on the canopy frame will be visible after the canopy installation is complete. Shims on the roll bar are hidden under the fiberglass trim strip and behind a fillet of epoxy paste laid between the aft side of the roll bar and the windscreen.

To ensure that no shims will be needed on the canopy frame, the height of the canopy frame is adjusted at the roller brackets so the windscreen portion of the canopy is even with, or slightly lower than the sliding portion of the canopy. Use a unibit to drill 11/16" holes in scraps of .063 aluminum to create temporary spacers that are inserted between the bottoms of the sliding canopy forward bow and the Wd-644 roller brackets. If it is necessary to lower the canopy frame, the bottoms of the sliding canopy forward bow may be shortened slightly.

After all height adjustments have been made, match-drill the canopy frame and canopy roller brackets for the AN525 screws. See DWG 41, Detail A. The proper alignment of the Wd-644 roller brackets to the C-657 roller tracks is critical. Verify proper alignment before match-drilling by clamping a straight edge to the inboard flat surface of Wd-644 and aligning the straight edge with the roller track.

Drill the windscreen to the roll bar beginning at the top/center and progress down each side. If it is necessary to place shims between the roll bar and windscreen, be sure to install the shims at each hole location before moving down the roll bar and drilling the next hole. The shims can be neatly cut pieces of aluminum or a stack of AN960-6 washers. It helps to have a worker inside the cabin to fit the shims while the driller works from the outside. An absolutely perfect transition from windscreen to sliding canopy is not essential, any mismatch less than 1/32" is not worth fussing over. A fiberglass trim strip (similar to the windshield base molding) will be laid up over the top of the windscreen. The trim strip will conform to and hide any remaining minor mismatch.

Remove the windscreen, countersink for 6-32 flush head screws, then enlarge the holes in windscreen to 5/32" using a plexi bit or Unibit. Enlarge the holes in the roll bar to #35 and tap 6-32. See DWG 43, Section K-K.

Set the windscreen aside for now.

CANOPY LATCH AND ANCHOR BLOCKS

FITTING THE LATCH

Assemble Wd-642 Canopy Handle, C-667 Bushing, and C-654 Canopy Latch Arm. See DWG 43, Canopy Latch Isometric View and Section C-C. The AN310 nut should be tightened on the AN23 screw lightly so that the latch is free to pivot. The latch arm should fit easily around the C-667 bushing. If not, carefully enlarge the notch in the arm so that it fits freely.

Install the Wd-642 canopy handle sub-assembly through the bushing on the upper front of the Wd-640 canopy frame. Slide the canopy all the way forward to the closed position. While holding the canopy handle sub-assembly up against the bushing, rotate it so that the C-654 latch arm contacts the latch pin on the Wd-641 roll bar. First, check that the elevation of the latch mechanism aligns the latch hook so it contacts the latch pin. See DWG 43, Detail B. Adjust as necessary by shortening the bottom of the latch bushing on the canopy frame or by adding spacers.

When you have determined the correct level for the hook, fit the C-671 washer and the C-656 outside handle and note the amount which the Wd-642 handle shaft needs to be trimmed to bring the C-656 handle down close to the canopy. Trim the shaft and re-install the outside handle. Drill and tap for a machine screw as shown on DWG 43.

The C-654 latch arm has been made with excess material so that the exact location of the hook can be varied to accommodate each different canopy installation. See DWG 43, Section C-C. After all other aspects of the canopy installation are complete, the latch arm should be filed and/or trimmed so that it holds the canopy firmly in the closed position, but does not pull so hard that it distorts or mis-positions the canopy and frame assembly.

Remove the canopy and frame from the fuselage.

FITTING THE REAR ANCHOR BLOCKS

Lay-out the hole pattern in the C-677 Rear Pin Mounts as shown on DWG 41. Initially drill holes at #40. Initially drill the holes through the side of the pin mounts only on the outboard side. Make one left pin mount and one right pin mount. Match-drill and mount the C-677 Rear Pin Mounts to the top of the F-718 longerons per DWG 42, Detail B. Also see DWG 41, Detail B.

Place the C-665 Anchor Blocks in position in the C-677 mounts. Slide the canopy almost all the way closed so that the pins on the canopy frame are just touching the anchor blocks. Mark the points of contact and use a #30 or #40 drill bit to make a 1/16" deep mark in each of the blocks. Place the anchor blocks back in position in the mounts and again slide the canopy forward so that the pins are just touching the blocks. Verify the points of pin contact and adjust if/as necessary. Line-up a straight edge with the axis of the pins and project this angle to the sides of the blocks. Slide the canopy fully aft. Line-up a straight edge with the canopy tracks and project this angle to the tops of the blocks. See DWG 41, Detail B, and C-665 detail views. Also see DWG 42, Detail B. Remove the blocks and using a drill press and drill press vise, drill ¼" diameter holes in the blocks for the pins to engage. Check the fit of the blocks to the pins on the canopy frame. The pin holes may need to be enlarged slightly by wiggling the drill bit while drilling. Chamfer the edges of the pin holes as shown on DWG 41, C-665 detail views.

Place the blocks in the rear pin mounts. Slide the canopy all the way closed with the pins engaged in the blocks. Drill through the blocks using the pre-drilled holes in C-677 as drill guides.

Finish-up the mounting of the C-762/C-763 rear slide track by final drilling all holes and installing screws/washers/ nuts.

FITTING THE SIDE SKINS

Study Section F-F on DWG 43 and the Exploded View on DWG 41 to understand how all the parts fit together. If the distance from canopy deck to canopy frame side bow varies considerably from front to back, you may want to skew the mounting of the skirt to the frame so that the top edge of the skirt remains parallel to the canopy deck.

Pre-drill the hole patterns in the C-660 Canopy Skirts. See DWG 41.

Fit the canopy skirts to the canopy frame. Start at the front, drilling #40 and clecoing to the frame as you progress aft. Remove the skirts from the canopy frame.

Modify the C-759 Inside Canopy Skirts as shown on DWG 41.

Lay the C-759 against the inside surface of C-660, lining up the top edges of the two parts. Use C-660 as a drill guide and match-drill the four forward most holes in C-759 using a #40 drill. See DWG 43, Detail E & Section F-F.

Cleco C-759 and C-660 to the canopy frame. Hold C-759 and C-660 tightly against the canopy frame as you drill #40 and cleco, working from front to rear.

Drill #30 holes through the canopy lower edges and into the upper flange of C-759 using the pre-drilled holes in C-660 as a drill guide. Use a piece of wood to bridge vertically from the fuselage side to the canopy frame side bow to the canopy holding everything in alignment while drilling. Begin in the middle of C-660 and work forward and aft from there.

Cut lightening holes and notch the lower flange of C-791 as shown on DWG 41. Pre-drill the holes in the upper flange of C-791 using a #40 drill.

While holding the upper flange of C-791 against the inside surface of the canopy frame side bow, match-drill #40 to the canopy frame. See DWG 43, Section F-F. Drill and cleco working from front to rear.

With one person on the inside of the cabin using a wood block to hold the lower flange of C-791 tightly against the inside surface of C-660 and a second person on the outside, match-drill #40 into C-791 using the pre-drilled holes in C-660 as guides. The person on the outside must hold the canopy skirt in the desired final position relative to the fuselage while drilling and clecoing. After these holes are drilled, the canopy side skirt final shape is essentially locked-in.

Remove all the pieces of the side skirts. Enlarge the holes in C-759 and C-660 for the #6 canopy attach screws and the holes for the MK-319-BS blind rivets. De-burr and dimple all holes as appropriate. Countersink the holes in the canopy, then enlarge them to 5/32" a plexi bit or a Unibit. De-burr the insides of the holes in the canopy.

Re-cleco all the side skirt pieces in place and install #6 screws through the canopy before beginning the aft canopy skirt installation.

FITTING THE REAR SKIRTS

Installing the C-666 aft canopy skirts is perhaps the most demanding detail of the canopy installation. These skirts, right and left, are riveted along with the canopy, to the rear bows of the canopy frame. The trick is in attaching the skirt so that its unsupported rear edge contacts the rear top fuselage skin when the canopy is closed. Accomplishing this will depend both upon the fit of the canopy frame to the fuselage, and how well the builder is able to fit and attach these aft skirts.

Fit the skirts in place with tape and progressively trim them to the best shape and fit possible. In some places the skirts will lie down nice and flat. In other places the trailing edge will probably tend to pull away from the fuselage. Cut the aft skirts generously oversize to start with and begin drilling them to the canopy at the top of the fuselage. Use a strap duplicator (also known as a "hole-finder") to align the holes with the holes that have already been drilled. Use one that lifts the skirt away from the plexi as little as possible.

Have an assistant pull the lower forward corner of the skirt forward, as hard as possible without buckling the front edge, as you drill. This will pull the aft edge of the skirt in toward the fuselage and the ratio of forward movement to inward movement may startle you. The skin can be held here while it is drilled to the frame. If the canopy is blocked open slightly while the aft skirts are fitted, they will more snugly when the latch is reinstalled and the canopy pulled forward.

The aft skirts can exert enough pull on the canopy frame aft bows to slightly expand the canopy frame out of shape, so hand form the aft skirts to fit the shape of the canopy and fuselage so they exert as little pre-load as possible.

Install C-792 as shown on DWG 42, Section G-G. Also see DWG 42, C-792 detail view.

Builders who have mastered the black art of fiberglass molding may wish to mold the canopy rear skins of this material rather than using the aluminum skins. In so doing, a better initial fit can be achieved because of the ability to make compound curves with fiberglass. The disadvantages include the longer construction time because of the molding and sanding process, the thicker lap joints caused by the fiberglass, and the tendency of fiberglass to warp over a period of time.

INSTALLING CANOPY BASE MOLDING STRIP

Now that the canopy has been riveted and screwed to the frame, a fairing joining the windshield portion to the front skin can be fabricated and installed. This may be made of aluminum, or fiberglass, molded in place. Because an aluminum fairing requires some relatively advanced metal working skills, most builders choose one of the fiberglass options. If you choose fiberglass, be certain to use only epoxy resins. Do *not* use the more common polyester or vinyl ester resins. They are not compatible with plexiglass and cause crazing that might (probably will) ruin the canopy. We have had excellent luck with West Systems epoxy, available from boat yards and mail order houses.

The following directions were written by an expert RV builder, known for the beautiful finish around his canopies: They were written during the installation of a sliding canopy, but the techniques work equally well for the strip around the front of the tip-up.

If you choose to mold your own fairing, begin by cleaning the aluminum skin. Several builders have reported markedly better adhesion after they etched the skin with a mild phosphoric acid, but don't get any of this on the windshield! The molding should continue around the base of the windscreen back to the point where the windscreen is under the aluminum skin. At this point the fiberglass molding is to be faired smoothly into the skin line.

Imagine (or draw on a sheet of paper) a cross section view of the fwd base of the windshield to the top deck of the fuselage. It will be an inside radius. Cut out about a 4" diameter circle in poster board or similar and hold on edge at the base of the windshield. Where the circle touches the windshield and the skin is about where the fiberglass will end on each. Also notice that the space formed by the circle that you want to fill with fiberglass is not the same thickness across the whole section. This is why you can't use cloth all one width (unless you want to do more sanding than any metal airplane builder should have to do).

A couple of general tips -

The closer you get to your finished shape, and the more accurately you lay up the glass/resin, the less finish work (read: sanding) will be involved.

Make sanding tools in the exact shape/radius for the areas you wish to sand. For example: All around the forward base of the windshield, you will be sanding a varying inside radius. Find some type of round tube (thick wall PVC pipe works very well) that you can glue different grits of sandpaper to that has the radius you want the finished shape to be. I use about a 3-4" inch radius and glue sandpaper with spray contract adhesive.

Before doing any glass layups you need to do some prep work.

First, figure out where the edges of your finished glass work will be on the plexi. Use your round circle radius gage to find the contact points around the front of the windshield, and bring it around the sides to match up with the top of the canopy side skirts. I usually match the portion that goes over the top, to the front edge of the roll bar. Mark these edges with a layer of good quality (3M) electrical tape to protect the plexi.

Now carefully sand all of the plexi and aluminum that you intend to bond to with 60 to 80 grit sandpaper. Sand until there is no gloss of the plexi remaining. Do not worry about removing the alclad because it will be sealed in epoxy.

Mix up some resin with microballons to make a small fillet to fill the recess where the windshield mates to the fuselage. Mix it very dry (lots of micro balloons / not much resin) so it will not run. This fillet will prevent the cloth from dropping down into this space.

Cut the cloth strips. On the portion around the front I start with about a 1/2 " wide strip and then make each successive strip about 1/4" wider (1/8" to each side) which will give you about 7 or 8 layers if you go up to 2 inches. The last layer you put down should be the width of the finished fairing. These strips <u>do not</u> need to be cut 45 degrees to the weave. If fact, in this case it is easier to cut the strips parallel with the weave. I use at least 2 pieces of fabric for each layer to go around the entire front of the windshield. Because the strip is being pulled on a compound curve the end will not be square as you lay it down. You can just cut it square before laying it down and then butt the next strip up to it. On each successive layer vary the lengths slightly so that the butt joints don't fall on top of each other.

A rotary cloth cutter (available from cloth stores, or get in touch with your friendly local composite airplane builder) and a long straight edge works great for cutting long skinny strips. The more accurate you are cutting (and installing) the strips, the less finish work that will be needed.

Now add another layer of electrical tape to the first one already applied and start laying up the layers.

Center the first ½" strip around the base of the windshield at what will be the center of the fairing. Put on each successive layer centered on the previous ones with the final layer butted up next to the electrical tape but not over lapping onto it. These strips can be laid up all at once – there is no need to let each layer cure before applying the next layer.

Let this begin to set up slightly and then do the portion over the top for the canopy to windshield intersection using a similar procedure. Apply release solution or mylar packaging tape to the top of the sliding canopy so the resin will not bond…gluing your canopy halves together is embarrassing and makes the airplane difficult to enter. The strip over the top of the windshield has an outside radius, and typically needs fewer layers with the layers differing in width by about 1/2" instead of 1/4").

Once everything hardens for a day or so it is time to start sanding…very carefully. Use the shaped tools mentioned previously and start with about 40 to 50 grit paper. This will get you quickly to the general shape --but be careful to not get into the electrical tape. When you get down near the tape switch to about 80 to 100 grit paper and work very carefully until you are just contacting the tape and the skin metal on the edges of the layup. If you sand through the first layer of tape the second one should protect the plexi if you are watching carefully.

Now remove the second layer of tape (leaving just one layer) and sand very, very, very carefully using about 150 grit until you just start to see sanding marks in the tape.

Brush on a heavy coat of epoxy (after getting rid of all sanding dust) overlapping the epoxy onto the tape and the metal at the edges, and let harden.

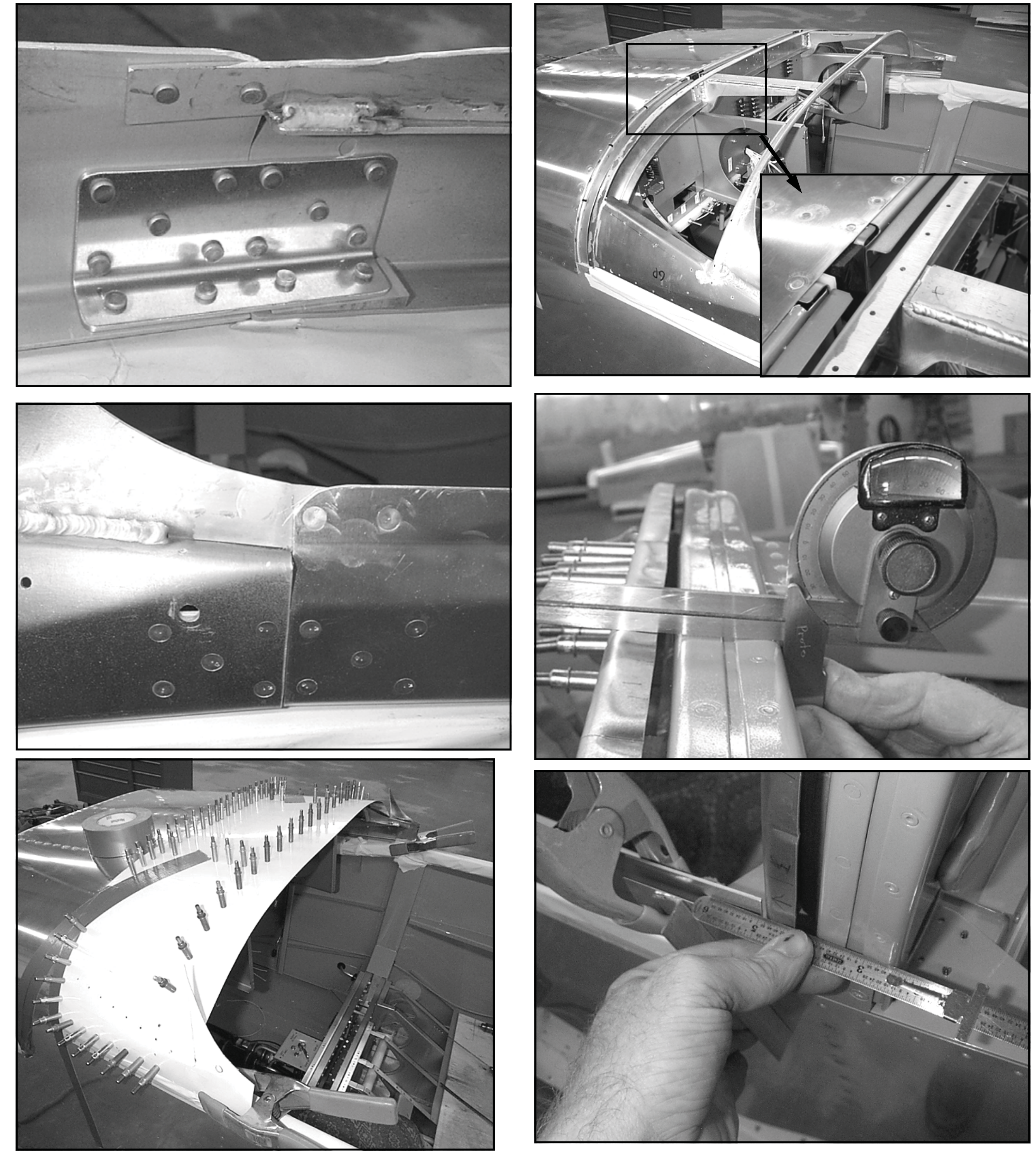
More sanding with 100 and then 150 grit paper.

If you have areas that need filling you can fill them now by scuffing with 40 or 50 grit paper and filling with a dry mix of epoxy and microballoons.

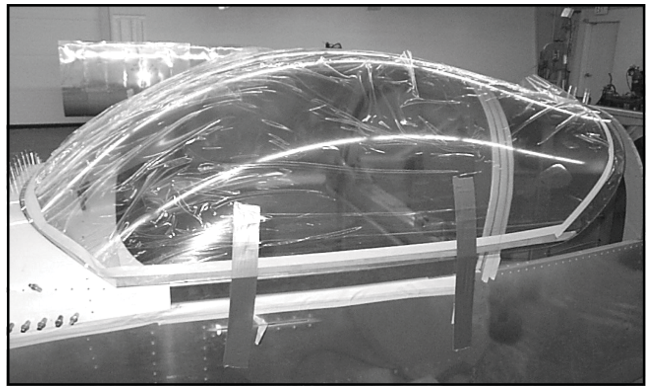
The goal is to have a layup with the outer surface being a buildup of 2 or 3 coats of epoxy that has been finish sanded to final shape with the epoxy blending onto the plexi being the thickness of the electrical tape or less, and the epoxy on the metal skin blending out to nothing.

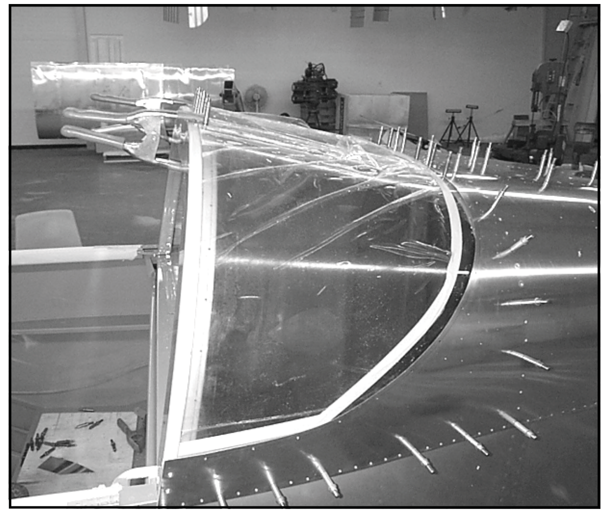
The final blending into the metal may require a couple of wet sanded applications of a filler primer to blend it out entirely.

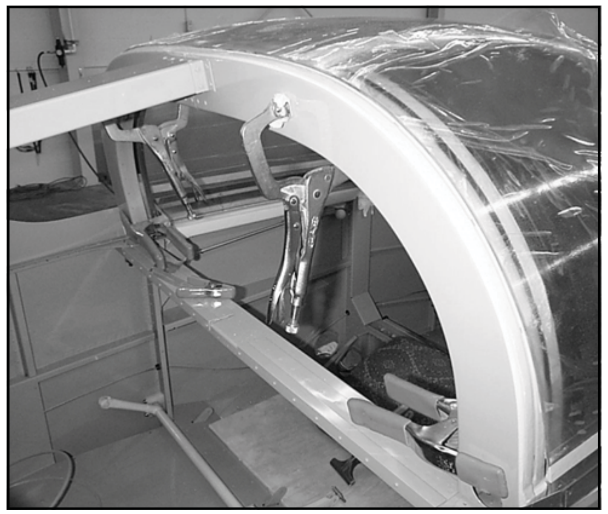
If you do it properly it will give you a very nice looking low drag intersection and it will make all the "Fast Glass" builders wonder how a rivet pounder could get a windshield/canopy finish that looks so good.

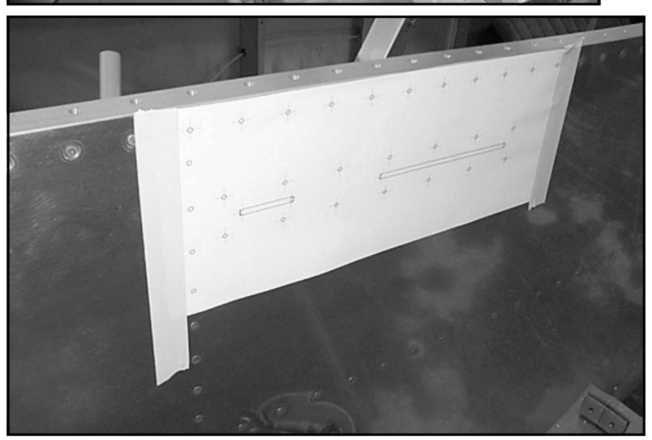


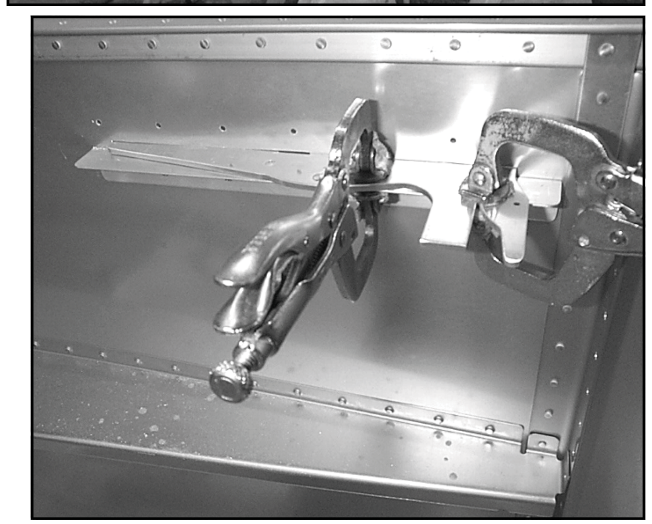
Aligning the tip up canopy frame to the fuselage and cabin frame.



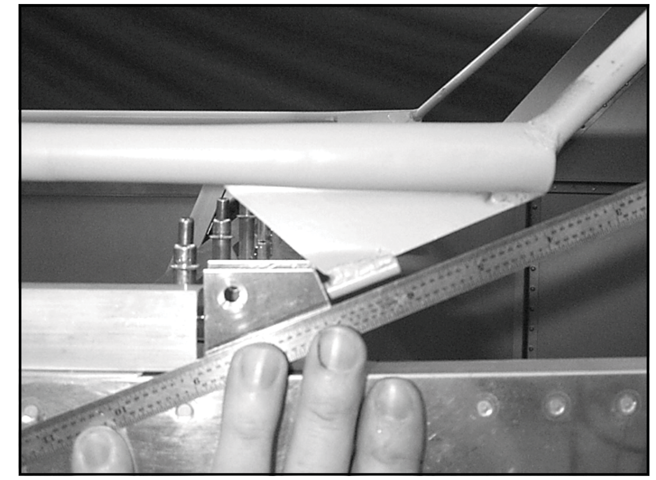


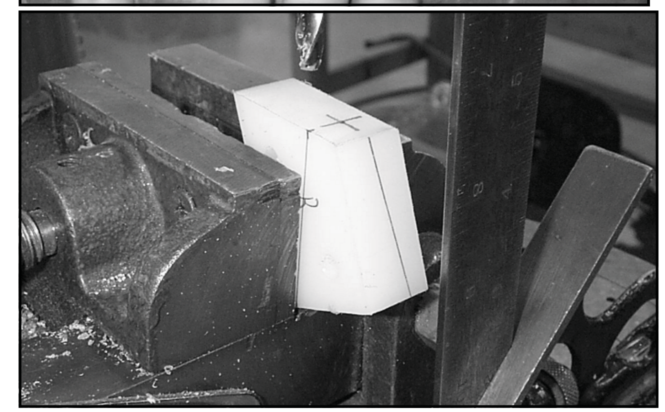


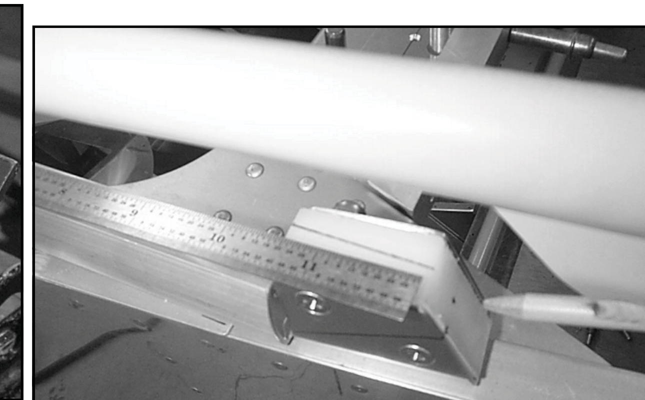




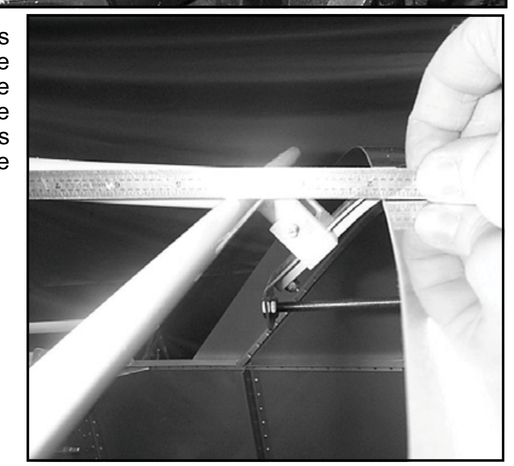
Fitting the plexiglass canopy bubble and tip canopy latch.

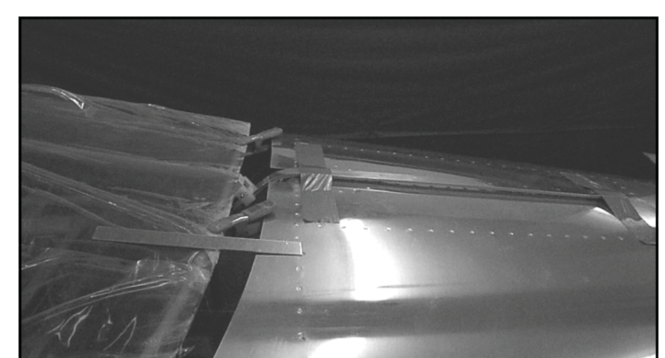


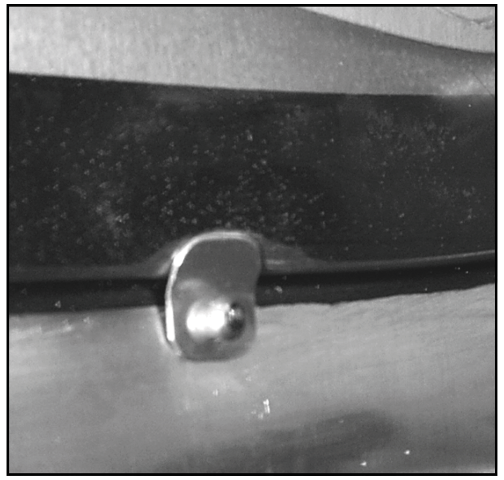


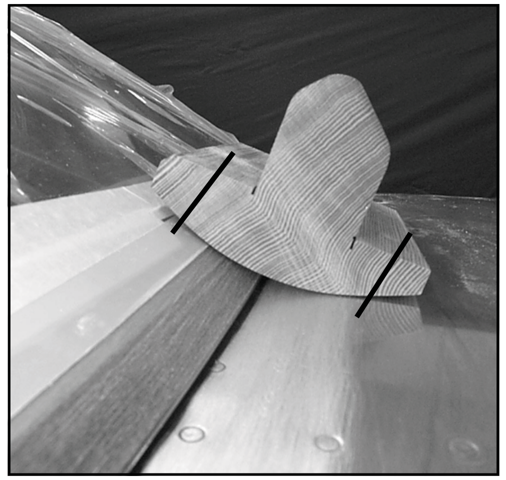


Various views of aligning the canopy frame and fitting the skirts as described in the text.



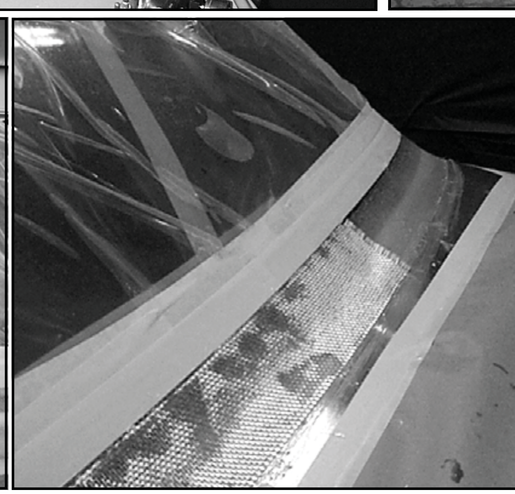






Left: Small clips of .040 aluminum can be used to hold the windshield in place. These are blind riveted to the forward deck and simply buried in the fiberglass fairing.

Right: A homemade sanding block contoured to the desired raduis. It was later narrowed to the width shown by the black lines.



Above: Laying up the fiberglass fairing around the front of the windshield and over the top of the sliding canopy. Note how well the plexi is protected .

Left: Nearing completion. The cleaner the lay-ups, the less sanding and finishing.

NOTES

SECTION 10: ENGINE MOUNT, LANDING GEAR AND LANDING GEAR FAIRINGS

The RV-7/7A uses a well-proven tapered rod landing gear. Developed by race pilot and aviation pioneer Steve Wittman, this gear arrangement has been widely used on both production and experimental aircraft. It is rugged, simple, relatively light, and inexpensive. By using simple landing gear leg fairings, drag is minimized.

The RV-7/7A uses an engine mount fabricated from aircraft grade steel tubing. The mount incorporates a mounting provision for the RV-7 main gear legs or RV-7A nose gear leg.

Since the gear legs are round, they permit the wheels to move in all directions and do a good job of smoothing out runway bumps. But, because they are spring steel, they are not as well damped as are the air-oil ‘‘Oleo’’ struts on some aircraft landing gear installations. Spring steel gear legs do not absorb much energy, but rather tend to rebound to release the energy taken in by smoothing a bump. This is the same as a leaf spring gear (Cessna), but the leaf spring gear can only flex inward and outward from the aircraft centerline, not fore and aft as the round rod gear can. When flexing inward and outward, the tire ‘‘scrubs’’ on the runway and damps the rebound action.

THE ENGINE MOUNT

The engine/landing gear mount is shown on DWG 46 (RV-7) or DWG 46A (RV-7A.)

The mount is fitted by squaring it with the firewall of the fuselage and aligning it with the pre-drilled holes in the corners of the firewall. Variations in the dimensions of the mount should be small enough that they can be compensated for by the differences between the undersize holes in the firewall and the 3/8" full size holes in the mount. The two center holes are also drilled at this time. Spacers can be used between these two attachment points and the firewall if necessary.

Drill the holes in the firewall to full size using the engine mount as a guide.

INSTALLING THE LANDING GEAR LEGS

Landing gear legs are made of 6150 steel, a nickel alloy with poor corrosion resistance. They are supplied powder coated except for the surfaces which contact the landing gear mount and axle. These cannot be painted because the thickness of the paint would prevent installation. A film of wheel bearing grease applied during installation will keep unpainted areas from corroding.

Installation could scarcely be easier: a round rod is inserted into a round tube and secured with one bolt.

The following instructions for installing the landing gear, wheels, brake lines, fairings and stiffeners are much the same for both RV-7 and RV-7A installations, but actual dimensions may vary. Be sure you are working with the correct drawings. Details of the RV-7 main gear are shown on DWG 46. RV-7A landing gear is shown on DWGs 34A, 46A, and C1.

INSTALLING THE WHEELS AND BRAKES

Details showing the installation of the wheels and brakes are shown on DWG C2. The axle and U-403 Brake Mounting Flange on RV gear legs have been designed to use the Cleveland 5:00x5 wheel and brake assemblies. The brake mounting flange has been honed and drilled to fit the axle at the factory. The hole through one side of the U-403 is still undersize, so, before final installation, pass a 5/16” drill through the assembly. Now install the Allen head screw that secures the brake flange to the axle. It is possible that the heat treating process used to strengthen the gear leg has expanded the axle slightly, and the flange will not slip on smoothly. A strip of fine crocus cloth briskly worked around the axle will remove enough material to allow the flange to be installed.

Cleveland brakes are included in the kit. Swap the fittings on one brake assembly to make a left and right brake. Each brake has a mounting plate supplied, which bolts to the U-403. Three of these bolts, running through U-408 spacers, also attach the U-810 Wheel Fairing Mount. The exact length of these spacers may be altered slightly to achieve the correct gap between U-810 and the brake disc.

Mount the U-810, U-408 spacers and Cleveland mounting flange to the U-403 brake mounting flange. Install the AN822 brake line elbow in the Cleveland brake assembly. Remove the inboard brake shoe from the brake caliper, and bolt the caliper to the mounting flange. Brakes are mounted with the caliper aft of the axle, and the bleed nipple down.

Fit the 5:00x5 Cleveland wheels and U-405 Axle Spacers (one on each side of the wheel) on the axle. Install the VA-106 wheel nut. Tighten this nut carefully, until there is no side play in the wheel, but it still rotates smoothly. Then, through the cotter pin hole in the nut, center punch mark the position of the cotter pin hole in the axle. Remove the nut and wheel, and drill a 1/8’’ hole in the axle for the cotter pin.

MAIN WHEELS and TIRES

Split the wheels by removing the bolts holding the wheel halves together.

Remove and inspect the wheel bearings. This requires removing the circlip retainer and popping the tapered bearing assemblies out. Be sure they are fully greased with Aeroshell #5 or equivalent.

Re-install the bearings and mount the tubes and tires on the wheels. Dust the inside of the tire with talcum powder before installing the tube. Discard the nuts and washer on the valve stem. The red dot on the tire should be installed next to the valve stem of the tube.

Bolt the wheel halves together. Carefully observe the manufacturer’s bolt torque specifications, shown on the document in the wheel/brake package.

SLOWLY inflate the tire to 25 psi. Deflate it fully and re-inflate it SLOWLY a couple more times to work out any wrinkles in the tube. Inspect for a good seat around the wheel rim.

Install the wheel and re-install the inside brake shoe with bolts and safety wire.

BRAKE LINES

DWG 36 (RV-7) and DWG 36A (RV-7A) show details of the brake system, including both single and dual brake installations. The brake lines have been designed so the same master cylinders, brake fluid reservoirs, and flexible brake line segments can be used for either the single or dual brake system.

Nylo-Seal tubing was selected for use as a connector between the primary and the optional secondary brake master cylinder sets because of its flexibility, high pressure capability, light weight, and low cost. Brass fittings are used on the high-pressure lines because they provide a better pressure seal than do plastic Nylo-seal fittings. Both fittings require inserts as shown on DWG 36/36A to provide leak free service. These are much easier to install if the tubing is warm, so dip the end in hot water or heat it evenly with a hair dryer before pressing the inserts into place.

As the exact length and route of the tubing is being determined, the rudder pedals should be moved throughout their range of travel to observe the action of the tubes. In routing the brake lines, care should be taken to protect them from chafing where they pass through bulkheads or around corners. Such protection can be in the form of plastic fairlead bushings as shown, wrapping the brake lines with protective tape, or slipping a piece of polyethylene tubing over the brake line at the wear point.

Note the brake line routing at the lower end of the gear leg as shown in DWG C2. This routing permits the brake line to come straight out of the fitting for a distance before making a bend. The brake caliper moves inward and outward along the line of the axle as the brakes are used. The ‘‘spiral wound’’ routing shown accommodates this movement very well with little stress on the brake line or the fitting.

Once the brake lines are fitted, the brake fluid may be added.

NOTE: *Use ONLY the aircraft brake fluid recommended by the manufacturer. DO NOT use automotive brake fluid, especially silicone based fluid. The seals in aircraft systems are not compatible with automotive fluids. Serious damage may result if they are used.*

Brake lines must be “bled” to force air from the lines. Use a clean squeeze-pump handle oil can with the appropriate fluid. Connect it to the bleed nipple on the wheel cylinder with a clear plastic tube that seals tightly to the nipple, loosen the nipple about 1/4 turn, and pump the system full. Work carefully and watch the plastic lines that connect the master cylinders to the fluid reservoir until no more bubbles appear.

WOOD GEAR LEG STIFFENERS (OPTIONAL)

With a rod gear leg, the wheels can move fore and aft, so, with no scrubbing action on the tire, there is no damping, and a fore-and-aft shimmy can result. This is most prevalent at low speeds (10-15 mph) and on paved surfaces. Turf surfaces have sufficient rolling resistance to provide a damping action. Out of balance wheels and higher than necessary tire pressures also promote wheel shimmy (lower pressure in the tires increases rolling resistance, and thus provides damping). Generally such shimmy occurs on landing roll out or while taxiing, and can be stopped with light brake application. Un-checked shimmy can transmit vibrations into the landing gear mount and eventually cause cracking. However, wheel shimmy is a rather nebulous thing; it occurs on some airplanes and not others, and with varying degrees of severity. The cause, or combination of causes, is very difficult to detect and define. Fly the plane first to determine if you need the stiffeners.

Wheel shimmy tendencies can be minimized by using the lowest practical tire pressures, having well balanced wheels and tires, and brake discs which run true and don't drag at one point of rotation.

Bonding a wooden block to the spring steel rod gear leg will alter its vibration characteristics and decrease the tendency to shimmy. This is shown on DWG C3. The wood used in this illustration is a standard window molding available from most building supply stores. The shape of this molding provides a good place to start. Sawing two pieces of this molding lengthwise and bonding them together as shown will provide a tapered piece, which attaches easily to either the front or rear of the gear leg. The resulting assembly is attached with putty of epoxy and thickening agent or even a "Bondo" type body filler.

Once this has cured, sand or file the excess bonding agent smooth, and wrap the whole assembly with 2 or 3 layers of 9 oz. fiberglass cloth. Fiberglass tape, 2-3" wide wrapped around the gear leg works well because it is easier to keep taut than a large sheet of fiberglass cloth. These wrappings of fiberglass tape are saturated with polyester resin (or epoxy if you prefer) as they are applied.

The wood stiffener blocks may also be attached temporarily by spiral wrapping them with fiberglass filament re-inforced packaging tape. This should be viewed as a short term installation, because the filament tape will deteriorate and may not last for more than one or two years; much less if directly exposed to sunlight for long periods of time.

INSTALLING THE FIBERGLASS MAIN GEAR LEG FAIRINGS

Gear leg fairings are very important for drag reduction. While one might feel that a fairing on the large wheel and tire would add more speed than a fairing on the small, round gear legs, just the opposite is true. Wheel fairings add about 3-4 mph but the gear leg fairings add at least 8 mph. The combined wheel and gear leg fairings add around 12 mph to the top speed. Looking at it another way – it would take an additional 27 horsepower from the engine to achieve the 12 mph contributed by the fairings. Obviously, a good fairing installation is necessary if high speeds are to be obtained from your RV.

Proper alignment of the gear leg fairings is also important for several reasons. Since the gear legs are located forward of the aerodynamic center of the aircraft, they have a de-stabilizing effect on directional trim. Any mis-alignment will have the same effect as a rudder input, but in the opposite direction and of much greater magnitude. For instance, it was found that just a 1/4 inch mis-alignment of the lower trailing edge of one gear leg fairing produced a half-range deflection of the skid ball. A very noticeable opposite rudder input was required to re-center the ball.

Main gear leg fairing installation is shown on DWG C3. Place the fairing, leading edge down, on a table or other flat surface and use a square at one end to position the trailing edge exactly above the leading edge. Make sure that the other end of the fairing also has the trailing edge exactly above the leading edge. This will verify that the fairing was molded without twist. With the fairing in the "no-twist" position, place two or three spring clamps on the trailing edge. Wrap a piece of tape around the trailing edge and then use a razor blade to split it at the trailing edge or make a thin pen mark across the trailing edge. If the fairing becomes twisted, the tape edges or pen mark will not line up.

Cut out the paper trim template (for YOUR airplane) found on DWG C3. Position the trim template over the fairing using the molded-in scribe lines and the leading edge parting line as reference points. Smooth the template over the outside of the fairing and use spring clamps to hold it in place. Trace the root end, trailing edge, and tip end trim lines onto the fairing. Make small "tick-marks" on the tip and root at the gear leg centerline. Extend the gear leg centerline marks approximately ¼" to the center of the part after removing the template. The marks will be helpful later when positioning the fairings to the gear legs. Trim the root and tip ends of the fairing, but not trim the trailing edge. After trimming, file or saw notches approximately 1/16" deep in the edges of the fairing at the gear leg centerline marks.

Trim the hinge material to 2 inches longer than the length on the drawing. Do not trim the hinge pins yet. The hinge material is left 2 inches long so there will be a 1" excess on each end to help clamp the hinge to the fairing. Mark (but do not drill) fastener locations and final trim locations on each of the hinge segments. When drilling the hinge to the fairing, the fastener location marks will be visible through the translucent fairing.

Place the trimmed gear leg fairing on the gear leg and clamp the trailing edge closed with two or three spring clamps. Use the tape or pen marks to be sure that the fairing is not twisted. Adjust the position of the fairing to align the gear leg centerline marks with the gear leg centerline. The trim as defined by the pattern was conservative, and the fairing may be slightly oversize. Trim the lower end of the fairing as required for proper fit.

Note: Each hinge half must be drilled, clecoed, de-burred, countersunk, and riveted before moving to the next hinge half because the fairing section is too thin at the tip to allow installation of clecos in both sides without interference.

Position the marked hinge inside the trailing edge of the fairing and clamp the ends of one hinge half in place. With the hinge ends clamped in position, begin at one end and drill #40 through the fairing and hinge using the fastener

locations marked on the hinge to position the holes. Use light pressure and high drill speed, and allow the bit to cut through without distorting the hinge. Work from one end of the fairing to the other, clecoing each hole before drilling the next.

Un-cleco the hinge from the fairing and clean out any metal chips. De-burr holes and trim the 1" excess hinge from each end. Remove and countersink the fairing for AN426AD3 rivets. Because the fairing is quite thin, it is recommended to that you keep the hinge clecoed to the fairing while countersinking. The holes in the hinge will guide the countersink cutter and keep it from elongating the holes in the fairing. Rivet the hinge to the fairing, using a hand squeezer. Don't fully set the rivets as you would in a metal structure. This would cause the thin composite fairing to crack around the holes.

Remove the fairing from the aircraft and insert the hinge pin to join the trailing edge. Use a long sanding block to remove any excess "tail" on the fairing and even the sides of the trailing edge.

Remove the pin and bend the lower 1" to 90º. Grind the upper end to a chisel tip. This shape helps guide the pin through the eyes of the hinge. Drill a #40 hole in the upper surface of the lower end of the fairing. A piece of safety wire can be looped to hold the hinge pin in place.

Wrap the gear leg with wear resistant plastic adhesive tape at two or three locations to prevent chafing and hold the brake line in place. Slip the fairings over the gear legs and insert the hinge pin from the bottom. The hinge pin is thin enough to curve as it is inserted without taking excessive permanent bend.

Roughly align the fairing to the airflow, and align the gear leg centerline marks with the gear leg centerline. At the top end of the fairing, install a hose clamp around the gear leg capturing the ¾ inch wide fingers of the fairing to help hold it in place. When installing the hose clamp for the first time, use a heat gun to soften the fingers so they conform to the surface of the gear leg as the hose clamp is slowly tightened. When the hose clamp is fully tightened, leave the fairing in place and allow it to cool.

You can also, as an option, add one or two layers of fiberglass cloth under the fingers. The purpose is twofold: to strengthen the finger and to contour the inner surface of the finger to the landing gear leg. Cut one or two laminations of 9 oz. fiberglass cloth so they fan out and anchor to a larger surface area of the gear leg fairing. See the dashed lines on the full scale trim templates.

Before laying up the fiberglass, prepare the surface of the gear leg by locally coating it with wax, mold release agent, or thin cellophane packaging tape. Cut out the glass cloth doubler patches and attach them to the inside surface of the fairing with a liberal application of epoxy resin. Before the resin cures, install the fairing to the gear leg using the hinge pin to close the trailing edge. Lightly clamp the lower end of the fairing if necessary to hold the fairing in place. After cure, remove the fairing and trim any rough edges around the doubler patches. The exterior surface of the finger can be filed or sanded to provide a smoother contact surface for the hose clamp.

The alignment of the fairings is important and can substantially affect the way the airplane flies. While a very careful "eyeball" alignment job might come close, this is difficult because of visual illusions created by the sweepback of the gear legs.

The gear leg fairing must be aligned with no load on the wheels, simulating the in-flight condition of the gear legs. Jack and support the fuselage far enough off the ground that the wheels no longer touch. Set the tail up so the airplane is level at the cockpit longerons (datum line). Use caution while the airplane is on jacks. Don't let it tip or it will fall off the jacks!

Align the fairings as shown. Pick a point on the landing gear fairing and measure the distance to the center of the fuselage. Pull a string from a point on the landing gear to a similar point the same distance from the center of the fuselage near the tail of the airplane. This string is a displaced centerline of the airplane. A stick is clamped between the stabilizer and the floor at this point. The string is then wrapped around the leading edge of the fairing and both ends pulled tight to the stick under the stab. Be sure the string is held level and parallel to the longerons… usually measuring from the floor is accurate enough. The leading edge and trailing edge of the fairing should be centered between the strings.

The string is then relocated up and down the gear leg (and of course, the stick at the tail will have to be move inboard/outboard the same distance, so the displaced centerline remains parallel to the aircraft centerline). This will align the fairing and eliminate any twist. Slightly loosen the hose clamps so the fairings can be accurately aligned. When the alignment is correct, tighten the clamps.

The installation is completed by fabricating intersection fairings between the upper end of the gear leg fairing and fuselage/wing and between the lower end of the gear leg fairing and the wheel fairing. The process for creating the intersection fairings is outlined later in this Section.

On the completed wheel fairing/gear leg fairing/intersection fairing installation, the custom molded intersection fairings will define proper alignment of the gear leg fairing, so the hose clamp is used primarily to keep the fairing from sliding down the length of the gear leg. This also means that the gear leg fairing alignment procedure need not be repeated each time the fairings are removed.

INSTALLING THE MAIN WHEEL FAIRINGS

Main wheel fairing installation is shown on DWG C2.

The VA-157 wheel fairing consists of two pieces, the VA-157A forward half and the VA-157B aft half. They should mate as accurately as possible. Because of the variations possible in fiberglass moldings, the first step must be to make the halves fit. Use coarse sandpaper glued to a straight stick as a disposable file to remove any material that prevents the halves from matching smoothly. Typical areas that might need some extra work are shown on Details D and E; the inside radius of the flange on the rear half, the inside of the front half where glass cloth layers overlap, etc. Take the time to custom fit the halves of your fairings as exactly as possible.

Drill and cleco the VA-157 fairing halves together. Begin at the tops of the fairings and work down the sides to help minimize bulging and mismatch between the fairing halves. Space fasteners per Section A-A. Do not install the second fastener up from the bottom on the inboard side of the fairings as this part of the fairing will be cut away to clear the axle. The fairings as supplied are symmetrical (no right or left hand fairing) but the asymmetrical installation of the fasteners will establish which fairing will be installed on the right side of the aircraft and which will be installed on the left.

Attach front and rear halves of wheel fairings to each other as shown. Mark a lengthwise centerline across the top of the assembled fairing.

The airplane will need to be supported on jacks to get the wheels on and off the axles. Unfortunately, you may need to remove and re-install the wheels a few times while getting the bracket-to-disc gap just right. Use caution while the airplane is on jacks. Don't let it tip or it will fall off the jacks!

Install U-810-L and –R Brackets to the U-403 Brake Mount Flanges using 3 each: U-408 Spacers, AN4-11A Bolts, AN365-428A Nuts, and AN960-416 Washers. There should be 0.032” to 0.094” gap between U-810 and the brake disc when the wheel/brake assembly is installed.

Raise the airplane on jacks so the tires are just off the ground (zero to 1/16” gap). Level the airplane (longitudinally and laterally) at the upper longeron. Once again, use caution while the airplane is on jacks!

Attach U-808 Outboard Brackets to the VA-106 Axle Nuts using AN4-5A Bolts and AN960-416 Washers. There is not a right hand or left hand U-808, but the brackets do have a top and bottom to them. The longer leg of U-808 goes to the top. Using a carpenters square or drafting triangle on the floor, rotate U-808 so the forward and aft edges are perpendicular to the floor. Tighten the bolts.

Install a 1 inch thick wood/metal/plastic spacer between the top of the tire and the inside of the wheel fairing. This spacer will be placed on the top of the tire to establish the correct vertical position of the fairing relative to the wheel/tire. (The 1” dimension assumes a 14” diameter tire is being used. The spacer thickness should be varied to account for tire wear or inflation pressure.

Tape the spacer to the top of the tire.

The inboard forward edge of the aft fairing must be locally trimmed to clear the axle. The wheel fairing is positioned correctly in the fore/aft direction when the forward edge of U-808 lines-up with the molded in “step” located approximately 1” aft of the forward edge of the aft fairing (see Detail C).

Center the rear half of the fairing over the tire while using the spacer to hold it in the correct vertical position. Locate and use some blocks of wood/metal/plastic to place under the aft end of the fairing to position the center of the aft edge of the fairing roughly 8 5/8” off the floor (see Wheel Fairing Side View). Mark the area of interference with the axle, remove the fairing, locally trim a small amount of the fairing, re-position the fairing over the wheel, re-mark and trim as required to achieve the correct final position. Trim the minimum required to clear the axle as this will make the shaping of the clay mold for the wheel fairing to gear leg fairing intersection easier.

When the weight of the airplane is off the gear, the wheels naturally camber inward. The vertical axis of the fairing is intended to be aligned with vertical axis of the wheel and tire.... not perpendicular to the ground. The tire tread provides a good alignment guide. The centerline on the top of the fairing and center of the opening on the bottom should align with the center of the tire.

When the aft fairing is located vertically (by the spacer on top of the tire), fore/aft (by alignment of the “step” with the forward edge of U-808), approximately leveled (by the blocks under the aft end), and aligned with the tire, (look and see) drill and cleco it to the U-808 bracket using the pre-punched 0.125” diameter holes in U-808.

U-808 mates to the wheel fairing in a region where the part thickness is changing. This will cause mis-alignment of

the bracket, so a few plies of fiberglass cloth must be bonded to the inner surface of the aft fairing to make the thickness constant in the two areas where U-808 touches the fairing. Use coarse sandpaper to roughen the surface of the fairing --really roughen it, don't be shy --before bonding patches of fiberglass cloth in place with epoxy resin.

Locate an approximately 1” wide shim thick enough (0.032” to 0.094”) to fit tightly between the U-810 bracket and the brake disc. This shim will keep the bracket from deflecting excessively when drilling through from the outside of the fairing. Scrap pieces of aluminum with strips of duct tape added to achieve a snug fit work well.

Attach the forward half of the fairing to the aft half. Now carefully adjust the fairing position until it is aligned with the aircraft centerline both in a horizontal plane and in a vertical plane (see wheel fairing side view). Drop plumb bobs from the center of the fuselage, fore and aft, and mark the position on the floor. Snap a chalk line through these marks, transferring the centerline to the floor.

With the fairing held in its final position, drill and cleco the fairing to U-810 in four places (two front and two rear). It is easier and safer to initially drill the holes #40 and then work up to the final #20 size. Use your “sharpie” pen to make four ink “dots” on U-810 where each of the four fasteners will ideally be located. The ink dots can be seen through the translucent fiberglass and the holes are then drilled and clecoed.

When the holes are located, reinforce the area about three inches around them by laying up 2 or 3 layers of fiberglass on the inside of the wheelpants. Re-check alignment and adjust as necessary while enlarging the holes. Enlarge all holes to final size and remove the wheel fairing. Install K1000-08 Nutplates to U-810 using AN426AD3-5 Rivets. Attach U-808 to the aft half of the fairing using AN426AD4-6 Rivets. Remove all blocks, spacers, shims, etc., and install the wheel fairing to the airplane.

FINISHING THE WHEEL FAIRINGS

After the wheel fairings are fitted it is necessary to remove them for sanding, filling, and paint preparation.

This can take longer than most people realize, but it is necessary to achieve a good finish when you paint. It will also cure you of any lingering desire to build a whole airplane from fiberglass!

When you put everything back together, remember to install and safety wire the inside brake pads and install the permanent cotter pin in the wheel nut before re-installing the wheel pants.

INTERSECTION FAIRINGS

To fully fair the landing gear, small intersection fairings cover the intersection of the gear leg or gear leg fairing and wheel fairing, and the gear leg/fairing and fuselage. Because of the variation between individual airplanes, these are best made in place.

A mold is made of oil based modeling clay. This can be the common modeling clay found in toy stores, or more professional variety used by commercial designers. The clay is applied between the gear leg and wheel fairing or fuselage and formed to a pleasing shape by hand or with any plastic or metal tool. A wet spoon works well.

The clay is oil based and is a natural parting agent. However, since the intersection fairing must part from one or more of the adjoining metal or fiberglass parts, it will be necessary to use automotive wax, PVA (a special liquid parting agent) or brown mylar packaging tape on these parts to prevent adhesion.

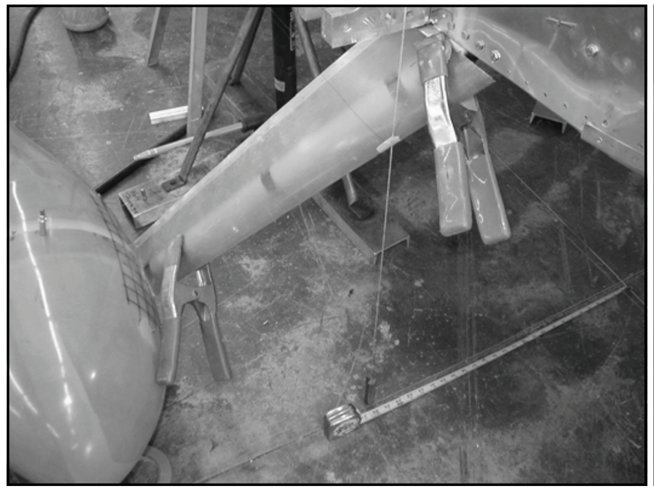
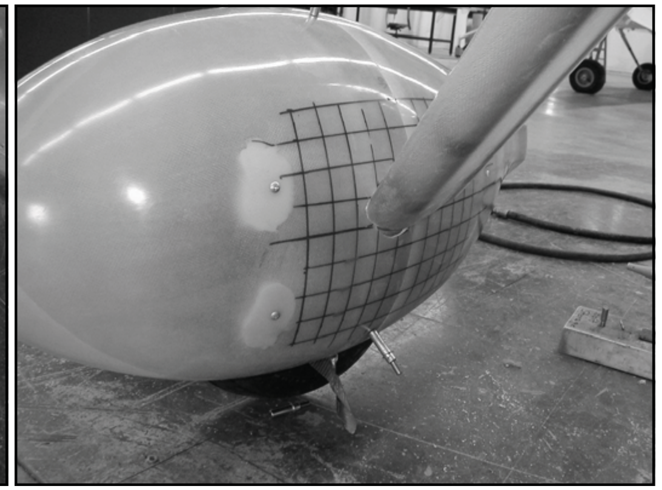
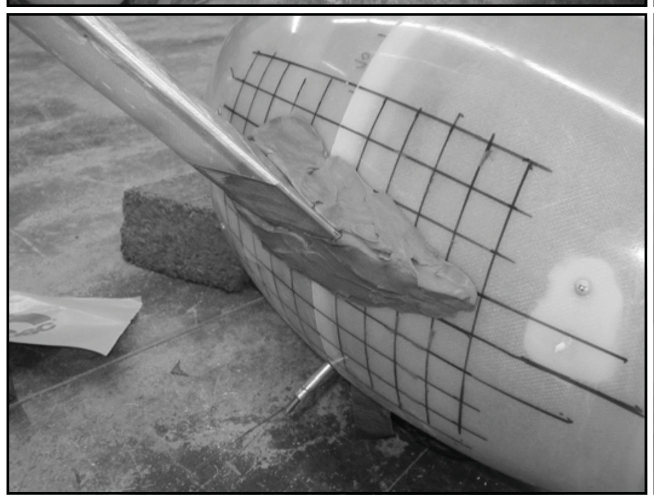
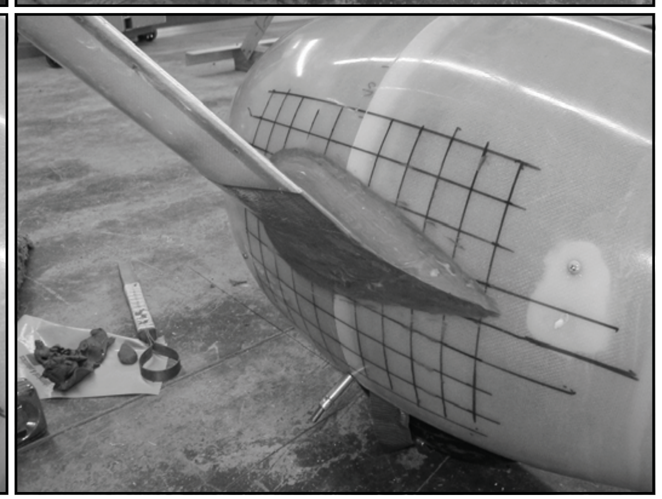
Because the wheel fairings are made using epoxy resin, epoxy must be used when creating the intersection fairings between wheel fairing and gear leg fairing. At the gear leg fairing to fuselage intersection, polyester resin may be used instead of epoxy if desired. A lay up of three thickness of 9 oz. fiberglass cloth is about right for intersection fairings. After the initial lay up has cured, several more brush coats of resin are applied to fill the cloth weave. The final coat of resin should be “finishing” resin which cures to harder finish, making sanding easier.

The upper intersection fairings are not permanently joined aft of the gear leg. The natural flexibility of the fiberglass allows them to be opened and removed if necessary.

The intersection fairings for the gear leg/wheel fairings are intended to become an integral part of the wheel fairing, so sand the surface of the wheel fairing with 60 grit sandpaper until all the gel coat is removed and fiberglass strands start to show. Clean with acetone to improve adhesion.

Lay up the fairing as one piece and when it is cured, split it top and bottom at the wheel pant joint, using a die grinder and cutting disc. The split can be made by carefully using a small cutting wheel in a Dremel tool. To protect the gear leg fairing, a 3/8 inch wide piece of scrap 0.016 or 0.020 aluminum which has had one end sanded to an edge can be slipped under the edge of the uncut intersection and the gear leg fairing at the split line. If the cut is started at the top of the intersection, the aluminum can be pushed in as the cut progresses down the intersection.

The following photos and text illustrate how we fabricated the gear leg to wheel fairing intersection fairings on our RV-10 prototype. Use a similar method to make the upper fairings.

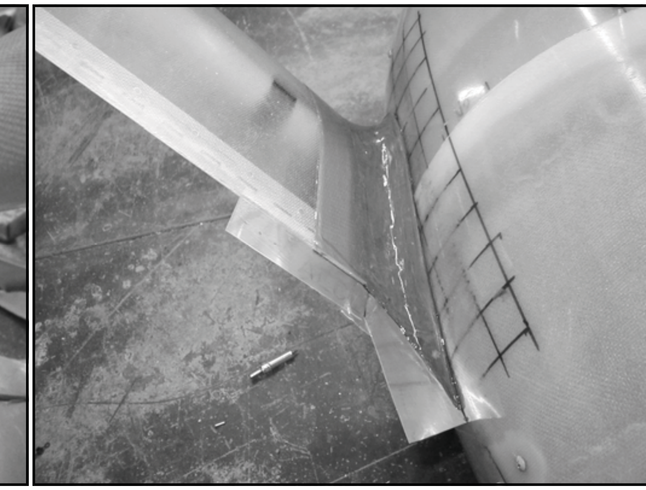
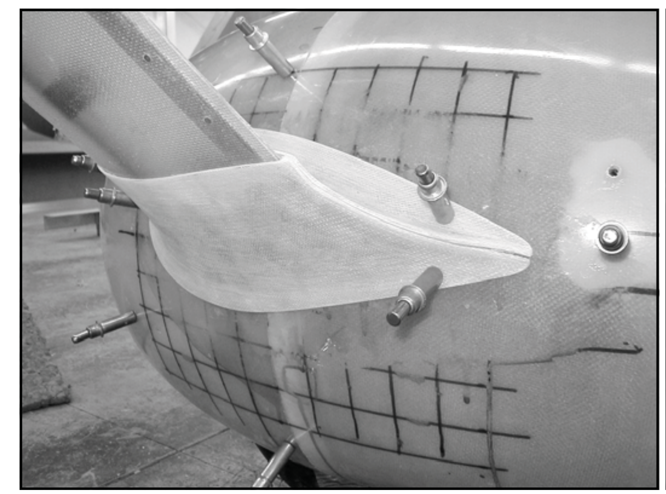
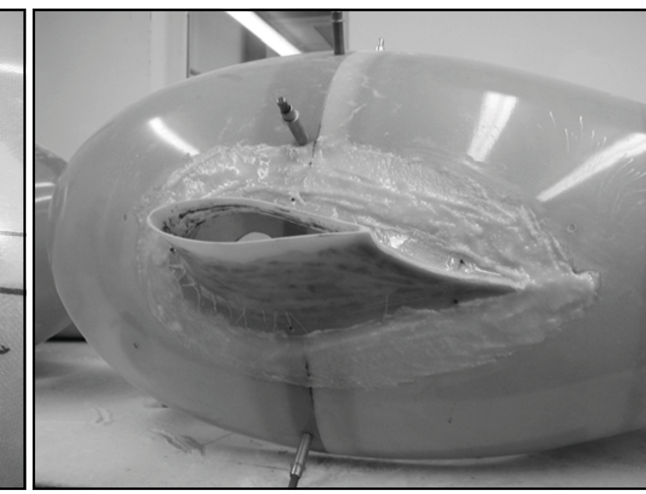
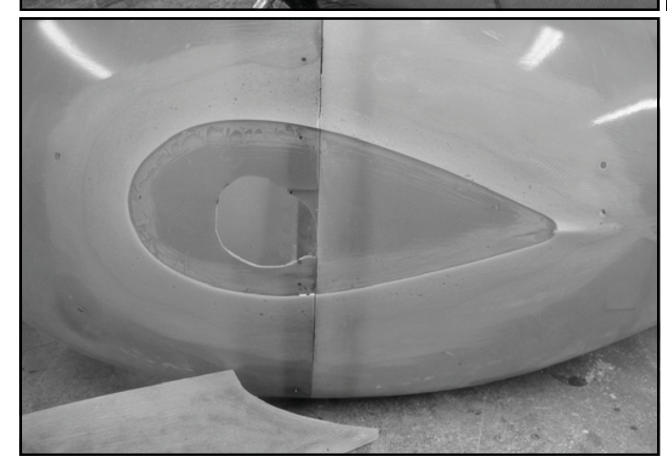

Top left: The wheel pant and gear leg are installed and aligned to their flying position, as explained in the builder's manual.

Top right: Before installation, a simple grid was drawn on the inboard side of the wheel pant. Without this reference, the swoopy intersection fairing would be almost impossible to make symmetrical.

Middle left:: Oil-based modeling clay is applied to the intersection.

Middle right: Careful work with trimming tools like the one on the floor (simply a loop of crate banding strap attached to a wood handle. It works better if it isn't sharp), a damp spoon and a scraper made from a section of plastic milk jug streamlines the clay shape.

Bottom left: The intersection fairing will be a separate piece. It is not bonded to the wheel pant, so the pant is covered with a release solution or mylar tape. Strips of fiberglass cloth are laid up with resin. Be sure to cut all the cloth strips you will need before you start the lay-up.

Top left: Wider layers of glass cloth are applied. A total of four or five layers of 9 ounce cloth works well.

Top right: Scraps of taped aluminum sheet are inserted into the rear of the gear leg fairing to prevent the aft edge of the intersection fairing from bonding to itself. The finished intersection fairing will be flexible enough to open to remove from around the gear leg.

Middle left: The cured, sanded intersection in place, held by clecos. In the finished installation, nutplates will be installed on small fiberglass pads laid up inside the wheel pant and the fairing will attach with # 6 screws and recessed washers.

Middle right: For a smooth transition, the surface of the wheel pant is built up around the edge of the intersection fairing. The intersection fairing, covered in release solution, is screwed on, and a slurry of resin and cotton fibers (brand name Cabosil) is applied to the sanded surface of the wheel pant.

Bottom left: the hardened slurry is sanded to a smooth surface. After the usual filling and sanding, the landing gear fairings are painted and begin a hard, hard life.

Be very careful not to damage the gear legs or brake lines.

INSTALLING THE NOSEWHEEL

Coat the interior and bead of the tire with talcum powder. Also coat the inner tube so it will easily slide into the tire.

Van's uses Matco brand wheels for the RV-7A nosewheel. See DWG C1. The bead of the tire fits very tightly on the rim of the wheel. Insert the wheel halves into the tire and align them as carefully as possible... then, with two people, compress the halves together enough to get the three bolts started. BE SURE that the tube is NOT caught between the two wheel halves. Use the bolts then to draw the halves together. It is often helpful to inflate the tube slightly during this process to keep the tube away from the wheel parting line.

Once the wheel halves are together, torque bolts to the AN specification of 50-70 in-lbs, inflate the tube slowly to at least 60 psi and then remove the valve stem to allow it to relax completely. Doing this a couple of times will insure that the tube and tire are both in their correct positions. Final tire pressure should be around 30-35 psi.

Now, prepare the wheel bearings for installation. Clean the interior of the wheel, including the installed bearing races. Then grease the wheel bearings with the appropriate lubricant (Aeroshell #5 or equivalent). The bearings have a built-in dust shield and seal of black rubber. This seal MUST have a coat of grease on its perimeter where it contacts the aluminum wheel. Insert the greased bearing sections into the wheel being sure that the rubber seals also fully insert. Then insert the U-623-1 axle hubs into the bearings per the attached drawing.

The final step is to compress the U-623-1's as much as possible with your fingers and then insert the wheel into the nose fork (WD-630) of the airplane. Once centered on the axle bolt hole, insert the axle bolt and any washers, brackets, etc. and torque the AN6-60A axle bolt to 7-10 FT-LBS. At this point there may be considerable rotational wheel drag. This is normal. A few hours of flight will break in the rubber seals and the tire will rotate freely.

SETTING THE BREAKOUT FORCE OF THE NOSEWHEEL

When installing the nose wheel/fork assembly for use, tighten the nut down so it requires 14 ft/lbs of torque to swivel the fork on the axle. Measure this by rigging a small tension scale (like a fish scale) to pull in-line with the axis of the axle. DWG C1 shows this arrangement. Progressively tighten the axle nut while swiveling the fork and taking readings with the scale as the ''break out'' force increases. When the scales measure 22 pounds, temporarily safety the axle nut. Swivel the fork several times from stop to stop. Measure the pull both to the right and to the left. Be sure the scale is perpendicular to the wheel when pulling. If the scale reading varies significantly from one direction to the other, re-adjust the axle nut as required.

After the breakout force is correct, drill the gear leg for the cotter pin with the nut in place. You can drill from each side. Start with a drill that just fits the slot in the nut and drill just deep enough to get a drill point started. Then switch to the correct drill size for the cotter pin.

INSTALLING THE WHEEL PANT and U-713C SUPPORT BRACKETS

Install the Wd-630-1 fork and the nosewheel, with tire mounted, onto the nose gear leg as shown in DWG C1. The airplane must be properly set up to use the dimensions on the plans for fitting the wheel fairings. See Note 1, DWG C1.

Finish the U-713CL/R wheel pant support brackets by cutting the notch shown in the U-713C Trim Detail on DWG C1 and deburring all the edges. Mark locations for the screws that will attach the U-813A nose wheel fairing on each "ear" of the brackets. These marks will be visible through the wheel fairing.

Tape a 7/8" thick spacer – almost any solid material will work – to the top of the nosewheel tire. Slide the U-713C brackets onto the axle, fitting the slot around the smaller AN960-616 washers. Bolt the brackets to the fork. When this is accomplished, slide the U-813A Nose Wheel Fairing Rear into approximate position and support it with blocks on the floor.

All the ears of the U-713C brackets should rest on the inside surface of the wheel fairing. Note any adjustments necessary on the ears, remove the wheel fairing and bend the ears to fit. While the wheel fairing is off, make measurements and marks on the floor (or a temporary template) to the position of the Allen bolt heads. Replace the rear wheel fairing, allowing friction to hold it on the brackets.

Fit the U-813B Wheel Fairing Front. Cut a slot in top of the fairing that will clear the nose gear leg and allow the front and rear halves of the fairing to join. The gap between the fairing and the nose gear leg will be visible, so take care to trim it to an even 1/16-3/32". Cleco the wheel fairing together and check for clearance between the fairing and the tire – there should be at least 5/8" in all directions.

Adjust and block the wheel fairing into position. Drill and cleco the wheel fairing rear to the ears of the brackets.

Remove the wheel fairing front and determine the position of the Allen bolt on the outside of the wheel fairing rear. Drill this hole undersize, file any adjustment necessary to keep the hole centered on the bolt, and finish the hole to 11/16" for the Allen bolt or sufficient size to allow tow bar access to the bolt.

Remove the wheel fairing and brackets and install the nutplates in both the bracket and wheel fairing rear. Complete the necessary countersinking, etc. on the fairings.

Permanently install the brackets on the nose fork and re-install the nose wheel fairing.

COWL/NOSE GEAR LEG INTERFACE

It will be necessary to inter-relate the following instructions with those for cowl installation in Section 12. Refer to DWG 45 which shows the relationship of the lower cowl and the nose gear leg.

A slot must be cut in the fiberglass cowl to allow it to slide on and off around the nose gear leg. The slot (the length varies depending on the number of blades on the propeller) leaves an unsupported opening in the bottom of the cowl. To strengthen the cowl, and to improve cooling air outflow, aesthetics, a removable gap seal is installed. Details of the gap seal are shown on DWG 45.

Fabricate parts U-620B/C/D and U-621 shown on DWG 45. Clamp parts U-720B through U-620C together and drill the holes for the rivets. Deburr, machine countersink for the rivet heads in U-620D, and rivet these four parts together. Then carefully mark the holes on U-621 plate and drill each with a #30 drill. Clamp the U-621 plate to the riveted assembly (note the 1/4'' overhang on the aft end.) Then drill the screw holes through the stack, using the U-621 plate as a drill guide. Remove the U-621 plate and enlarge the center holes, and drill additional holes as shown.

Install the nutplates on U-620B and U-720B. Note that the rivets attaching these nutplates go all the way through the stack, so if a nutplate ever needs replacement, the rivets can be drilled out.

Install the lower cowl and screw the U-620 assembly to it. Temporarily install the bolt holding U-620B to the engine mount. Fit U-720A to the firewall and the F-720B. Drill and cleco F-720A to the firewall flange and clamp it tightly to the F-720B. Remove the lower cowl, with the F-720A clamped to it, and drill the holes for the rivets attaching F-720A to F-720B.

The slope and the vertical rise of the gear leg make it necessary to slide the cowl aft past the firewall before it can be lifted to fit behind the spinner. This means the slot must be continued in front of the gear leg (quite a long way forward if you are using a three blade propeller). To cover the exposed slot, and to make a pleasing juncture between the cowl and the nose gear leg fairing, an intersection fairing is made right on the airplane, using the same method used for the main gear intersection fairings.

FIBERGLASS NOSE GEAR LEG FAIRING

The nose gear leg fairing is a simple fiberglass wrap-around fairing much like the main gear leg fairings. It is installed in almost exactly the same way. Details are shown on DWG C1.

Remove the nose wheel fairing and fit the gear leg fairing to the gear leg. Use two or three spring clamps to hold the trailing edge of the fairing closed. The lower end of the part is molded to fit the contours of the bend in the nose gear leg. Trim the upper end of the fairing if/as required to clear the nose gear socket.

Reinstall the nose wheel fairing and determine the trim of the lower end of the gear leg fairing. With the nose wheel fairing installed, there should be a constant 3/16" gap from the bottom of the gear leg fairing to the top of the nose wheel fairing. When the final trim has been determined, the nose wheel fairing should be removed and set aside.

Align the gear leg fairing and install the hinges exactly as you did the main gear leg fairings. Note that the pin of the hinge is left 2" longer than the hinge. The extra length is bent and secured by the hose clamp that holds the fairing.

Fabricate an intersection fairing using the same techniques used on the main gear legs.

SECTION 11. ENGINE AND PROPELLER SELECTION AND INSTALLATION

Engine installation is one of the most time consuming and most important phases of construction. Although it is extremely important that everything be done correctly, these instructions are not very specific at times. This is intentional. The wide variation of possible engine/propeller combinations means there may be more than one ''right way''. In most respects, the engine installation in an RV is just like that of any other airplane using the same engine. The same ''quality control'' rules and practices which apply to factory aircraft apply to homebuilts as well.

To help simplify the process, Vans has developed Firewall Forward Installation kits for the Lycoming engines that we sell. We will briefly consider a number of common points in this section, but for detailed drawings and instructions you will need to buy the Firewall Forward documentation, which is available separately from the Firewall Forward kits.

RECOMMENDED ENGINE INSTALLATION MANUAL

One of the books recommended in Section 1, *Firewall Forward* by Tony Bingelis, is an excellent reference manual for engine installations, and contains much more detailed information than we are able to include in this manual. This is particularly true if you choose to vary from standard procedures. We recommend acquiring and thoroughly studying this book before beginning your engine installation. *Firewall Forward* is available from the Experimental Aircraft Association, (EAA) Oshkosh, WI.

INSTALLING THE ENGINE MOUNT TO THE FUSELAGE

The typical RV engine mount is unique because it combines mounting structure for both the engine and the main landing gear legs. (There are a couple of exceptions: RV-6A/7A/8A/9A engine mounts includes the mount for a nose gear leg, and the landing gear in the RV-8 is mounted in the fuselage.) Because of the gear leg mount feature and forward cockpit design, six attach points are used rather than the usual four. An offset is built into the mount to help compensate for "P" factor, so the engine is not aligned with the airplane centerline.

The rough position of the mount is shown by the pre-punched tooling holes in the firewall. Do NOT simply drill the tooling holes to 3/8. Offer the mount to the firewall, and use some long 3/16 bolts to attach it. The holes in the weldment will likely not align perfectly as the weldments vary slightly. It may be necessary to pull the part into alignment, and/or file the 3/16 tooling holes to shift them slightly. If the mount is not exactly centered on the firewall, that is OK. 3/8" either side to side or up and down will make no difference.

With the mount thus attached to the firewall, drill the holes out to 3/8 using the mount as a guide, and insert 3/8 bolts as you proceed. Any gap between the firewall and mount will usually disappear when the fasteners are tightened. If the gap is still there when the nuts are appropriately torqued, AN9790 washers may be used to eliminate it.

CONICAL ENGINE MOUNT INSTALLATION

The conical engine mount supplied with the kit has the correct alignments built in. It simply bolts to the firewall.

Attaching a conical mount engine is relatively easy because all four bolts through the engine case are parallel. The conical rubber mounts that give the mounting style its name are set into the recesses in the engine case, the engine is mated to the mount and the bolts installed. Tightening all bolts evenly will position the engine correctly.

DYNAFOCAL ENGINE MOUNT INSTALLATION

Study the construction drawings until you understand the correct placement of the isolation mounts and washers. (Isolation mounts and mounting bolt kits are available through Van's Accessories Catalog. Because the mounting bolt kits must supply all the washers for builders installing used isolation mounts, if you buy both new isolation mounts and a new bolt kit, you will probably end up with some duplication and some extra large washers if you order new isolation mounts. Throw them in your spare hardware box. Use only the number and type of washers shown on the drawing.)

Mounting a dynafocal engine is a bit more difficult because of the converging lines of the mount bolts. The rubber isolation mounts (commonly known as "Lord" mounts, although Lord is a specific brand name and

there are several other brands) are designed so they align when tightened and compressed. The bolt holes through the four mounts will not coincide with the holes in the engine case at repose (no compression load). When installing the engine, it is necessary to have it suspended from a hoist. When the engine is suspended, it can be moved into position on the engine mount and the two upper isolation mounts and bolts installed and partially tightened. Then, by lifting the engine with the hoist, and actually lifting part of the airframe weight too, the upper isolation mounts are flexed upward enough that the lower mounts are brought (almost) into position. Basically, the technique is to get one or more bolts started, and then force the engine in the opposite direction so that remaining bolt holes can be aligned. We have found that the best place to start is the top.

Once in place, tightening is easy. The bolt simply "bottoms out" on the steel tube insert that passes through the center of the isolators.

EXHAUST SYSTEM

Probably the first thing that should be installed on the engine, once it is mounted on the airframe, is the exhaust system. This is the big, hot, unmovable item which cables and fuel lines must be routed around.

Several suppliers have made systems available specifically for RVs. Be sure to specify your aircraft type and engine model when you discuss requirements with your supplier. Beautifully made stainless steel exhaust systems for all RVs are available through Van's Accessories Catalog.

If you prefer to do your own exhaust system fabrication, you can save some money. Unless you are a very talented welder, you will want to use mild steel automotive exhaust pipe instead of stainless. A good place to start is to purchase the required exhaust flange, some 1-3/4'' exhaust pipe of the thinnest wall thickness available, and several 6'' radius ''U'' bends of 1-3/4'' dia. These pipes can be cut into sections for the various curves needed. By splicing together a number of these bends, a satisfactory system can be made inexpensively, but it will weigh more than the stainless system. However, there is a lot of labor involved, and we have found that nearly all builders prefer to purchase a ready made exhaust system.

THROTTLE CONTROL

The standard throttle differs between the side-by-side and tandem airplanes. In the side-by-side RVs it is a locking push/pull control in the center. Installation is straightforward; through the firewall and to the control arm on the carb. The tandem airplanes use a throttle quadrant, mounted on the left sidewall of the cockpit. Cables are available through Van's Accessories Catalog.

MIXTURE CONTROL

Many builders may prefer more traditional vernier or quadrant controls and cables. These are usually fitted with rodend bearings that connect to the mixture arm on the carburetor. Fittings, special washers, and hardware for anchoring and connecting the engine end of throttle and mixture cables are offered in Van's Accessories Catalog.

TACHOMETER DRIVE

The Lycoming engine is equipped with a mechanical tachometer drive. A cable turned by this drive is connected directly to a mechanical tachometer on the instrument panel. The cable can be made to order by any automotive speedometer shop, or ordered from various homebuilt aircraft supply shops. Routing should maximize the bend radius of the tach drive line to prevent excess friction, wear, and premature breakage.

Electronic tachometers are also widely available and should be installed using the manufacturer's instructions.

FUEL LINES

Fuel lines up to fuel filter (gascolator) can be 3/8" soft aluminum tubes, just like the remainder of the system back to the tanks. However, since there is relative motion between the engine and the airframe, flexible lines must be used for routing the fuel from the fuselage to the engine mounted fuel pump.

One good hose for this purpose is Aeroquip 701, a medium pressure hose with a stainless steel wire braid shield on the outside. It is available for use with reusable fittings and hose assemblies can easily be fabricated by the homebuilder. Wherever possible, hoses should be routed so there is ''slack'' or ''bows'' in the line to permit easy movement and flexing due to engine vibration, and to lessen the load on end fittings. Fuel lines should *not* be installed straight and tight between the accessories. Fuel lines should also avoid close proximity to exhaust pipes, or should be thermally insulated if close routing is unavoidable. Sometimes a heat shield must be installed to shield the fuel lines.

Thermal insulation of all fuel lines within the engine compartment is recommended even if proximity to exhaust pipes is not a factor. During operation, the air temperature within the lower rear portion of the engine compartment (where these fuel lines are located) can rise to a level sufficient to vaporize fuel within the lines and thus cause vapor lock. The engine will run rough or stop. This condition is likely to occur during ground operation where engine cooling is marginal because of limited ram air flow through the engine compartment, and because fuel flow volume is low. With a high air temperature and low fuel flow, the fuel has more time to heat up and possibly vaporize before entering the carb or fuel injector. This situation is further complicated by the use of auto fuel which normally has a lower vaporization temperature than Avgas. One product often used for thermal protection of fuel lines is Aeroquip Firesleeve, which, as the name implies, is a hose-like cover installed over the fuel line and clamped at both ends. As the name also implies, this material is designed to protect the fuel lines (or oil and hydraulic lines) from the direct flames of an engine compartment fire. Assembled fuel and oil lines are available from Vans in lengths suitable for most RV installations.

NOTE: *Automotive type hose and hose fittings are not acceptable for use in aircraft engine or fuel line installations. Never use the type of fittings that require the hose (without flared nut end fittings) to slip over a male fitting and be secured with a hose clamp. Even for low pressure or suction lines, ''tube fitting'' hose assemblies should be used, not hose fittings (clamps). NEVER use an aluminum, copper or other rigid fuel line to connect the fuel system from the fuselage to the engine. It is almost certain to fail, with serious consequences. This applies to fuel pressure lines and oil pressure lines also. When fabricating fuel line assemblies, check for line blockage after installing the end fittings. Sometimes the tip of the inner fitting can gouge out bits of the soft rubber from the inside of the hose, and these can flip up like a butterfly valve and block the line.*

OIL PRESSURE GAUGE LINE

A braided Aeroquip hose similar to fuel lines, is recommended between the oil port on the engine and the fuselage. 1/4" diameter or smaller is adequate because it is just a pressure line with no volume flow requirement. Generally a bulkhead fitting is used in the firewall, with an aluminum or copper line running back to the oil pressure gauge in the panel. Use of an electrical oil pressure sensor would eliminate the need for these lines and routing.

A restrictor fitting should be used in the engine oil port to limit oil loss in the event of line failure. If not readily available, a restrictor fitting can be made by taking a standard AN fitting, tapping the inside of the pipe thread port for a bolt thread, screwing the bolt in tight, cutting it off flush with the end of the fitting, and then drilling the smallest possible hole through the plug. Welding could also be used to form the plug.

Sensors should not be mounted directly on the engine case or rigid mountings, like pipe nipples, mounted to the case. The vibration will eventually cause the fitting to break, letting the engine pump pressurized oil overboard. The sensor is mounted on the firewall and connected to the engine with a flexible hose.

FUEL PRESSURE GAUGE LINE

This should be a hose tapped into the fuel line somewhere between the fuel pump and the carb, and should be routed to a bulkhead fitting on the firewall, and then to the fuel pressure gauge. If an electric gauge is used, the sensor may be mounted on the firewall and connected to the fitting with a flexible line.

A Tee fitting on the ''out'' port of the fuel pump is a good source for the fuel pressure line. A restrictor fitting, like that described for the oil pressure line, should be used at the source end of the fuel pressure line.

MANIFOLD PRESSURE LINE

A good source for this is the primer port of the left rear cylinder (#4). The line may be 1/8" copper tubing with compression fittings and a "vibration loop". Route it through a fitting on the firewall similar to other lines.

Even though there is no flow through the manifold pressure line, a restrictor with a small orifice is still a good idea. Sonic waves can cause fuel vapors to move through the line and condense in the instrument. Also, the rapidly varying pressure caused by the valves opening and closing can cause the gauge to flutter wildly and become unreadable.

PRIMER SYSTEM

The Lycoming 0-320 and 0-360 carbureted engines can be primed for cold starting by cycling the accelerator pump with the throttle (O-235 engines do not have an accelerator pump). This can be effective for temperatures down to freezing or slightly below, but will depend on the idle mixture adjustment and jetting of the specific carb. If starting is routinely required at sub-freezing temperatures, installation of a conventional hand operated primer system will probably be necessary. Priming three cylinders will be sufficient (one cylinder's primer port has probably been used for a manifold pressure source).

Plunger type primers, as used on many light aircraft, work well, but require a separate system. On carbureted engines, you may also prime the cylinders using pressure supplied by the boost pump. Primer lines are routed from a port on the gascolator to the cylinders and flow is controlled by a small solenoid-controlled valve installed between the gascolator and the cylinders. When the pump is on, the lines are pressurized, the solenoid is activated by a momentary switch in the cockpit and fuel flows to the cylinders. The only known disadvantage is that the primer system is dependent on the battery for operation. If the battery were dead, the engine could not be primed manually.

INDUCTION AIR INTAKE

Most RVs are fitted with the filtered airboxes available in Van's Accessories Catalog. Different airboxes are necessary for different sizes of engines and types of induction devices, so be sure you order and install the airbox appropriate to your airplane.

All of the optional air intake systems are designed to offer a minimum frontal area and flow resistance to the incoming air. The intake systems also provide excellent manifold pressure from the ram air effect with little complexity or weight.

FUEL BOOST PUMP

Because of the low (below carb level) location of the wing fuel tanks, an RV must be equipped with a fuel boost pump as back up for the engine driven pump. Usually the boost pump is a small electric pump, an example of which (p/n ES 40108 in Van's Accessories Catalog) is shown in the fuselage plans. Other pumps and installation locations may be used. However, some pumps are not self-priming and must be located at or below tank level. Check the pump manufacture's specifications about this.

When using a fuel injection system or a pressure carb, a high-pressure boost pump and a high-pressure engine driven pump (quite different than those used on carbureted engines) are required. These pumps are also available from Van's.

ENGINE BAFFLING

Section 12 includes a basic explanation of cooling theory and baffling. Prefabricated baffle kits are available as an option through Van's Accessories Catalog and should save the builder a lot of time. These kits include pre-formed aluminum baffling, cowl seal material, and all the hardware and instructions needed. Drawing and patterns are also available for those masochists who wish to make their own baffles.

Inter-cylinder baffles are normally supplied as a part of the engine. They are essential to proper cooling, and the exact shape, size, and fit should be maintained if these baffles are being fabricated rather than using the Lycoming parts. Intercylinder baffles are not included in Van's baffle kits.

ENGINE BREATHER LINE

An engine crankcase breather line is needed to run from the breather port on the upper rear engine case, to an overboard dump point. Because there are often droplets of oil included in the blow-by air exiting the engine crankcase, breather tubes are a major cause of dirty fuselage bottoms. This can be partially avoided by positioning the breather line outlet so that its contents are blown directly onto the exhaust pipes and burned. The breather line itself can be 5/8'' I.D. radiator hose except for the end closest to the exhaust pipe which should be aluminum or steel tubing.

A relief hole should be drilled in the line several inches above the exit. If the breather line plugs or freezes shut, the pressure build-up inside the crankcase can blow the front crankshaft seal out of the engine, causing the rapid loss of oil and engine failure.

Breather separators are available. Usually mounted on the firewall, these units receive the direct line from the breather outlet and use a screen and sump to separate the oil from the gasses. A vent line is run overboard for the gasses, and the separator must be drained and cleaned periodically. It's a messy job, but many builders prefer it to constantly cleaning the bottom of their airplanes.

CARB AND CABIN HEAT MUFFS

The carb air intake box previously described uses air from the hot air side of the engine cooling system for alternate air and/or carb heat. While this has proven adequate on the prototype RVs, each builder will have to evaluate his own installation based the likelihood of carb ice in his intended operating environment. The air intake box could be altered so that a completely sealed carb heat system could be used, or one could run a 2'' air hose from a heat muff and position it to feed into the alternate air inlet of the carb air box without being attached and closed. At least exhaust heated air would be available for carb heat rather than just engine heated air.

The heat muff is fabricated to fit around a straight portion of an exhaust pipe. A muff 6-12 inches in length should be enough to supply heat for the carb and the cabin. Note that the clean air intake is located on the forward cowl baffle, from which air is routed into the heat muff. The object of this is to assure that un-contaminated air is heated and routed to the cabin. Other homebuilts have used a much simpler system, taking warm air directly from the engine compartment, through a simple door on the firewall, and using it for the cockpit heat. This is a potentially very hazardous practice, as engine compartment air can contain exhaust from gasket leaks, smoke from burned oil, etc. If a heat muff were being made strictly for carb heat air, it could intake engine compartment air without risk of problems.

OIL COOLER

Any of the oil coolers typically used in production airplane installations should work well in an RV. The cooler may be installed on the rear vertical baffle behind cylinder #4, with air admitted through a hole through the baffle, or on the firewall with a shroud and a SCAT tube supplying pressurize air from the baffle plenum. Baffles should be reinforced to withstand the weight of the cooler and lines. Oil lines from the ports on the rear case, typically 3/8" for the O-320 and ½" for larger engines, should be AEROQUIP 701 or equivalent.

The size of oil cooler necessary for a specific engine is difficult to specify. Engines seem to be quite individual in their needs, and even engines and airplanes of the exact same type will run "hot" or "cool" with the same cooler. The only general rule of thumb seems to be the bigger the engine, the bigger the cooler. IO-360 200 hp engines use oil to cool the piston skirts and are more dependent on oil coolers than their parallel valve cousins. We have found the Stewart-Warner coolers work better than the Positech coolers on the 200 hp engine.

ENGINE SELECTION

The RV-4 and RV-6/6A are designed to use Lycoming (I)0-320 (150 & 160 HP) and (I)0-360 (180 HP) engines. The RV-7/7A and RV-8/8A will accept these engines and and have the added option of the 200 hp Lycoming angle valve IO-360. The RV-3 and RV-9A are designed for Lycoming O-235, O-290 and O-320 engines rated between 118 hp and 160 hp.

At a glance it would appear that you have four choices of engines: 150, 160, 180, and 200 HP. Actually, it is a bit more complex than that. The engine list at the end of this section includes approximately 200 individual model numbers for individual engine variations encompassed within these two general engine types. The letters and numbers in the engine model number each refer to some feature of that engine. By becoming familiar with these designators, primarily the prefix and suffix numbers and letters, you can select the engine best suited to your needs by matching the features on the engine to your needs or preferences.

A guide for to Lycoming designator symbols is presented at the end of this chapter. Below is a sample engine model number with a point-by-point description of features:

- I0-320-D1A
- I: Fuel Injected.
- O: Designates a Horizontally Opposed cylinder placement.
- 320: Engine displacement in cubic inches.
- D: High (8.5:1) compression ratio; meaning 160 HP and a 100 Octane fuel required.
- 1: Controllable Propeller. Engine is suitable for constant speed prop.
- A: Rear Mounted Accessories, Bendix Magnetos.

NOTE: There are two styles of Dynafocal mounts. Dynafocal I and Dynafocal II. Dynafocal II engines are scarce in the used engine market and not available as "new" through our OEM agreement with Textron-Lycoming. Van's Aircraft will <u>not</u> supply mounts for this type of engine.

A list of engine identifiers to avoid follows: (the letters listed below are the "first" letter after the cubic inch number: example, IO-320B2A is Dynafocal II and is to be avoided.

IO-320A,B or C, IO-360E (180HP), IO-360D (200HP)

There is a wealth of information in these lists, (which may not be complete down to the most recent engines) but they often seem like a treasure hunt when you are trying to find specific information.

<u>How much horsepower?</u> The RV series was designed around the most plentiful and reliable of aircraft engines, the Lycoming 0-320. In production since the early 1950s, this engine has proven to be one of the most reliable internal combustion devices ever built. There are two basic versions, and a vast array of different models and sub-models.

The low compression (approx. 7:1) version is rated at 150 hp and designed for 80 octane fuel. The high compression (approx. 8.5:1) develops 160 hp and is designed for 100LL. Low compression engines are often modified to produce 160 hp, but this is NOT sanctioned or approved by Lycoming.

The O-360 (or its cousin, the parallel valve IO-360) develop 180 hp on 100LL.

An RV with 150 hp is *not* an underpowered airplane. Remember, this is the same engine that drags four place production airplanes around. Installed in the light, clean RV, it provides excellent performance. Installing higher powered engines usually increases the climb rate, shortens the take off and increases the cruise and top speeds slightly. There is a price, of course; power comes from gasoline, not the engine. If you use the extra power needed for better performance, you will burn more fuel.

Although the temptation to install the biggest engine and get the most performance is great, remember, even with the lowest horsepower, a clean RV is capable of speeds very close to the published VNE. Engines with more horsepower can easily drive the airplane past redline in level flight. Just because you *can* install a big engine doesn't mean it is a smart thing to do.

<u>What model?</u> The rumor that Lycoming once built two identical engines has never been proven. The variety is so large that Van's often (very often) cannot offer advice on whether a specific model will work in an RV. Remember, you, the builder, are ultimately responsible for making sure the engine you acquire will fit your airplane. Here are a few tips to help with engine shopping:

- Mounting Style: Lycoming engines have been built in three basic mounting styles, conical, Dynafocal 1 and Dynafocal 2. The difference is in the angle that the engine mount bolts form with the crankshaft. An engine mount to fit any of these is available from Van's, although the Conical and Dynafocal 2 mount are a special order item, requiring extra time to supply.
- Induction: One of the critical items in determining whether an engine will fit in an RV is the placement of the "induction device", the carburetor or fuel injection servo. In an effort to accommodate airframe manufacturers, engines have been developed with several different carb locations.
- Aft mounted carbs, feeding through the side of the oil sump, will not fit an RV. However, often a change of sump to an updraft version is all that is required to make the engine fit.
- Most engines with updraft carbs will fit an RV, but some engines have the carb mounted at the very rear of the sump, which interferes with the RV-6A nose gear mount.
- In general, any engine with a forward facing or vertical induction device on the middle or front of the sump will work.
- ***<u>Fuel pumps:</u>*** The low wing design of the RVs requires an engine driven fuel pump. Since many engines on the used market originally powered high wing airplanes with gravity feed systems, they do not have fuel pumps. Usually it is relatively simple to convert an engine without a fuel pump, but this matter should be checked. Carbureted and injected engines require different pumps, so check carefully.
- ***<u>"Different" engines:</u>*** The O-320-H2AD engine, used for several years in the C-172, is a special case. It is unrelated to the rest of the O-320 family, and requires a special mount, which Van's can supply upon request. It also has a pad for a forward mounted fuel pump, but, since the C-172 does not require a pump, none was ever installed. The case must be opened and modified to operate an engine driven mechanical pump.
- Some engine models we have encountered that will NOT fit in an RV, at least without modification, include the I0-320-B1A and the O-360-A4K. This is by no means a complete list.
- Note that the 200 hp IO-360 angle valve engine is not recommended for the RV-4 or RV-6/6A. It is physically larger than the parallel valve 180 hp IO and O-360s and will not fit without major modifications to the cowl. It may, however, be used in the RV-7/7A or RV-8/8A.

PROPELLER SELECTION

The RV builder has four propeller options to consider: fixed pitch wood, fixed pitch metal, and constant speed metal or constant-speed wood/composite. Just to make it more complicated, the wood/composite props feature either hydraulic or electric actuation. The metal constant speed props are hydraulically actuated.

Traditionally, metal props have been used on production light aircraft because they offered the best compromise of performance and serviceability. A fixed pitch metal prop will usually weigh about two or three times more than a wood prop. For a 150-180 HP engine, this represents a difference of about 17-22 lbs. The metal prop, because of the greater strength of the material, can be made with a thinner airfoil section and is generally considered more efficient than a wood prop. This means more overall performance. Not necessarily significantly more performance, but more than enough to justify the added weight.

All of the fixed pitch metal props manufactured to fit factory designs powered by O-320 and O-360 engines were designed for much slower airplanes so their pitch angles are much too low to be effective at RV cruise speed. While it is true that metal props can be re-pitched for more or less speed, they *cannot* be re-pitched to the extent needed for an RV. In addition to a loss of efficiency incurred through excessive re-pitching, the stress on the metal renders them *<u>unsafe</u>*. The stresses on metal props are very involved, and are caused by harmonic vibrations which cannot be felt by the pilot. Extensively reworked metal props have a history of losing sections of their blades without warning. The result is a catastrophic imbalance, capable of tearing the engine completely free of the mount and airframe before the pilot can react. People have died.

The *<u>only</u>* fixed pitch metal props suitable for RVs are the Sensenich 70CM for the O-320, and the Sensenich 72FM for the O-360.

Because metal props have not been available, wood props have been, and still are, widely used. These have both advantages and disadvantages compared to the metal prop.

<u>DISADVANTAGES:</u>

- The finish of wood props will deteriorate and weather-check over a period of time and require refinishing every 2-5 years depending on operating conditions.
- Wood props suffer when flown in rain. While most wood props now offer some form of leading edge

protection, usually a tough cast urethane leading edge inlay, rain damage is still a concern. Even a short time at reduced rpm in heavy rain will cause enough damage to require refinishing.

- Wood props are lighter, but this is a mixed blessing. While the lower weight is of benefit in keeping the empty weight of the airplane down and the useful load up, it does have disadvantages. The lightweight wood prop has less inertia and therefore puts greater strain on the starter because there is less propeller flywheel effect to carry through the compression stroke. For the same reason, engines equipped with wood props will not idle as slowly or as smoothly as they would with metal props. Many RV pilots with wood props find that when they are operating in the cross-country mode, with baggage and a passenger, the CG is near the aft limit. A heavier prop on the front may actually allow more weight to be carried.
- Wood is an organic material, and even though wood props are varnished and painted, they expand and contract with the weather. This means the pilot must pay constant attention to the torque values of the bolts holding the prop to the airplane.

ADVANTAGES

- One problem with fixed pitch props on fast airplanes is that it is difficult to get the correct combination of static and cruise RPM. We have to compromise, accepting less static RPM (less thrust, take-off, climb, etc.) than we would like, and also accepting some engine overspeed to achieve max. power cruise. Our experience has been that wood props offer the advantage of a lower RPM spread than do the metal props.
- Wood props are considerably smoother. This is not particularly noticeable until one has flown behind a well balanced wood prop for awhile, and then changes back to a metal prop. The normal reaction is wanting to land immediately because of the rough engine operation. The difference is really quite noticeable. This experience alone has caused some builders to throw away the metal prop forever.
- While we would rather not think about such things, wood props will help protect the engine from internal damage in the event of a prop strike. Because the prop breaks readily, the force transmitted to the engine will not be as sudden and as violent as with a similar strike with a metal prop. Wood props are far cheaper than engine crankshafts, and replacing one may cost less than repairing a bent metal prop.

In the real world, the cost of the fixed pitch metal and wood props is not greatly different. The extras required by a wood prop; extension, crush plate, bolts, etc., are included in the price of the metal prop. The metal prop should outlast the wood prop and requires less maintenance.

Fixed pitch propellers fall into two general categories: “climb” props and “cruise” props.

A ‘‘Cruise’’ prop is one with a high pitch angle which will produce more thrust and speed at a given RPM. A ‘‘Climb’’ prop is one with a low pitch angle which will permit the engine to attain a higher RPM at low speeds, thus produce more power which will result in a higher climb rate. But, we need to know much more than that in order to make a wise prop selection. Assuming that both the cruise and the climb props have the same blade efficiency, each will produce the same airspeed for a given power output. Note that we said ‘‘Power Output’’, *not* RPM. They are not necessarily the same. Power output varies not only with RPM but also with manifold pressure. Manifold pressure is determined primarily by the amount of throttle opening. (This is a powerful argument for having a manifold gauge in your fixed pitch airplane, even though this is not standard practice in factory aircraft.)

RPM is determined largely by the load on the prop, which is determined by prop diameter and pitch, and aircraft forward speed. To simplify this explanation, let’s consider a 160 HP RV-6 cruising at 8000 ft. with the throttle wide open. At 2600 RPM it will be developing 120 HP or 75% power, the maximum attainable output at this altitude. Substituting a higher pitch prop will load the engine and cause RPM to drop. The drop in RPM will cause a loss of power which means that the airplane will go slower. On the other hand, if we substitute a lower pitch prop, the RPM will increase because of the lower work load that the engine is subjected to, and the power output and speed increase. So, for a fixed throttle position, a high pitch (cruise) prop will actually cause a loss of speed, and a low pitch (performance) prop will cause a speed increase. Because of the increased RPM with the performance prop, fuel consumption will be greater, the noise level higher, and engine wear greater. The cruise prop will provide greater fuel efficiency, less noise, and less engine wear.

From another perspective, let’s view the different pitch props operating at a fixed engine speed, 2500 RPM for example. The median pitch prop might require a throttle setting of 23 in. manifold pressure to achieve 2500 RPM. The low pitch performance prop might require only 21” manifold pressure, but would be slower and burn less fuel. The high pitch cruise prop might require 25’’ MP for the same 2500 RPM, but would be faster and burn more fuel. If we ignored manifold pressures and fuel consumption, it would be easy to conclude that the cruise prop is the fastest, but the preceding explanation showed just the reverse to be true. If we concluded that more pitch means more speed, we could choose a prop with a pitch so excessively high that we would not be able to attain 2500 RPM even at full throttle, and our take off and climb performance would suffer greatly. Because of the reduced RPM, power output would diminish which means less speed.

In summary, a cruise prop is one with high pitch which will yield a high speed at a low RPM. A performance prop is one with low pitch which will yield more RPM at a given throttle setting, and thus more power, particularly for take off and climb. Since it will also (within limits) provide a higher top speed, it improves

performance all around at the expense of higher fuel consumption and engine wear.

CONSTANT SPEED PROPELLERS

If you want the ultimate performance from your RV, there is no substitute for a constant speed (CS) propeller by a certified propeller manufacturer. (There are a number of variable pitch props under development and/or available for homebuilts, but none of which have been sufficiently developed or proven to warrant our recommendation at this time.

Constant speed props use pressurized oil from the engine to vary the pitch of the blades. The angle is controlled by a governor that automatically adjusts prop pitch angles to maintain the RPM selected by the pilot. Van’s prototypes have flown with aluminum-blade Compact Hub constant speed propellers manufactured by Hartzell Propeller Co. of Piqua, Ohio and composite/wood-blade constant-speed props manufactured by MT Propellers of Germany.

Typical installed weight of an aluminum constant speed, including the governor and controls, will be around 60 lbs or 35-40 lbs heavier than a fixed pitch wood prop installation. The composite/wood constant speed will be somewhat lighter

Maintenance of a metal CS prop is a ‘‘Good news/Bad News’’ proposition. Blade maintenance will be minimal because of its resistance to rain erosion. However, the complex control mechanisms in the prop hub require periodic maintenance which must be conducted by approved prop repair facilities. This is expensive. Also, any damage to the blades due to striking something (like the runway) will be expensive to repair. If a serious prop strike does occur, it is probable that the engine crankshaft flange will also be damaged.

The primary reason for using CS props is performance. The ability to control the prop blade angles permits the pilot to maximize engine and prop performance for any given flight condition. Below is a description of the performance offered by CS props for several flight conditions:

- ***Take off:*** Setting a low propeller pitch reduces the prop load on the engine and permits it to rev up to full power RPM. The low prop pitch angle is also more efficient. A CS RV can expect take off distances to be reduced between 20 to 40 percent from that of a fixed pitch prop. This is a significant performance difference, but is not a major factor because RV take offs are short even with fixed pitch props. In other words, the CS prop is not as necessary on an RV as it is on most production airplanes with comparable top speeds, which would have unacceptable take off performance if equipped with fixed pitch props.
- Climb: For the same reason as the take off the CS prop will improve the climb rate and climb angle. Climb rate will increase by approximately 10-15%, depending on the climb speed.
- ***Cruise:*** This is the flight condition at which we feel the CS prop offers the greatest advantage to an RV. Most RVs will spend the majority of their flight time in cruise, so any benefit gained will be of greater value. Though the fixed pitch prop is operating at its best in the cruise condition, it is still a compromise. But, there is a wide variety of conditions which occur under the general heading of ‘‘Cruise’’; anything from full throttle & RPM (at altitude), to just enough power to maintain minimum power flight. ‘‘Rated Cruise Speed’’ for production aircraft is quoted for conditions under which the maximum permissible continuous speed can be achieved. This usually occurs (for non-supercharged engine) at about 8,000 ft. and at maximum permissible continuous RPM. This combination produces about 75% of maximum rated power. Under this condition, the CS prop will offer little advantage over the fixed pitch prop, other than what little it may gain from better blade efficiency.

  The CS prop offers its main cruise advantage under reduced power cruise conditions. Engines operate at peak efficiency when the throttle is full open. This is because the air flow control vane in the carb or injector throttle body is completely open and offering the least resistance to airflow. This reduces what is known as ‘‘pumping losses’’ within the engine. There are two primary means (from the pilots vantage point) of reducing power output of an engine. One is to reduce the RPM of the engine and the other is to reduce the manifold pressure. With a fixed pitch prop, the only means of reducing RPM is to retard the throttle setting. In so doing, the control vane (butterfly) in the carb partially closes, manifold pressure is reduced, and engine efficiency drops. With a variable pitch (CS) prop, the RPM can be controlled through adjusting the blade angle, and thus the propeller load on the engine. The throttle can be left full open (in its most efficient position) and the power output can be reduced by lowering the RPM. This reduced RPM, full throttle condition achieves both reduced engine friction because of the lower RPM, and minimum pumping losses. Fuel efficiency will be improved, but speeds will drop because less than full cruise power is being used. Above we mentioned 8,000 ft. as the optimum cruise altitude. This is because it s the lowest altitude at which an engine will develop no more than 75% power at rated RPM. With a variable pitch prop, selecting low RPM can cause the engine power output to be 75% or less at altitudes of less than 8,000’, making it possible to utilize the efficiency of a continuous full throttle opening at altitudes well below 8,000’. Just leave the throttle wide open and pull the RPM back to a number which, according to the Lycoming manual, produces 75% power or less.
- The bottom line when analyzing prop performance and efficiency in cruising flight is fuel consumption. One can expect rates of 1/2 to 1 gph less than with fixed pitch wood props. Savings might be as high as 1 1/2 gph under extreme conditions with 180 HP engines.

- ***Descents:*** Constant speed props offer two completely different advantages over fixed pitch props during descents. First, they can offer added speed during long, slow descents from cruise altitude. With fixed pitch props, power descents are not practical because the added speed causes excessive RPM requiring power reduction. Constant speed props will control the RPM as speed increases in the descent. Now, red line speed, not RPM becomes the limiting factor.

  On the opposite end of the scale, when the throttle is retarded to idle or near idle power, the CS prop can be moved to low pitch which will offer noticeable aerodynamic braking action.
- ***Aerobatics:*** During aerobatic flight, the braking action of a CS prop can help to control speed build up during the diving portions of maneuvers. And, of course, its slow speed thrust advantages are helpful during the climbing, particularly low speed climbing, portions of the maneuvers. On the negative side, the added inertia of the CS prop causes greater stress on the engine crankshaft and slows down maneuverability to a small degree.

Note that electrically actuated constant speed props are NOT recommended for aerobatics.

INSTALLING CONSTANT-SPEED PROPELLERS

Most constant speed props are controlled by a hydraulic governor which controls oil pressure to the prop through a hollow crankshaft. The majority of 0-320 engines, and many 0-360 engines are not configured to accept a hydraulic CS prop and governor. Thus, the RV builder planning to use a CS prop should shop for the specific model engine offering CS features.

When installing a constant-speed propeller, the builder should research any operational restrictions on the engine/prop combination under consideration. Many combinations are placarded with "avoid continuous operation" ranges. This information can be gathered from the propeller manufacturer's Type Certificate Data Sheets. These Data Sheets are available from the manufacturer or the FAA, and are often obtainable over the Internet. The builder is strongly advised to do his/her own research and obtain, read, and understand the Data Sheets for the prop to be installed. Constant-speed props should be installed according to the manufacturer's instructions. Bolts and hardware for installation are supplied with new propellers. Even constant-speed props should be checked for track. Always consult the engine and prop manufacturer recommendations when installing or reinstalling a prop.

INSTALLING FIXED PITCH PROPELLERS AND PROP EXTENSIONS

The sleek shape of the RV cowl was achieved, partially, by using a spacer between the back of the fixed pitch prop and the forward face of the crankshaft. This is called a "prop extension" although a more correct term might be "crankshaft extension". By moving the prop forward from the crank, the designer can achieve a more streamlined shape. See DWG C-4.

The prop extension is a very important component. It must made strong enough transmit the full power of the engine to the propeller, and withstand the gyroscopic stress imposed by the movement of both the prop and the aircraft. It must be made accurately enough to exactly match the bolt patterns in the crank and prop and allow the prop to track accurately. No compromises should be accepted when considering a prop extension.

Two types of prop extensions have been used on RVs. This first is shaped like spool, with separate sets of bolts (two sets of six, or 12 total bolts) holding the prop to the extension and the extension to the crank. This style places the propeller 4" ahead of the crank face and fits older "fixed-pitch" cowlings. Since 1994, the "constant speed" cowl has become standard, and a shorter, 2 1/4" cylindrical prop extension is used when a fixed pitch propeller is installed. This extension uses six long bolts running through the spinner backplate, the crushplate (wood prop), the prop itself, the extension and into the crank.

Depending on the engine, the bolts mounting fixed pitch props and extensions may be either 7/16" or 3/8" diameter on the O-320 (new O-320s from Van's use 7/16") or 1/2" on the O-360. Sensenich fixed pitch metal props are supplied with the proper extension and bolts.

Prop extensions and prop extension bolts are peculiar to the experimental aircraft field. A common supply line for these bolts has not been established within the production aircraft field. Drilled head AN bolts of the necessary length can be easily found, but they usually have standard length threads which, for this application, are too short. Some builders have felt that they can just take regular AN bolts and cut longer threads on them. This should never be done! Threads on aircraft bolts are *rolled,* not cut. Cutting threads, particularly with the low quality dies found in the typical homebuilder's shop, can cause stress risers and eventually cracks in the bolt threads. DON'T CUT THREADS ON ANY AIRCRAFT BOLTS, ESPECIALLY PROP BOLTS. Having prop bolts break in flight is a terrifying and potentially deadly experience!

Wood prop installations must have a 3/8'' (minimum) aluminum faceplate under the bolt heads to protect the wood and provide even pressure. Bolts should be tightened to the specific torque value called out by the prop manufacturer. As will be covered later, frequent re-torquing of prop bolts on wood props is vital to safety. Checking and re-setting the torque on prop bolts usually requires removing the spinner bowl and cutting safety wire, which often deters builders from this important preventative maintenance practice. Do not overlook this important safety check!

If you are using a spool extension, we suggest using a prop crush plate designed or modified to lock the prop

bolt heads from rotation.

Quality prop bolts, extension bolts, prop extensions, crush plates, etc., are available through Van's Accessories Catalog. Consult the charts and descriptions there to determine the proper components for your installation.

Both prop tip track and prop extension alignment should be checked. If the crankshaft flange is not true, installation of the prop extension will then position the prop off center. Check the forward flange of the extension with a dial indicator. Common writing paper may be use as shim stock, placed between the crankshaft flange and the prop extension. Once this is done (if required), the prop track can be checked and should be within 1/16 inch. This can be adjusted with paper shims also, between the forward flange of the extension and the prop. Always consult the engine and prop manufacturer recommendations when installing or reinstalling a prop.

SPECIFIC PROPS FOR RVs

The subject of prop selection generates more questions than any other topic. Unfortunately, propeller performance is probably the most difficult area to quantify and define, so there are no ready answers. To complicate matters, there is little standardization. Propeller pitch numbers used by one manufacturer have no meaning when applied to another, and are useless for comparative purposes.

Here is one example: The prop initially chosen for the RV-6 was a wooden two blade, 68" in diameter and with, by the manufacturers definition, 69" of pitch. It worked quite well, though it was a ''cruise'' rather than ''performance'' prop. With a 160 HP engine, it gave a static RPM of 2200 and a top speed RPM of 2850. At 8,000 ft. cruise altitude, full throttle (75%) yielded about 2775 RPM and 192 mph. It is our understanding that continuous operation of the Lycoming engines at high RPM is not a cause for concern other than for higher fuel consumption, noise, and engine wear. But, since 2775 RPM is a bit higher than the 2700 RPM recommended for maximum cruise, we throttled back about 1" bringing the RPM down to 2700 and the speed to 188 mph. As discussed earlier, cruising at less than full throttle causes a slight loss of engine efficiency and inability to lean the engine quite as well. Additional prop pitch to hold the RPM down would also drop the static RPM and would effect the take-off distance and climb. Since the RV-6/6A is a general purpose sportplane, we consider the minor cruise penalty a reasonable trade-off.

This same airplane was later converted to a fixed pitch metal prop, 70" in diameter, and having, according to the manufacturer, 79" of pitch. If the pitch numbers were taken at face value, the large increase should have made a very big change in the airplane's performance. Instead, take-off performance was only slightly less, and top speed slightly greater. Fuel consumption at normal cruise decreased a few percentage points.

We later changed props yet again, going to the Hartzell Constant Speed metal prop. The performance realized from the CS prop was in keeping with the earlier discussion on CS prop performance. Would this increased performance be worth the extra cost to you?

Keep in mind this example is for one airplane only. Any significant difference in drag or weight will make a difference that would dictate a different optimum prop pitch. An RV not aerodynamically finished as well as the example might experience a speed loss corresponding to an inch or two of pitch. Restated, a higher drag RV would require a prop with less pitch to cruise at the same RPM as a more efficient airplane which goes faster at the same power output.

MATCHING THE ENGINE TO THE PROPELLER

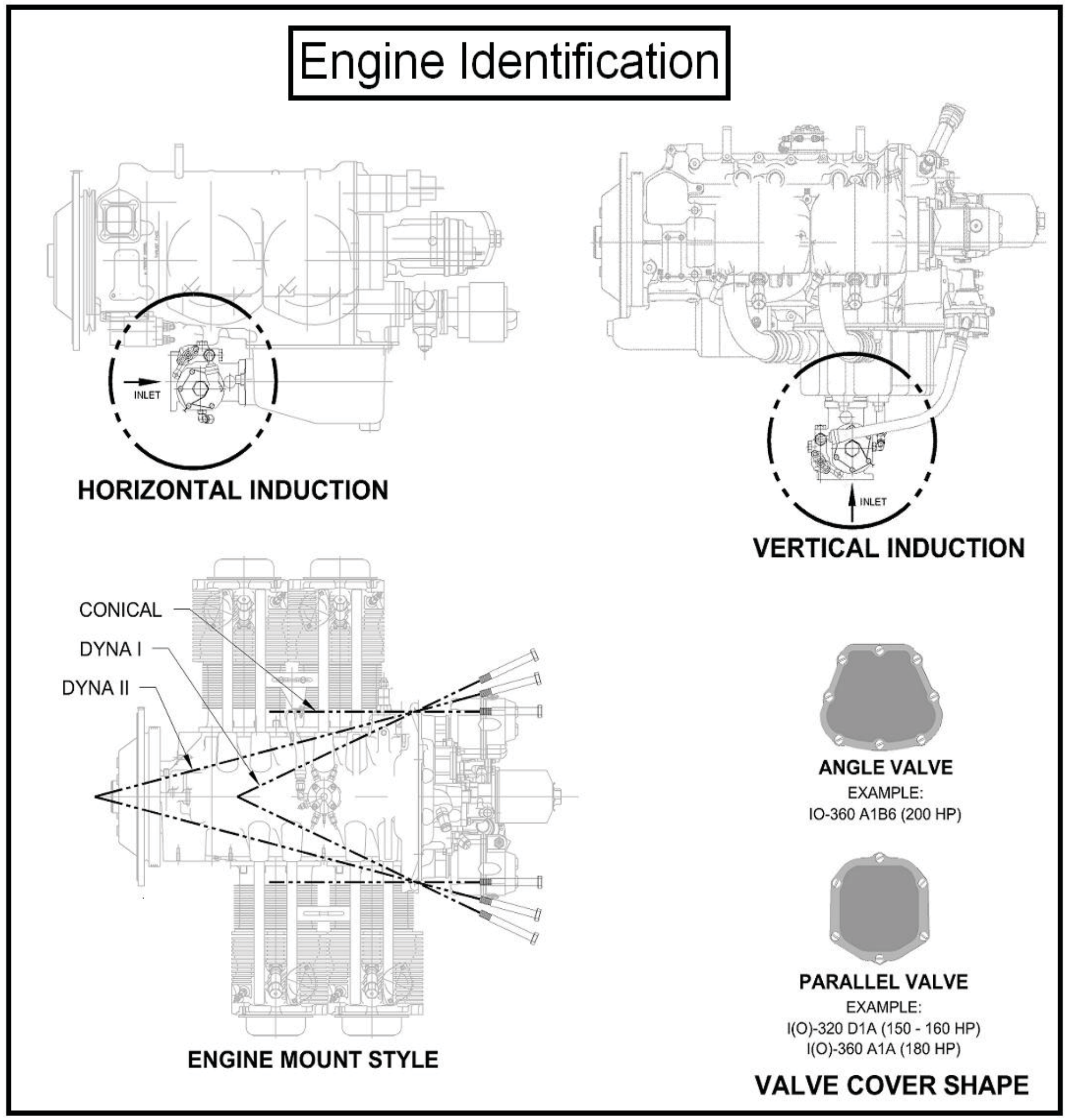
There are many different models of Lycoming engines. Some can run both constant-speed or fixed-pitch propellers, some can only run fixed-pitch props. If you are buying a used engine, be certain the engine is correctly set up to run the type of propeller you intend to install. Incorrect installation can result in damage to the engine or even an in-flight failure.

Regardless of whether you are using a new or used engine, acquire, read and understand a copy of Lycoming Service Instruction No. 1435. This Service Instruction details the modification necessary to the engine when converting from constant-speed to fixed-pitch propellers or vice versa. These modifications include installing or removing an oil line from the governor, removing, replacing and/or piercing various plugs in the crankshaft, replacing crankshaft bushings and more.

ALL new engines from Van's must be modified before installing ANY propeller. They are supplied with a temporary front crankshaft plug (Lycoming p/n STD 1211) in place. This must be removed completely if a constant-speed prop is installed. If the engine is to turn a fixed pitch prop, the plug must be removed, the rear plug down inside the crankshaft pierced as detailed in Service Instruction 1435, and a new STD 1211 installed.

PROPELLER SUPPLIERS

Van's does not sell wood props. There are many wood prop manufacturers, especially of wood fixed pitch propellers, and we cannot keep up with their moves and changes. Van's does not conduct a regular program of propeller testing, so we cannot recommend one manufacturer over any other. We recommend checking the ads in magazines such as *Kitplanes* or EAA's *Sport Aviation* for prop manufacturers . Call and discuss your needs with them. Don't be afraid to ask for references.



SUMMARY OF LYCOMING O-320 and O-360 ENGINE IDENTIFICATION

LETTERS	DISPLACEMENT CU. IN.	POWER SECTION	NOSE SECTION	ACCESSORIES
O	235	A	1	A
I	290	B	2	B
T	320	C	3	C
A	360	D		D

O - Opposed Cylinders
I - Fuel Injected
T - Turbo Supercharged
A - Aerobatic

POWER SECTION: Crankcase, Cylinders, Horsepower

NOSE SECTION: 1 & 3 Controllable Propeller
2 Fixed Pitch Propeller

ACCESSORY SECTION: A - Rear Mounted Accessories
Bendix Magnetos
B - Different Magnetos
other letters designate magneto, oil sump, and carburetor variations. (most of these are readily interchangeable

Engine Serial Numbers Identify Engines
O-320 A and E are Low Compression 150 HP @ 2700 rpm
A has conical mount
E has Type 1 (30°) Dynafocal Mount
(O320 E2D has O-235 Front Main Bearing)
O-320 B and D are High Compression 160 HP @ 2700 rpm
B has conical mount
D has Dyna Focal Mount
O-320 C is a Field Conversion of O-320B to Low Compression 150 HP @ 2700 rpm
O-320 H is an engine peculiar to itself from other O-320's. Rated 160 HP @ 2700 rpm with 9.00:1 compression ration. Most parts do not interchange with other O-320 engines and many airworthyness directives - A, D's - and modifications have been required on this engine.

11-13

IO-320 A and E Low Compression 7.00:1 150 HP at 2700 rpm Bendix fuel injection system
A - type 2 (18°) Dyna-focal Mount
F - Conical Mount
Serial Dash No. 55

IO-320 B, C, D, F. High compression 8.50:1 160 HP @ 2700 rpm. Bendix Fuel Injection System
B - Type 2-18° Dyna Focal Mount
C - 18° Dyna Focal - set up for turbo supercharging - piston cooling, long reach plugs, etc.
D - type I 30° Dyna Focal Mount
F - Same as C with type I 30° mount
serial dash No. 55

Serial numbers end with a dash number, such as (-27) which is for all O-320A's and E's. For O-320 B, C, and D's, the dash number is (-39) .

Dash number followed by an A (-39A) designates wide deck engines. This (A) also applies to O-360 engines.

Internal parts of the same engine designation either wide or narrow deck are the same,

Wide deck engines have a larger diameter bolt circle at the cylinder base and the cylinders have a thicker base flange of a larger diameter than narrow deck cylinders.

High compression Narrow deck engines have hold down plates atop the cylinder base flanges.

O-360 A and C are high compression 8.5:1 180 HP @ 2700 rpm with parallel valves
A has Dyna Focal Mount
C has conical Mount
Serial d sh No. 36

O-360 B and D are low compression 7.20:1 168 HP @ 2700 rpm with parallel valves.
B has Dyna Focal Mount.
D has Conical Mount
Serial Dash No. 36

IO-360 A, C, and D high compression 8.7:1, 200 HP @2700 rpm angle head valves Bendix fuel injection.
A - Dyna Focal Mount - 30° Dyna Focal Mount
C - Rear Air Inlet - 30° Dyna Focal Mount
D - Type 2 18° Dyna Focal Mount
Serial Dash No. 51

IO-360 B and E 8.5:1 180 HP @ 2700 rpm parallel head valves
E Type 2 18° Dyna Focal Mount
D Type I 30° Dynafocal Mount
Serial Dash No. 51

AIO -360 is Aerobatic IO360

AEIO-360 is AIO360 with Aerobatic Kit, Serial Dash No. 63.

A GUIDE TO LYCOMING FOUR CYLINDER PARALLEL VALVE ENGINES

Model	HP	T/O† RPM	Fuel	C.R.	Description	E S/N Suffix
O-235-N2A	116	2800	100/100LL	8.10:1	Same as -L2A but lower comp. ratio and power	-15
O-235-N2C	116	2800	100/100LL	8.10:1	Same as -L2C but lower comp. ratio and power	-15
O-235-P1	116	2800	100/100LL	8.10:1	Same as -M1 but lower comp. ratio and power	-15
O-235-P2A	116	2800	100/100LL	8.10:1	Similar to -P1 but has AS-127, Type 1 propeller flange	-15
O-235-P2C	116	2800	100/100LL	8.10:1	Same as -M2C but lower comp. ratio and power	-15
O-235-P3C	116	2800	100/100LL	8.10:1	Same as -M3C but lower comp. ratio and power	-15
O-290-D	130	2800	80	6.50:1	Solid tappets, hydro control	-21
O-290-11	127	2800	80	6.50:1	Same as O-290-D	-21
O-290-D2	140	2800	80	7.50:1	Hydraulic tappets, 18° spark advance	-21
O-290-D2A	140	2800	80	7.50:1	Same as -D2 but new crankcase for controllable prop.	-21
O-290-D2B	140	2800	80	7.00:1	Same as -D2, 25° spark advance and lower C.R.	-21
O-290-D2C	140	2800	80	7.00:1	Same as -D2B with Retard Breaker Magnetos	-21
O-320-A1A	150	2700	80	7.00:1	Controllable propeller, 25° spark advance Bendix S4LN-20 and S4LN-21 Magnetos	-27
O-320-A1B	150	2700	80	7.00:1	Same as -A1A with straight riser in oil sump and -32 carburetor	-27
O-320-A2A	150	2700	80	7.00:1	Same as -A1A but fixed pitch propeller	-27
O-320-A2B	150	2700	80	7.00:1	Same as -A2A with straight riser in oil sump and -32 carburetor	-27
O-320-A2C	150	2700	80	7.00:1	Same as -A2B with Retard Breaker Magnetos	-27
O-320-A2D	150	2700	80	7.00:1	Same as -E3D but with conical mounts and O-320-A sump and intake pipes	-27
O-320-A3A	150	2700	80	7.00:1	Same as -A1A but uses 7/16 in. dia. propeller bolts	-27
O-320-A3B	150	2700	80	7.00:1	Same as -A3A except for straight riser in oil sump and -32 carburetor	-27
O-320-A3C	150	2700	80	7.00:1	Same as -A3B except for Retard Breaker Magnetos	-27
O-320-B1A	160	2700	100/100LL	8.50:1	Same as -A1A but high C.R.	-39
O-320-B1B	160	2700	100/100LL	8.50:1	Same as -B1A except for straight riser in oil sump and -32 carburetor	-39
O-320-B2A	160	2700	100/100LL	8.50:1	Same as -B1A fixed pitch propeller	-39
O-320-B2B	160	2700	100/100LL	8.50:1	Same as -B2A except for straight riser in oil sump and -32 carburetor	-39
O-320-B2C	160	2700	100/100LL	8.50:1	Same as -B2B except for Retard Breaker Magnetos	-39
O-320-B2D ★	160	2700	100/100LL	8.50:1	Same as -D1D except fixed propeller and conical mounts	-39
O-320-B3A	160	2700	100/100LL	8.50:1	Same as -B1A except for 7/16 inch propeller attaching bolts	-39

PISTON - (4) FOUR CYLINDER SERIES

Model	HP	T/O† RPM	Fuel	C.R.	Description	E S/N Suffix
O-320-B3B	160	2700	100/100LL	8.50:1	Same as -B1A except for 7/16 inch attaching bolts and straight riser in oil sump and -32 carburetor	-39
O-320-B3C	160	2700	100/100LL	8.50:1	Same as -B3B except for Retard Breaker Magnetos	-39
O-320-C1A	150	2700	80	7.00:1	Low compression field service conversion of -B1A	-39
O-320-C1B	150	2700	80	7.00:1	Low compression field service conversion of -B1B	-39
O-320-C2A	150	2700	80	7.00:1	Low compression field service conversion of -B2A	-39
O-320-C2B	150	2700	80	7.00:1	Low compression field service conversion of -B2B	-39
O-320-C2C	150	2700	80	7.00:1	Low compression field service conversion of -B2C	-39
O-320-C3A	150	2700	80	7.00:1	Low compression field service conversion of -B3A	-39
O-320-C3B	150	2700	80	7.00:1	Low compression field service conversion of -B3B	-39
O-320-C3C	150	2700	80	7.00:1	Low compression field service conversion of -B3C	-39
O-320-D1A	160	2700	100/100LL	8.50:1	Same as -B3B but with Type 1 dynafocal mounts	-39
O-320-D1B	160	2700	100/100LL	8.50:1	Same as -D1A except for Retard Breaker Magnetos	-39
O-320-D1C	160	2700	100/100LL	8.50:1	Same as -D2C but with provision for controllable prop.	-39
O-320-D1D	160	2700	100/100LL	8.50:1	Similar to -D1A but has horizontal carburetor and induction housing and has Slick Magnetos	-39
O-320-D1F	160	2700	100/100LL	8.50:1	Same as -E1F except has high compression pistons	-39
O-320-D2A	160	2700	100/100LL	8.50:1	Same as -D1A but with fixed pitch propeller and 3/8 in. attaching bolts	-39
O-320-D2B	160	2700	100/100LL	8.50:1	Same as -D2A except for Retard Breaker Magnetos	-39
O-320-D2C	160	2700	100/100LL	8.50:1	Same as -D2A except for -1200 series Magnetos	-39
O-320-D2F	160	2700	100/100LL	8.50:1	Same as -E2F except has high compression pistons	-39
O-320-D2G	160	2700	100/100LL	8.50:1	Same as -D2A but with Slick Magnetos, 7/16 instead of 3/8 in. propeller flange bolts	-39
O-320-D2H	160	2700	100/100LL	8.50:1	Same as -D2G but with 0-320-B sump and intake pipes and has provision for AC type fuel pump	-39
O-320-D2J	160	2700	100/100LL	8.50:1	Similar to -D2G but has (2) Slick impulse coupling magnetos and an unmachined governor pad on front of crankcase	-39
O-320-D3G	160	2700	100/100LL	8.50:1	Same as -D2G but with 3/8 in. propeller attaching bolts and has provisions for fuel pump	-39
O-320-E1A	150	2700	80	7.00:1	Same as -A3B but with Type 1 dynafocal mounts	-27
O-320-E1B	150	2700	80	7.00:1	Same as -E1A except for Retard Breaker Magnetos	-27
O-320-E1C	150	2700	80	7.00:1	Same as -E1A but has -1200 series Magnetos	-27
O-320-E1F	150	2700	80	7.00:1	Same as -E1C but with propeller governor drive on left front of crankcase	-27

PISTON - (4) FOUR CYLINDER SERIES

Model	HP	T/O† RPM	Fuel	C.R.	Description	E S/N Suffix
O-320-E1J	150	2700	80	7.00:1	Same as -E1F but has Slick Magnetos	-27
O-320-E2A	150/ 140	2700/ 2450	80	7.00:1	Same as -E1A but with fixed pitch propeller and uses 3/8 inch attaching bolts and has alternate rating of 140 HP at 2450 RPM.	-27
O-320-E2B	150	2700	80	7.00:1	Same as -E2A except for Retard Breaker Magnetos	-27
O-320-E2C	150/ 140	2700/ 2450	80	7.00:1	Same as -E2A but has -1200 series Magnetos	-27
O-320-E2D	150	2700	80	7.00:1	Similar to -E2A but with Slick Magnetos, O-235 front main bearing and 7/16 inch propeller flange bushings	-27
O-320-E2F	150	2700	80	7.00:1	Same as -E1F but with fixed pitch propeller	-27
O-320-E2G	150	2700	80	7.00:1	Same as -E2D but has 0-320-A sump and intake pipes	-27
O-320-E2H	150	2700	80	7.00:1	Same as -E2D but equipped with S4LN-20 and -21 Mags.	-27
O-320-E3D	150	2700	80	7.00:1	Same as -E2D but uses 3/8 inch instead of 7/16 inch propeller flange bushings	-27
O-320-E3H	150	2700	80	7.00:1	Same as -E3D but equipped with S4LN-20 and -21 Mags.	-27
O-320-H1AD	160	2700	100/100LL	9.00:1	Integral accessory section crankcase, front mounted fuel pump, external mounted oil pump and D4RN-3000 impulse coupling dual magneto	-76
O-320-H1BD	160	2700	100/100LL	9.00:1	Same as -H1AD but with D4RN-3200 retard breaker dual magneto	-76
O-320-H2AD	160	2700	100/100LL	9.00:1	Same as -H1AD but with fixed pitch propeller	-76
O-320-H2BD	160	2700	100/100LL	9.00:1	Same as -H2AD but with D4RN-3200 retard breaker dual magneto	-76
O-320-H3AD	160	2700	100/100LL	9.00:1	Same as -H2AD but uses 3/8 inch instead of 7/16 inch propeller flange bushings	-76
O-320-H3BD	160	2700	100/100LL	9.00:1	Same as -H3AD but with D4RN-3200 retard breaker dual magneto	-76
IO-320-A1A	150	2700	80	7.00:1	Same as O-320-E1B but with rear Bendix fuel injection and Type 2 dynafocal mounts	-55
IO-320-A2A	150	2700	80	7.00:1	Same as -A1A but with fixed pitch propeller and 3/8 inch propeller flange bushings	-55
IO-320-B1A	160	2700	100/100LL	8.50:1	Same as O-320-D1A but with Type 2 dynafocal mounts and rear mounted Bendix fuel injector	-55
IO-320-B1B	160	2700	100/100LL	8.50:1	Same as -B1A but has AN fuel pump drive	-55
IO-320-B1C	160	2700	100/100LL	8.50:1	Same as -B1A but has adapter for mounting fuel injector straight to the rear	-55
IO-320-B1D	160	2700	100/100LL	8.50:1	Same as -B1C but with -1200 series Retard Magnetos	-55
IO-320-B1E	160	2700	100/100LL	8.50:1	Same as -D1C but with rear mounted horizontal fuel injector	-55
IO-320-B2A	160	2700	100/100LL	8.50:1	Same as -B1A but with fixed pitch propeller and 3/8 inch propeller flange bushings	-55

PISTON - (4) FOUR CYLINDER SERIES

Model	HP	T/O† RPM	Fuel	C.R.	Description	E S/N Suffix
IO-320-C1A	160	2700	100/100LL	8.50:1	Same as -B1A except converted for use with turbocharger, long reach spark plugs, piston cooling oil jets, vented fuel nozzles, two S4LN-21 impulse coupling magnetos and AN fuel pump drive	-55
IO-320-C1B	160	2700	100/100LL	8.50:1	Same as -C1A but with fuel injector mounted straight to the rear and 24 volt system standard	-55
IO-320-D1A	160	2700	100/100LL	8.50:1	Same as O-320-D2C except has Bendix RSA-5AD1 fuel injector, provision for controllable propeller and 7/16 inch propeller flange bushings	-55
IO-320-D1B	160	2700	100/100LL	8.50:1	Same as -D1A but with propeller governor drive on left front of crankcase	-55
IO-320-D1C	160	2700	100/100LL	8.50:1	Same as -D1B but with Slick Magnetos, 24 volt system and 100 amp alternator standard	-55
IO-320-E1A	150	2700	80	7.00:1	Same as O-320-A3B except has Bendix fuel injector	-55
IO-320-E1B	150	2700	80	7.00:1	Same as -E1A but with Slick Magnetos	-55
IO-320-E2A	150	2700	80	7.00:1	Same as -E1A but with fixed pitch propeller and 3/8 inch propeller flange bushings	-55
IO-320-E2B	150	2700	80	7.00:1	Same as O-320-A2D but with Bendix RSA-5AD1 fuel injector	-55
IO-320-F1A	160	2700	100/100LL	8.50:1	Same as -C1A but with Type 1 dynafocal mounts	-55
LIO-320-B1A	160	2700	100/100LL	8.50:1	Similar to IO-320-B1A but has left hand rotation crankshaft	-66
LIO-320-C1A	160	2700	100/100LL	8.50:1	Similar to IO-320-C1A but has left hand rotation crankshaft	-66
AIO-320-A1A	160	2700	100/100LL	8.50:1	Aerobatic engine with performance similar to IO-320-D1A	-65
AIO-320-A1B	160	2700	100/100LL	8.50:1	Same as -A1A but has impulse coupling Magneto	-65
AIO-320-A2A	160	2700	100/100LL	8.50:1	Same as -A1A but with fixed pitch propeller	-65
AIO-320-A2B	160	2700	100/100LL	8.50:1	Same as -A2A but has impulse coupling Magneto	-65
AIO-320-B1B	160	2700	100/100LL	8.50:1	Similar to -A1B but with front mounted fuel injector	-65
AIO-320-C1B	160	2700	100/100LL	8.50:1	Similar to -B1B but the fuel injector is vertically mounted on the bottom of the sump	-65
AEIO-320-D1B	160	2700	100/100LL	8.50:1	Same as IO-320-D1B but is equipped with Aerobatic kit	-55
AEIO-320-D2B	160	2700	100/100LL	8.50:1	Same as -D1B but with fixed pitch propeller	-55
AEIO-320-E1A	150	2700	80	7.00:1	Same as IO-320-E1A but is equipped with Aerobatic kit	-55
AEIO-320-E1B	150	2700	80	7.00:1	Same as IO-320-E1B but is equipped with Aerobatic kit	-55
AEIO-320-E2A	150	2700	80	7.00:1	Same as IO-320-E2A but is equipped with Aerobatic kit	-55
AEIO-320-E2B	150	2700	80	7.00:1	Same as IO-320-E2B but is equipped with Aerobatic kit	-55
O-340-A1A	170	2700	100/100LL	8.50:1	Controllable propeller	-30
O-340-A1B	170	2700	100/100LL	8.50:1	Same as -A1A except for Retard Breaker Magnetos	-30

PISTON - (4) FOUR CYLINDER SERIES

Model	HP	T/O† RPM	Fuel	C.R.	Description	E S/N Suffix
O-340-A2A	170	2700	100/100LL	8.50:1	Same as -A1A but fixed pitch propeller	-30
O-340-B1A	160	2700	80	7.15:1	Low compression -A1A	-30
O-340-B2A	160	2700	80	7.15:1	Low compression -A2A	-30
O-360-A1A	180	2700	100/100LL	8.50:1	Dynafocal mounts	-36
O-360-A1AD	180	2700	100/100LL	8.50:1	Same as -A1A but with D4LN-3000 impulse coupling dual magnetos	-36
O-360-A1C	180	2700	100/100LL	8.50:1	Similar to -A1A but has horizontal induction housing, Bendix PSH-5BD pressure carburetor and retard breaker magnetos	-36
O-360-A1D	180	2700	100/100LL	8.50:1	Same as -A1A except for Retard Breaker Magnetos	-36
O-360-A1F	180	2700	100/100LL	8.50:1	Same as -A1A with -1200 series Magnetos	-36
O-360-A1F6	180	2700	100/100LL	8.50:1	Same as -A1F but has (1) sixth and (1) eighth order counterweights	-36
O-360-A1F6D	180	2700	100/100LL	8.50:1	Same as -A1F6 but with D4LN-3000 impulse coupling dual magnetos	-36
O-360-A1G	180	2700	100/100LL	8.50:1	Similar to -A1F but has horizontal carburetor and induction housing	-36
O-360-A1G6	180	2700	100/100LL	8.50:1	Same as -A1G but has (1) sixth and (1) eighth order counterweights	-36
O-360-A1G6D	180	2700	100/100LL	8.50:1	Same as -A1G6 but with D4LN-3000 impulse coupling dual magneto	-36
O-360-A1H	180	2700	100/100LL	8.50:1	Same as -A1G but with propeller governor drive on left front of crankcase and -21, -204 magnetos	-36
O-360-A1H6	180	2700	100/100LL	8.50:1	Same as -A1H but has (1) sixth and (1) eighth order counterweights	-36
O-360-A1LD	180	2700	100/100LL	8.50:1	Similar to -A1A but with D4LN-3000 impulse coupling dual magneto and has propeller governor drive on left front of crankcase	-36
O-360-A1P ★	180	2700	100/100LL	8.50:1	Same as -C1G except dynafocal mounts	-36
O-360-A2A	180	2700	100/100LL	8.50:1	Same as -A1A but fixed pitch propeller	-36
O-360-A2D	180	2700	100/100LL	8.50:1	Same as -A2A except for Retard Breaker Magnetos	-36
O-360-A2E	180	2700	100/100LL	8.50:1	Same as -A2D with provision for AN fuel pump drive	-36
O-360-A2F	180	2700	100/100LL	8.50:1	Same as -A2A with -1200 series Magnetos	-36
O-360-A2G	180	2700	100/100LL	8.50:1	Same as -A1G but fixed pitch propeller	-36
O-360-A2H	180	2700	100/100LL	8.50:1	Same as -A1H but has fixed pitch propeller	-36
O-360-A3A	180	2700	100/100LL	8.50:1	Same as -A2A but has 6 special long bushings in propeller flange	-36
O-360-A3AD	180	2700	100/100LL	8.50:1	Same as -A3A but with D4LN-3000 impulse coupling dual magneto	-36

PISTON - (4) FOUR CYLINDER SERIES

Model	HP	T/O† RPM	Fuel	C.R.	Description	E S/N Suffix
O-360-A3D	180	2700	100/100LL	8.50:1	Same as -A3A except for Retard Breaker Magnetos	-36
O-360-A4A	180	2700	100/100LL	8.50:1	Same as -A3A but has solid crankshaft	-36
O-360-A4AD	180	2700	100/100LL	8.50:1	Same as -A4A but with D4LN-3000 impulse coupling dual magneto	-36
O-360-A4D	180	2700	100/100LL	8.50:1	Similar to -A4A except with Retard Breaker Magnetos, (2) magneto drive isolators and -A2A propeller Flange Bushings	-36
O-360-A4G	180	2700	100/100LL	8.50:1	Same as -A2G but has -A4A crankshaft with -A2G propeller flange bushings	-36
O-360-A4J	180	2700	100/100LL	8.50:1	Same as -A4G but has -21 and -204 Magnetos	-36
O-360-A4K	180	2700	100/100LL	8.50:1	Same as -A4J but with Slick Magnetos	-36
O-360-A4M	180	2700	100/100LL	8.50:1	Same as -A4A but with Slick Magnetos	-36
O-360-A4N	180	2700	100/100LL	8.50:1	Same as -A4M but has an unmachined governor pad on front of crankcase and -A2G propeller flange bushings	-36
O-360-A4P ★	180	2700	100/100LL	8.50:1	Same as -A4M except for propeller flange bushings	-36
O-360-A5AD	180	2700	100/100LL	8.50:1	Same as -A4AD but has standard length propeller flange bushings	-36
O-360-B1A	168	2700	80	7.20:1	Same as -A1A but low compression ratio	-36
O-360-B1B	168	2700	80	7.20:1	Same as -B1A except for Retard Breaker Magnetos	-36
O-360-B2A	168	2700	80	7.20:1	Same as -B1A except for fixed pitch propeller	-36
O-360-B2B	168	2700	80	7.20:1	Same as -B2A except for Retard Breaker Magnetos	-36
O-360-B2C ★	168	2700	80	7.20:1	Same as -B2A except has IO-360-A crank and rods	-36
O-360-C1A	180	2700	100/100LL	8.50:1	Same as -A1A but conical rubber mounts	-36
O-360-C1C	180	2700	100/100LL	8.50:1	Same as -C1A except for Retard Breaker Magnetos	-36
O-360-C1E	180	2700	100/100LL	8.50:1	Same as -C1A but with Slick Magnetos	-36
O-360-C1F	180	2700	100/100LL	8.50:1	Same as -A1G with conical mounts and Slick magnetos	-36
O-360-C1G	180	2700	100/100LL	8.50:1	Same as -C1A but with propeller governor drive on left front of crankcase	-36
O-360-C2A	180	2700	100/100LL	8.50:1	Same as -C1A but fixed pitch propeller	-36
O-360-C2B	180	2700	100/100LL	8.50:1	Same as -C1A but fixed pitch propeller and horizontal pressure carburetor and has helicopter rating	-36
O-360-C2C	180	2700	100/100LL	8.50:1	Same as -C2A except for Retard Breaker Magnetos	-36
O-360-C2D	180	2700	100/100LL	8.50:1	Same as -C2B except for Retard Breaker Magnetos	-36
O-360-C2E	180	2700	100/100LL	8.50:1	Same as -C2A but with Slick Magnetos	-36
O-360-C4F ★	180	2700	100/100LL	8.50:1	Same as -C1F except has solid crankshaft and no provision for propeller governor	-36
O-360-C4P ★	180	2700	100/100LL	8.50:1	Same as -A4M except for propeller flange bushings and conical mounts	-36

PISTON - (4) FOUR CYLINDER SERIES

Model	HP	T/O† RPM	Fuel	C.R.	Description	E S/N Suffix
O-360-D1A	168	2700	80	7.20:1	Same as -B1A but conical rubber mounts and -1200 series magnetos	-36
O-360-D2A	168	2700	80	7.20:1	Same as -B2A but conical rubber mounts	-36
O-360-D2B	168	2700	80	7.20:1	Same as -D2A except for Retard Breaker Magnetos	-36
O-360-E1A6D	180	2700	100/100LL	9.00:1	Integral accessory section crankcase, front mounted fuel pump, external oil pump, D4RN-3000 impulse coupling dual magnetos and counterweighted crankshaft	-77
O-360-F1A6	180	2700	100/100LL	8.50:1	Similar to O-360-A series with new sump for nose wheel clearance, rear HA-6 carburetor, has (1) sixth and (1) eighth order counterweights and has propeller governor drive on left front of crankcase	-36
O-360-G1A6	180	2700	100/100LL	8.50:1	Same as -F1A6 but with a machined pad on right front of crankcase	-36
HO-360-A1A	180	2700	100/100LL	8.50:1	Same as 0-360-A2D but with MA-4-5AA carburetor and type 2 dynafocal mounts	-36
HO-360-B1A	180	2900	100/100LL	8.50:1	Same as 0-360-C2D except for rated speed	-36
HO-360-B1B	180	2900	100/100LL	8.50:1	Same as -B1A but with two (2) S4LN-200 Magnetos	-36
IO-360-A1A	200	2700	100/100LL	8.70:1	Bendix fuel injection, tuned induction	-51
IO-360-A1B	200	2700	100/100LL	8.70:1	Same as -A1A but has -1200 series impulse coupling magnetos	-51
IO-360-A1B6	200	2700	100/100LL	8.70:1	Same as -A1B but has (1) sixth and (1) eighth order counterweights	-51
IO-360-A1B6D	200	2700	100/100LL	8.70:1	Same as -A1B6 but has (1) Bendix D4LN-3000 impulse coupling dual Magneto	-51
IO-360-A1C	200	2700	100/100LL	8.70:1	Same as -A1A but with -1200 series Magnetos	-51
IO-360-A1D	200	2700	100/100LL	8.70:1	Same as -A1B but has S4LN-21 impulse coupling and S4LN-204 Magnetos	-51
IO-360-A1D6	200	2700	100/100LL	8.70:1	Same as -A1B6 but with propeller governor drive on left front of crankcase	-51
IO-360-A1D6D	200	2700	100/100LL	8.70:1	Same as -A1D6 but has (1) Bendix D4LN-3000 impulse coupling dual magneto	-51
IO-360-A2A	200	2700	100/100LL	8.70:1	Same as -A1A but fixed pitch propeller	-51
IO-360-A2B	200	2700	100/100LL	8.70:1	Same as -A2A but has -1200 series impulse Magnetos	-51
IO-360-A2C	200	2700	100/100LL	8.70:1	Same as -A1C but has fixed pitch propeller	-51
IO-360-A3B6 ★	200	2700	100/100LL	8.70:1	Same as -A1B6 with propeller flange bushings rotated 120° clockwise	-51
IO-360-A3B6D	200	2700	100/100LL	8.70:1	Same as -A1B6D but with propeller locating bushings rotated 120° clockwise	-51
IO-360-A3D6D	200	2700	100/100LL	8.70:1	Same as -A1D6D but with propeller locating bushings rotated 120° clockwise	-51

PISTON - (4) FOUR CYLINDER SERIES

Model	HP	T/O† RPM	Fuel	C.R.	Description	E S/N Suffix
IO-360-B1A	180	2700	100/100LL	8.50:1	Same as O-360-A1D except for Simmonds 530 Fuel Injection System	-51
IO-360-B1B	180	2700	100/100LL	8.50:1	Same as -B1A except for Bendix Fuel Injection System	-51
IO-360-B1C	177	2700	100/100LL	8.50:1	Conversion of O-360-A1C to Bendix Fuel Injection	-51
IO-360-B1D	180	2700	100/100LL	8.50:1	Same as -B1B but with AN fuel pump drive	-51
IO-360-B1E	180	2700	100/100LL	8.50:1	Similar to -B1B with rear mounted fuel injection and -1200 series impulse coupling magnetos	-51
IO-360-B1F	180	2700	100/100LL	8.50:1	Similar to -B1B except has (2) -1227 Magnetos	-51
IO-360-B1F6	180	2700	100/100LL	8.50:1	Same as -B1F but with one (1) sixth and (1) eighth order counterweights	-51
IO-360-B2E	180	2700	100/100LL	8.50:1	Same as -B1E but has fixed pitch propeller	-51
IO-360-B2F	180	2700	100/100LL	8.50:1	Same as -B1F but fixed pitch propeller	-51
IO-360-B2F6	180	2700	100/100LL	8.50:1	Same as -B2F but with one (1) sixth and one (1) eighth order counterweights	-51
IO-360-B4A	180	2700	100/100LL	8.50:1	Similar to -B1B but has S4LN-21 (impulse coupling) and S4LN-20 magnetos and O-360-A4A solid crankshaft	-51
IO-360-C1A	200	2700	100/100LL	8.70:1	Same as -A1A but with rear air inlet	-51
IO-360-C1B	200	2700	100/100LL	8.70:1	Same as -C1A but with -1200 series Magnetos	-51
IO-360-C1C	200	2700	100/100LL	8.70:1	Similar to -C1B but has 14° injector adapter and impulse Magneto	-51
IO-360-C1C6	200	2700	100/100LL	8.70:1	Same as -C1C but with one (1) sixth and one (1) eighth order counterweights	-51
IO-360-C1D6	200	2700	100/100LL	8.70:1	Similar to -C1C but has straight injector inlet and has (1) sixth and (1) eighth order counterweights	-51
IO-360-C1E6	200	2700	100/100LL	8.70:1	Similar to -C1C but has propeller governor drive on left front of crankcase, has (1) sixth and (1) eighth order counterweights	-51
IO-360-C1E6D	200	2700	100/100LL	8.70:1	Same as -C1E6 but with D4LN-3000 impulse coupling dual Magneto	-51
IO-360-C1F	200	2700	100/100LL	8.70:1	Same as -C1C but with AN fuel pump drive and pump	-51
IO-360-D1A	200	2700	100/100LL	8.70:1	Same as -C1B but has Type 2 dynafocal mounts	-51
IO-360-E1A	180	2700	100/100LL	8.50:1	Similar to -B1E but has Type 2 dynafocal mounts and Retard Breaker Magnetos	-51
IO-360-F1A	180	2700	100/100LL	8.50:1	Similar to -B1E except converted for use with Turbocharger	-51
IO-360-J1AD	200	2700	100/100LL	8.70:1	Similar to -A1B except equipped with a D4LN-3000 dual magneto and has a rear type engine mount similar to TO-360-F1A6D	-51
IO-360-J1A6D	200	2700	100/100LL	8.70:1	Same as -J1AD but with (1) sixth and (1) eighth order counterweights	-51

Model	HP	T/O† RPM	Fuel	C.R.	Description	E S/N Suffix
O-540-A1A	250/ 235	2575/ 2400	100/100LL	8.50:1	Two sixth order counterweights	-40
O-540-A1A5	250/ 235	2575/ 2400	100/100LL	8.50:1	Same as –A1A but one fifth and one sixth order counterweights	-40
O-540-A1B5	250/ 235	2575/ 2400	100/100LL	8.50:1	Same as –A1A5 except for short propeller governor studs and two impulse Magnetos	-40
O-540-A1C5	250/ 235	2575/ 2400	100/100LL	8.50:1	Same as –A1A5 except for two impulse Magnetos	-40
O-540-A1D	250/ 235	2575/ 2400	100/100LL	8.50:1	Same as –A1B5 except for two sixth order counter-weights with Retard Breaker Magnetos	-40
O-540-A1D5	250/ 235	2575/ 2400	100/100LL	8.50:1	Same as –A1B5 except for Retard Breaker Magnetos	-40
O-540-A2B	250/ 235	2575/ 2400	100/100LL	8.50:1	-A1A with short propeller governor studs and propeller locating bushing, relocate 60° counterclockwise	-40
O-540-A3D5	250	2575	100/100LL	8.50:1	Special Navy "Aztec", same as –A1D5 except for pro-vision for propeller de-icing and chrome barrels, 24 volt system standard	-40
O-540-A4A5	250/ 235	2575/ 2400	100/100LL	8.50:1	Same as –A1A5 but with more effective counter-weights for use with Hartzell "compact" propeller	-40
O-540-A4B5	250/ 235	2575/ 2400	100/100LL	8.50:1	Same as –A1B5 but with more effective counter-weights for use with Hartzell "compact" propeller	-40
O-540-A4C5	250/ 235	2575/ 2400	100/100LL	8.50:1	Same as –A1C5 but with more effective counter-weights for use with Hartzell "compact" propeller	-40
O-540-A4D5	250/ 235	2575/ 2400	100/100LL	8.50:1	Same as –A1D5 but with more effective counter-weights for use with Hartzell "compact" propeller	-40
O-540-B1A5	235	2575	80	7.20:1	Same as –A1D5 but low compression ratio	-40
O-540-B1B5	235	2575	80	7.20:1	Same as –B1A5 but with impulse coupling Magnetos and a field conversion of –A1A5, -A1B5 or –A1C5 to low compression	-40
O-540-B1D5	235	2575	80	7.20:1	-B1A5 with –1200 series Magnetos	-40
O-540-B2A5	235	2575	80	7.20:1	Same as –B1A5 but does not have provision for controllable propeller	-40
O-540-B2B5	235	2575	80	7.20:1	Same as –B2A5 but with impulse coupling Magnetos	-40
O-540-B2C5	235	2575	80	7.20:1	Same as –B2B5 but with –1200 series Magnetos	-40
O-540-B4A5	235	2575	80	7.20:1	Same as –B1A5 but with more effective counter-weights for use with Hartzell "compact" propeller	-40
O-540-B4B5	235	2575	80	7.20:1	Same as –B1B5 but with more effective counter-weights for use with Hartzell "compact" propeller	-40
O-540-D1A5	250	2575	100/100LL	8.50:1	Same as –A1D5 but with Bed-type mounts	-40
O-540-E4A5	260	2700	100/100LL	8.50:1	Same as –A4D5 except for higher speed and rating	-40
O-540-E4B5	260	2700	100/100LL	8.50:1	Same as –E4A5 but with impulse coupling Magnetos with integral feed-thru capacitors	-40
O-540-E4C5	260	2700	100/100LL	8.50:1	Same as –E4B5 but has –1200 series Magnetos	-40
O-540-F1A5	260	2800	100/100LL	8.50:1	Same as –A1A5 except for special studs for front end mounting	-40

O-540-F1B5	260	2800	100/100LL	8.50:1	Same as –F1A5 except for new style crankcase and Retard Breaker Magnetos	-40
O-540-G1A5	260	2700	100/100LL	8.50:1	Similar to –E4C5 except has stiffer crankshaft and -A1D5 counterweights	-40
O-540-G2A5	260	2700	100/100LL	8.50:1	Same as –G1A5 but does not have provision for con-trollable propeller	-40
O-540-H1A5	260	2700	100/100LL	8.50:1	Similar to –G1A5 but has piston cooling oil jets and -21 and –20 Magnetos	-40
O-540-H1A5D	260	2700	100/100LL	8.50:1	Same as –H1A5 but equipped with D6LN-3000 impulse coupling dual Magneto system along with the dual Magneto accessory housing and related drive system	-40
O-540-H1B5D	260	2700	100/100LL	8.50:1	Same as –H1A5 but equipped with D6LN-3200 dual Magneto system, dual Magneto accessory housing, gear train and related parts	-40
O-540-H2A5	260	2700	100/100LL	8.50:1	Same as –H1A5 but with fixed pitch propeller	-40
O-540-H2A5D	260	2700	100/100LL	8.50:1	Same as –H2A5 but equipped with D6LN-3000 impulse coupling dual Magneto system along with the dual Magneto accessory housing and related drive system	-40
O-540-H2B5D	260	2700	100/100LL	8.50:1	Same as –H2A5 but equipped with D6LN-3200 dual Magneto system, dual Magneto accessory housing, gear train and related drive system	-40
O-540-J1A5D	235	2400	100/100LL	8.50:1	Similar to –A4A5 except for rating, speed, D6LN-3000 impulse coupling dual Magneto and various items of weight reduction	-40
O-540-J1B5D	235	2400	100/100LL	8.50:1	Same as –J1A5D but with D6LN-3200 Retard Breaker dual Magneto	-40
O-540-J1C5D	235	2400	100/100LL	8.50:1	Same as –J1A5D but with rear mounted HA-6 horizontal carburetor	-40
O-540-J1D5D	235	2400	100/100LL	8.50:1	Same as –J1C5D but with D6LN-3200 Retard Breaker dual Magneto	-40
O-540-J2A5D	235	2400	100/100LL	8.50:1	Same as –J1A5D but with fixed pitch propeller	-40
O-540-J2B5D	235	2400	100/100LL	8.50:1	Same as –J1B5D but with fixed pitch propeller	-40
O-540-J2C5D	235	2400	100/100LL	8.50:1	Same as –J1C5D but with fixed pitch propeller	-40
O-540-J2D5D	235	2400	100/100LL	8.50:1	Same as –J1D5D but with fixed pitch propeller	-40
O-540-J3A5	235	2400	100/100LL	8.50:1	Same as –J3A5D but has Slick 6251 (impulse coupling) and 6250 Magnetos	-40
O-540-J3A5D	235	2400	100/100LL	8.50:1	Same as –J1A5D but has heavier counterweights for use with Hartzell extended hub controllable propeller	-40
O-540-J3C5D	235	2400	100/100LL	8.50:1	Same as –J1C5D but has heavier counterweights for use with McCauley controllable propeller	-40
O-540-L3C5D	235	2400	100/100LL	8.50:1	Similar to –J3C5D except for long reach spark plugs, high pressure fuel pump, piston cooling oil jets and turbocharger scavenge pump	-40
IO-540-A1A5	290	2575	100/100LL	8.70:1	High compression tuned induction, Retard Breaker Magnetos, Bendix fuel injector	-48
IO-540-B1A	290	2575	100/100LL	8.70:1	Same as –A1A5 except for updraft exhaust cooling	-48
IO-540-B1B5	290	2575	100/100LL	8.70:1	Same as –B1A5 except for Simmonds fuel injector	-48
IO-540-B1C5	290	2575	100/100LL	8.70:1	Same as –B1A5 except it has external servo bleed in fuel injection system	-48
IO-540-C1B5	250	2575	100/100LL	8.50:1	Same as O-540-A1D5 but with Bendix fuel injector	-48
IO-540-C1C5	250	2575	100/100LL	8.50:1	Same as –C1B5 but has AN fuel pump	-48
IO-540-C2C	250	2575	100/100LL	8.50:1	Conversion of O-540-A2B to Bendix fuel injection and AN fuel pump drive	-48

IO-540-C4B5	250	2575	100/100LL	8.50:1	Same as –C1B5 but with more effective counter-weights for use with Hartzell "compact" propeller	-48
IO-540-C4C5	250	2575	100/100LL	8.50:1	Same as –C4B5 but has AN fuel pump drive	-48
IO-540-C4D5	250	2575	100/100LL	8.50:1	Same as –C4D5D except has two Magnetos	-48
IO-540-C4D5D	250	2575	100/100LL	8.50:1	Same as –C4B5 but with D6LN-3000 impulse coupling Magneto	-48
IO-540-D4A5	260	2700	100/100LL	8.50:1	Same as O-540-E4A5 but with Bendix fuel injection	-48
IO-540-D4B5	260	2700	100/100LL	8.50:1	Same as –D4A5 but has –1200 series impulse coupling Magnetos	-48
IO-540-D4C5	260	2700	100/100LL	8.50:1	Same as –D4B5 but with Retard Breaker Magnetos	-48
IO-540-E1A5	290	2575	100/100LL	8.70:1	Same as –B1C5 but with piston cooling oil jets	-48
IO-540-E1B5	290	2575	100/100LL	8.70:1	Same as –E1A5 but with –1200 series Magnetos	-48
IO-540-E1C5	290	2575	100/100LL	8.70:1	Same as –E1B5 with RSA-10ED1 fuel injector	-48
IO-540-G1A5	290	2575	100/100LL	8.70:1	Same as –A1A5 but with piston cooling oil jets	-48
IO-540-G1B5	290	2575	100/100LL	8.70:1	Similar to –G1A5 but has –1200 series Magnetos and RSA-10ED1 fuel injector	-48
IO-540-G1C5	290	2575	100/100LL	8.70:1	Same as –G1B5 but has impulse Magnetos and 38-1/2° injector adapter	-48
IO-540-G1D5	290	2575	100/100LL	8.70:1	Same as –G1C5 but has straight injector inlet	-48
IO-540-G1E5	290	2575	100/100LL	8.70:1	Same as –G1A5 but has –1200 series Magnetos	-48
IO-540-G1F5	290	2575	100/100LL	8.70:1	Same as –G1E5 but with (2) impulse coupling Mags.	-48
IO-540-J4A5	250	2575	100/100LL	8.50:1	Same as –C4B5 except conversion for use with turbo-charger – long reach spark plugs, piston cooling oil jets, AN fuel pump drive, vertical fuel nozzles and -1200 series Magnetos	-48
IO-540-K1A5	300	2700	100/100LL	8.70:1	Similar to –G1A5 but has –1200 series Magnetos, RSA-10ED1 injector, large crankshaft and 38-1/2° fuel injector adapter	-48
IO-540-K1A5D	300	2700	100/100LL	8.70:1	Same as –K1A5 but with D6LN-3000 impulse coupling dual Magneto	-48
IO-540-K1B5	300	2700	100/100LL	8.70:1	Similar to –K1A5 but has two impulse coupling Magnetos and straight injector adapter	-48
IO-540-K1B5D	300	2700	100/100LL	8.70:1	Same as –K1B5 but with D6LN-3000 impulse coupling dual Magneto	-48
IO-540-K1C5	300/ 290	2700/ 2575	100/100LL	8.70:1	Similar to –G1A5 but has –K1A5 rotating system	-48
IO-540-K1D5	300	2700	100/100LL	8.70:1	Same as –K1A5 but has –200 series Magnetos, flange fuel injector and straight injector inlet	-48
IO-540-K1E5	300	2700	100/100LL	8.70:1	Similar to –K1C5 but has –1200 series impulse Mags.	-48
IO-540-K1E5D	300	2700	100/100LL	8.70:1	Same as –K1E5 but with D6LN-3000 impulse coupling dual Magneto	-48
IO-540-K1F5	300/ 290	2700/ 2575	100/100LL	8.70:1	Same as –G1B5 but with -K series rotating system	-48
IO-540-K1F5D	300	2700	100/100LL	8.70:1	Same as –K1F5 but with D6LN-3000 Retard Breaker dual Magneto	-48

Model	HP	T/O† RPM	Fuel	C.R.	Description	E S/N Suffix
IO-540-K1G5	300	2700	100/100LL	8.70:1	Same as –K1A5 but has diaphragm type fuel pump and drive	-48
IO-540-K1G5D	300	2700	100/100LL	8.70:1	Same as –K1A5D but has diaphragm type fuel pump and drive	-48
IO-540-K1H5	300	2700	100/100LL	8.70:1	Same as –K1B5 but has diaphragm type fuel pump and drive	-48
IO-540-K1J5	300	2700	100/100LL	8.70:1	Same as –K1F5 but has diaphragm type fuel pump and drive	-48
IO-540-K1J5D	300	2700	100/100LL	8.70:1	Same as –K1F5D but has diaphragm type fuel pump and drive	-48
IO-540-K1K5	300	2700	100/100LL	8.70:1	Similar to –K1A5 except modified to use with an Aerobatic kit	-48
IO-540K2A5	300	2700	100/100LL	8.70:1	Same as –K1A5 except has different propeller bushings	-48
IO-540-L1A5	300	2700	100/100LL	8.70:1	Similar to –K1A5 but with front air inlet and Retard Magnetos	-48
IO-540-L1A5D	300	2700	100/100LL	8.70:1	Same as –L1A5 but with D6LN-3000 impulse coupling dual Magneto	-48
IO-540-L1B5D	300	2700	100/100LL	8.70:1	Similar to –L1A5D except for a modified oil sump	-48
IO-540-L1C5	300	2700	100/100LL	8.70:1	Same as –L1A5 but has diaphragm type fuel pump and drive	-48
IO-540-M1A5	300	2700	100/100LL	8.70:1	Similar to –K1A5 but has Retard Breaker Magnetos and up exhaust heads	-48
IO-540-M1A5D	300	2700	100/100LL	8.70:1	Same as –M1A5 but with D6LN-3200 Retard Breaker dual Magneto	-48
IO-540-M1B5D	300	2700	100/100LL	8.70: 1	Similar to –M1A5D but with RSA-10ED1 fuel injector, automotive type fuel pump, D6LN-3000 impulse coupling Magneto and straight fuel injection adapter	-48
IO-540-M1C5	300	2700	100/100LL	8.70:1	Same as –M1A5 except has impulse Magneto	-48
IO-540-M2A5D	300	2700	100/100LL	8.70:1	Similar to –M1A5 but has D6LN-3000 Retard Breaker dual Magneto and provision for fixed pitch propeller	-48
IO-540-N1A5	260	2700	100/100LL	8.50:1	Similar to –D4A5 but with O-540-G1A5 crankcase and crankshaft and –K1A5 counterweight assembly	-48
IO-540-P1A5	290	2575	100/100LL	8.70:1	Same as –G1B5 but has larger oil pump and is suitable for turbocharging	-48
IO-540-R1A5	260	2700	100/100LL	8.50:1	Similar to –N1A5 except converted for use with turbo-charger, long reach spark plugs, piston cooling oil jets, AN fuel pump, vented fuel nozzles and –1200 series Magnetos	-48
IO-540-S1A5	300/ 290	2700/ 2575	100/100LL	8.70:1	Same as –P1A5 but with –K series rotating system	-48
IO-540-T4A5D	260	2700	100/100LL	8.50:1	Similar to –D4B5 but has D6LN-3000 impulse coupling dual Magneto and horizontal rear inlet fuel injector	-48
IO-540-T4B5	260	2700	100/100LL	8.70:1	Same as –T4B5D except has two Slick Magnetos	-48

Model	HP	T/O† RPM	Fuel	C.R.	Description	E S/N Suffix
IO-540-T4B5D	260	2700	100/100LL	8.50:1	Identical to –T4A5D except for fuel drain boss location	-48
IO-540-T4C5D	260	2700	100/100LL	8.50:1	Same as –T4B5D but has Bendix D6LN-3200 Retard Breaker Magneto	-48
IO-540-U1A5D	300	2700	100/100LL	8.70:1	Same as –L1A5 but with up-exhaust cylinder heads and D6LN-3000 impulse coupling dual Magneto	-48
IO-540-U1B5D	300	2700	100/100LL	8.70:1	Same as –U1A5D but has diaphragm type fuel pump and drive	-48
IO-540-V4A5	260	2700	100/100LL	8.50:1	Same as –V4A5D except has two Slick Magnetos	-48
IO-540-V4A5D	260	2700	100/100LL	8.50:1	Same as –T4B5D except for front mounted fuel injector	-48
IO-540-W1A5	235	2400	100/100LL	8.50:1	Same as –W1A5D except has two Slick Magnetos	-48
IO-540-W1A5D	235	2400	100/100LL	8.50:1	Similar to O-540-J1A5D except is equipped with IO-540-V4A5D sump, intake pipes and fuel injection system	-48
IO-540-W3A5D	235	2400	100/100LL	8.50:1	Same as –W1A5D but has heavier counterweights for use with Hartzell propeller	-48
IO-540-AA1A5	250	2425	100/100LL	7.30:1	Similar to –S1A5 except for compression ratio	-48
IO-540-AA1B5	270	2700	100/100LL	7.30:1	Same as –AA1A5 except has impulse Magneto and higher rating	-48
IO-540-AB1A5	230	2400	100/100LL	8.50:1	Similar to –W1A5 except has different counterweights, two Slick impulse Magnetos, bottom mounted injector and 230 H.P. rating	-48
IO-540-AC1A5	300	2700	100/100LL	8.70:1	Top induction, down exhaust, impulse coupled Magneto and Precision Airmotive fuel injection	-48
IO-540-AE1A5★	260	2800	100/100LL	8.70:1	Similar to O-540-F1B5 with IO-540-K angle valve cylinders, pistons, piston squirts and fuel injection and induction system	-48

TEXTRON Lycoming

Reciprocating Engine Division/
Subsidiary of Textron Inc.
652 Oliver Street
Williamsport, PA 17701 U.S.A.

SERVICE INSTRUCTION

DATE: April 25, 1986

Service Instruction No. 1435
Engineering Aspects are
FAA Approved

SUBJECT: PART I: Conversion from Constant Speed to Fixed Pitch Propeller and Vice Versa
PART II: Propeller Governor Oil Line Nut and Elbow

MODELS AFFECTED: Avco Lycoming Direct Drive Engines

TIME OF COMPLIANCE: At next overhaul or earlier at owner's discretion.

PART I: CONVERSION

A change from constant speed to fixed pitch and vice versa dictates a change in model designation. Replacement nameplates are only issued if the original nameplate is lost. Refer to the latest edition of Service Instruction No. 1304. Engines may be changed from constant speed to fixed pitch installations or vice versa if the serial number on the nameplate is stamped with a letter "C" to denote a model conversion and a copy of FAA Form 337 listing all parts used with part numbers included, and a description of the conversion or alteration are accomplished. Also, the proper logbook entry should be made. In some cases, conversion does require changing propeller flange bushings. Refer the latest edition of Service Instruction No. 1098 for appropriate bushing part numbers.

FRONT MOUNTED PROPELLER GOVERNOR

When changing from a fixed pitch to a constant speed propeller, it is necessary to remove the expansion plug from the front of the crankshaft, and install a plug behind the oil return tube. See Figure 1. Some crankshafts for fixed pitch propellers cannot be converted to constant speed models because the inside front of the crankshaft has not been machined. Also, those models with a 4-piece split front main bearing and/or no oil transfer tube cannot be converted.

When changing from a constant speed to a fixed pitch propeller, it is necessary to pierce a 1/8" to 3/16" hole in (or remove) the plug behind the oil return tube, and install an expansion plug in the front of the crankshaft. See Figure 1. As in Figure 2, if the crankshaft incorporates a 1/8" 1102 pipe plug, it must be removed when making this conversion.

REAR MOUNTED PROPELLER GOVERNOR

When changing from a fixed pitch to a constant speed propeller, it is necessary to remove the expansion plug in the front of the crankshaft, and install a plug behind the oil return tube. See Figure 1. A propeller governor, adapter, oil line and fittings must be installed. See Parts Data for application. Some crankshafts for fixed pitch propellers cannot be converted to constant speed models because the inside front of the crankshaft has not been machined.

This copy of Lycoming Service Instruction 1435 is provided *for conceptual purposes* only. Before installing a propeller, obtain a current copy from Textron Lycoming.

Service Instruction No. 1435

When changing from a constant speed to a fixed pitch propeller with crankshafts as shown in Figure 1, it is necessary to remove or pierce a 1/8" to 3/16" hole in the plug behind the oil return tube, and install an expansion plug in the front of the crankshaft. If the crankshaft incorporates a 1/8" 1102 pipe plug as shown in Figure 2, it must be removed when making this conversion. The propeller governor, adapter, oil line and fittings are no longer required and should be removed. Install the proper plugs in the accessory housing and crankcase after removal.

CAUTION

WHEN PIERCING THE PLUG BEHIND THE OIL RETURN TUBE, BE CAREFUL NOT TO DAMAGE THIS TUBE.

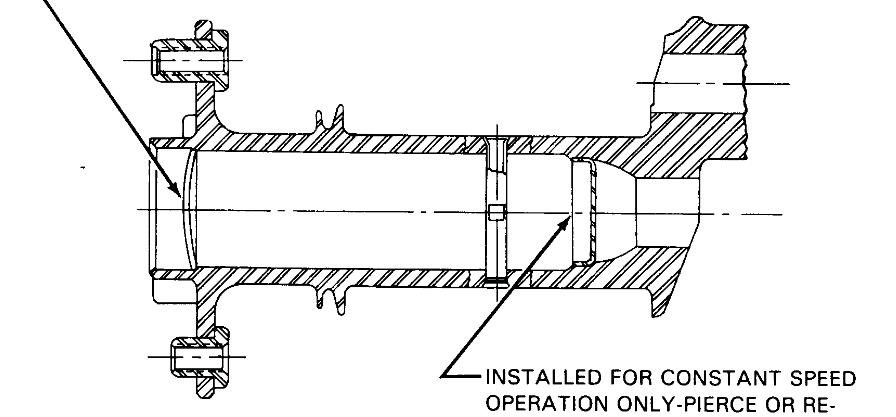


Figure 1. Plug Installations for Propeller Conversion

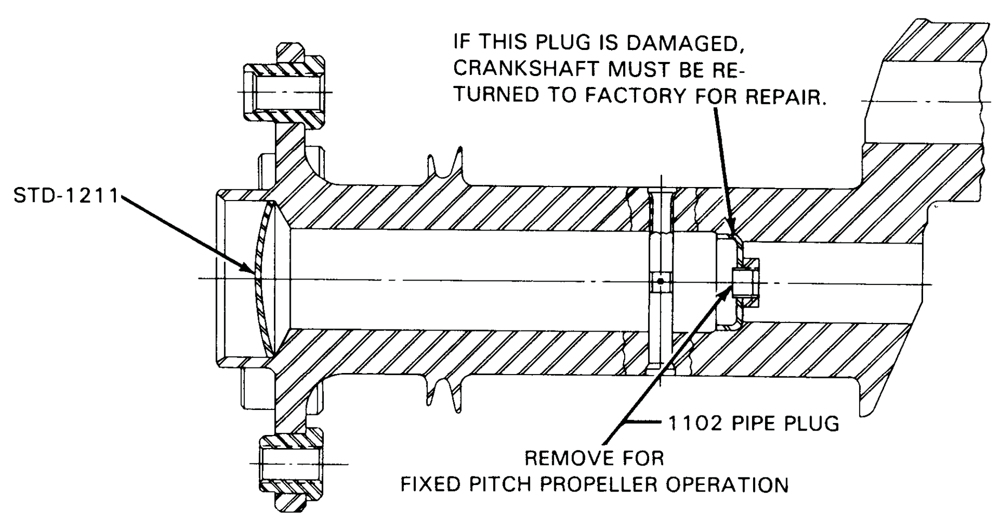


Figure 2. 1/8" Plug for Propeller Conversion

Service Instruction No. 1435

PART II: PROPELLER GOVERNOR OIL LINE NUT AND ELBOW

As a product improvement, the propeller governor oil line now comes equipped with a steel connecting nut P/N AN818-6. This nut is a component of the tube assembly and has been changed from aluminum to steel without changing the tube assembly part number. Therefore, there are two ways to identify which nut you have; (1) aluminum nuts are anodized making them blue in color or (2) the use of a magnet to determine aluminum from steel. Also, the aluminum elbow at the front of the crankcase has been replaced by a steel elbow P/N MS20822-6. See Figure 3 and Parts Data.

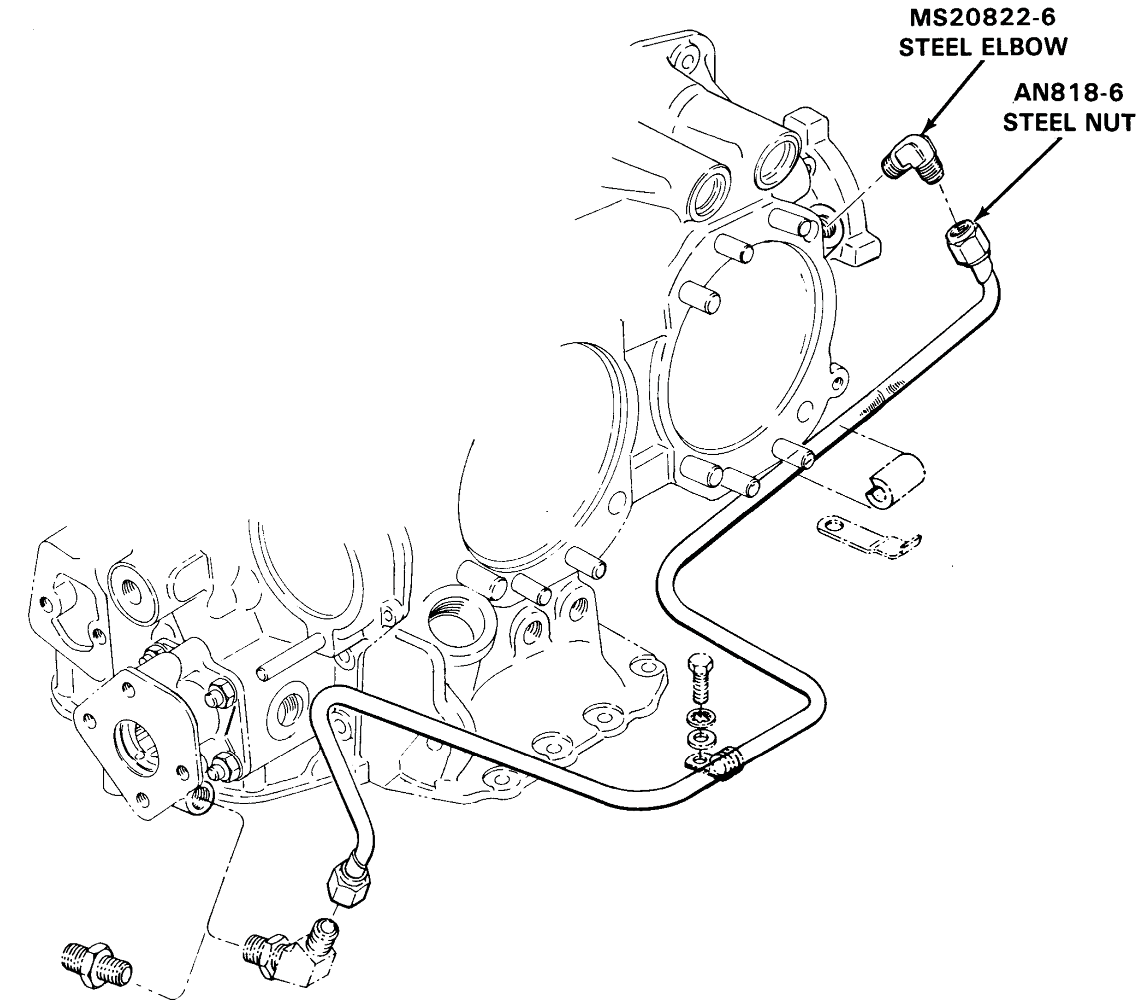
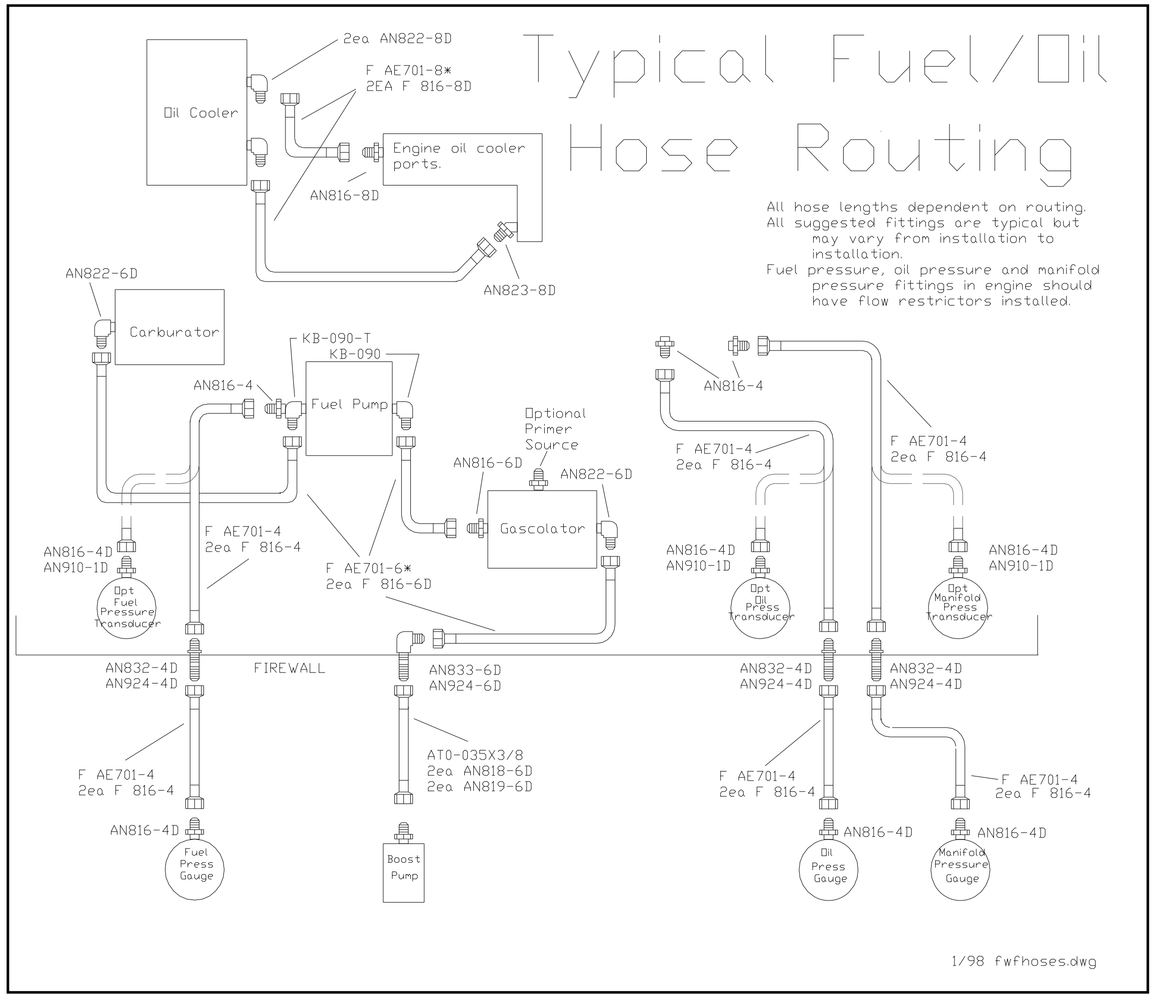
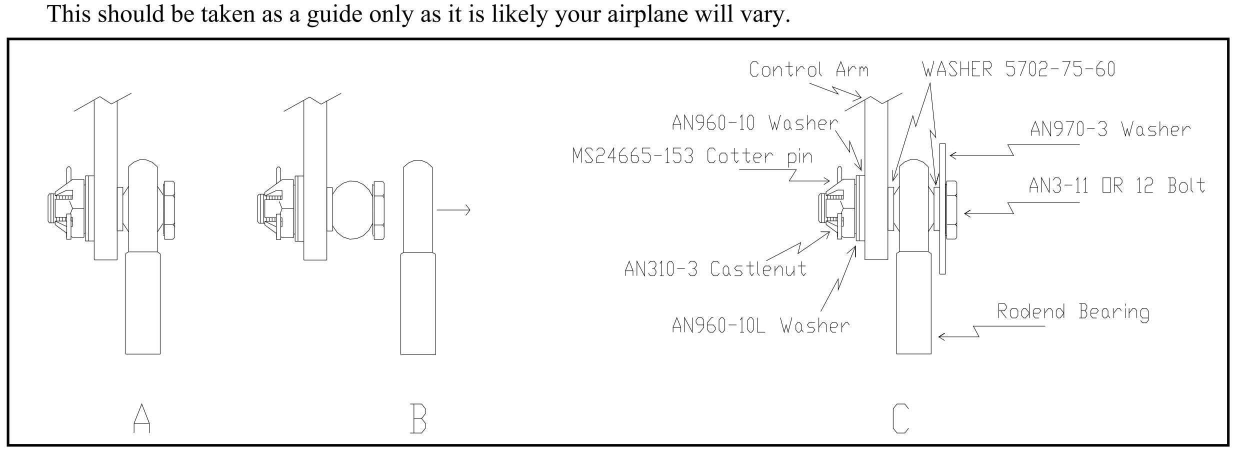


Figure 3. Propeller Governor Oil Line Nut and Elbow



TYPICAL ENGINE PLUMBING DIAGRAM

This should be taken as a guide only as it is likely your airplane will vary.



TYPICAL INSTALLATION OF A CONTROL CABLE TO THE MIXURE OR THROTTLE ARM

The rodend bearing (at the engine end of the throttle and mixture cables) and control arm (on the carburetor) are connected by an AN bolt, sized as necessary, (an AN3 is shown in the example above) with a hole for the cotter pin. On each side of the rodend is a small spacer washer (WASHER 5702-75-60) which holds the rodend away from the washer and the control arm, and allows the bearing to move freely at various angles without binding. Examples A and B show a situation where the rodend bearing housing has worn and slipped off the ball and bolt. This is prevented by installing the AN970-3 capture washer. The AN960-10 and AN960-10L washers are used as needed to position the nut for the cotter pin. The AN310-3 castle nut should be torqued to 20-25 in-lbs. The MS24665-153 cotter pin restrains the nut from backing off. *NOTE: the hole in the mixture arm is typically 1/4" and will need a bushing to fit an AN3 bolt.*

NOTES

SECTION 12: FITTING THE COWL, SPINNER & COOLING BAFFLES

We believe the RV cowls to be an attractive and efficient design. Its smooth contours streamline the engine for low drag, and, in addition, it has been designed internally to reduce engine cooling drag; something often overlooked in homebuilts. It is light and mounts with no external fasteners to cause drag or detract from appearance. The cowls are designed to fit nearly all versions of the Lycoming O-320 and 0-360 engines and 200 HP I0-360 engines with forward injectors. Either fixed-pitch and Hartzell Compact Hub model constant-speed propellers may be installed.

The cowl is supplied in five separate fiberglass pieces; the top half, lower half, a pair of upper inlet ducts, and an oil filler door. The lower cowl half includes an air intake scoop appropriate to the engine. Installing the cowl requires attaching the two cowl halves to each other and to the firewall. The inlet duct moldings must be bonded in place and an oil access door cut out and mounted. These points and more will be covered later, but first, let's review some engine cooling theory so that we can better understand why these installation procedures need to be followed.

All engines recommended for use in the RVs were designed for pressure cooling. The pressure is supplied by the velocity of the aircraft moving through the air, but it is probably easier to understand if we assume the engine to be stationary and the air is moving past it. In Fig. 12-1 we try to show just what pressure cooling consists of. It is much more involved than just letting “wind" in through a hole in the front of the cowl to “blow" on the engine. As the drawing shows, the incoming air, because of the forward velocity of the aircraft, forms a high pressure parcel of air on the upstream or “cold air plenum" side of the engine. A properly designed air outlet tends to act as a vacuum pump and cause the air in the downstream or “warm air plenum" area to have a lower air pressure than that upstream. It is this pressure differential which causes the air to flow past the cooling fins of the engine and carry away the excess heat. Cooling baffles are required on the engine to direct the air past the cylinder cooling fins, and to serve as a barrier between the “intake" and “outlet" air plenum chambers. The air inlet and outlet openings should be carefully designed and constructed to maximize the pressure differential between the two portions of the cooling system.

Aircraft engines are designed to require a certain volume of air per minute to operate within temperature limits. This is about 2500 cubic feet of air per minute for the O-320 and O-360 engines. From this we have determined the area required for the inlets to provide this volume of air at a full throttle climb speed of 90-100 mph; the flight mode which will impose the greatest cooling requirements. Then for higher speeds and/or lower power settings, cooling will be assured.

There are three basic components we must consider in designing an efficient cooling system: inlet, baffling, and outlet. In the inlet we seek to pass air into the engine compartment with the minimum pressure loss and the minimum internal and external drag. With the baffles we attempt to direct the air over the cooling fins of the cylinders as evenly as possible and with a minimum of “waste” or loss through holes, gaps, or other unnecessary openings. The outlet is designed to cause the heated air to exit at a speed as near to slipstream velocity as is possible.

Fig. 12-1 shows that the area of the inlets is much less than the cross section area of the cold air plenum inside the cowl. This means that the air must decelerate as it enters the engine compartment. As it slows down, its energy of motion is converted into pressure. The purpose of the contoured inlet ducts is to maintain a smooth flow during deceleration and thus maximize the pressure recovery. According to theory, a sharp edge inlet would cause a disturbed airflow resulting in energy being lost in conversion to heat rather than pressure. It is very important that the engine baffle is properly designed and fitted so that the only openings for this air to escape are those past the cylinder cooling fins. This means the area around the front of the engine must be baffled as well, to prevent air escaping forward around the starter ring gear.

Fig. 12-1 shows a typical cowl and engine compartment. Fig. 12-2 shows the same cowl with improved contours on the inlets and outlets which make a significant difference in engine cooling and cooling drag. These consist mainly of inlet and outlet ducts with improved contours for smoother air flow. Also important, but not shown here, is a portion of the baffle near the front of the engine which blocks the cooling air from flowing forward over the front center of the engine and starter ring gear, and then out the bottom. This would be “wasted” air and cannot be tolerated in an efficient cooling system.

The object of a pressure cowl baffle is to maximize the air pressure differential between incoming and outgoing air, and to provide the tightest possible seal between these two air chambers. Air entering the cowl openings which

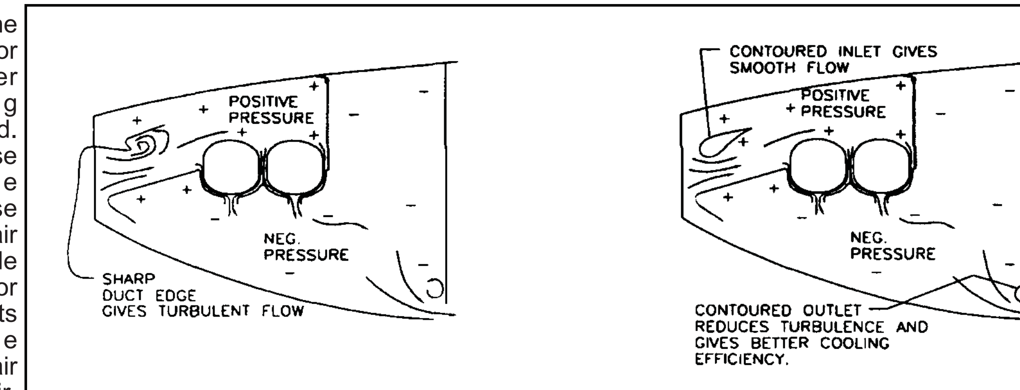


FIG 12-1. TYPICAL BAFFLING ARRANGEMENT

FIG 12-2. AN IMPROVED BAFFLE AND COWL

does not pass over the cylinder cooling fins, or serve some other accessory cooling function, is wasted. “Wasted air” will cause either engine overheating because there is not enough air remaining to provide cooling, or the need for larger inlets and outlets to provide the necessary cooling air plus the wasted air. This means more drag and less speed. While it is difficult to completely seal an engine baffle, the combined area of these “waste air” leaks should be held to not over 1 or 2 square inches.

Further improvements of the baffle are possible. Since the fit of the aluminum baffle to the engine will not be air-tight, high temp. RTV Silicone Rubber can be used to seal these small gaps. The fabric airseal material used as a seal between the baffle and cowl, often “puckers” away from the aluminum and permits air to escape. This may be sealed with RTV as well.

AIR FILTER SYSTEMS

The RVs are designed to accept Lycoming engines from 115-200 horsepower. These engines may be fitted with a wide range of induction devices including carburetors, fuel injection systems by different manufacturers, throttle body injectors like those made by Ellison, and more. Just to make it more complicated, these devices may be mounted in a variety of places on the engine. The cowls supplied with kit for 115-180 hp engines have an induction scoop molded onto the bottom. This scoop is designed to fit the “standard” carburetor location on the bottom of the sump (as used on new engines ordered through Van’s.)

Filtered air induction systems for the various engines and induction devices are offered in Van’s Accessories Catalog and used by a vast majority of RV builders. These systems improve induction efficiency, filter all the air entering the engine and include provisions for alternate air or carb heat. Installation instructions are included.

The cowl supplied for the 200 hp IO-360 angle valve engine has no scoop. Instead, it is designed to work with the Horizontal Induction filtered air induction system in Van’s Accessories Catalog. Air is inducted through a filter mounted in the left “nostril” of the cowl and routed through a molded fiberglass duct to the forward-facing injection servo on the sump. In this case the engine cooling baffles should be fitted before the induction system.

BEFORE FITTING THE COWL

The following instructions are meant to cover all RV models. Some may not apply to your particular RV.

Before attempting to install the cowl, the engine (without the exhaust system installed) must be mounted. Check to see that the engine mount bolts are tight, the rubber mounts are properly seated, and anything else which might effect engine positioning or alignment is resolved. Some builders run the engine for a few minutes to “shake” everything into place. We *do not* recommend this: Engines are designed to run with baffles and cowls in place and will not cool properly without them. We have also received reports that running the engine on partial airframes (without wings, etc., installed) has caused vibration damage to the airframe itself.

If you have chosen a fixed pitch prop, install the propeller extension on the front of the crankshaft. *(NOTE: All RV cowls are designed to use a 2 ¼” propeller extension or a constant-speed prop with an equivalent hub. See Section 11 and DWG C4).* Install the spinner or at least the spinner back plate to use as a reference for positioning the front of the cowl. If you are installing a constant-speed propeller, it is best if the prop is installed, because, in this case, the spinner back plate mounts to the prop. If the prop is not available, a spacer 2 1/4” thick, attached to the front of the crankshaft (be sure the starter ring gear is installed!) may be used to simulate it.

INSTALLING THE HINGES

The RV cowls use piano hinges as attachment fasteners. This offers several advantages: evenly distributed loads along the attachment line, smooth cowl lines with no external fasteners, and easy installation and removal.

Several hinge segments are used for both attaching the upper and lower cowl halves together, and attaching the cowl to the aircraft firewall. An aluminum hinge with rolled or “open” eyes, AN257-P3, is used to join the upper and lower cowls.

The pins on all these hinges must be replaced with the hardened stainless steel wire supplied separately with the kit. The pin supplied by the hinge manufacturer is soft aluminum and is inadequate for our purposes. On the side and bottom segments, 1/8’’ pin is used. However, the curved hinge attaching the upper cowl requires a smaller pin, 0.090” in diameter. This undersize pin can be pre-bent to the approximate curvature of the firewall top, and can be inserted into the curved piano hinge. It would be impossible to use 1/8'' pin in the curved hinges.

Hinges are attached to the fiberglass cowl with rivets, or rivets supplemented by bonding for best results. The rivets used are AN426AD3-4 countersunk head rivets, selected because of their small heads blend well with the fiberglass of the cowl and because their setting pressure is much lower than for 1/8'' AN rivets, so they do not crush the fiberglass. AVEX CS4-4 blind rivets also work well.

The forward fuselage has been constructed with a forward sloping upper firewall, so the attachment hinge will naturally lay flush with the fuselage skin and cowl. Install the hinges on the firewall (use shims as required). Make all the pins and fit the opposite halves of the hinges together

Since there is the possibility that vibration could loosen rivets in fiberglass over time, we recommend supplemental bonding of the hinge to the cowl. This is an optional procedure, but the cost in weight and time is not great.

Drill 1/4” holes in the hinge to provide more bond area for better adhesion. For best results, mix a slurry of epoxy, thickened with flox or cabosil and apply it to the inside of the cowl where the hinge will rest. Rough up the underside of the hinge with coarse sandpaper for better adhesion, and then cleco the hinge in place and install the rivets.

Other adhesives could be used instead of the resin/glass mat combination. Any industrial grade epoxy glue should work well, as would fuel tank sealant. The main purpose of the adhesive is to relieve the rivets of some of the vibration forces which tend to loosen them. Bonding is an optional procedure and is not a requirement. The experience with Van's Aircraft prototype cowl installations has shown that AN426AD3 rivets work well when spaced at 1'' intervals and when set with a rivet squeezer rather than a rivet gun.

Fit and drill the hinge shown in the Cowling Attach Detail of DWG 43 (RV-4), DWG 63 (RV-6), DWG 45 (RV-7/9), DWG 48 (RV-8), using the holes left open during fuselage construction. Note carefully the details of fitting and shimming shown in the various section details. Before fitting the cowl, pin the other half of these hinges in place. **Don’t forget to taper the hinge segments shown in Detail F**

FITTING THE UPPER COWL

RV cowls are made of fiberglass and epoxy resin. The glass cloth is filled with a precise amount of resin during manufacture. The result is known as “pre-preg” cloth. Two layers of cloth, separated by a honeycomb core are laid up in a mold and held by a vacuum bag, which applies even pressure to the entire surface. Heat is applied while the cloth is held in place. The heat triggers the resin, curing it while it is held in the mold. The result is a very strong, light, and accurate molded part.

Because the cowl is made of epoxy, only epoxies must be used when bonding the inlet ducts or making any other additions/modifications.

The best tools for cutting, trimming, and fitting the fiberglass cowls are a die grinder with a reinforced cutting disc (like those included in the Finishing Kit for cutting the canopy), coarse sandpaper, usually glued to straight edged sanding boards, and used drills/files. Try not to use your best drills and files, as fiberglass will dull them very quickly.

The cowl is fitted to the fuselage as shown on the drawings. The edges of the cowl are a solid fiberglass layup, with no honeycomb core. There is adequate “flange” around the perimeter to allow trimming without encountering the honeycomb.

Cut the oil filler access opening out of the upper cowl. This door is supplied separately and will be installed later, but you will need the access hole when fitting the cowl**.** Be sure to smooth the edges of the opening or tape them to protect your arms when working inside.

Fit the cowl halves together at the front, sanding & filing the flanges and thick areas to get a good fit. The spinner opening should be round (height the same as the width). You may have to sand the flanges slightly shorter on the top cowl so that when they nest you get the proper shape.

Mark the screw pattern for joining the top & bottom behind the spinner. Clamp the top & bottom together at the spinner and drill the screw locations with a #40 drill to allow for slight repositioning later if required.

The cowl top has been molded with trim margins on the sides and rear. In order to fit it in place, it will first be necessary to trim the rear to conform with the firewall. The desired spacing between the front flange of the cowl and the spinner is 1/4”. An absolute minimum of 1/8'' could be tolerated, and any gap of more than 3/8” would appear excessive.

The cowl is supplied slightly longer than necessary. This means that it will overlap the fuselage skin at the firewall. Variations from one airplane to another make it impossible to determine the exact trim line at the factory.

Mark a reference line on the fuselage side skin 2 inches back from the edge. Then when the cowl is placed in temporary position, it is a simple matter to measure back to the hidden skin edge and mark the cowl for trimming.

With this method, it is possible to get a near perfect fit on the first cut. Some additional grinding or sanding of the edge may be necessary.

Level the fuselage side to side. Set the top cowl in place. Block the forward end up to be 1/8” to 3/16” below the spinner to allow for future engine sag. Check that the front is level from side to side. Mark the aft edge by using the reference marks on the skin and trim to fit. Sand the edge straight, mark and pre-drill for the rivets. Replace the top, drill and cleco to the hinge.

FITTING THE LOWER COWL

There are three different lower cowls, each specific to an engine type. Be certain you have the correct lower cowl for your engine -- O-320, (I)O-360 180 hp, or IO-360 (200 hp). Lower cowls for the O-320 and (I)O-360 180 hp engines have an induction scoop molded on. Lower cowls for the IO-360 200 hp engine have no induction scoop and assume the use of Van’s Horizontal Induction System.

When the upper cowl fits the fuselage, drill and cleco it to the firewall hinge in two or three places. Clamp it to the spinner back plate, or wood disc on the crank flange. When the position of the upper cowl is fixed, the lower cowl is fitted to the fuselage.

If this is a tri-gear, cut the slot in the lower cowl to clear the nose gear leg. The length of this slot will depend on the propeller…a 3-blade prop will require a longer slot to remove the cowl.

Lift the bottom cowl into place, cleco at the front and duct tape at the rear. The sides will not fit correctly yet, just overlap the edges at this stage. Mark along the bottom and just around the curve, but not the sides. Trim the bottom, reinstall the cowl, then mark and trim the sides. Trimming the bottom first, allows the cowl to be lifted in to the proper position to trim the sides.

Drill the bottom to the hinges, starting at the bottom, then working up the sides. Trim and sand the sides of the bottom to fit the top. Fit the hinge to the bottom of the cowl first. Reinstall the top cowl and drill to the hinges.

Install the screws and nutplanes behind the spinner shown in on the drawings.

Align the bottom of the cowl as closely as possible with the fuselage bottom. The sides can shift slightly up or down by flexing the lower corners of the cowl. If this radius corner of the cowl aligns with the radius of the fuselage corner, the position is correct. The aft edge of the cowl will overlap the firewall and fuselage side skin.

Trim the cowl using the same method described for the top cowl. Tape the cowl to the fuselage and clamp it to the spinner back plate at the front.

At this point both top and bottom cowls are attached to the fuselage. They should form a smooth even joint along the sides and behind the spinner.

When both halves of the cowl fit, finish drilling the holes for the hinges along the fuselage. If it has been necessary to drill a few extra holes during fitting, these can be filled when the hinges are bonded in. Drill the holes in the short section of overlap behind the spinner as shown on Detail C.

When both top and bottom cowls are clecoed to the hinges along the firewall, remove the clamps at the spinner and pull the pins holding the top cowl to the firewall. Remove the upper cowl.

When the cowl halves match, the side hinges may be fitted and drilled to the lower cowl. See Section N-N’ and Section P-P’, DWG 45 or 48. Allowing the hinge to “drift” slightly upward as it moves aft will make the cowl easier to remove.

MODIFYING THE COWL FOR THE RV NOSEGEAR LEG

A slot is cut in the lower cowl, or induction air scoop (depending on the engine) just wide enough to fit around the gear leg. When the lower cowl is installed, the lower brace is fitted as shown on View U-U, DWG 48 (RV-8A), View T-T, DWG 45 (RV-7A-9A), DWG 61 (RV-6A).

The cover plate is fabricated from two pieces of aluminum sheet. The narrower sheet fits on the inside of the slot cut into the lower cowl, and the wider sheet spans the gap. Screws and nutplates hold the cover plate to the cowl. RV-8 note that one screw in the center of the cover plate attaches it to the U-816 brace.

Those using the 200 hp IO-360 will find that the cluster of tubes at the bottom of the engine mounts hangs slightly below the bottom of the cowl, so an intersection fairing will improve the appearance noticeably. While this is not true for those using the O-320/O-360 induction scoop, an intersection fairing will still clean up the junction both aesthetically and aerodynamically. Fabricate a fairing using the same techniques as the gear leg intersection fairings described in Section 10 and DWG C3.

INSTALLING THE INLET DUCTS

A detail on the drawing illustrates the installation of the cooling air inlet ducts. These are essential for proper engine cooling. While the inlet ducts and the cowl itself tend to be flexible by themselves, when bonded together they become quite rigid. Thus, the cowl should be installed on the airplane, and all fasteners installed, the ducts are bonded on. Otherwise, the upper and lower cowls may not match each other once the ducts are in place.

Fit the ducts to cowl, trimming and sanding as necessary for a good fit. Drill and cleco them in place. Clean the area to be bonded by sanding with a coarse (40-60 grit) disc sander. Sand away the glossy surface of the resin until the fibers of the glass cloth are exposed on all the mating surfaces.

The only way to hold the ducts to the cowl while bonding them is to drill holes and use clecos. These holes can later be filled with resin. Enough clecoes should be used to assure contact at all points. Once the ducts are in place, the cowl should be pinned in place on the airframe before the resin cures. This prevents any possibility of shifting out of alignment.

After the resin cures, use coarse sandpaper to remove the rough edges and oozes. Sanding with progressive grades of sandpaper will result in a smooth and pleasing surface.

INSTALLING THE OIL FILLER DOOR

A recess for the oil filler door is molded into the upper cowl. The door itself is supplied as a separate molded piece with trim lines scribed in the surface.

A scribe line on the cowl marks the shape of the opening. Cut this out with a disc or hacksaw blade. Make sure the edges are smoothly finished or you will regret it later. The upper cowl pins are installed though this opening, which requires sticking your arm in a lot farther than just reaching the dipstick.

Trim the door to its finished shape and tape it in place on the cowl.

The hinge and fasteners are installed as shown on the drawing.

FINISHING THE SURFACE OF THE COWL

Epoxy pre-preg structures like the cowl are pressed into the mold during curing by vacuum pressure. This process precludes the use of the traditional gel coat, so the outside surface must be filled after the cowl is removed from the mold. If this step is omitted, the painted surface will be covered with pinholes -- not a pretty sight.

The following is the process that the prototype shop has found to be a fast and efficient way to prep the prepreg cowlings for paint. This is not the only way, it is just what works for us.

STEP 1: Fit the cowling fit to the fuselage, with all the hinges, retaining screw holes, and nut plates installed. Leave the oil door installation for later. Sand the entire surface with 80 grit sandpaper , being careful not to remove too much material and damage the core.

STEP 2: When the cowling is completely sanded, use an air hose to blow off the dust, paying close attention to the voids in the finish. These areas must be clean for the resin to adhere. Mix a small amount of epoxy resin (about 1 oz. We use West Systems 105 resin and 205 hardener, but any good epoxy will work.) Thin the resin about 1 to 1 with acetone (or approved product recommended by the epoxy manufacturer). This may seem thin but it works well. Use a cheap bristle paintbrush (not a foam one) to cover the cowling with a thin coat and let it dry overnight. If the resin begins to thicken while you are applying it, just thin it with more acetone.

STEP 3: When the resin has dried, block sand it with 80 grit. At this point you are just trying to remove the high spots. Blow the cowl off and look closely for any large voids or depressions. Most will be found at outside corners and where the core and the foam end. Mix a marble sized portion of polyester ("bondo") body filler – the filler will dry fast so do not mix too much. Use a popsicle stick to fill the larger areas and use a new single edge razor blade as a squeegee to fill smaller voids and pinholes.. Come back across the area with the razor blade at a 90 degree angle to remove extra filler. Work a small area at a time. After the filler has dried sand the areas with 80 grit and blow off the cowl. Extra time spent on this part will pay off later. Now repeat step 2.

STEP 4: If you are not going to paint or if you are going to wait until after you fly the plane(this is understandable if the weather is nice and you don't have something else to fly) stop here. The resin coat will protect your cowl from grease and grime until you are ready to paint. When that day comes, sand again with 80 grit and apply a filler-surfacer. We use Featherfill made by Evercoat. There are other brands and they will probably work fine. Just follow the directions on the can. After the feather fill has dried, sand down to 400 grit and apply your paint system.

PROTECTING THE INTERIOR OF THE COWL

The fiberglass cowling can be damaged by excessive heat radiating from the exhaust pipes. Van's recommends covering the inside of the cowl with reflective, heat-resistant material similar to the EA EXHST/COWL SHIELD supplied in Van's Firewall Forward kits. Make paper patterns for the areas on the inside surface of the cowl where protection is required. The cowl shield will also protect the fiberglass from oil/fuel drips as well as heat, so consider applying it to the majority of the lower cowl.

Prepare the cowl by sanding the interior smooth with 80-100 grit sandpaper. Clean the sanding residue away and roll, sponge, or brush a layer of thinned epoxy resin over the sanded area. The goal is a lightweight glossy smooth surface – but brush/roller marks are not significant. Once the resin has cured, cut the adhesive backed cowl shield material to match the paper patterns. Peel the backing from the shield and begin applying the shield to the cowl. Make sure it is exactly where it needs to be – the adhesive is fast-acting and strong, so re-positioning the shield once it's attached is impractical. Work carefully and, as much as possible, avoid wrinkles. Rub the entire surface with a stiff plastic squeegee, working the inevitable wrinkles and bubbles to an edge.

SPINNER INSTALLATION

Before installing the spinner, be sure you have the correct parts for YOUR propeller. Constant-speed, wood or fixed pitch metal propellers require different parts. On the constant-speed propeller, the back plate mounts to the hub of the prop and is reinforced with an aluminum ring. The front plate is a different size, as well. Follow the installation instructions included in the constant-speed spinner kit and DWG C4.

The following instructions describe mounting the spinner on a fixed pitch propeller. If you are installing a Sensenich fixed-pitch metal prop, use the appropriate front plate.

The S-601-1 spinner is a translucent cone shaped fiberglass molding. Cut-outs are made for the prop blades. The cone is fitted over the prop hub and fastened to two flanged aluminum mount plates, installed on the front and rear faces of the prop.

The rear spinner mount plate is the main structural mount, and the front plate provides alignment and stability to the spinner. Because of the tapering cone shape of the spinner, the required diameter of the front plate will vary with the thickness of the prop hub. The prop cut-outs in the spinner must be sized to the cross section of the prop being used, and will vary considerably with props supplied by different manufacturers. Sometimes there are noticeable differences between props of the same manufacturer. Since it is desirable to achieve a close fit of the spinner cut out to the prop, it is suggested that the cut out be custom tailored to the specific prop being used.

Before installing the S-602-1 and S-605 (or S-605SEN) spinner mount plates to the prop, fit them to the spinner. This will verify that the prop hub thickness corresponds to the relative diameters of the mount plates. It is imperative that the mount plates be placed in the spinner perpendicular to its center line. This can be checked by measuring equal distances from the plate to the rear skirt of the spinner all around. When both the front and rear plates are aligned with the spinner and with each other, the distance between them will be the required thickness of the prop hub.

If the distance is greater than the thickness of your prop hub, spacers may be installed between the front plate and the forward surface of the prop. These spacers are available through Van's Accessories Catalog. If the distance is less than the thickness of your prop hub, a smaller front plate will be required. Sometimes, if the mis-fit is very slight, sanding the inside of the spinner will allow the front plate to fit. Keep this sanding to a minimum to avoid weakening the spinner bowl.

Mount the rear plate on the back side of the prop and the front plate on the forward face of the prop or whatever spacers the prop requires, and under the crush plate. Install and tighten the prop bolts to the prop manufacture's recommendations.

The cutout in the spinner cone should match the contour of the prop blade closely. A sliding pin “copycat” contouring tool, widely available at hardware stores, can make the job easy. If you do not have such a tool, use a sheet of single ply (shoebox type) cardboard to make a hole template for the prop. Using the cardboard to simulate the spinner, align the edge of the cardboard with the rear edge of the rear mount and cut out an opening just large enough to clear the prop blade. If this piece is carefully cut and removed, it may be used later to fill in behind the prop. If not, the gap behind the prop must be filled with a separate aluminum plate riveted to the back plate. It may require a couple of tries to achieve the desired shape.

On the spinner, mark two points at the rear edge exactly opposite each other, 180° opposed. Mark one point and then measure the circumference of the opening. Divide the circumference by two to determine the location of the opposing mark. Then lay the cardboard template on the spinner aligned with one of the marks, and mark the cut out. Repeat for the opposing cut out.

The fiberglass can be cut with a tin snips or a cutting disc on a die grinder or Dremel tool. Because the tin snips crush the fiberglass, cut about 1/16" inside the marked line and then use coarse sandpaper to enlarge the opening.

Fit the spinner onto the prop. Chances are that the opening will not be quite large enough. Progressively enlarge the openings as needed until they have approximately 1/16 to 1/8" clearance from the prop blade. You do not want a contact fit because there is enough movement between spinner and prop during operation to cause the edge of the spinner to cut into the prop.

If the prop is thinner than the spinner plates were designed for, it may be necessary to build up the inside of the spinner to mate with the flange of the front plate.

A fiberglass build up can be molded in place. Mark a ring around the inside of the spinner where it contacts the front plate flange. Then lay up a ring of fiberglass mat 3/4" wide around this ring. Wax the spinner flange so it will not bond to the spinner. Slip the spinner with the wet lay-up into place and hold with clecos. When it is cured, the spinner can be removed and any roughness in the reinforcement fiberglass can be sanded smooth. Remember that anything added to the spinner should be evenly distributed around the circumference to help maintain balance.

The spinner should be aligned with the axis of the crankshaft so it does not “wobble” as it spins. This requires that the prop and spinner be mounted on the engine. First, align the spinner as closely as possible and tape it to the bulkhead. Then, mark a point in the exact center of the nose of the spinner. Stand a step ladder up in front of the spinner with a pencil clamped to it and place the pencil point near at the mark on the spinner nose. Remove a spark plug from each cylinder so that the prop can be rotated easily and safely. If the spinner is in perfect alignment, its tip will remain in position with the pencil point through full 360 degree rotation. If not, reposition prior to drilling.

While the spinner is still in place, cut out the gap filler plate to be used on the back side of the prop. Make this plate of aluminum between 0.040” and 0.063" thick, or use the fiberglass piece removed when the spinner was first fitted.

DWG C4 shows the fabrication and installation of this gap filler. It is riveted to the back plate and stays in place as the spinner is installed and removed. The flange shown riveted to the long edge of the gap filler is essential and should not be overlooked. The primary forces acting on the spinner are centrifugal, and without this flange which ties the gap fairing to the spinner, it would bend outward and tear off.

Drill and cleco all holes in the rear mount plate; then progress forward to the front plate. While the spinner screws are #8 size and require a #19 drilled hole, we suggest drilling the holes to 1/8" (#30) initially. A 1/8" cleco can then be used to hold the K1000-08 nutplate in place while it is being drilled and riveted. Cleco the nutplate to the outside of the mount plate flange and use it as a drill guide. Remove the nutplate, machine countersink the holes for AN426AD3-3.5 rivets, drill out the screw hole to #19, and rivet the nutplate on.

The spinner is one of the most critical of the non-structural parts on an airplane. While it doesn't support any productive loads, it is subject to considerable internal forces. Any weight imbalance can cause high loads on the spinner mounts. In addition, the reversing, pulsating, loads caused by the intermittent combustion of the engine come to bear on the spinner installation. Therefore, it is necessary to mount the spinner firm and true; to prevent it from destroying itself. Use 14 equally spaced #8 screws in the rear mount plate and 6 in the front plate. Place screws holes 5/8” from the edge of the prop hub cut-out, and then equally spaced around the circumference. Rivet K1000-08 nutplates to the inside of the spinner mount flanges. The front plate should fit snugly in the spinner.

If you wish to use countersunk screws (many builders are satisfied with roundhead) the holes in the spinner may be machine countersunk for AN509-8R8 screws and countersunk washers. If you do not have a #19 piloted machine countersink, the spinner holes can be countersunk while they are still 1/8" diameter.

ENGINE BAFFLE INSTALLATION

Cutting and bending the many sheet metal components of a complete baffle system is a tedious task. Almost all RV builders choose to buy the optional baffle plans or the complete baffling sets available in Van's Accessories Catalog. These include installation drawings and instructions.

SECTION 13: PAINTING

An entire book could be written on the subject of aircraft painting and still leave many questions unanswered. There are many surface preparations, primers, and paints available, and more coming on the market every day. Paints range anywhere from the older enamels and acrylic lacquers up through the newer acrylic enamels, urethanes, and epoxy finishes. Which one is best probably depends on the end result desired by the individual builder. However, the urethanes seem to be favored by most builders now because of their relative ease of application and shiny, maintenance free finish. The purpose of this section is only to present some general ideas, not to provide the ‘‘best way’’ of applying the ‘‘best’’ paint.

COLOR SCHEME

Before getting serious about the type of paint to be used and the method and technique of application, most builders spend many months (or years?) while building trying to decide their paint scheme. Toward this end, little can be offered other than the suggestion that conservative colors and paint scheme will always look good on the basically good lines of an RV. More daring combinations of colors and patterns may result in a ‘‘fabulous’’ paint scheme, or could result in an eyesore which is too ‘‘busy’’ or gaudy to be appealing. Unless you have a very good eye for colors and patterns, it may not be worth the gamble. We have provided two drawings; one perspective, and the other a three view, for you to practice on. Just run off a few dozen copies of these drawings on your office copier (when the boss isn’t looking), buy a box of colored pencils and start sketching out your dream scheme. Aside from the aesthetic aspects of color scheme selection, you might also give serious thought to recognition; i.e.; how well will your combination of colors stand out from the background when in flight. How visible will it be to pilots of other aircraft in flight? With the dense air traffic and haze of air pollution encountered around many airports, see-and-be-seen should be a major safety concern to all pilots. Light colors are generally considered to be the most visible against typical backgrounds found while flying in the USA. Yellow is probably the most universally visible, and can also be trimmed to provide very attractive paint schemes.

The question of whether a painted or bare aluminum airplane goes faster is often raised. Experience with the prototype RVs has not provided a definitive answer, so it would appear that there is little difference in skin friction drag from a typical painted surface to a typical bare aluminum surface.

PAINTING HEALTH HAZARDS

Spray painting can present a health hazard, particularly with most of the newer two-part paints. Chemicals used in the hardeners of urethane, acrylic enamel, and epoxy paints cause them to be potentially very hazardous if breathed, and can be harmful even through excessive exposure to the skin. For this reason, the painting area must be well ventilated and a UL approved respirator must be used. A simple particle filter is just not good enough. Also, full coverage clothing should be used to prevent skin exposure. Builders sometimes disregard warnings on the likes of paint cans because they become indifferent after daily exposure to warnings on all sorts of relatively benign household items. But where modern paints products are concerned, the warning should be taken very seriously

PLEASE TAKE PAINT CAN TOXIC WARNINGS SERIOUSLY!!!

PAINTING: ONE EXAMPLE

While we are not presenting this to be the proven ‘‘most ideal’’ paint and procedure, it was used on the prototype RV-4 under ‘‘home’’ conditions and by amateur painters. It consists simply of preparing the bare ‘‘alclad’’ aluminum surface with an acid wash (DuPont 255S cleaner, Martin Senour 6879 Twin Etch, etc.), followed by an application of Alodine, and then directly by DuPont Imron Polyurethane paint. While a primer or primer/surfacer could be used between the Alodine and the Imron, it was left off as a weight saving measure. Only the minimum thickness of Imron was used to get the desired flow-out for a slick surface. After the Alodine application, the skins were completely dried to remove any moisture which might later contribute to filiform skins corrosion. This was done with an air nozzle and repeated passes over all metal seams and rivets. The RV-6 prototype was painted with a similar ‘‘Minimum weight’’ approach, but in this instance Ditzler Durethane paint was used.

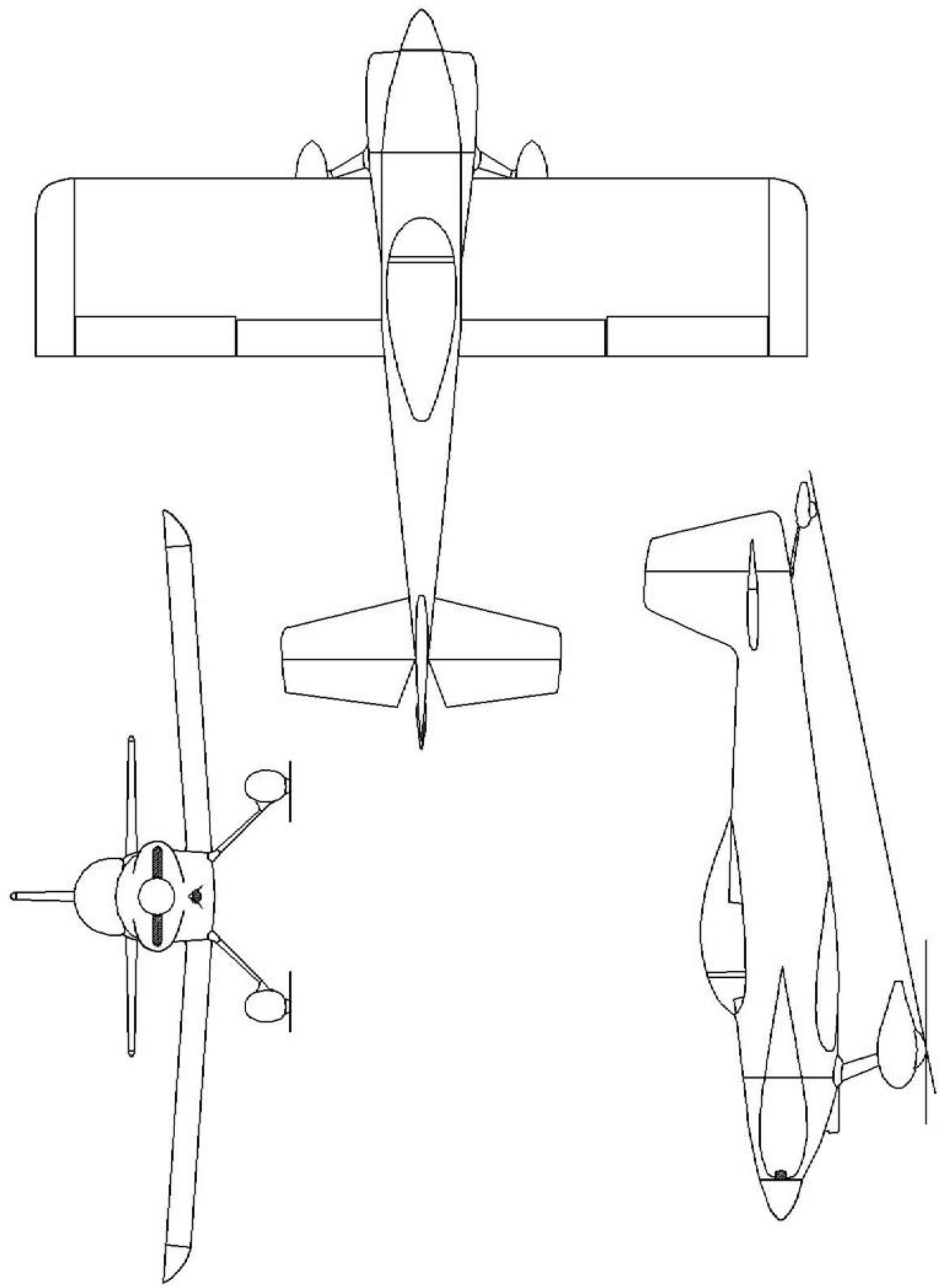
Painting an airplane obviously adds to its weight. The amount of weight depends on the type and amount of paint, primer and surface filler used. The ‘‘No-primer’’ Imron process described above will weigh about 15 lbs; about minimum for a complete paint job. A really elaborate paint job with all the extras could add two or three times this weight. In addition, heavy paint jobs will tend to shift the Center of gravity rearward because of the paint weight on the empennage. Control surface balance on the RVs has not been found to be critical. A normal (light) paint application on the ailerons and elevator will not upset their balance to a noticeable degree. However, a heavy paint job will require that these surfaces be re-balanced and additional counter balance weight added if necessary.

MASKING

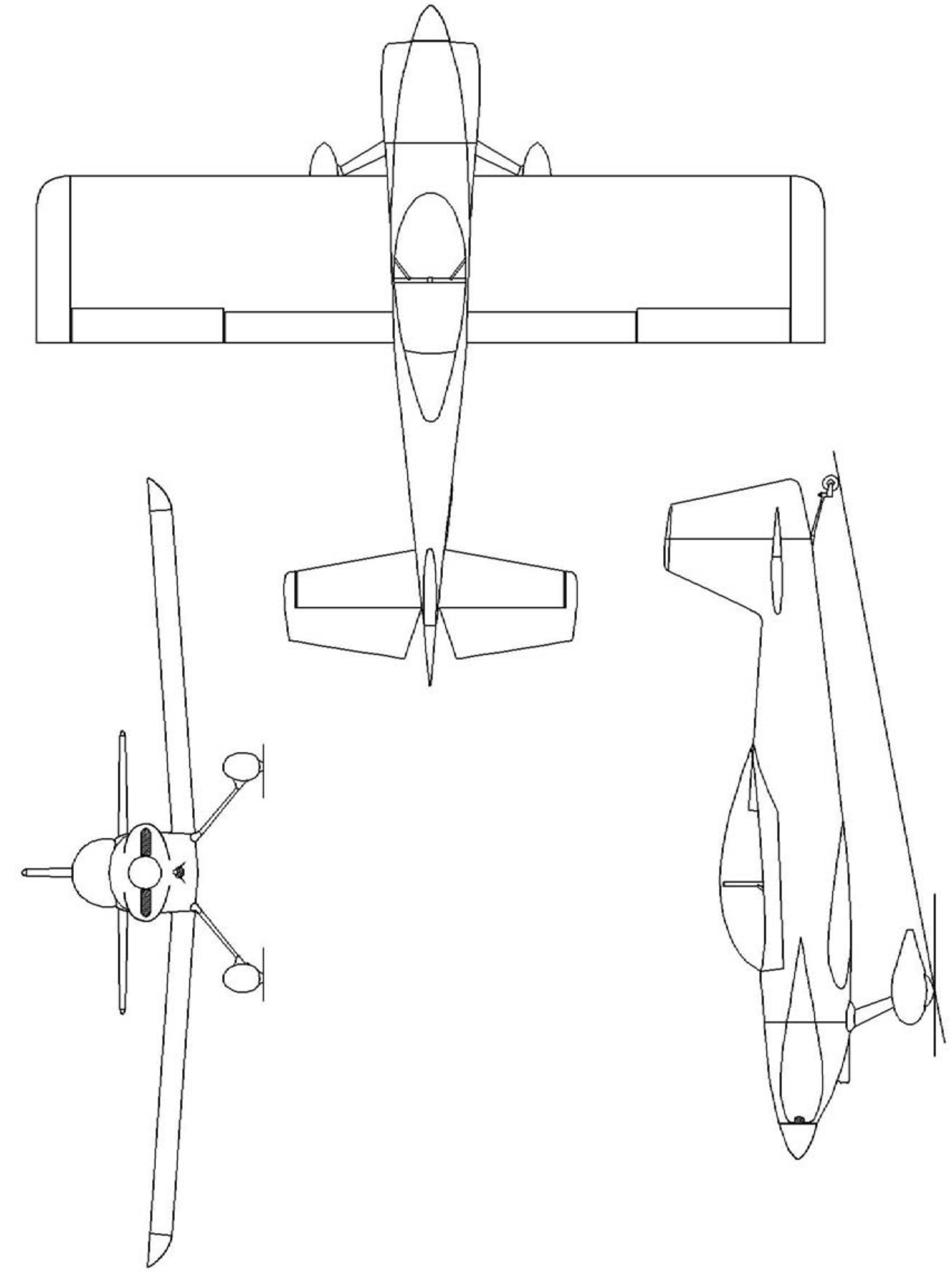
Application of masking tape for color separation and pin-striping is perhaps the most time consuming part of painting. Masking a straight line is tough enough, but getting just the right curve or ‘‘sweep’’ to a line is an art. Common hardware store masking tape usually gives poor results for distinct line separation because it permits too much ‘‘bleed under’’. Plastic ‘‘decorator’’ tape yields a nice crisp edge, but is rather expensive. Plastic electricians tape works fairly well and is relatively cheap. ‘‘Scotch’’ tape also works well, but is hard to remove after painting.

There is no doubt that a smooth, wave free surface offers less aerodynamic drag than an imperfect one, but it is not known how much effect this will have on the speed of an RV. Probably not much unless the entire airframe is filled and smoothed before painting, and then the paint is rubbed-out perfectly smooth. This would entail much work, would add weight, and would probably not be advisable unless the builder wanted a 100% perfect airplane rather than a 98% perfect one. The price for that last 2% would be high in terms of added work required.

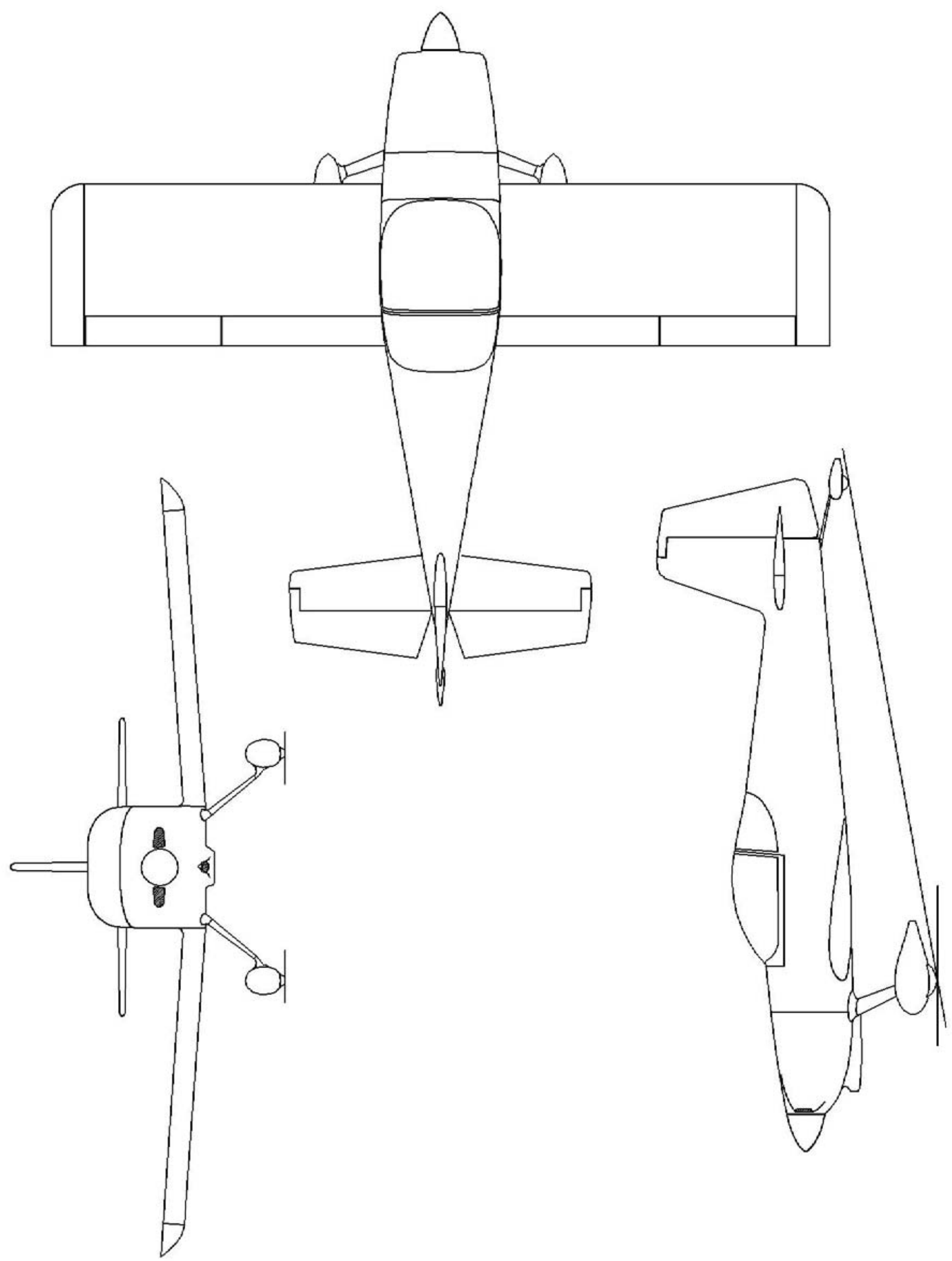
For the typical paint job, the builder obviously should try to work in a dust free environment so the paint surface will be as smooth as possible without the need for rub-out. Spanwise trim stripes should be avoided very near the wing leading edge. Much is being written about the effects of spanwise surface irregularities on the boundary layer control on airfoils, particularly those on canard configuration airplanes. The concern is that any surface irregularity near the wing leading edge, particularly spanwise ones, can disrupt the boundary layer airflow, upset laminar flow, and cause an increase in drag and a decrease in lift. On canard airplanes this can seriously affect not only performance, but also stability and control. On an RV, with its conventional configuration and non-laminar flow airfoil, the effects of surface irregularities are relatively minor. However, a rough paint trim line within the first few inches of the wing leading edge would probably cause a measurable effect on stall and top seeds. Trim lines more than 8-9 inches from the leading edge have a minimal effect, but even then should be rubbed out as smoothly as possible.



RV-3



RV-4



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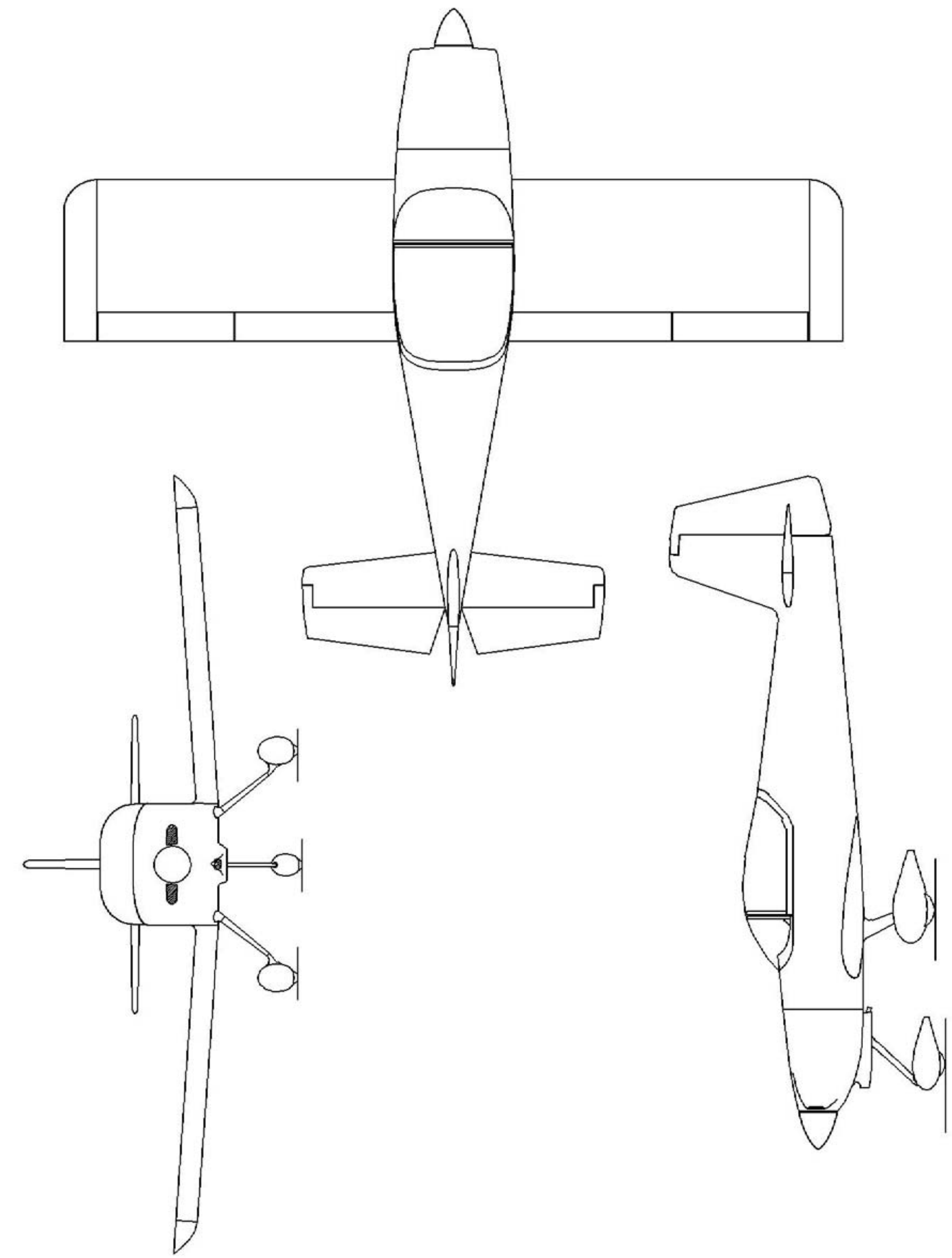

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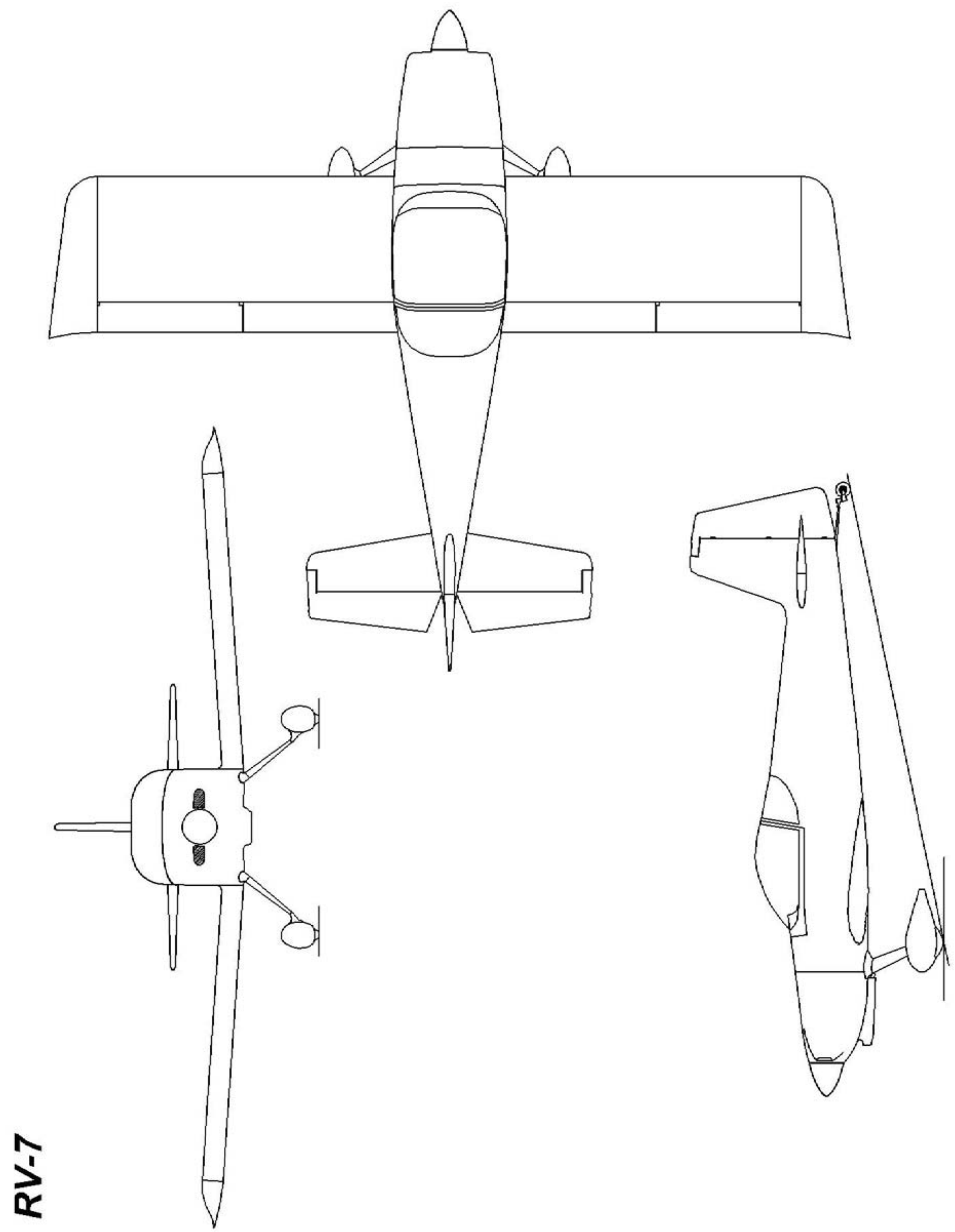
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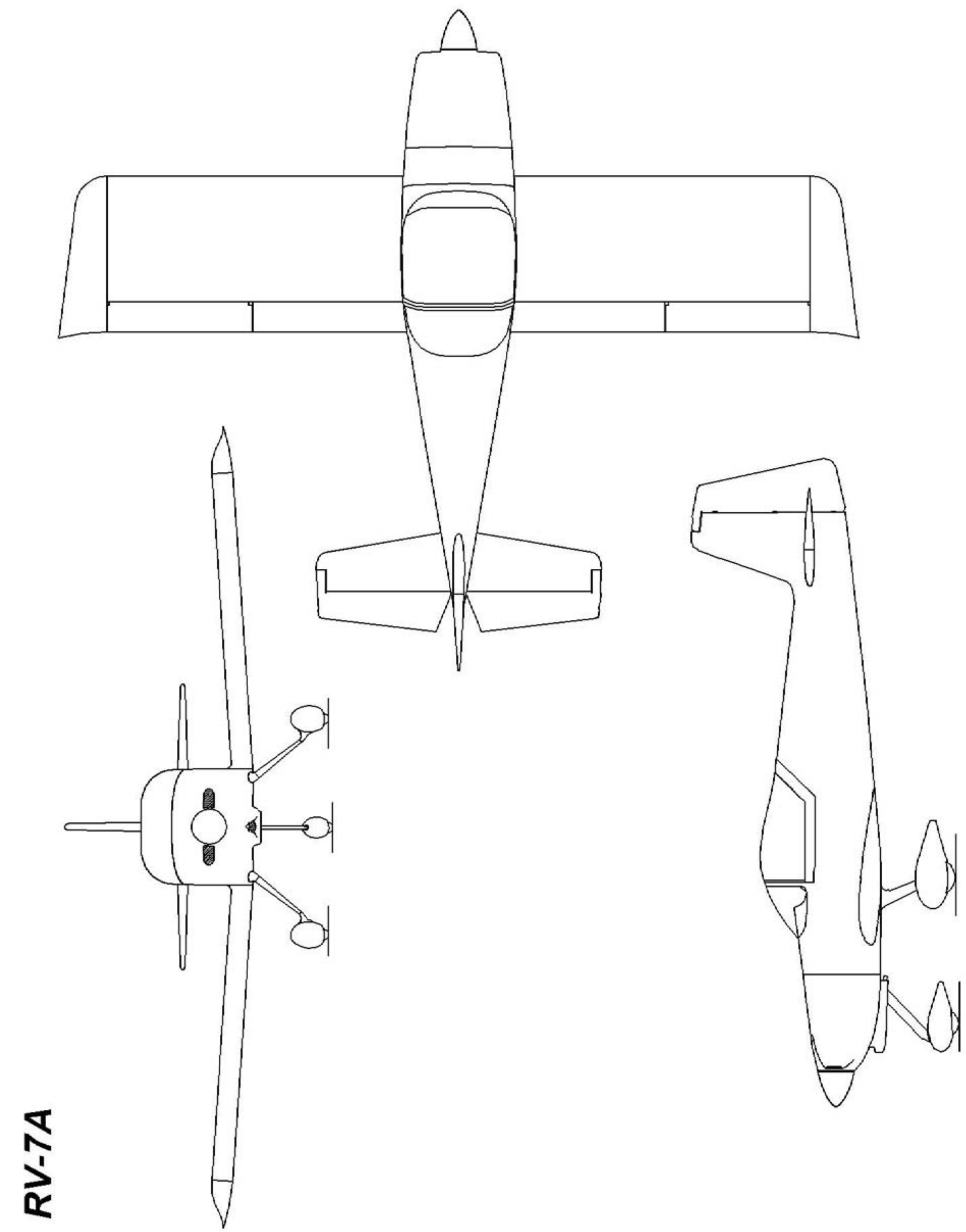
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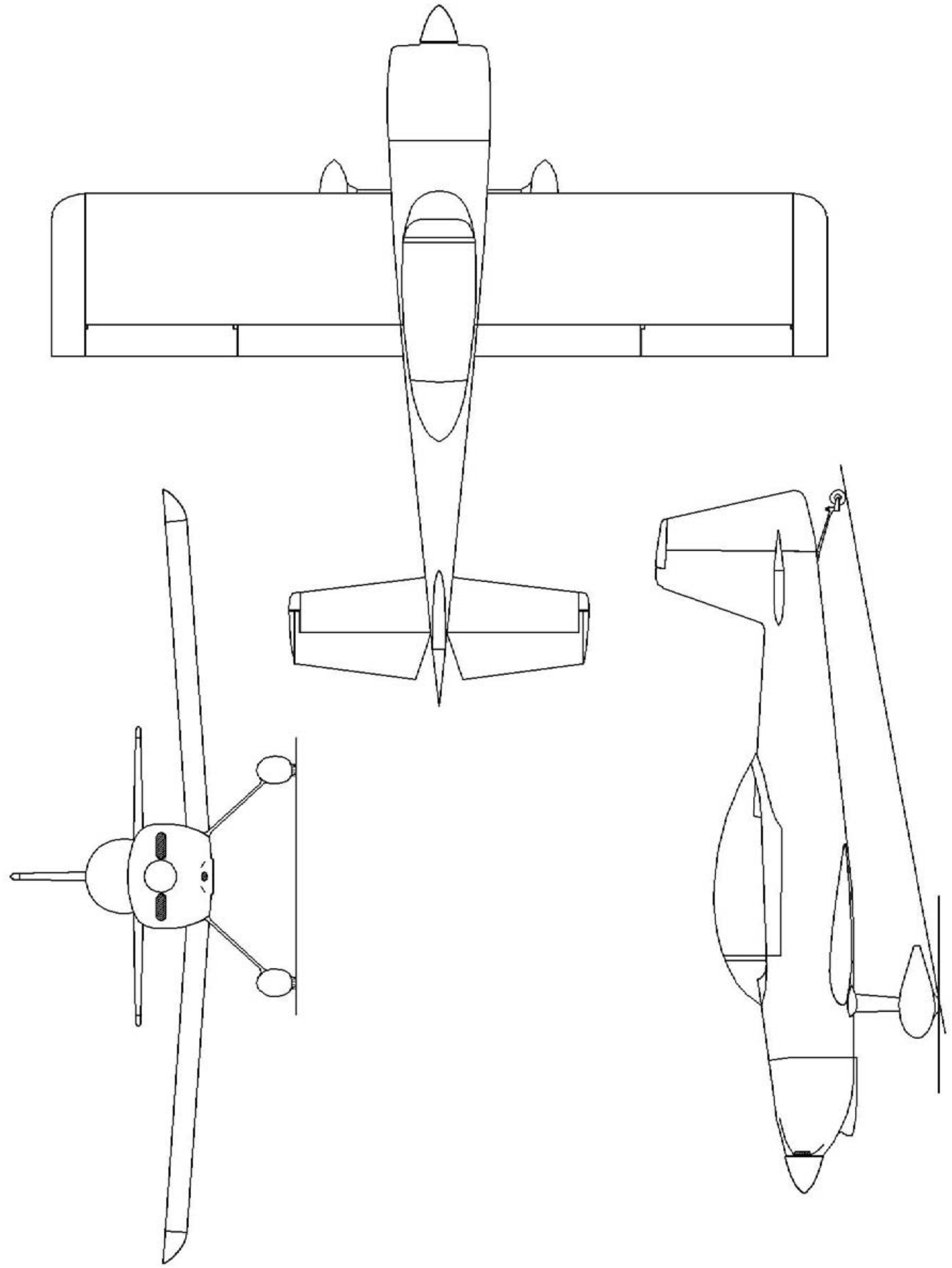

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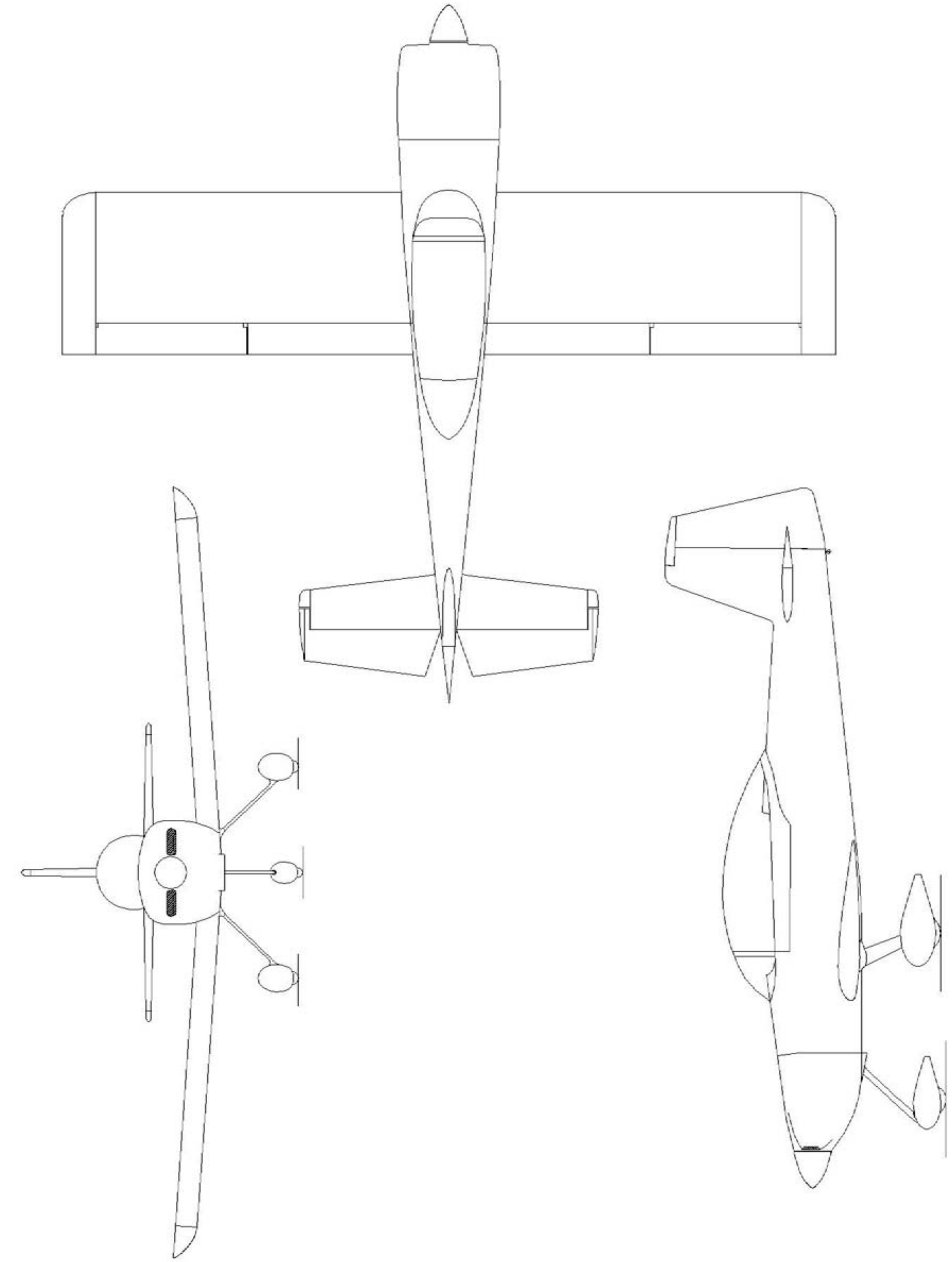
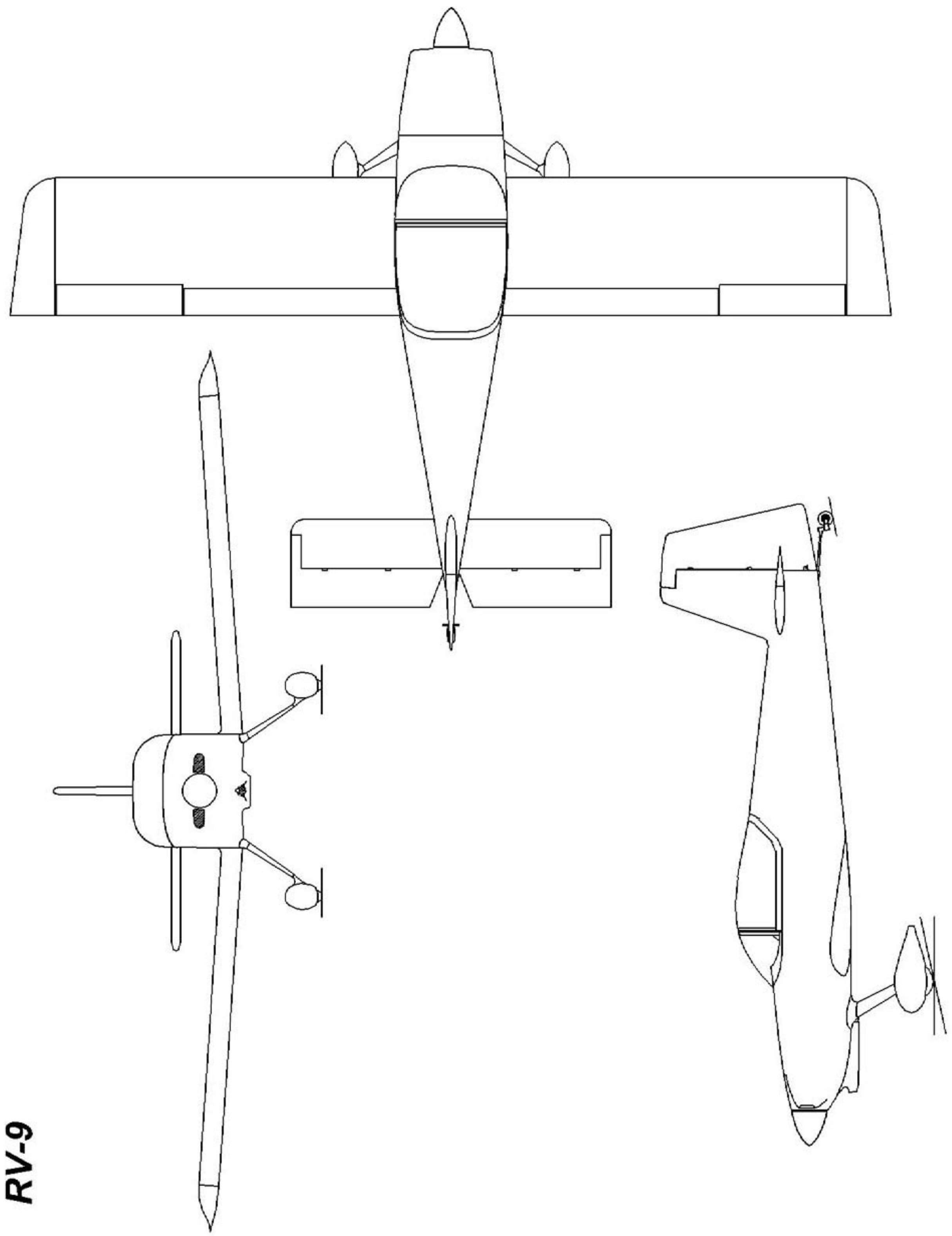
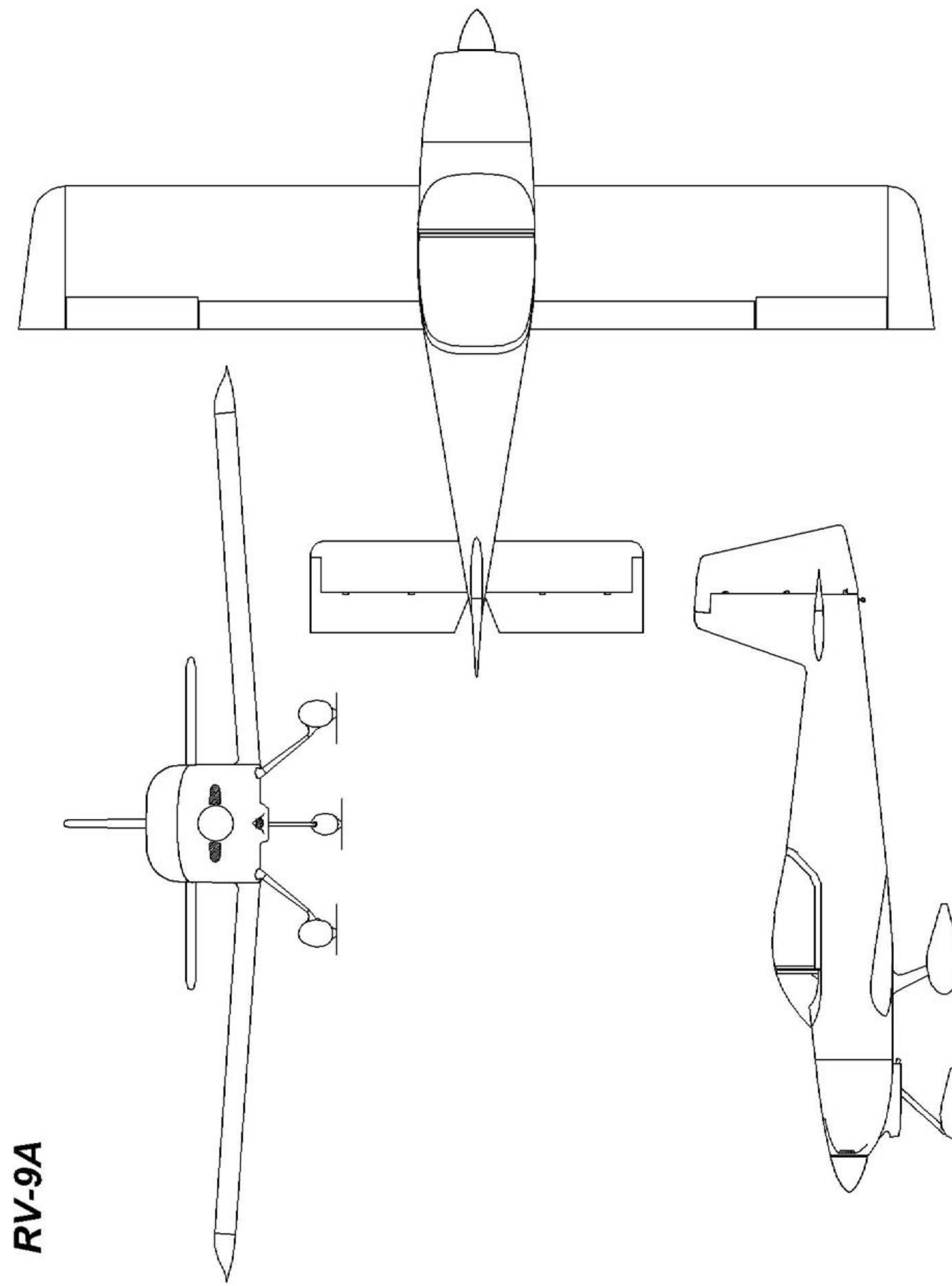


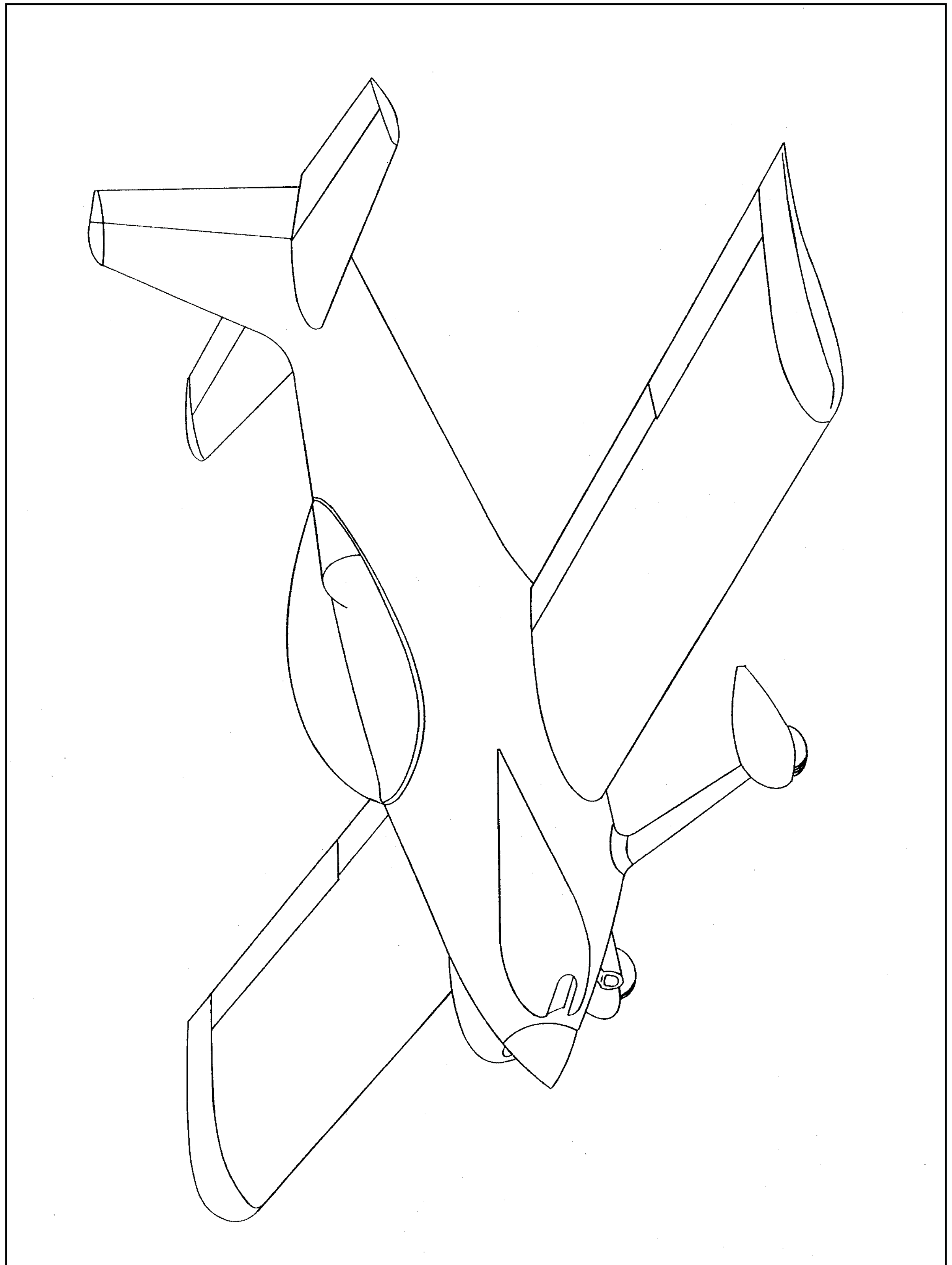
RV-8A

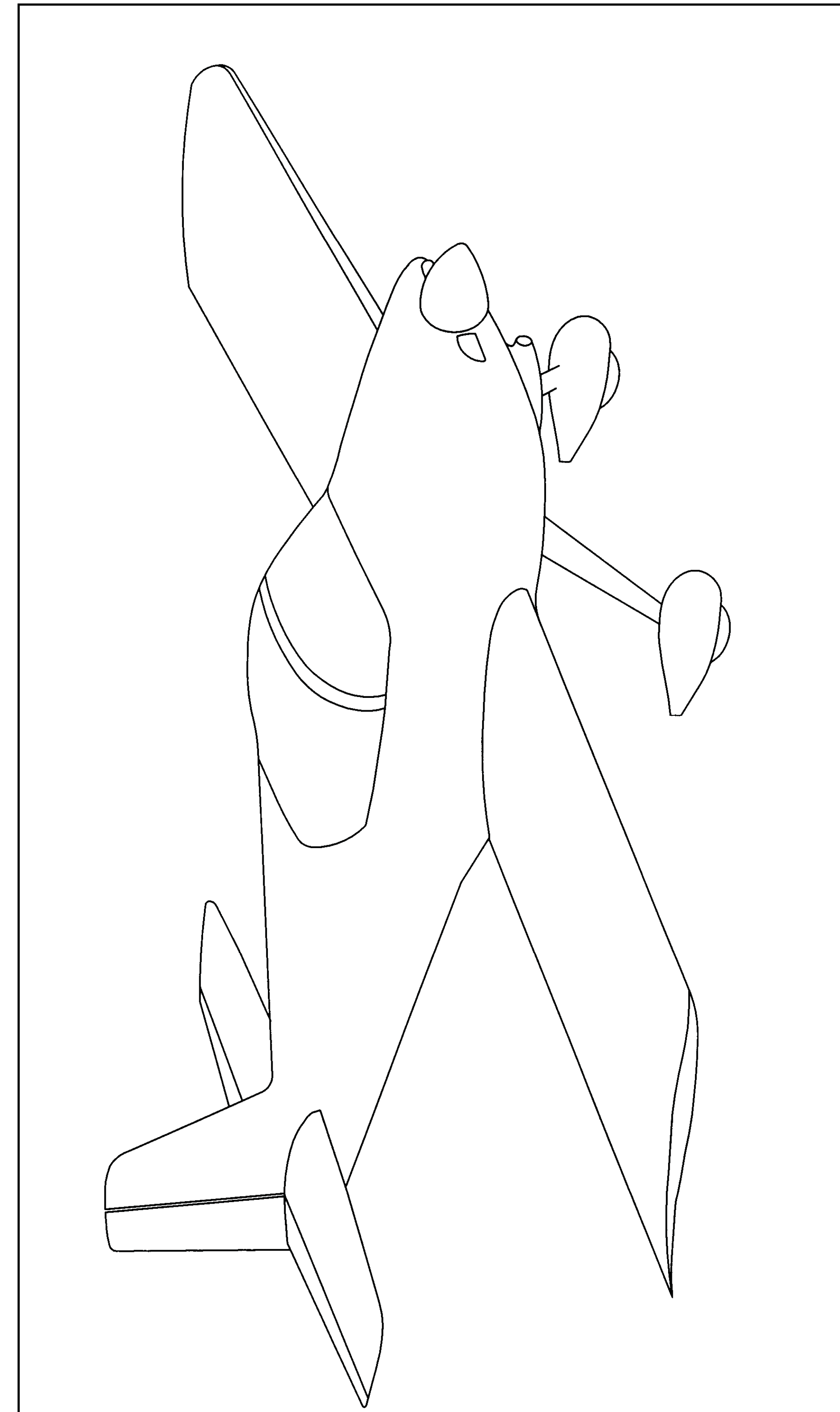


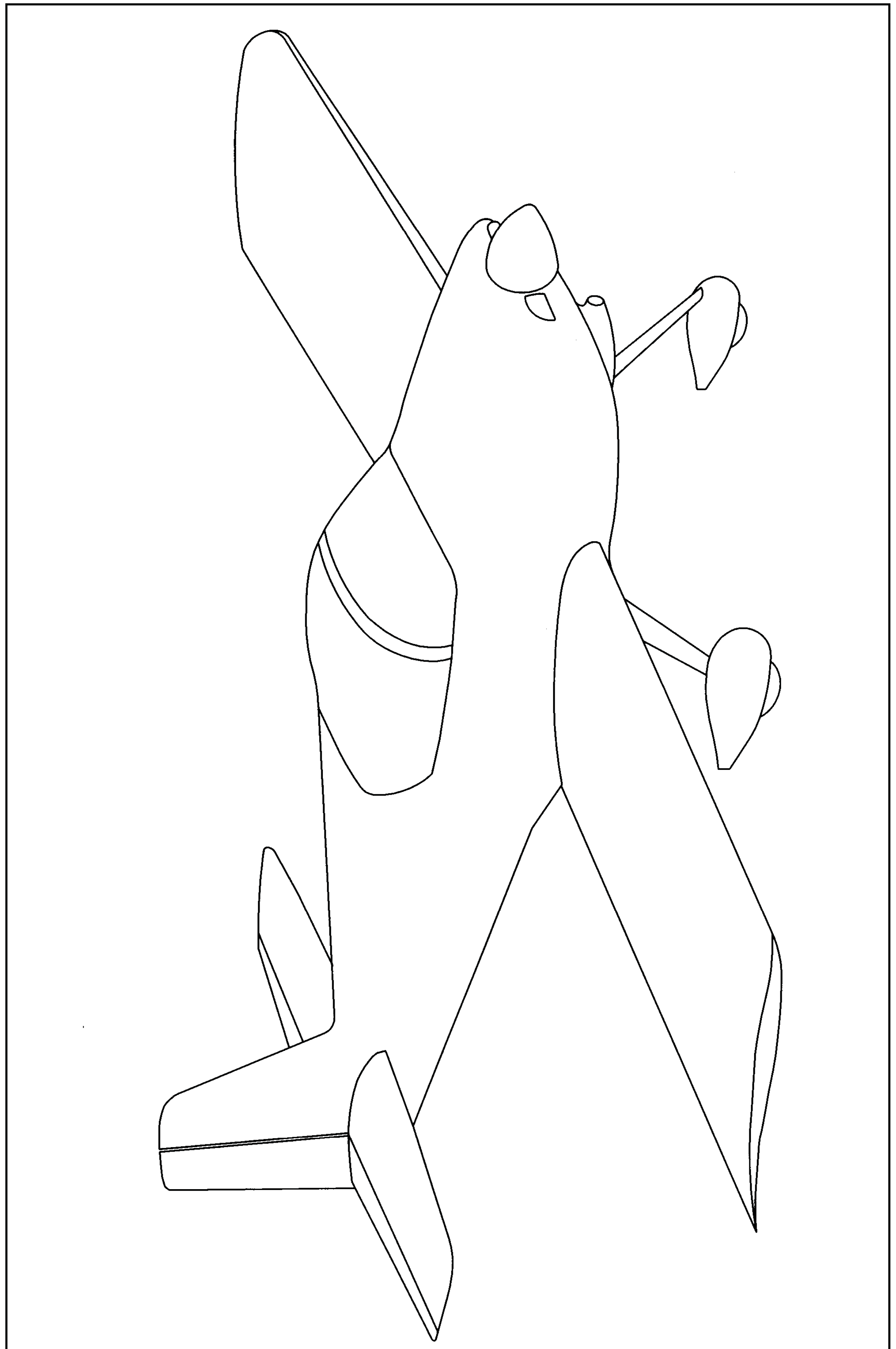
RV-9

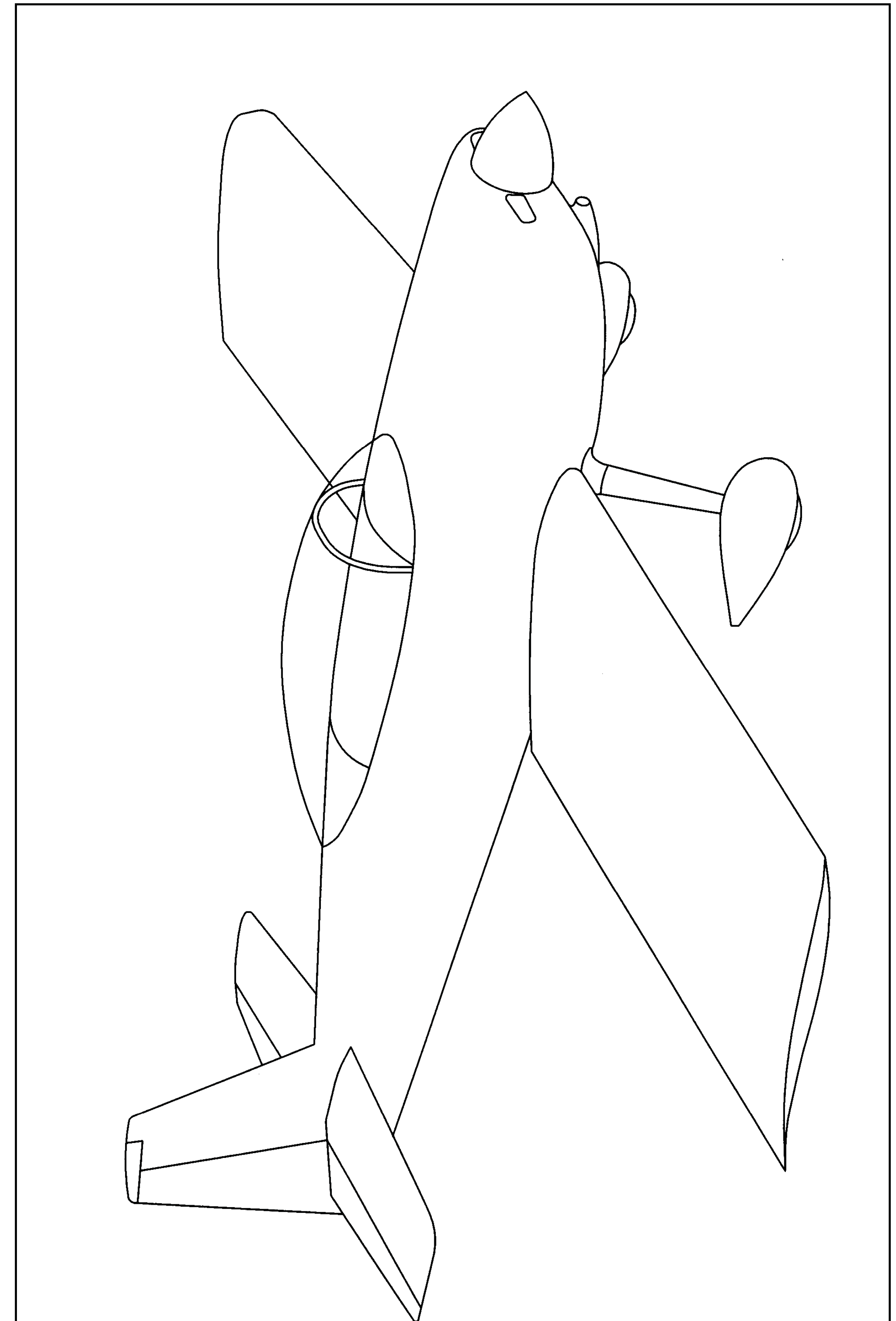


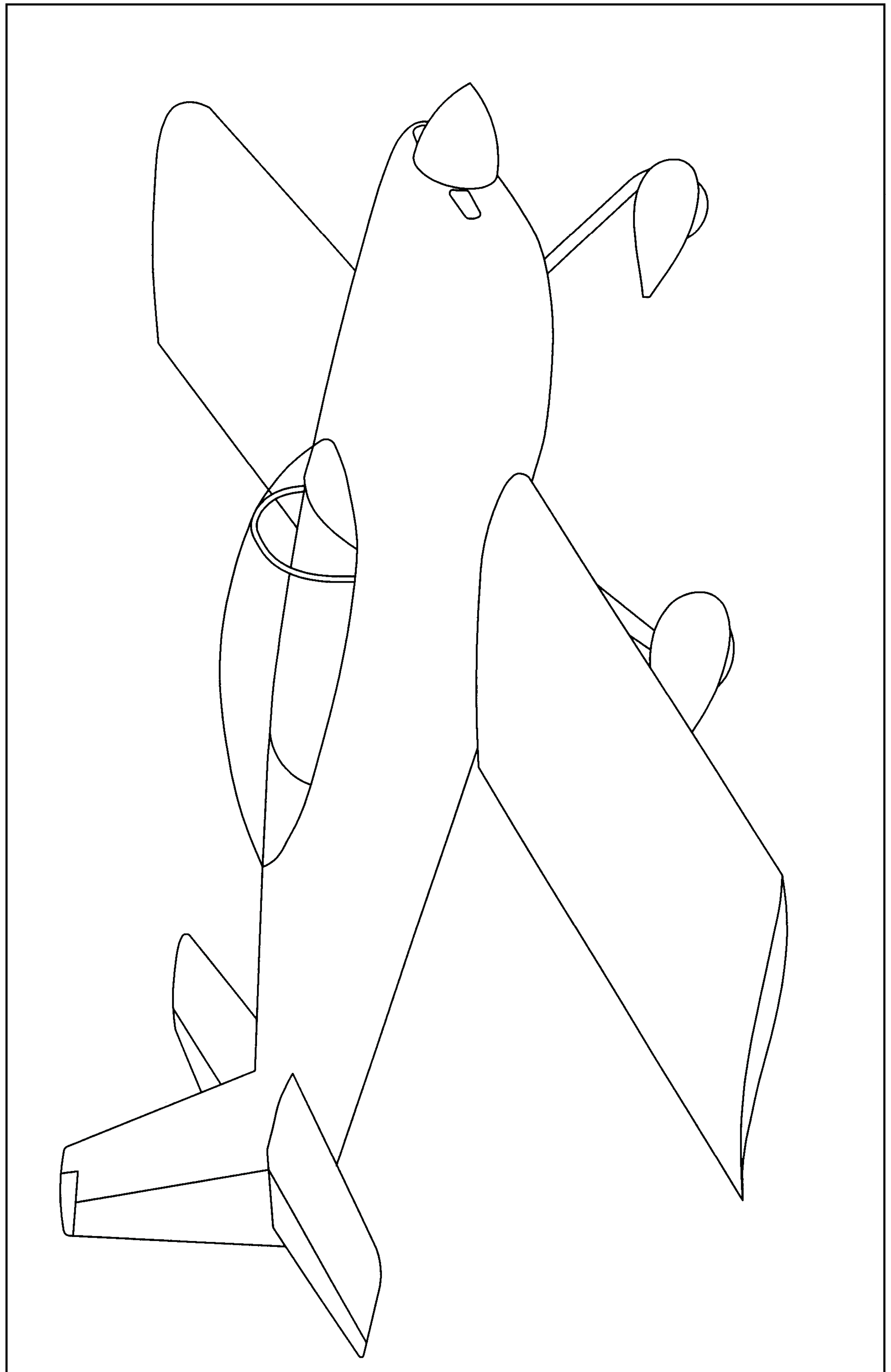
RV-9A











NOTES

SECTION 14: WEIGHT AND BALANCE

Any aircraft must, for safety's sake, be operated within its weight and balance envelope. Weight and its distribution can severely affect performance, handling, controllability, and even structural integrity. This section will give you basic procedures for weighing your RV-7/7A and performing weight and balance calculations.

The forms presented and calculations performed here are only for standard operating conditions and for Standard FAA Pilot Weights. We all know that not all pilots and passengers weigh exactly 170 lbs. Performing weight and balance calculations based on these weights provides both the pilot and the FAA with typical anticipated loading conditions. For operating the aircraft under conditions where the average pilot and passenger weights exceed 170 lbs., additional calculations must be performed to verify compliance with C.G. and/or Gross Weight limits.

The pilot should not only be familiar with the limit load and C.G. calculations as required by the FAA, but should also be familiar with the theory of how C.G. location affects aircraft stability and handling. Day-to-day flight operations will not always involve loads which are exactly matched to the limit load calculations, so accurate estimates or further calculation will be necessary to assure safe flight operations. It is possible to perform weight and balance computations for an airplane simply by following procedures and doing the mathematics, without really understanding all of the terms and computations. However, as pilot of the airplane, it is highly desirable to have a good understanding of weight and balance, the effects that weight and balance have on the flight characteristics of the airplane, and the reasons for C.G. limits.

Before getting into the details of performing weight and balance measurements and calculations for your RV-7/7A, let's review the definitions of some of the terms involved so that we can better understand the significance of weight and balance figures.

1. **Empty Weight** - Weight of the airplane including fixed ballast, unusable fuel, and oil.

- 2. **Gross Weight** - Sum of empty weight plus crew, passengers, fuel, and baggage. It is important because of the effect it has both on the structure and performance of the airplane. Obviously, higher gross weights will diminish all aspects of performance, particularly take-off and climb performance. Increased weight also increases stall speed. Higher gross weights will tend to overstress the airplane's structure both in flight and on the ground.
- 3. **Maximum Gross Weight** - The maximum allowable operating weight, with all variable load items located such that the Center of Gravity (C.G.) remains within prescribed limits. In the Experimental Amateur Built Category – the category in which the RV-7/7A would typically be licensed – the aircraft builder is allowed to specify this weight. Van's recommends an 1800 pound limit.
- 4. **Maximum Aerobatic Gross Weight:** The maximum weight that the structure of the airplane can support at the 6G limit of the Aerobatic Category. For the RV-7/7A, this weight is 1600 lbs.
- 5. **Payload** - Weight of passengers and baggage.
- 6. **Useful Load** - Weight of passengers, fuel, and baggage.
- 7. **Center of Gravity** - The point at which the mass of an object is considered to be concentrated. (The point at which the airframe plus all added weights are concentrated.)
- 8. **Arm - (or Moment Arm)** - The horizontal distance along the longitudinal axis from the datum to the C.G. of an item being considered, or from the datum to the point where a force is applied. Normally measured in inches; aft of datum is plus (+) and forward of datum is minus (-).
- 9. **Moment** - The product of a weight or force and its moment arm (M=W x D)
- 10. **Datum** - Arbitrary reference plane selected by the manufacturer (builder) from which all arm measurements are made for weight and balance computations. Normally, the datum chosen will be in front of the aircraft nose so that all arm measurements will be positive. This makes weight and balance computations easier. The weight and balance datum for the RV-7/7A has been established at 70 inches ahead of the leading edge of the wing. The weight and balance form and the sample calculations at the end of the chapter are based on this.
- 11. **Leveling Datum** - A point or surface on the airframe where a level can be placed to determine when the aircraft is in a level position for weighing. For the RV-7/7A the Level Datum line is the fuselage top longeron at the cockpit.
- 12. **C.G. Location (or range)** - Usually defined two different ways. One is by establishing certain positions or limits with reference to the chord of the wing such as "between 15% and 29% of chord". This position is then converted into inches by multiplying the wing chord by that percentage (for RV-7/7A, 15% x 58"= 8.7", and 29% x 58" =

16.82") The C.G. location with reference to datum is then computed by adding these distances (arms) to the distance from wing leading edge to datum.

- 13. **Forward C.G. Limit** - An airplane operating at or near its forward C.G. limit will have improved stall and spin resistance and improved stall & spin recovery characteristics. It will also have higher elevator stick force and trim force requirements, and will require more stick force for landing flare. It will have higher trim drag which will tend to decrease speeds, but will increase the pitch stability of the airplane. In general, it makes the airplane more stable and safe, but less fun to fly.
- 14. **Aft C.G. Limit** - An aircraft flown at or near its aft C.G. limit will have lighter elevator stick force requirements and will therefore be easier to rotate to a high angle of attack from which stall entry is more likely. Stall and spin recovery at a rearward C.G. is slower and requires more corrective control action. Trim drag is minimized and thus speeds tend to be at their highest when C.G. is more aft. In general, C.G.s in the aft half of the range make the airplane less stable but more fun to fly, at least when maneuvering. C.G.s at or beyond the aft limit can cause control reversals and other dangerous flight conditions.
- **15. Aft "Aerobatic" C.G. Limit** – This limit is often established because of the deteriorated aft C.G. stall and spin recovery characteristics and the increased likelihood of accidental stalls and spins due to the unusual attitudes associated with aerobatic operations. The aft aerobatic C.G. limit is always forward of the max. aft C.G. limit. For the RV-7/7A it has been established at 25% chord, 14.5" aft of the wing leading edge, or 84.5" aft of the datum.
- **Maximum Weight on Nosewheel** (Applicable to RV-7A only) - The weight on the nosewheel varies with both gross weight and CG location and must be checked so as to be sure that it is within limits. Because of the inter-relationship an aircraft with forward CG but low gross weight may place an unacceptably high load on the nosewheel. Use the chart on the last page to calculate the nosewheel weight for a particular CG and gross weight.

MAXIMUM BAGGAGE WEIGHT

The maximum allowable baggage weight is determined by the structural limits of the baggage compartment floor, and is the maximum weight which can be carried in the baggage compartment under the most ideal conditions. For the RV-7/7A, the maximum permissible baggage limit is 100 lbs. This means that when C.G. limits and gross weight limits will permit, up to 100 lbs. of baggage can be carried in the RV-7/7A baggage compartment. An example of this condition is a single pilot operation where this amount of baggage will not likely cause either the C.G. or the gross weight to exceed limits. With a single occupant, additional baggage can be carried in the passenger seat, but only if the C.G. and Gross weight remain within limits, and if it is secured so that it cannot possibly interfere with the pilot's ability to operate the controls.

AIRCRAFT WEIGHING

Weigh your RV-7/7A with three platform type aircraft scales which have been certified for accuracy. At times, good scales are not available to homebuilders so bathroom scales are used instead. Bathroom scales are often highly inaccurate and usually do not have sufficient capacity to weigh an RV-7/7A main wheel. However, two can be ganged together with a plank over them if no other scales are available. Because a homebuilder can probably borrow any number of bathroom scales, it would be good to get 5 or 6 of them and weigh yourself on each one. This way, the most accurate can be selected and the others calibrated based on it.

Regardless of the scales used, the airplane should be weighed in the empty condition and in a level attitude. Level attitude is established at the datum line which is the cockpit rails. Scales should be placed simultaneously under both main wheels and the nose wheel. Use plumb lines or vertical levels to measure the locations of the main wheels relative to the wing leading edge, and then convert this to an arm relative to datum. The same applies to the nose wheel location, which can be accurately located by dropping a plumb line to the floor and measuring aft to the wing leading edge.

The forms at the end of this section show a sample calculation for the empty weight Center of Gravity for an RV-7/7A. To keep all moments positive, a datum has been selected at a point forward of the prop spinner. Only three moments must be calculated and combined to determine the C.G. position. This figure is not in itself too meaningful, but is important for further loaded weight C.G. calculations.

Also provided are sample calculations for gross weight loading conditions and other limiting conditions. The procedure is to enter the desired loads into the calculation, and then check the resultant C.G. location to see if it falls within the design limits. If not, then further calculations will be needed using varying loads until the resultant C.G. is within limits. This will then become the limit load, or load combination permitted. Such calculations are always based on the amount of fuel which will be on board during the most critical portion of the flight. In other words, if full fuel imposes the extreme loading condition (maximum allowable gross weight) it is the figure used. In other instances, most aft C.G. for example, the minimum fuel supply is assumed because this is the condition which could exist at the end of the flight. The airplane could be within limits at take-off, but outside the limits upon landing. This instance is illustrated in the sample calculations where we have substituted extra baggage and a heavy pilot in lieu of fuel to remain within design gross weight limits. The gross weight C.G. calculations show everything within limits. But, when we re-calculate the C.G. for this same condition, subtracting the weight of the fuel burned, the C.G. moves outside of the aft limit. A reduction in baggage weight will be needed to attain an acceptable loading condition. By trial and error calculations, we can thereby establish the maximum baggage permitted under minimum fuel conditions. C.G. calculations combine the effects of all loads placed in the aircraft and consider them as one, centered at a median point. Many different combinations of loads and locations are possible to achieve the same end loading result.

In Sample 4 considers the most forward loading that can be achieved – full fuel, a very light pilot, no passenger, and no baggage. This low gross weight loading places the largest load on the nosewheel and must be checked to assure that it is within limits. Some aircraft, due to the builder's selection of propeller & engine as well as equipment mounted in the forward fuselage, may require that ballast be carried in the baggage compartment so as to reduce the nosewheel load to an acceptable level.

In Sample 5, consider a gross weight condition in which the weight of the pilot and passenger is increased from 170 lbs to 228.5 lbs. The baggage load is also increased up to the structural limit of 100 lbs. A reduction in the fuel load is needed to remain within the gross weight limit of 1800 lbs. The calculations show that the C.G. remains within limits for this loading condition.

In Sample 6, when an additional C.G. calculation is made for minimum fuel at this loading condition, the C.G. falls outside of limits. Further calculations, shown in Sample 7, are then necessary to determine the maximum baggage which can be carried along with the pilot and passenger weights specified. This sample loading condition has been selected to illustrate an unacceptable loading condition, and the method for determining loading changes necessary to remain within C.G. limits. The pilot is responsible for additional C.G. calculations for any loading conditions other than the documented standard conditions listed on the FAA required papers.

Following the sample calculations is a blank C.G. form which may be used for calculating the C.G. for *your* RV-7/7A. Arms for the locations of the standard loads are provided in the sample calculations. If those for your airplane remain the same, (no changes in the seat locations, etc.) these figures can be used. The sample calculations are only representative figures and may not be the same as those you determine for your RV-7/7A. While the loads and weights of pilot, passenger, and fuel may be the same, a different empty weight C.G. for your RV-7/7A could cause the final loaded C.G. to be considerably different. Any changes in the airframe such as the use of a metal prop, particularly a constant speed prop, will considerably affect the empty C.G. Such changes may require relocation of other items, such as the battery, to keep the empty C.G. within an acceptable range. Increased empty weight will decrease useful load; either passenger weight, fuel weight, or baggage weight must be reduced to remain within the permissible gross weight. This is a common practice in production light planes where it is rare that full fuel, pilot and passengers, and baggage can all be loaded simultaneously and remain within gross weight limits.

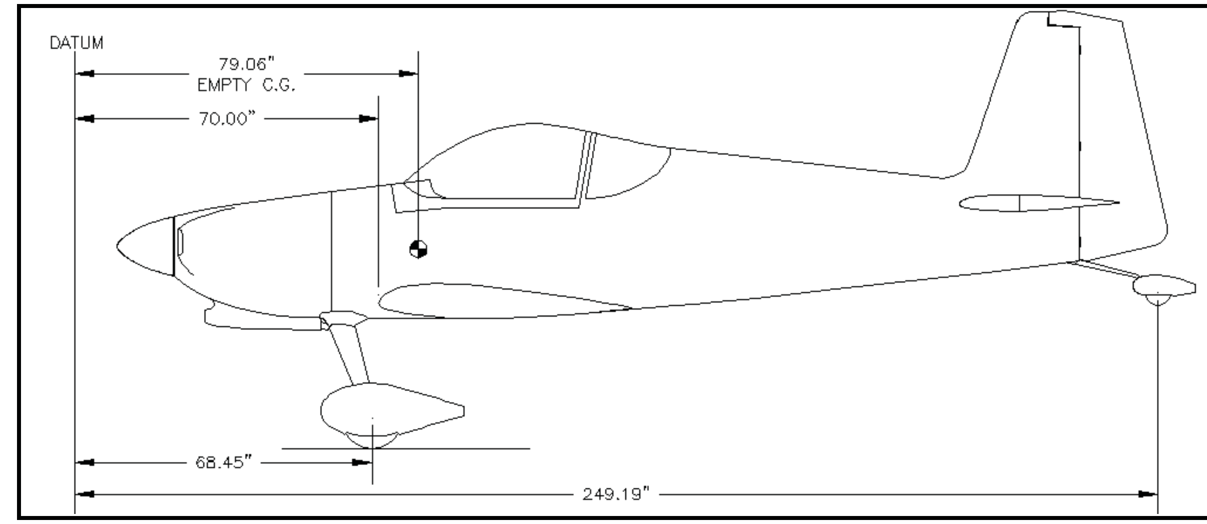
RV-7/7A WEIGHTS AND LIMITS - EASY REFERENCE

Recommended Gross Weight	1800 lbs
Aerobatic Gross Weight	1600 lbs
Forward CG Limit	15% of chord or 8.7" aft of leading edge
Aft CG Limit	29% of chord or 16.82" aft of leading edge
Aerobatic Aft CG Limit	25% of chord or 14.5" aft of leading edge
RV-7A Max Weight on Nosewheel	375 lb

SAMPLE WEIGHT & BALANCE FOR AN RV-7

Datum	70 inches forward of wing leading edge. (L.E.)
Design C.G. Range	15%-29% of wing chord, or 8.7-16.82 inches from L.E., or 78.7-86.82 inches aft of Datum.
Wing L.E.	70 inches aft of datum.
Fuel	80.0" aft of datum
Pilot & Passenger	97.48" aft of datum
Baggage	126.78" aft of datum

Aircraft weighed in level flight attitude. (includes 8 qts. of oil, no fuel)



Main wheel, right 68.45" aft of datum.
Main wheel, left 68.45" aft of datum.
Tail Wheel 249.19" aft of datum

DETERMINING EMPTY CG

	Weight	Arm	Moment
Right Wheel -	522.89	68.45	35792
Left Wheel -	522.89	68.45	35792
Tail Wheel -	65.22	249.19	16252
Total:	1111.00		87836

C.G. = 87836/1111= 79.06" aft of datum for empty weight CG

SAMPLE SITUATION 1: GROSS WEIGHT CG

	Weight	Arm	Moment
Aircraft	1111	79.06	87836
Fuel (42 Gal.)	252	80.0	19994
Pilot	170	97.48	16572
Passenger	170	97.48	16572
Baggage	97	126.78	12298
Total:	1800		153438

CG = 153438/1800= 85.24" aft of the datum. This is less than the aft limit of 86.82, so is within CG limits RV-7A Load on Nosewheel = 288 lb. This is less than the limit of 375 lb so is within max nosewheel load limits.

SAMPLE SITUATION 2 : MOST AFT CG (Gross weight, minimum fuel)

	Weight	Arm	Moment
Aircraft	1111	79.06	87836
Fuel (5 gal.)	30	80.0	2400
Pilot	170	97.48	16572
Passenger	170	97.48	16572
Baggage	97	126.78	12298
Total:	1578		135678

CG=135678/1578=85.98" aft of datum. This is less than the aft limit of 86.82, so is within CG limits. RV-7A Load on Nosewheel = 231 lb. This is less than the limit of 375 lb so is within max nosewheel load limits.

SAMPLE SITUATION 3: MOST FORWARD C.G. (STD PILOT WT.)

	Weight	Arm	Moment
Aircraft	1111	79.06	87836
Fuel (42 Gal.)	252	80.0	20160
Pilot	170	97.48	16572
Total:	1533		124568

CG = 124568/1533= 81.26" aft of the datum. This is greater than the forward limit of 78.7, so is within CG limits . RV-7A Load on Nosewheel = 357 lb. This is less than the limit of 375 lb so is within max nosewheel load limits.

SAMPLE SITUATION 4: MOST FORWARD C.G. (MIN. PILOT WT.)

	Weight	Arm	Moment
Aircraft	1111	79.06	87836
Fuel (42 Gal.)	252	80.0	20160
Pilot	100	97.48	9748
Total:	1463		117744

CG = 117744/1463= 80.48" aft of the datum. This is greater than the forward limit of 78.7, so is within CG limits. RV-7A Load on Nosewheel = 362 lb. This is less than the limit of 375 lb so is within max nosewheel load limits.

SAMPLE SITUATION 5: GROSS WEIGHT WITH HEAVY PILOT & BAGGAGE, REDUCED FUEL

	Weight	Arm	Moment
Aircraft	1111	79.06	87836
Fuel (22 Gal.)	132	80.0	10560
Pilot	228.5	97.48	22274
Passenger	228.5	97.48	22274
Baggage	100	126.78	12678
Total:	1800		155622

CG = 155622/1800= 86.46" aft of the datum. This is less than the aft limit of 86.82, so is within CG limits. RV-7A Load on Nosewheel = 247.5 lb. This is less than the limit of 375 lb so is within max nosewheel load limits.

SAMPLE SITUATION 6: AS ABOVE, BUT WITH MINIMUM FUEL

	Weight	Arm	Moment
Aircraft	1111	79.06	87836
Fuel (5 Gal.)	30	80.0	2400
Pilot	228.5	97.48	22274
Passenger	228.5	97.48	22274
Baggage	100	126.78	12678
Total:	1698		147462

CG = 147462/1698= 86.84" aft of the datum. THIS EXCEEDS THE AFT LIMIT OF 86.82", SO IS NOT WITHIN THE PRESCRIBED CG ENVELOPE. These examples illustrate how it might be possible to begin a flight within CG limits, but be out of limits upon landing. RV-7A Load on Nosewheel = 221 lb. This is less than the limit of 375 lb so is within max nosewheel load limits.

SAMPLE SITUATION 7: AS ABOVE, BUT WITH REDUCED BAGGAGE

	Weight	Arm	Moment
Aircraft	1111	79.06	87836
Fuel (5 Gal.)	30	80.0	2400
Pilot	228.5	97.48	22274
Passenger	228.5	97.48	22274
Baggage	95	126.78	12044
Total:	1693		146828

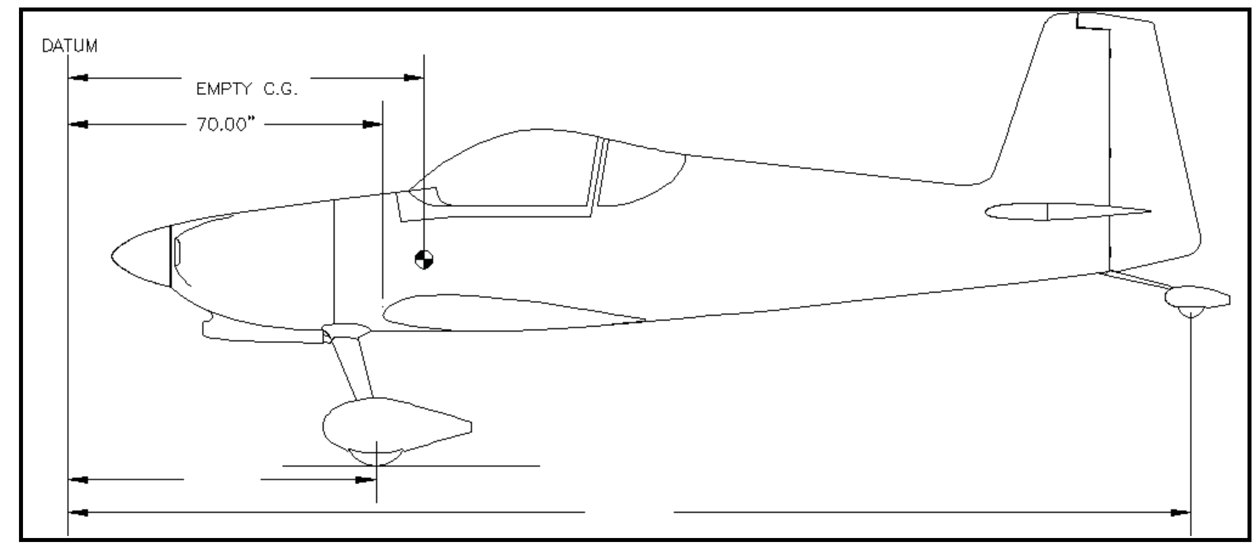
CG=146828/1693=86.73" aft of the datum. This is less than the aft limit, so by reducing the baggage by only 5 lbs, the CG is kept within limits at the end of the flight RV-7A Load on Nosewheel = 224 lb. This is less than the limit of 375 lb so is within max nosewheel load limits.

WEIGHT & BALANCE DATA for RV-7:

MAKE:__________________ MODEL:______________ SERIAL___________
REGISTRATION______________

Datum	70 inches forward of wing leading edge. (L.E.)
Design C.G. Range	15%-29% of wing chord, or 8.7-16.82 inches from L.E., or 78.7-86.82 inches aft of Datum.
Wing L.E.	70 inches aft of datum.
Fuel	80.0" aft of datum
Pilot & Passenger	97.48" aft of datum
Baggage	126.78" aft of datum

Aircraft Weighed empty in level flight attitude. Includes 8 qts. of oil, no fuel)



Main wheel, right ________________in. aft of datum.
Main wheel, left ________________in. aft of datum.
Tail wheel ________________in. aft of datum.

DETERMINING EMPTY CG

	Weight	Arm	Moment
Right Wheel	________	_____	__________
Left Wheel	________	_____	__________
Tail Wheel	________	_____	__________
Total:	________		__________

*EMPTY AIRCRAFT C.G. =*__________/__________=________*inches aft of datum.*

SITUATION 1: GROSS WEIGHT CG

	Weight	Arm	Moment
Aircraft			
Fuel (42 Gal.)			
Pilot			
Passenger			
Baggage			
Total:			

C.G. = __________/____________ = ________in. aft of datum.

SITUATION 2: MOST AFT CG (GROSS WEIGHT, MINIMUM FUEL)

	Weight	Arm	Moment
Aircraft			
Fuel (5 Gal.)			
Pilot			
Passenger			
Baggage			
Total:			

C.G. = __________/____________ = ________in. aft of datum.

SITUATION 3: MOST FORWARD C.G. (STD PILOT WT.)

	Weight	Arm	Moment
Aircraft			
Fuel (42 Gal.)			
Pilot			
Total:			

C.G. = __________/____________ = ________in. aft of datum.

SITUATION 4: MOST FORWARD C.G. (MIN. PILOT WT.)

	Weight	Arm	Moment
Aircraft			
Fuel (42 Gal.)			
Pilot			
Total:			

C.G. = __________/____________ = ________in. aft of datum.

SITUATION 5: GROSS WEIGHT (HEAVY PILOT & BAGGAGE, REDUCED FUEL)

	Weight	Arm	Moment
Aircraft			
Fuel [ ] Gal			
Pilot			
Passenger			
Baggage			
Total:			

C.G. = __________/____________ = ________in. aft of datum.

SITUATION 6: AS ABOVE, BUT WITH MINIMUM FUEL

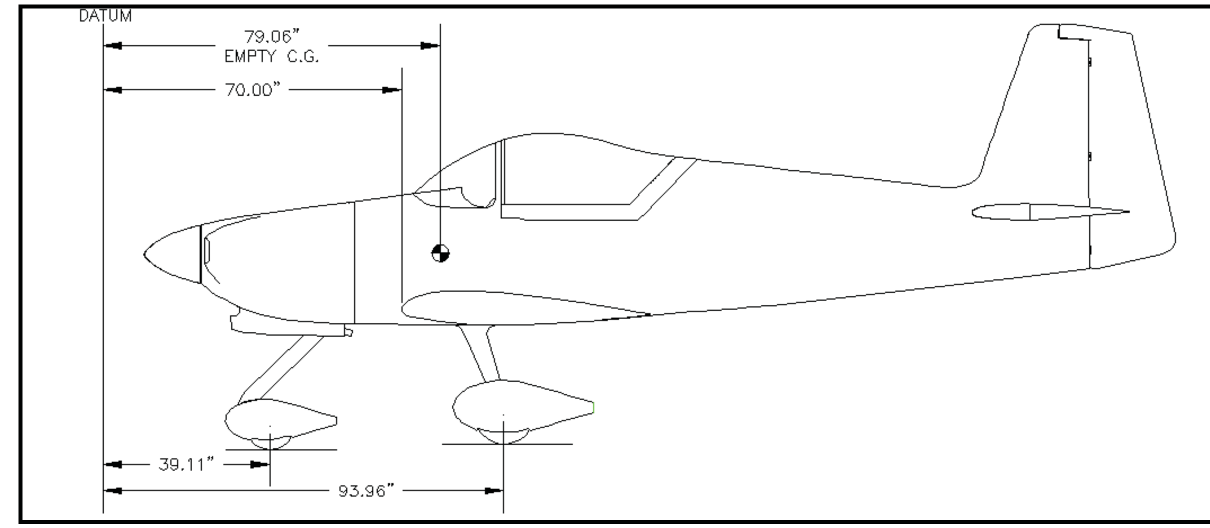
	Weight	Arm	Moment
Aircraft			
Fuel (5 Gal.)			
Pilot			
Passenger			
Baggage			
Total:			

C.G. = __________/____________ = ________in. aft of datum.

SAMPLE WEIGHT & BALANCE FOR AN RV-7A

Datum	70 inches forward of wing leading edge. (L.E.)
Design C.G. Range	15%-29% of wing chord, or 8.7-16.82 inches from L.E., or 78.7-86.82 inches aft of Datum.
Wing L.E.	70 inches aft of datum.
Fuel	80.0" aft of datum
Pilot & Passenger	97.48" aft of datum
Baggage	126.78" aft of datum

Aircraft weighed in level flight attitude. (includes 8 qts. of oil, no fuel)



Main wheel, right 93.96" aft of datum.
Main wheel, left 93.96" aft of datum.
Nose Wheel 39.11" aft of datum

DETERMINING EMPTY CG

	Weight	Arm	Moment
Right Wheel -	408.24	93.96	38358
Left Wheel -	408.24	93.96	38358
Nose Wheel -	304.52	39.11	11910
Total:	1121.00		88626

C.G. = 88626/1121= 79.06" aft of datum for empty weight CG

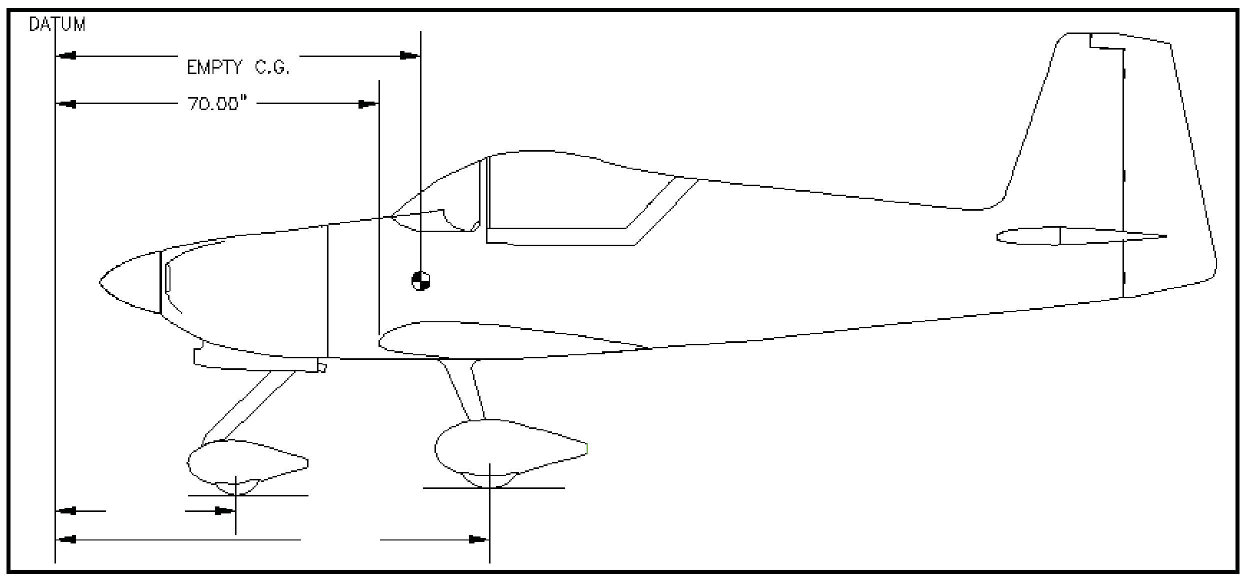
SEE RV-7 FOR SAMPLE SITUATIONS 1 THROUGH 6

WEIGHT & BALANCE DATA for RV-7A:

MAKE:__________________ MODEL:_____________ SERIAL___________
REGISTRATION_______________

Datum	70 inches forward of wing leading edge. (L.E.)
Design C.G. Range	15%-29% of wing chord, or 8.7-16.82 inches from L.E., or 78.7-86.82 inches aft of Datum.
Wing L.E.	70 inches aft of datum.
Fuel	80.0" aft of datum
Pilot & Passenger	97.48" aft of datum
Baggage	126.78" aft of datum

Aircraft Weighed empty in level flight attitude. Includes 8 qts. of oil, no fuel)

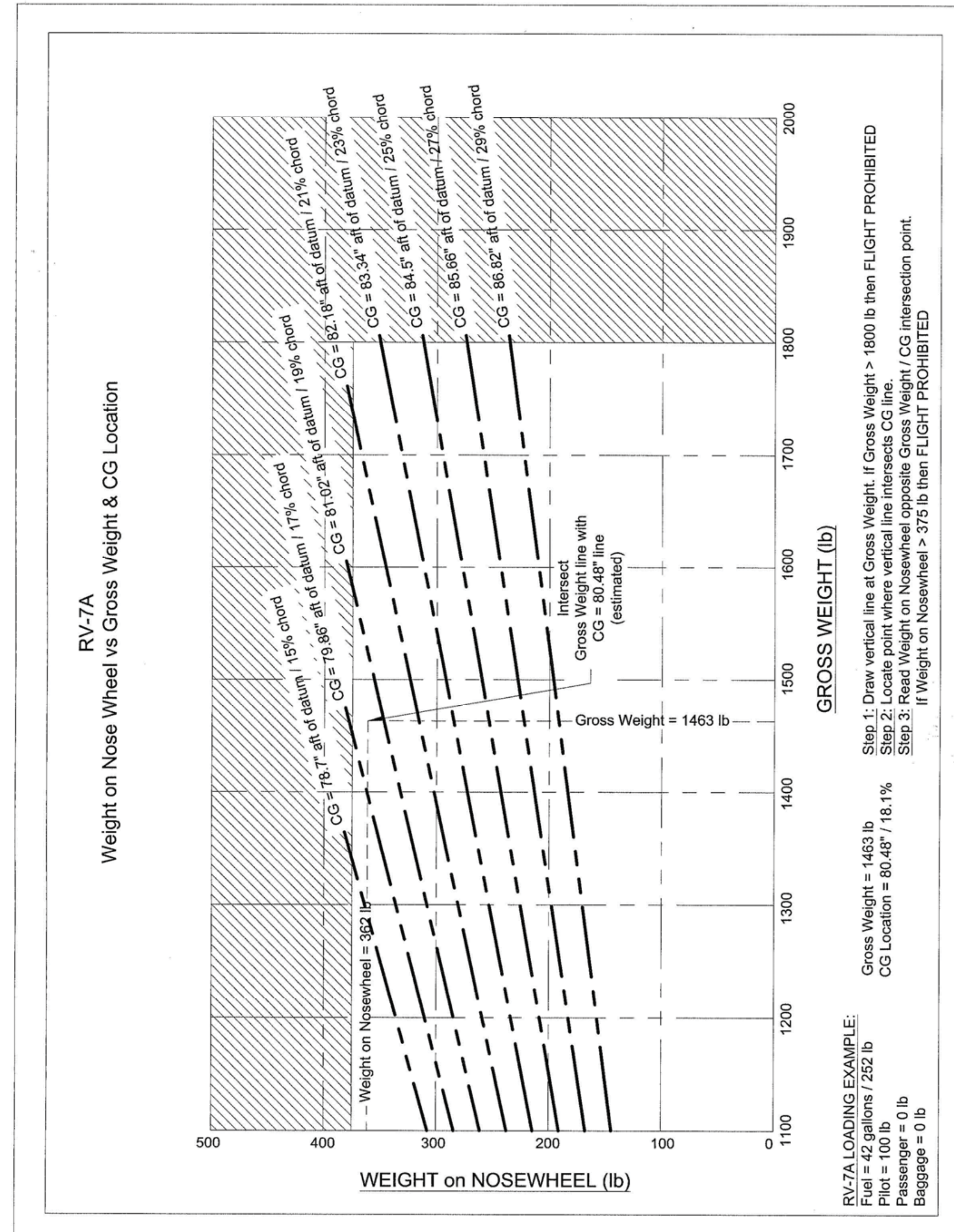


Main wheel, right ________________in. aft of datum.
Main wheel, left ________________in. aft of datum.
Nose wheel ________________in. aft of datum.

DETERMINING EMPTY CG

	Weight	Arm	Moment
Right Wheel	________	_____	__________
Left Wheel	________	_____	__________
Nose Wheel	________	_____	__________
Total:	________		__________

EMPTY AIRCRAFT C.G. =__________/__________=_______inches aft of datum.



SECTION 15. FINAL INSPECTION AND FLIGHT TEST

In the life of every homebuilder there comes the day when his airplane is finished and ready to fly.

Or is it?

For some builders the process has been long, sometimes several years. We learn from experience and we pass that learning along to our builders as needed. Before you undertake the test flying of your new airplane, check for **"Service Bulletins"** on our web site at www.vansaircraft.com. It is in your best interest to check this web site periodically to keep up with the latest improvements in your aircraft.

A reported 20% to 30% of homebuilt aircraft fatal accidents occur within the flight test phase (first 25-40 hrs.). Flight test statistics for RVs are far safer than this. However, these sobering statistics should provide the incentive to undertake flight testing in the most professional manner possible. Because the majority of accidents, perhaps 80-90%, result from pilot error, pilot "airworthiness" should be of paramount concern.

The last steps in building an airplane are a very thorough final inspection of both the pilot and the aircraft to assure that everything possible has been done to make it airworthy, followed by a carefully planned and organized flight test program to verify that the airplane not only flies, but meets all performance, stability, and handling goals.

One who builds a homebuilt airplane is known as an "amateur builder". However, we don't often use the term "amateur test pilot" to define his role during the flight testing of an airplane. In reality, the typical private pilot is terribly under-qualified to serve as a test pilot, at least when contrasted to the training and qualification of professional test pilots. Fortunately, the flight testing of many ABE (Amateur Built Experimental) aircraft consists of little more than a self help check out in a new airplane. Aircraft of proven design (such as the RVs), which have been accurately built from high quality kits, usually pose few challenges to their test pilots, even in the early hours of flight. However, this ideal cannot be guaranteed and no assumptions of unquestionable airworthiness should be made. A "test" pilot must be prepared for any irregularity which may occur.

The goal of this chapter is to help you do flight test planning and flight testing in a way that eliminates the need for you to demonstrate that you have the "right stuff". When it comes to flight testing, boredom beats excitement. This chapter will also help you gain a better knowledge of the fine points of the performance, stability, and handling qualities of your airplane. Put another way, we will try to teach you some of the things which test pilots need to know.

Using the first flight of your RV as the central point, we can consider two basic phases of testing: Pre-First Flight and Post First Flight.

PRE FIRST FLIGHT

Pre-First Flight activities include two main topics; inspection and preparation of the aircraft, and inspection and preparation of the pilot. Everyone agrees that the aircraft should be thoroughly checked over and made airworthy, but not everyone is as concerned about the airmanship of the pilot, particularly the pilot himself. They should be. After the first flight is completed, subsequent flights can be dedicated to increasing the proficiency of the pilot, improving his or her connection to the airplane, and exploring the performance and limits of the airplane itself.

The following sequence of inspection, preparation and flight test procedures has been compiled from a series of flight test articles authored by Tony Bingelis in the Jan-Mar. 1989 issues of *Sport Aviation,* a 1989 FAA Advisory Circular titled *Amateur-built Aircraft Flight Testing Handbook*, and insights from RV designer Richard VanGrunsven. Another more in depth and very valuable book is *Flight Testing Homebuilt Aircraft* by Vaughn Askew, published by the Iowa State University Press, and also available from Van's Aircraft.

INSPECTION AND PREPARATION OF THE AIRFRAME

Weight and Balance: Go over your figures one more time. How will the airplane be loaded for test flight? Will it be under gross? Don't fly the airplane with an aft CG condition. If necessary, add ballast and fasten it securely. Be sure the ballast will not interfere with the controls, or chafe on installed wiring and fuel lines. Carry plenty of fuel for the first flight, but limit it to no more than half your fuel supply.

Landing Gear: For RV-8 builders, assure compliance with the wheel alignment specification presented in Section 10 of this manual. If a tailwheel is installed, examine it to see that its pivot axis is vertical, or, preferably, slopes back slightly (trails.) Difficult runway handling often results when the tail wheel pivot axis is raked forward and the tire contacts the ground ahead of the imaginary projected pivot axis.

Be sure the linkage and springs on a steerable tailwheel are correctly tensioned. There should be between 1/4" and 1/2" sag in the chain/cable assembly.

Brake System: Check for positive pressure at the brake pedals. Both should have similar feel; a firm resistance after about 1/2" of pedal travel. The pressure should hold as long the foot pressure is held on the pedal. While holding the brakes, have someone try to push or pull the plane to make sure that the brakes are working. "Soft" pedals usually indicate the presence of air in the brake lines, require the system to be purged. Pedals that "bleed" down and need to be "pumped" up often indicate a fluid leak in the lines, master cylinder, or brake cylinder itself.

Flap Operation: Check the flap system through its full travel for freedom of movement. On manual flaps, have someone apply lifting pressure to the flap itself while you operate the flap handle to make sure the latch mechanism holds and releases as it should. Check to assure that the flap handle and/or flaps have travel limits and cannot be extended beyond the maximum intended position, causing an over-center binding.

Flight Controls: Your control system is vital to safe flight and requires very close scrutiny. Operate the rudder, elevator, and aileron controls through their full travel. Assure yourself that ALL the controls are connected, secured and safetied -- and that they all operate freely and smoothly and in the correct direction. No play should be permitted in the control hinges; sloppiness may induce flutter. Likewise the trim tabs must be free of excessive play. Review the control travel limits.

Design Travel in degrees	*Maximum Up/Down*	*Minimum Up/Down*
Elevator	30/25	25/20
Aileron	32/17	25/15
Rudder	35/35 l/r	30/30 l/r
Flaps	40–45	(32–37 RV-9/9A)
Trim Tab	25–35	

Fuel System: Check your fuel selector valve. Perform tests to assure that the tank indicated is actually feeding, and that the "off" position does stop the fuel flow. It must function easily with a definite click in each tank position. Verify that the engine will run in each tank position (except OFF, of course.) Smell fuel in the cockpit? Check the connections for each fuel line. A fuel leak cannot be tolerated.

Are your vent lines open (are you sure?) and properly exited outside the aircraft? Protect the vent openings with aluminum screen to keep the bugs out.

Propeller: Re-torque and re-safety the propeller bolts -- especially if a wood prop is installed. Recheck the track of the propeller to make sure the blades are rotating in the same plane. An easy procedure that should take about thirty minutes is shown in Section 12.

An out-of-track propeller condition can be corrected by placing a paper shim between the rear face of the prop and the mounting flange, on the side with the trailing tip. Common typing or copier paper can be used for the shim,. By loosening the prop bolts, a paper shim can be slipped in and the bolts re-torqued with a minimum effort. A single sheet thickness of copier paper is equal to a tip correction of about 1/16". After shimming, re-check for track. Repeat this process until the prop blades track within 1/16".

Propeller Shaft Extension Alignment: A less common but more serious problem than prop tracking is that of crankshaft prop flange misalignment. If the crankshaft flange is bent slightly, it would cause an out-of-track prop condition, if a prop were bolted directly to it without an extension. When a shaft extension is used, the prop becomes not only out of track, but off center as well. If this condition goes undetected, a serious vibration (out-of-balance)condition can result, even though the prop is balanced and in track.

Checking for an out-of-alignment flange and prop shaft extension is done with a dial indicator. Aircraft mechanics and machinists are familiar with this tool, and can probably help you with this test.

The dial indicator mounting stand (shaft) must be clamped to the engine and positioned so that its sensor tip is in contact with the front flange of the prop extension. Rotating the prop through 360 degrees will indicate an out of line condition. The prop extension can be shimmed straight using the same technique as for prop tracking.

Engine Controls: Verify direction of movement and security of attachment at the engine. This means somebody needs to check the movement at the carburetor -- takes two people to do it. Beware of possible spring-back or inadvertent locking in the linkage when any engine control is moved to its extreme position.

Checklists and placards: No excuses, you need them. Review them for accuracy, completeness, and ready access.

One pre-takeoff check list that is easy to remember is based on the letters in the word C I G A R E T T E. They stand for:

- **Controls:** Move and visually check for proper operation.
- **Instruments:** Check functioning of oil pressure, fuel pressure, tachometer, MP, and any other instruments which are in operation prior to flight.

- **Gas:** Check quantities in both tanks and set selector on the fullest tank.
- **Altimeter:** Set for field elevation
- **Radio:** Turn on and set primary and secondary frequencies needed.
- **Engine:** Run-up RPM to check mags, carb heat, and cycle prop if applicable. Set mixture full rich for takeoff.
- **Trim:** Set to take-off position. (for first flight, set trim at about 1/3 nose up travel.)
- **Traffic:** If non-controlled airport, check the traffic pattern for arriving and departing aircraft.
- **Extra Equipment:** (for initial flight, this might include a parachute and crash helmet. Check that they are fitted for function and are as comfortably and non-restricting as is practical. (1st flight equipment might also include a rabbits foot, 4-leaf clover, or St. Christopher medal. Avoid horse shoes, particularly from large horses, or race track losers)
- **Seat Belts & Shoulder Harnesses:** Check that they are fastened and tight. Also, check them for smooth operation and adjustment. Are the attachment ends secured and safetied?

Use any checklist you are comfortable with, as long as it includes all necessary pre-take off check items. The use of a "key" word as above is just a gimmick to help make the checklist easy to recall.

Canopy: Be sure that the latches work and are easily reached. In the event of a nose-over accident, the canopy will probably shatter and permit the occupants to exit. In the event of an in flight bail-out, an RV canopy may be jettisoned or opened. We hope. We know of nobody who has bailed out of an RV.

Electrical: Do all the radios work on all the frequencies? Do all the avionics and electric instruments perform their intended functions? Battery held down and vented? All lights functional? Ignition switch kills engine? (good ground connections?) Is it mounted securely and is the wiring behind adequately protected and separated behind the panel?

Fasteners: Cowling, inspection plates, and hatches: All fasteners in place?

PREPARATION AND INSPECTION OF THE ENGINE

Engine Operation: With the cowling removed, look the engine compartment over. Look for possible chafing of wiring, hoses, fuel, and oil lines. Secure all wiring and lines that need to be kept away from exhaust pipes. Disconnect the fuel line at the carburetor and perform a volume test on the electric boost pump. Pump fuel into a measured container and keep track of the time. The boost pump should supply enough fuel to keep the engine running at full power if the engine driven pump fails. Reinstall and double check the fuel line when you're done.

Operate the engine briefly through full power (not more than 30 seconds or as permitted by the engine manufacturer) to assure yourself that the acceleration and power is there.

Make a magneto check for both mags. Momentarily switch the ignition switch off (at idle rpm) to be sure the magneto ground connections are good and the engine will stop.

If necessary, adjust the idle rpm to that recommended for your engine. You don't want it to quit on throttling it back for landing. On the other hand, if the idle is too high, you may not be able to reduce the rpm enough to land.

When shutting the engine down with the mixture control, you should get a slight rise in rpm as the mixture control is moved to idle cut-off. Otherwise, the mixture should be readjusted.

If the engine exhibits fluctuating fuel pressure, excessively high oil temperatures, or cylinder head temperatures during ground operations, do not attempt to fly without correcting the problem. They will only become worse with the high power settings, and the relatively low speeds encountered during take-off and climb.

Finally, with the cowling and propeller spinner reinstalled, make a full power check to be sure the engine will accelerate and run smoothly at full power. Keep the airplane pointed into the wind to take advantage of the cooling air. Of course, the airplane should be chocked. It wouldn't hurt to tie it down during ground engine operations.

NOTE: Builders with a new or newly overhauled engine face a dilemma. A newly overhauled engine with chromed cylinders, or a new engine, must be broken in properly. The engine needs to be operated for several hours at high power or the piston rings will never seat. Unfortunately, this means that the engine temperatures during initial ground operation will be critical, and often the engine operations must be severely limited.

This usually precludes prolonged taxi testing and high-speed runway tests. Such a limitation, unfortunately, coupled with an untested airplane, creates a problem. It's ironic but this is a situation that gives all the initial advantages to the builder who has had to install a used engine in his airplane without overhauling it. He may not have a fresh overhaul, but neither does he have to worry about break-in problems. In addition, he can, ordinarily, perform all the taxi tests he

feels he needs, concentrating on testing the airplane rather than the engine.

An untested engine in an untested airplane doubles the potential for the unexpected happening. You must, whatever the status of your engine, operate it in strict conformance with the manufacturer's recommendations. Doing otherwise could result in serious engine damage, or at the very least, will cause it to burn a lot of oil because the rings failed to seat.

When engine break-in is a concern, perform flight testing without the wheel fairings and gear leg fairings. This will add around 15% to the airframe drag and thus cause higher engine temperatures at any given forward speed. Higher cylinder head temperatures, within limits, are necessary for seating piston rings (breaking in).

Is the carb heat connected and functioning properly? With the engine running and warm, application of carburetor heat should cause a definite drop in rpm.

INSPECTION (INTROSPECTION?) AND PREPARATION OF THE PILOT

Selecting the Test Pilot: Ideally, the amateur-builder should be competent in aircraft of the same general configuration and performance as that being tested. Often, though, the expense and time of building an airplane cuts into the money and time needed to maintain pilot competence and currency. These factors should be carefully and dispassionately considered when selecting a test pilot.

A test pilot should have at least the following qualifications:

- Be physically fit. Test flying an aircraft is a stressful and strenuous occupation.
- No alcohol or drugs in the system
- Rated, current, and competent in the same category and class aircraft .
- Current medical, flight review, and paperwork.

The test pilot should:

- Be familiar with the airport and nearby emergency fields
- Fly an airplane with similar characteristics. For example, if your airplane has a short low wing, take dual instruction in a similar type-certificated aircraft such as a Grumman Yankee. If you are testing a tail wheel airplane, instruction in a Citabria or Decathlon is recommended. A pilot is competent when he or she can demonstrate a high level of skill in all planned test maneuvers.
- Study the emergency procedures for the test aircraft and practice them in a similar airplane.
- Have at least an hour of practice in recovery from unusual attitudes within 30 days of the flight test.
- Learn everything possible about the performance and flight characteristics of the test aircraft. Read the manufacturer's or designer's instructions, articles by builders, watch videos, etc.
- Review the FAA/NTSB/EAA accident reports for the test aircraft.
- Should not undertake a test flight unless he is mentally and physically in tune. While no one should pilot any airplane when suffering from mental or physical stress, this is particularly true for test flying. Even a slight anxiety which might be overlooked for routine flying, should be reason to postpone test flying
- Become very familiar and comfortable with his working environment; the aircraft's cockpit. The pilot should spend as much time sitting in the cockpit as is necessary to become comfortable. Cushions should be selected which can be used along with a parachute to provide maximum comfort under the circumstances. All controls should be operated repeatedly to become familiar with their positions and functions. This includes engine controls as well as primary flight controls.

Beginning in 1995, RV Transition Flight Training was made available through an affiliate of Van's Aircraft Inc. Using RV-7 and RV-6A aircraft on loan from Van's, flight instructor Mike Seager has been providing transition flight training from his base at the Vernonia, Oregon airport. In addition, Mr. Seager has also provided this service at other locations in conjunction with trips to major fly-ins such as Sun'n Fun and Oshkosh. Customer satisfaction with this training has been unanimous. The results: more confident, competent pilots flying better test programs, lower insurance premiums, and very likely, fewer bent airplanes. Check our web site for other transition training instructors.

After the pilot feels that he is sufficiently familiar with the cockpit and controls, he should enlist someone's aid to help him conduct "blindfold" cockpit testing. Just as the name implies, this is done by covering the eyes of the pilot and having him carry out commands issued by an assistant. He should be able to select and operate all controls by position only; without visual reference. This testing should include emergency procedures such as loss of power and canopy ejection. Instinctively knowing the locations of everything in the cockpit will not only prepare the pilot for emergencies, but will prepare him to do routine flying with more accuracy, thoroughness, and confidence. (Rumors have it that spending time sitting the cockpit of unfinished airplanes is a pastime enjoyed by many builders. We understand that in some instances, this pastime is enriched by the would-be test pilot making engine sounds, and sometimes even machine gun sounds)

PRE FLIGHT PLANNING

An RV in proper trim is not difficult to fly or land. However, if the RV is a taildragger, the pilot should be proficient in tailwheel aircraft before attempting to fly one. Similarly, he should, if possible, have some exposure to aircraft with light control forces and quick response rates. But perhaps as important, he should plan his flight test program to systematically experience and evaluate all normal and emergency flight conditions. If the builder chooses to have someone else do the test flying, he should seek a pilot who not only has the necessary flying skills, but also the discipline to conduct the flight test program in a professional manner. This is opposed to the reports often heard about pilots of homebuilts who, on the first flight, take the plane up and "wring it out".

Some old Hollywood movies present the typical flight test scenario as one where the handsome, devil-may-care test pilot climbs the plane to its maximum altitude, puts it in a full power vertical dive, and after a seemingly endless descent punctuated with flashbacks and trauma, recovers just feet above the treetops. He is a hero, he wins the undying love of the leading lady, and his company gets the fat military/airline contract.

Sometimes it seems that this test flying image has become so ingrained in our aviation mentality that it is thought to be valid. Really, it bears little resemblance to test flying practiced today, whether in fighters or homebuilts.

In addition to the skill and proficiency considerations, a test pilot should be psychologically prepared. He should not be rushing to the extent that he is too tense and uptight to react properly. All pressure producing factors should be eliminated if possible. These include such things as pre-established test dates or times and large audiences. The important factor is that the pilot attempt the first flight only when he is totally ready. Typically, the builder has many friends who want to see the first flight, and in many cases there is a tendency to want newspaper and TV reporters on hand. While there is nothing inherently wrong with this, it does distract the pilot from making his flight preparations and cause him to attempt the first flight when wind and weather conditions are not ideal. We witnessed one test flight by a very experienced professional pilot in an airplane (not an RV) which was unknowingly badly out of rig. Nearly full aileron was needed to keep the plane level, and after one circuit of the field, the pilot barely had enough strength left in his arm to keep it level for landing. When asked why he didn't immediately land after lift-off (5000 ft. runway) he said "I didn't want to disappoint the crowd". This is obviously dumb. One way to prevent such dumb decisions is to eliminate the crowd. It would be better for the pilot to do the test flying in relative privacy and then invite friends and press out to see the "official" first flight.

WEATHER

The first flight of your RV should be attempted only under the best possible conditions. The best time to fly is early morning or late afternoon. The wind should be calm or light and right down the runway. Conditions are seldom ideal, but don't be so eager to fly that you accept gusty or crosswind conditions that will add to the workload of a first flight.

EMERGENCY PLANS AND PROCEDURES

On the way to the airport and after you get there, review your emergency plans, procedures and ground support needs.

Know what your ground support can and will do. Hopefully you did not invite a crowd. No first flight needs such distracting or tension inducing factors. This is not an air show. However, the first flight of a homebuilt, for most of us, is a once-in-a-lifetime event that should be appropriately covered. Try and get someone with a telephoto lens or video recorder to do the honors.
Emergencies do happen -- usually when they are least expected.
KNOW what you are going to do IF:

- The engine quits on takeoff.
- There's a fire on board and the cockpit fills with smoke.
- The airplane is terribly out of balance and very hard to control.
- You lose communications with your tower, support crew, or chase plane.
- The propeller throws a blade, or the spinner breaks.
- The throttle jams, full open, full closed or in between.
- One of the controls jams or a cable breaks.
- The engine temperatures rise rapidly past redline.
- Oil begins appearing on the windshield and the oil pressure drops.

- The canopy comes open unexpectedly.

Obviously these are not the only things that can happen without warning on that first test flight; however, they are probably the most life threatening.

Prepare yourself mentally and review the options and logical corrective actions you would take for any of these eventualities.

Keep this essential in mind. You must, regardless of what sort of airborne emergency arises, continue to fly and control that airplane.! DON'T LET IT STALL!! KEEP IT UNDER CONTROL!!! Fly it all the way to the ground if you have to, but the key words for survival are DON'T LET IT STALL!!

A stall too near the ground to permit recovery will usually result in greater damage and injury than would occur if the aircraft hit the ground at its best glide speed and angle. It is a normal tendency for the pilot to slow the aircraft to its minimum speed to try and reduce damage during a forced landing. But, an aircraft, which has stalled, is temporarily out of control, usually in a nose-down attitude. While it may have been at minimum speed just before the stall, it will probably have gained considerable speed by the time of impact. Even if it didn't, the impact angle will probably be steeper.

Injuries in aircraft crashes are the result of rapid deceleration. The shorter the stopping distance, the greater the deceleration rate. If the aircraft contacts the ground at a steep angle, the stopping distance will obviously be short, and the rate of deceleration high.

If the aircraft hits the ground at a shallow angle, its stopping distance will be greater. Even if the contact speed was higher, the deceleration rate will be less and the landing will be more survivable. Many factors, such as terrain and obstructions, will also affect the survivability of the crash, but the bottom line is that a controlled crash is better than an uncontrolled one.

If an accidental stall should occur during the early stages of an emergency (just after an engine failure or while trying to turn back, for instance) an innate, subconscious knowledge of stall recovery will be invaluable. As contact with unfriendly terrain becomes imminent, these words should echo through the pilot's mind: DON'T STALL!! KEEP THE NOSE DOWN!! DON'T STALL!!

SELECTING THE RIGHT AIRPORT

One of the first important decisions you must make is selecting an airport for flight tests.

Runways and surroundings: The airport you select should have at least one runway aligned with the prevailing wind. The runway should have the proper markings and a nearby, easily visible wind indicator. Avoid airports in highly developed areas or with heavy traffic. To determine the needed runway length you can use the following rule of thumb:

The runway should be at least 3000' long and 100' wide. If you are testing a high-performance aircraft or intend to operate at high density altitudes, the runway should be 5000' or more and at least 150' wide, for a greater margin of safety.

Scout emergency landing fields within gliding distance from any point in the airport pattern. Since 1983, engine and mechanical failures have accounted for 38% of amateur-built aircraft accidents. Since there is a possibility of this type of emergency occurring, appropriate preparations should be a mandatory part of your Flight Test Plan.

Communications: Even if the test aircraft is not equipped with a radio, it is still a good idea to conduct flight tests from a field with an active Unicom or a tower. Those using an uncontrolled field should set up their own communications base. Small, hand held radios should be borrowed or rented. The pilot should have a headset and a push to talk switch mounted on the stick. These help reduce the pilot workload. The added insurance of radio communication more than makes up for the rental fees.

Equipment: Your airport should have fully functional telephones, rescue, and firefighting equipment.

Other: Additional considerations when selecting an airport include available ramp and hangar space. You will need a place to run-up your engine and test aircraft systems on the ground, without fighting inclement weather, or distracting bystanders.

Make an appointment to talk with the airport manager, or owner, about your Flight Test Plan and emergency preparations. He or she may be able to assist you with communications, space or equipment.

EMERGENCY PLANS AND EQUIPMENT

Every test of an amateur-built aircraft should be supported by a ground crew; usually between one and four people. Their function is twofold: first, to help the pilot with the flight test and second, to assist in case of an actual emergency.

Every builder should develop two sets of emergency plans, one for in-flight emergencies, the other for trouble on the ground. The ground emergency plan should include a briefing for the ground support crew and airport fire/rescue crew on:

- the cabin door or canopy latching mechanism
- the pilot's harness and its release mechanism
- the location and operation of the fuel shut-off valve
- location and operation of the master and magneto switches
- battery location
- engine cowling removal procedures.

Everyone on the ground team should know the locations and phone numbers of the nearest hospitals, fire and rescue squads. If the test pilot has a rare blood type or is allergic to some medications, these should be noted and left with the ground crew. A "medic-alert" bracelet is also a good idea.

There should be several fire extinguishers available to the ground crew and a halon fire bottle in the cockpit. The pilot should have a tool capable of breaking or cutting through the canopy from the inside.

If the airport does not have a fire rescue unit, a four-wheel drive vehicle equipped with fire extinguishers, first-aid kit, tools to cut through metal, and a crew trained in first aid is a must. Sometimes, for a small donation to cover expenses, volunteer fire rescue squads will stand-by and offer the extra insurance of a trained emergency team.

The possibility of fire should be considered during all phases of flight test. Ideally, the pilot should wear coveralls and gloves of Nomex, but if this is not available, all clothing should be cotton or wool. Synthetics like nylon or polyester melt and stick to the skin when exposed to heat, making a bad situation much worse. A crash helmet and face-shield or goggles provide protection from flame, smoke or hot fluids. Protection from impact demands a helmet, or at the very least, a hard-hat, and a correctly installed and adjusted shoulder harness.

Professional test pilots always wear parachutes. "Homebuilder" test pilots often don't, probably because of the scarcity of parachutes in the private flying community, and the limited cockpit space for this extra piece of flight test equipment. Also, many homebuilders apparently view testing more in terms of a "check out" because their kit built RV is not the same as a radically new experimental design. However, because it *is* an amateur built airplane and because the airframe and systems *are* new and untested, we encourage builders to secure the use of a parachute to wear during testing. At the very least, a parachute should be worn while conducting limit testing, such as testing maximum speeds, G loads, and spin testing. The probability of needing the parachute is very low. However, if you happen to draw the short straw, it sure would be nice to have that "personal vertical descent retardation device" available.

Probably the simplest and most effective safety device is a good helmet. Crop dusters, helicopter pilots and test pilots have all made these standard equipment, and you can be sure they have good reasons.

PERFORM A PREFLIGHT CHECK

No matter what you know or think you know about the condition of your airplane, and no matter how recently you checked everything, perform a complete preflight check. Not only is it the law, it's a good idea. Use a prepared preflight check list. Do NOT overlook:

- The ignition switch is OFF, the throttle is retarded, and the wheels are chocked.
- Pull the prop through five blades. Check for compression on all cylinders, the little click that tells you the impulse coupler is working, visual inspection of the prop and spinner.
- Visually check the fuel and fuel caps. Use a dipstick. Drain a goodly amount of fuel from the sumps and check for water.
- Clean and polish the windshield.

OTHER IMPORTANT PREPARATIONS

Try and plan for all possible contingencies.

Transport: Assure yourself that your standby crew knows where the nearest phone is located and that they have the EMS and fire emergency numbers.

A car should be available and your dependable standby crew should have tools, a fire extinguisher and a first aid kit onboard--and possibly a two way hand-held radio.

Chase Plane. A chase plane can be used to monitor the first flight if a qualified pilot and observer are available. A qualified pilot is one capable of flying in formation close enough to permit viewing of your airplane to verify control surface positions, oil streaming out of the cowl, etc. The primary purpose of a chase plane is safety. A secondary purpose is as a camera platform to record this historic first flight. However, never confuse these two goals and be-

come too intent on the photography function. The test flight should not be unnecessarily extended in time or geography just for the sake of getting more photos or video time. Also, proximity of formation flight and/or maneuvers for photo purposes should not be allowed to compromise safety. Keep your priorities in order.

Pilot & Crew Briefings: Before your first flight, brief your crew and/or chase plane pilot of your intentions. Discuss your intended flight sequence and emergency procedures. Make sure that your chase plane pilot realizes that he is always to keep out of your way, or be prepared to get out of your way at any time an emergency may arise. Discuss radio frequencies to be used or hand signals to be used.

How will you know when the airplane and test pilot are both ready for the test flight? When you can no longer find any reason not to!!!!

TAXI TESTS

Try a number of taxi tests, no faster than a slow walk, to familiarize yourself with the steering and braking effectiveness, and to become proficient in handling the aircraft on the ground. Learn how much runway or taxiway width is needed to turn the airplane around. Pilots of tail wheel aircraft can make good use of the taxi experience to establish an over-the-nose attitude reference to help in making the first three-point landings.

If you decide to perform high speed taxi tests remember the real purpose for high speed taxi testing is to learn how the airplane feels or behaves just before reaching lift off speed, and just after touchdown.

For safety's sake, select an abort marker about halfway down the runway. You should be able to cut your power when you reach that point and still have sufficient runway left for a safe stop without burning up the tires and brakes.

High speed runs down the runway must be limited to approximately ten mph below the anticipated lift off speed, or about 40 mph. Therein lies a problem. An RV can take off at throttle settings no higher than those needed for engine run up and mag check. Thus, an inexperienced pilot who accelerates to 30-40 mph and then reduces power in an attempt to maintain that speed will probably retain too much power and continue to accelerate up past minimum flying speed. As a result, he may find himself up the proverbial creek without the paddle, or more accurately, off the ground without a plan.

Never attempt high-speed taxi tests until *both the airplane and the pilot are prepared for flight.* Accidental lift-offs during high speed taxi testing are not uncommon, and often lead to unnecessary accidents. It has happened to a number of RV builders.

Make a couple of runs with and without partial flaps. Half flaps is the recommended take-off setting. For a tail wheel aircraft this will cause the tail to seem lighter (easier to lift), and will shorten the take-off roll slightly for either tail wheel or tri gear models. .

Pay attention to the amount of rudder input necessary to counteract engine torque and to keep the airplane straight on the runway. Watch out for rapid applications of throttle at low speeds.

Glance at your airspeed indicator during the high speed runs to make sure it is working.

Monitor fuel and oil pressures, oil temperature, and cylinder head temperature. If any of these are suspect, return to the ramp immediately.

Keep the tailwheel on the ground with stick back pressure at low runway speeds until rudder effectiveness is obtained, especially in crosswind conditions. Be very careful when the throttle is reduced after a high-speed taxi run and the tail starts to settle. Inadvertent back pressure on the stick (too soon and too quick) might cause an unexpected lift off and difficult runway control problems.

"Controlled lift-offs," particularly on a runway less than 5000 feet long, are dangerous and should not be attempted by inexperienced test pilots.

THAT FIRST FLIGHT

With all the above completed, along with the other preflight items for your airplane, you are ready to go. Give your last minute instructions to your ground crew. Complete your pre-start checklist and start the engine.

Check your oil pressure and the rest of the instruments. Switch tanks and run the engine off each tank. Set the fuel selector to the takeoff tank. Taxi to the runway and complete your pre-takeoff checklist.

Clear the area, including the runway, announce your intentions and begin the takeoff roll by advancing the throttle smoothly to FULL power. Check for rpm and oil pressure. If you are not airborne by midfield, abort the takeoff. Allow the airplane to fly itself off with light back pressure on the stick--don't pull it off. Guard against an excessively nose high attitude.

Should you feel a vibration immediately after takeoff, try the brakes. Your tires may be out of balance. Immediately feel out the controls. Gently! Don't over control.

Check your airspeed indicator at liftoff. This will assure you the instrument is working and give you a rough idea of landing speed.

Climb out at a shallow angle, easing the flaps up if you used them for takeoff. Start a gentle turn as you pass through 500' AGL so you won't get too far from the field.

Don't even think of changing the throttle unless engine temperature or rpm limits are being exceeded. Many engine takeoff failures seem to be related to the initial power reduction.

Turn off the fuel boost pump.

Check the engine pressures and temperatures. Staying over the airport, climb to 3000' AGL.

At altitude, reduce power and trim for cruise flight. Keep monitoring the engine gauges and be alert for strange vibrations or noises.

Everything is OK? Good. Relax.

Clear the area and make a few approaches to stalls, both power on and power off. Complete stalls are not necessary. Merely slow the airplane to the point where the controls get mushy or you detect a light pre-stall buffet. Note your indicated airspeed. Also note the nose-high attitude at stall which will be approximately the same as the landing attitude. Repeat the approach-to-stall exercise with half flap and then full flap conditions. Note the pressure needed to bring the plane down to stall speed, and the difference in pressure with and without flaps. Avoid the temptation to try anything more, other than practicing some shallow and medium bank turns. Gliding turns can also be practiced, concentrating on maintaining a steady speed of about 90 mph IAS. There will be plenty of flights after this one to explore other flight regimes and maneuvers. The first flight should be short -- 30 to 40 minutes. Relax and have the chase plane come in closer to visually check over your airplane, and make some videos. While you're flying side-by-side, compare airspeeds and power settings, especially at approach speeds.

LANDING

Complete your pre-landing checklist. Announce your intentions and enter the pattern. Make your approach speed 1.5 times the approach to stall speed you noted earlier, usually around 80-90 mph for a typical RV. On landing approach base leg, one notch (or about 20°) flap setting should be applied. One notch, 1/2 flap is suggested for the initial landing. The 80-90 mph approach is a little faster than ideal approach speed, but will be best for the first landing attempt because it will permit more time to execute the landing flare. A tail low, "three point" landing is suggested for the first attempt. Remember the nose high attitude experienced in the power off stall approaches. If the wheels touch before you have fully flared the plane, just release a bit of back pressure to prevent ballooning into the air again, and call it a semi-stall landing. If you should accidentally hit hard enough to cause a sharp bounce back into the air, apply power and make a go-around for another landing attempt. Unless the runway is very long, it is probably better to start over rather than to try to salvage a bad landing out of an abnormal condition (bouncing back into the air at an unusual attitude or speed.)

On tri-gear planes, land on the mains and hold the nose wheel off as long as possible. The nose wheel is taxiing gear, not landing gear. Keep the stick full aft while you taxi.

Try to touchdown a safe distance past the threshold. Concentrate on keeping the airplane straight and let it roll out. Stay off the brakes if you can.

Taxi carefully back to the ramp and to the congratulations you have earned. It's OK to wave and grin at your friends now.

POST FIRST FLIGHT

The initial test flight proved your airplane will fly and that it is controllable. Now you have to prove to yourself that it can perform safely under a variety of service conditions. This means you should now begin to gradually and carefully expand its flight envelope. Approach the second flight with the same concentration and preparation of the first. After all, there's still much you don't know about this airplane.

For example, your initial flight was probably made with less than full fuel and with a minimum payload. But how will the airplane behave with full fuel, and at gross weight? Will the CG stay within safe design limits?

Although you may have been pleased with the controllability and flight characteristics exhibited on that first flight, be realistic and accept that you may yet have to face up to some quirks that may not show up until all limits of the flight regime are explored.

At this early stage, it's normal to experience a degree of a concern regarding the airplane's controllability in the high speed ranges, and most of all regarding its freedom from flutter. These particular evaluations are considered critical and are potentially the most dangerous characteristics to explore. The only way to get all the answers is by working the airplane through a variety of flight conditions while gradually working up to the maximum performance limits.

EXPANDING THE ENVELOPE

Before you fly again, check the conditions in the engine compartment. You can't be too careful at this stage. Remove the cowling and look for fuel and oil leaks, loose clamps, wiring problems, and the security of all installed components. It might be advisable to remove all the inspection covers and check inside. Repeat this inspection every ten hours or so for the test period.

Start your evaluations by systematically performing all ordinary maneuvers. They should include the following:

- climb performance tests
- service and absolute ceiling tests
- slow flight
- stalls
- stability tests
- airspeed calibration
- fuel consumption
- prop evaluation
- CG loadings
- performance checks

Other, more potentially dangerous tests, may be deferred. These include spins, flutter testing, and aerobatics. Each new maneuver and test will reveal more and more about the airplane. In addition they will sharpen your skills in handling your new craft.

Repeat tests, if necessary, until you are satisfied with the airplane's responsiveness and your abilities. Don't slight any of the easy, simple-to-do tests-- you're not going anywhere for the next 25 to 40 hours anyway.

It's a sobering thought, but you must realize that every test involves some element of risk. Think through and rehearse your options ahead of time. Prepare as best you can for the unexpected.

PERTINENT THOUGHTS

Plan to devote the first portion of each flight to one or two test elements. Don't waste time simply boring holes in the sky. Know exactly what you want to accomplish during the flight before you take off. Think out how you will do it and approach every test carefully and cautiously. Complete only the test items you have planned - no more. Then you can spend a bit of time sight-seeing and enjoying.

Record all your observed results -- instrument readings and flight data. Use a kneeboard or a small pocket recorder. Don't trust to memory.

Tests flown in windy or turbulent weather are often so inaccurate as to be useless for recording performance data. Pick your weather carefully.

After each flight, debrief yourself. Review what you did: wrong and right. Give yourself time to absorb what you have learned.

Whenever some small problem occurs; some unexplained vibration, a slight binding of the controls or the like, correct it before the next flight. NEVER let things go.

CARRYING PASSENGERS DURING PHASE I TESTING:

FAR's dictate that during Phase I testing of Amateur built aircraft, the aircrew shall be limited to essential crew only. Van's Aircraft, Inc. interprets this in RV's as solo.

TYPICAL TESTS

Best Rate Of Climb: Use full throttle and check the rate of climb for several different airspeeds. Start at a fairly low altitude, stabilize your airspeed in climb and begin your timing as you pass the next thousand foot level. Note the time as you pass through each thousand feet of altitude. Make climbs of 4 to 5 thousand feet altitude gain. Normal anticipated indicated climb airspeeds will vary from 100 to 140 mph. Repeat the climb tests for each airspeed so that differing readings can be averaged.

Best Angle Of Climb: After climb tests have been made at normal anticipated speeds, perform timed climbs at indicated speeds of 90 IAS, decreasing in 10 mph increments, down to 70 mph. At the lower speeds, watch cylinder head and oil temperatures carefully to avoid overheating. Limit low airspeed climbs to 2 minutes or less for cooling reasons.

Plot Climb Charts: Following the procedure outlined here, plot on graph paper a climb curve for various airspeeds. After the points have been located for climb rates at different speeds, draw in a smooth curve which connects all points. Because of testing inaccuracies, the climb curve can be drawn to a smooth shape which approximately contacts the points. The speed for maximum climb rate is that at the top of the curve. As the speed increases past that point, the climb rate will decrease until it is zero at the airplane's top level flight speed.

Draw a straight line from the 0-0 beginning point of the chart up to a point where it is tangent to the curve. This point will be the BEST ANGLE OF CLIMB SPEED.

Plot another curve of climb rate vs. altitude for the best climb rates for each altitude. The best rate of climb will of course be at the lowest altitude, and will decrease with increasing altitude. A line connecting these points will be a straight line, and an upward projection of this line will provide the theoretical absolute ceiling of the airplane. The service ceiling would be the altitude at which a 100 fpm climb rate is indicated. On the other end of the line, where it intersects the "0" altitude line, will be the SEA LEVEL climb rate. Using these graphs, reasonably accurate ceilings and sea level climb rates can be found without ever flying at those exact conditions.

Slow Flight: The idea is to become familiar with the trim and attitude changes that take place while you are trying to maintain your altitude at minimum flight speed. Careful, you could stall unexpectedly. Do these maneuvers at a safe altitude. Try a few level turns with and without flaps. But, do a lot of slow flight practice. Practice until you can consistently maintain speeds within 5 mph above stall speed while transitioning from wings level through 15-20 degree banks to the right and left. The idea is to become so familiar with slow flight that it can be done almost subconsciously; being able to devote thought to traffic and other considerations at the same time. You want to be very familiar with the slow flight mode so that you are able to make landing approaches safely even with the distractions which are bound to occur, and to be able to detect the approach of stall speed even while dividing your attention to other factors such as traffic and ground obstructions.

However, watch your engine temperatures while practicing slow flight. The reduced cooling airflow, coupled with the relatively high power required for slow flight, will cause the engine to heat more than at cruise conditions. Slow flight practice sessions will probably have to be limited in duration for this reasons.

Years of experience gained from reviewing accidents and flight control problems have shown that a better mastery of slow flight could have prevented many accidents and minimized flight difficulty problems. ABE accident statistics show that 18% of accidents occur on takeoff and 33% on landing. Both of these flight regimes involve slow speed flight and the need for control under these conditions.

Takeoff: There are a few critical seconds following takeoff where flight must be controlled within a few mph of stall speed and where wind turbulence can significantly affect attitude, controllability, and airspeed. Even further into the takeoff/departure sequence, climb speeds can deteriorate to critically low margins because of turbulence, wind shear, obstacle clearance requirements, and other distractions.

Landing: The historical evidence of landing approach stall/spin accidents should be sufficient evidence of the need for a high level of pilot familiarity with low speed controllability. Slow flight skills are also of great importance to the final phase of the landing; pre-touch down. Particularly for tail wheel airplanes making full flare, 3 point landings, the last few seconds preceding touch down are crucial. Look at it this way. The pilot must keep the airplane under control within a few feet of the runway, within a few mph of stall speed, and in a straight line relative to the surface. Are these the circumstances under which slow flight should be learned? Of course not! Learn at altitude when time and distance(altitude) are in your favor. Then as you approach the critical landing sequence, many of the needed skills will have already been acquired.

Gliding Tests: In the event of an engine failure, it would be nice to know what airspeed will give the minimum gliding angle. These tests, logically, are most effectively performed following your climb tests because you could then use the altitude gained.

Start with plenty of altitude and complete your last practice turn at least 1000' AGL. Clear your engine briefly after each 90 degree turn. If you don't have a VSI, time your descent through different thousand foot levels.

To learn how your airplane behaves in gliding turns practice a few and note how the rates of descent change with airspeed and bank angle. It is important to keep your gliding turns coordinated. Try doing them at different airspeeds and record your observations.

Practicing these gliding turns is essential because you will be duplicating them each time you turn final for landing. Be careful -- an excess of uncoordinated rudder input (slip or skid) and excessive back pressure on the stick can cause the airplane to snap over the top, or snap under to an inverted attitude. At traffic pattern altitude, this can be fatal.

Determine and record how much altitude is ordinarily lost in making a 90 degree gliding turn, a 180 degree and a 360 degree turn. Make similar checks with partial and full flaps.

Plot Glide Speeds: On the same graph as climb performance, plot points for gliding rates of descent (sink) at various speeds tested. In addition to the rates of sink listed for the various speeds, a tangent line can be drawn to find the speed at which the best glide angle can be attained. By converting MPH to FPM forward speed, and then dividing by the sink rate in FPM, the glide ratio can be found.

While these sink rates and speeds are valuable guidelines, they are not totally representative of those which might be experienced during an actual engine failure emergency. At idle power, a fixed pitch RV will show a better glide ratio and angle than it will at zero power and the prop windmilling. The glide ratio with the prop windmilling (no combustion) will be better with the throttle open than if it were closed. The bottom line is that the pilot should be able to visually access the glide performance on the spot and plan his power off approach accordingly.

Engine Cooling Checks: Monitor and record engine temperatures on every flight. However, you should also study and record the effects produced by aggressive mixture control manipulation, changes in airspeeds, and changes in power setting. Prolonged climbs and glides will probably produce dramatic changes in engine temperatures and you should know to what degree. Remember, hot summer free air temperatures can intensify high engine temperature indications - often to a critical degree.

STABILITY INVESTIGATIONS

One of the more subjective areas of flight testing is that of aircraft stability. It is necessary to check for stability in all three axes, LONGITUDINAL (pitch), LATERAL (roll), and DIRECTIONAL (yaw.) Stability testing cannot be accomplished until the airplane has been checked for trim and any external tabs needed have been installed and adjusted to permit control free (hands off) flight. Before describing how to perform stability checks, we'll first define what the various forms of stability are.

- *Longitudinal (Pitch) Stability*: The tendency to remain at a constant trim speed, and to return to a that trim speed after being displaced by a pitch control input.
- *Lateral (Roll) Stability:* The tendency of the bank angle to remain constant, or to return to wings level.
- *Directional (Yaw) Stability:* The tendency of an airplane to maintain a directional heading when wings are level (no roll), and to return to a steady heading after release of a yaw input control (rudder).

Before describing the testing procedure, lets review some theory:

C.G. Considerations: While performing stability checks, it is important to that the pilot recognize the effects of the position of the C.G.

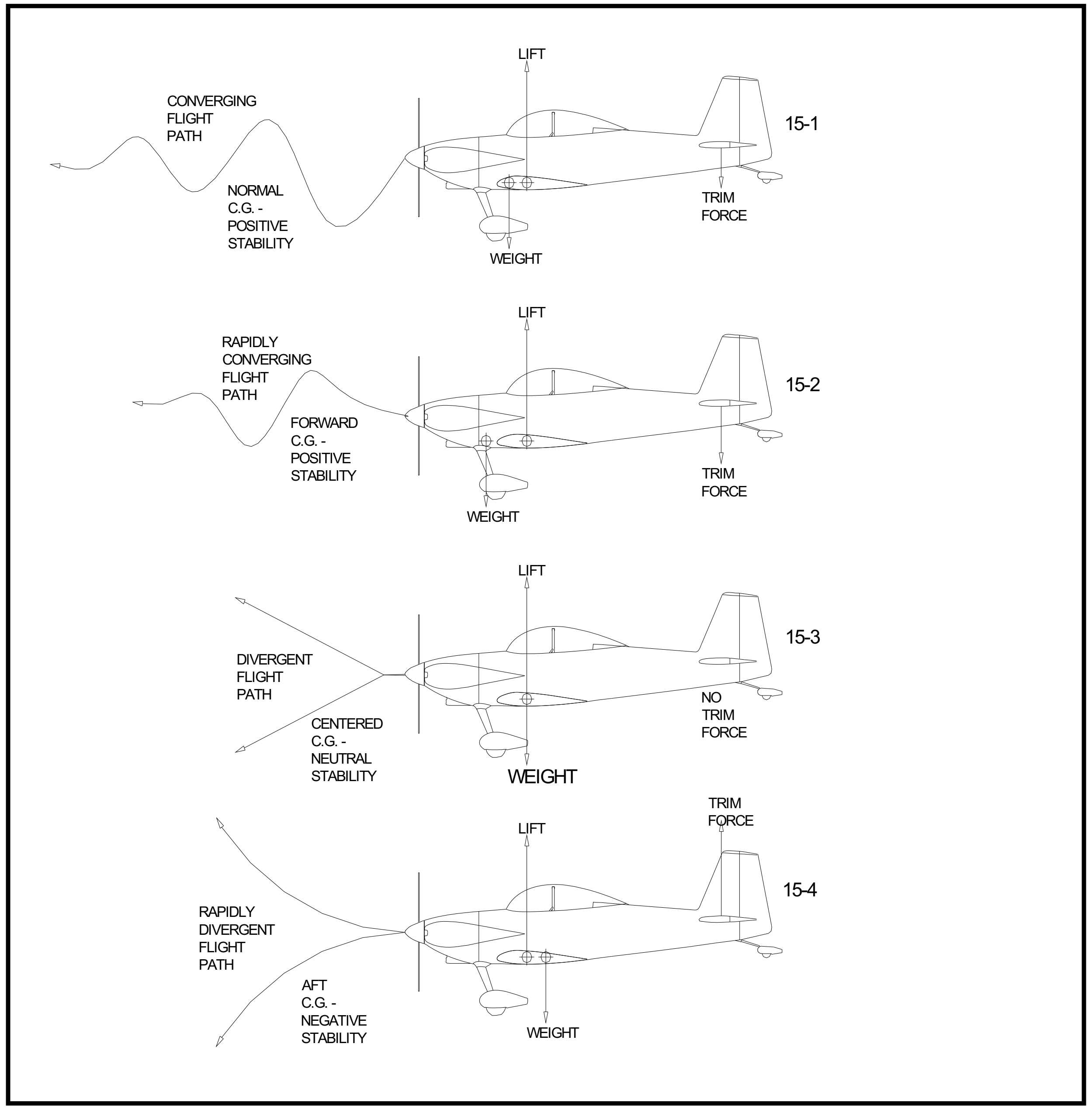
Pilots have all been exposed to the term "aft center of gravity" and are aware that this is a condition which has limits and is normally referred to in a precautionary tone. But, how well do you understand all of the ramifications of aft C.G. conditions? Perhaps you know that this is a condition to be avoided when doing aerobatics, but do you know how to recognize the symptoms of aft C.G. in normal flight conditions, or the problems which may be encountered under "normal" conditions as a result of an aft C.G. condition?

Fig. 15-1 shows the basic forces acting on an airplane. This airplane is designed to have positive stability with the C.G. located as shown. It is in equilibrium at a design cruise speed. The nose down tendency caused by the C.G. being forward of the center of lift (C.L) is balanced by the stabilizer down load resulting from the negative incidence angle (relative to the wing angle) of the stabilizer. So, a constant static load is balanced by an aerodynamic force which will vary with airspeed. If the aircraft's nose is lowered, an increase in speed will result, and that will cause a greater down-load on the stabilizer, which will in turn raise the nose again to bring the speed back to where it started. The converse will happen if the nose is raised. However, the aircraft will normally overshoot its original trimmed attitude and speed. Thus, there are usually several cycles of pitch hunting required to return to stable flight. Each cycle is of decreasing amplitude (altitude variation). These pitch cycles are called "phugoids".

Fig. 15-2 shows the aircraft loaded to a more forward C.G. condition, for which an elevator trim force is needed to maintain equilibrium. Generally, a nose heavy airplane is more stable because of the greater difference between the static weight position and the dynamic force of the trimmed elevator.

Fig. 15-3 shows the aircraft loaded so the C.G. and the Center of Lift are at the same point. Thus, no stabilizing trim load would be required of the tail. But, if there is no trim load, there no restoring load, and thus no positive stability. In this condition the aircraft would have neutral stability. It would continue to fly at whatever attitude it is placed or displaced to.

Fig. 15-4 shows the aircraft loaded to an extreme where the C.G. is aft of the Center of Lift, and where the horizontal tail surfaces must produce a lift force to maintain level flight. In this condition, when the nose is lowered, speed will increase and the stabilizer force will increase. But, since it is a lifting force or upload on the tail, it will continue to lower the nose and produce more lift and more speed. etc. If the nose were raised and the speed decreased to below trim speed, the reverse would occur; speed would continue to drop until a stall occurred, recovery from which would be difficult and spin entry would be probable. This is an unstable condition because the forces acting on the aircraft are destabilizing with a change in speed. In this condition the aircraft is PITCH DIVERGENT and is extremely difficult to fly and dangerous.



In summation, as the C.G. moves aft the aircraft will go from having positive stability, to neutral stability, and then to negative or divergent stability. The drawings show the aircraft with neutral stability retaining the attitude to which it has been pitched. The negative stability aircraft is shown with a flight path diverging from the intended flight path.

Not all airplanes will respond to C.G. positions exactly as shown because most airfoils exhibit a shift in their center of pressure as speed changes. This simplified explanation is sufficient to understand the basics of pitch stability.

FLIGHT TEST PROCEDURE:

Longitudinal Checks: Trim for level flight at cruise power. Raise the nose to lower the speed to 10 mph below trim speed. Release the stick. The airplane should nose down and the airspeed will increase to above the initial trim speed. Then the nose will again begin to rise and the speed will again fall to a value below the trim speed. This process will repeat itself for 3 to 4 cycles with decreasing speed excursions until trim speed is again established and maintained. This is an acceptable phugoid behavior and will approximate the flight path depicted in Fig. 15-1 and 15-2. This test should first be done at a forward C.G., usually solo. Then repeated with progressively more aft loadings up through the aft limit. All RV models should exhibit a positive pitch phugoid.

However, at aft loadings, the phugoid will be very long.

It is essential that the atmosphere be very stable while conducting these tests. If not, the results will be inconclusive. Also, the aircraft must be in good roll and yaw trim so that stick free flight can be maintained over a period of minutes needed to experience a complete series of dampening phugoid cycles. Because RVs tend to have neutral roll stability, and because of limited yaw/roll coupling, (rudder input has very limited effect on roll) it is often difficult to maintains wings level for these tests. A light string or rubber band can be attached to the top of the stick and used to apply a light roll correction without disturbing the pitch trim (stick freedom).

Repeat this test at an airspeed of 1.5 Vs (clean stall), or about 90 mph IAS. At this speed a typical RV exhibits weaker pitch stability than at cruise speed.

The worst pitch stability configuration will be a full power climb at low speed such as the 1.5 Vs condition. Particularly at an aft C.G., an RV will probably exhibit neutral or negative pitch stability. RVs with higher HP and/or low pitch (CS) props will be the least stable in this condition because of the pitch-up effect of higher thrust. Also, steeper climb angles associated with high thrust will diminish stability due to the adverse pendulum effect of the C.G. vs. the Center of lift of a low wing aircraft.

From the above flight test observations, we have learned that greater pilot attention will be needed under certain conditions. Since pitch stability will be less at low speed/high power conditions, the pilot must be more vigilant about monitoring indicated airspeed. For instance, during a steep departure climb a pilot can easily become distracted from monitoring airspeed, or the effects of turbulence can alter airspeed control.

The reduced stability of the power climb profile will be further accentuated in the classic very steep climb following a buzz job. Many pilots have been lost through attempting this dumb show-off stunt through lack of attention to the fundamentals covered above.

Stability and its Adjustments: Aircraft stability is rather complex field, generally beyond the grasp of the average builder/pilot. We will attempt to explain a few of the basics to test and what to watch for. The most obvious is probably pitch stability. When loaded within C.G. limits, an RV should have positive pitch stability. This means that when it is displaced in pitch (nose up or down) from a previously trimmed speed, it will return (hands off) to this trimmed speed within three oscillations. Factors, which might counter this stability, are aft C.G. loadings, and elevator trailing edges with a greater radius than the plans show. A large radius trailing edge on the elevator would tend to give lighter stick loads, and would probably manifest itself in a "hunting" or horizontal bobbing tendency. If so, a correction can be made by decreasing the radius by the clamping block method described in the empennage section of this manual.

When flying in turbulence, the aft loaded, less pitch-stable airplane will tend to pitch up or down due to the turbulent air and that pitching will intensify in magnitude unless corrected by the pilot. RV Pitch control forces are light and any over-controlling will require an opposite pressure to correct. A pitch divergent airplane will be much more demanding to fly and much more dangerous as well. Rather than a designed balance of weight and aerodynamic forces, the pilot is required to supply stabilizing control forces.

Production airplanes have had C.G. limits established which if adhered to will prevent the airplane from exhibiting characteristics of neutral or negative stability. The same is true for our RV sportplanes. However, because the testing of our prototype airplanes is not necessarily as technologically advanced and thorough as factory testing of type certificated airplanes, and because each of the RVs has a different manufacturer (homebuilder), we are less able to assure uniform stability characteristics for all RVs. For factory airplanes as well as for RVs flown at or near the aft C.G. limits, control responses approaching those described for neutral stability can be expected.

The normal loading of an RV, particularly a tandem seat RV-4 or RV-8, results in wide shifts in C.G. position. Aerobatics, because the associated unusual attitudes, are much more likely to result in accidental stalls and spins, than is non-aerobatic flight. Aerobatics performed at an aft C. G. condition can be hazardous both because of the light pitch control forces which can lead to accidental stalls and spins, and because recovery from those stalls and spins will be more difficult because of the aft C.G. In addition, the light pitch control forces and reduced pitch stability lead to the possibility of over controlling and thus over stressing the airframe.

For non-aerobatic flight, the aft C.G. condition is still a serious concern for normal everyday flying. This is primarily because of the statistical prominence of the landing approach stall/spin accidents. Light planes of all types have been plagued with this curse ever since the early days of powered flight. The compromise, which sport aircraft designers have to make, is between airplanes with very limited control authority and good stall/spin resistance, and those with good control authority and a lesser degree of stall/spin resistance. This design compromise is evident in all light aircraft with the exception of a couple of purportedly "spin proof" airplanes. In the RVs, the design choice of strong control authority for aerobatics and STOL flying has relegated some of the responsibility for stall/spin avoidance to the pilot.

Now, just what does this mean to the pilot; what changes in control forces and control response does he experience when flying at or near the aft C.G. limit? When flying in a condition of equilibrium the pilot doesn't necessarily notice any difference between the loading conditions. But, as soon as any pitch maneuvering is initiated, or turbulence upsets the stable pitch attitude, handling qualities are noticeably changed. The stabilizing force will be slight—it will take much longer for the aircraft to return to trim speed if flown hands-off.

However, pitch control (elevator) forces will be much lighter, increasing the possibility of over controlling.

It is obvious that the effects of an aft C.G. position on pitch stability demand extra attention to airspeed control when flying near minimum speeds. Very little change in control stick position and pressure will be need to induce a stall. Since landing approaches are made at near minimum speeds, coupled with the distractions of air and ground traffic, tower conversations, crosswinds, turbulence, and low altitude turns, they constitute an ideal situation for an accidental stall. An aft C.G. just makes an accidental stall easier to encounter, more prone to degenerate into a spin, and more difficult to recover from if it does occur.

To avoid falling prey to a approach stall/spin accident, pilots should do several things:

- He should practice slow flight with the aircraft loaded at or near aft C.G. limits.
- He should practice stalls and stall recovery from simulated landing approach conditions; speeds, power settings, banks angles. etc. He should learn to recognize the onset of the stall, and practice immediate recovery. (forward stick to break the stall, add power to gain speed and control response, and level the wings for added lift.)
- Landing approach stalls should be practiced at C.G. conditions up to but not exceeding the aft limits of the aircraft. Practice should include stalls in a medium to steep banked turn with inside rudder, the conditions which might be encountered on a 'tight turn to final". Only through practice can a pilot gain the experience necessary to make a safe stall recovery with a minimum altitude loss and with a maximum of controllability. *Adjusting Pitch Trim:* The pitch stability of the RV was designed to be achieved by a small positive wing incidence angle and a stabilizer incidence angle of zero. Ideally, the elevator trim tab should be in neutral position or slightly up (nose down) in cruise flight conditions and mid-C.G. range loadings. The leading edge of the elevator counterbalance should be slightly higher (approx. 1/4" for RV-6 & 8, and 3/8" for RV-4) than the stabilizer in these conditions.

Trim tab positions can be checked either by viewing from a chase plane, by marking of the trim control in the cockpit, or by leaving the trim control in the "cruise" position throughout the landing, and then visually checking its position after the flight.

Adjustment of the stabilizer incidence angle is recommended if the cruise position of the trim tab is more than 10 degrees up at cruise. The only correction for this is altering the incidence angle by repositioning the forward spar of the stabilizer up or down. The amount of re-adjustment needed will be determined by trial and error. Add or subtract spacers (washers) under the bolts which attach the front stabilizer spar to the fuselage. By adjusting one washer thickness (1/16") at a time, the desired trim can be attained. Repositioning the stabilizer will require an alteration of the stabilizer root fairing, so should only be attempted after careful testing to determine the necessity.

DIRECTIONAL (YAW) STABILITY:

An off-center skid ball, and/or a roll tendency that increases with speed are common for many new airplanes. Small trim adjustments should be made so the airplane flies straight and true in a stick free mode.

To test directional stability and trim, establish and hold level flight. Remove your feet from the rudder pedals. If the skid ball is does not remain centered, rudder trim will be needed. Apply rudder as necessary to center the ball and determine whether "right or left" trim will be needed. A fixed wedge type trim tab can be added to the rudder. Unlike tabs which stick out past the trailing edge, these do not alter the planform profile of the control surface, yet are very effective. A temporary tab of this type can be made of wood, sawed into a wedge about 3/8" at the thick edge and 1 1/4 to 1 1/2" wide. This can be temporarily taped on to the rudder trailing edge near bottom and adjusted simply by trimming the length. Attach to the side of the rudder opposite that of the rudder pedal effort needed to center the ball. It may take several flights to determine the exact size. Then the temporary wedge can be replaced by a wedge made of machined aluminum, plastic, or sealed wood, and attached with flush pop rivets.

Destabilizing effects of wheel fairings and gear leg fairings. When checking directional trim, don't overlook the effect of gear leg fairing mis-alignment. Though the gear leg fairings have a relatively small area, and are located near the center of rotation (C.G.-Center of lift) of the aircraft, they can have a profound effect on directional trim. This is because the destabilizing influence of are forward is greater than the stabilizing effect of area aft. It is a good idea to check directional trim with and without the gear leg fairings in stalled. If there is more un commanded yaw with the gear leg fairings installed, their alignment should be altered until the yaw is no greater than without them. Then final trim can be accomplished with a rudder tab. Re-aligning the gear leg fairings can be unpleasant because of the need to alter (re-mold) the intersection fairings at the wheel pant or fuselage. However, we cannot emphasize to strongly the amount of yaw which can be caused by as little as a 1/4" trailing edge misalignment of a gear leg fairing. Simply adding an oversize trim tab to the rudder is not acceptable. While it would correct adverse yaw, it could also cause spin recovery to be adversely affected.

Directional check:

Directional (yaw) stability is tested by establishing and holding level flight. Apply hard rudder to yaw the airplane in one direction and quickly release the pressure, keeping both feet off the pedals. The airplane should immediately return to aligned flight. In RVs, the yaw correction is so fast that an overshoot to yaw in the opposite direction will occur. Usually, 4-6 overshoots of decreasing intensity will occur before the yaw will dampen out. (An overshoot is an excursion to either side. A complete yaw cycle comprises 2 overshoots.)

Direction stability in a typical RV aircraft is quite positive. When a hard yaw is induced, the dampening cycles are rather short period—almost difficult to count fast enough. If a slow damping cycle is experienced and the overshoot count is high, it could be evidence of an improperly formed rudder trailing edge. Check to see that the trailing edge meets design and construction criteria. (see rudder drawings and the appropriate Figure in Section 6.) Rudder control is affected by blunt trailing edges in a manner similar to the elevators.

LATERAL STABILITY FLIGHT TEST;

Lateral check: Trim pitch control (elevator trim) for level flight and hold a heading with the rudder (if aircraft not in directional trim). Also, if an aileron trim system is installed, it should be set at center or neutral. Release the stick and note any roll tendency or "heavy wing". There is a good chance that any given RV will be out-of-trim laterally, requiring a small fixed tab on one of the ailerons to maintain neutral stability. However, remember that a fixed trim tab provides complete correction at only one speed, and should be set for the prevalent speed, usually cruise. Varying fuel loads in the wing tanks can either offset lateral stability or to a limited degree, be used to correct a trim imbalance. When checking aileron trim, right and left side fuel loads should be near equal.

Aileron trim is traditionally achieved through use of trim tabs as described for elevator and rudder trim. Because of the structure of RV ailerons, another means of trim adjustment is possible. This is through alteration of the aileron trailing edge bend radius. This does not apply to the RV-9/9A ailerons. The theory behind this phenomenon is thus:

The high pressure air on the lower surface tends to flow up around the trailing edge into the lower pressure on the upper surface. The size of the trailing edge radius affects these flow patterns and thus causes the aileron to lift or drop because of the "jet" effect of the attached airflow being deflected upwards. Altering just one aileron will have the same general effect as adding a trim tab.

Before installing trim tabs or altering the trailing edge of the aileron as described below, check aileron alignment carefully. If the vertical alignment of the ailerons differs visibly (i.e.: the nose of one aileron is noticeably higher or lower than the other when the ailerons are in neutral) this should be corrected before further measures are taken. This may require installing new A-406 and A-407 brackets on the aileron in a slightly different position than the original ones.

Experience has shown that roll trim can be achieved by decreasing or "tightening" the trailing edge of the aileron on the "light" wing - the one coming up as the airplane rolls. If the trailing edge is too blunt, squeezing it tighter (with just your fingers) along the length of the aileron can have an effect. If this is not completely effective, a mechanized method may be needed.

One method is to cover the jaws of a hand seamer with tape and use it to squeeze the trailing edge. However, even when being very careful, the ends of the seamer tend to leave small dents in the skin. Another method is that of using clamping blocks; small boards such as 1x2s place on top and bottom of the trailing edge and squeezed together with C-clamps., Regardless of the method used, the result should be a barely perceptible change in shape, as gauged by sighting down a straight edge laid on the skin. Small variations in shape can have very noticeable affects on control. Fly the airplane to gauge the result. Several such trial-and-error attempts may be needed to achieve the desired results. If an over-correction occurs, it can be corrected in two ways.

- The opposite aileron's trailing edge can be reduced slightly in the above manner. This is OK providing that the aileron control forces have not increased too much. As the trailing edge radius decreases, stick force increase. Also, the skins will crack if squeezed too tight.
- Expand the trailing edge radius, which has been squeezed too much. This can be achieved in an unlikely manner, with a board and a hammer. Yes, by holding a length of board such as a 2x2 butted up against the trailing edge and tapping the board along its length with the hammer, the radius can be "opened" up slightly—enough to have an effect on trim. But, be very careful.

If adjusting the trailing edge radius does not provide the desired trim effect, a trim tab wedge probably will. If the out-of-rig condition is too extreme to be corrected by a trim wedge of over 6 inches in length, there is a serious construction or rigging anomaly which must be identified and corrected. Contact the engineering staff at Van's Aircraft for possible assistance.

If the aircraft is equipped with an aileron trim control system, it can be used in lieu of fixed tabs. However, it is suggested that fixed trim methods be used to offset destabilizing effects of airframe irregularities, and that cockpit adjustable trim controls be used to offset variable loads such as fuel and passengers (for side-by-side seating).

Large trailing edge radii on the ailerons can cause a condition known as "aileron snatch" which is generally similar to the "hunting" tendency mentioned for elevators and rudders with blunt trailing edges. However, ailerons are different than the elevator or rudder because there are two of them, interconnected and operating opposite each other. The "snatch" is recognizable by the tendency of the ailerons to seek a neutral (stick free) point to one side or the other of center. Aileron snatch causes an uncomfortable control situation for the pilot because the control stick must be held in the center. Movement in either direction will initially be self driven for the first bit of travel, then normal loads begin to build as with additional stick deflection. When moving the stick from one side to the other, an area of control force reversal will be experienced when passing through center.

Stick free, aileron snatch will result in a rolling tendency. A fixed trim tab will not correct this as it would just push the ailerons over center to one side, rather than returning them to center as desired. Correcting aileron snatch can usually be accomplished by reducing the trailing edge shape and radii to that shown on the plans.

After the lateral control trim has been completed, another test can be made. Establish a medium bank of 20-30 degrees and release the stick. If the wings return to a level attitude, the airplane has exhibited positive lateral stability. If the angle of bank remains the same stick free, the aircraft has neutral lateral stability. If the bank angle continues to increase when the stick is released, the lateral stability is divergent; a potentially dangerous condition.

Neutral lateral stability is common for RVs because of their short span and low dihedral angle. Negative or divergent lateral stability is more likely to occur in aircraft with long wings and/or insufficient vertical control surface area.

Sometimes stability investigations can be confusing; situations where unlikely or unexpected factors cause seeming unrelated symptoms. One instance comes to mind where a certain RV exhibited asymmetric roll rates and control force. Naturally, the investigation centered on possible wing twist or wing rigging (we checked for unequal incidence angles, or aileron abnormalities.) The cause was eventually found to be a rather severe twist in the horizontal stabilizer which imparted a constant rolling moment. So, a lot of aileron trim was needed just to maintain wings level, and the stabilizer induced roll force either added to or subtracted from the rolling input of the ailerons. Corrective action in that case was construction of a new stabilizer.

This ends our presentation on stability and control. However, it by no means is a complete thesis on the subject. Rather, it is deemed sufficient to help an RV pilot evaluate his airplane and make corrections to minor abnormalities. A more authoritative and thorough dissertation can be found in the book FLIGHT TESTING HOMEBUILT AIRCRAFT by Vaughn Askew. This text is highly recommended and is available from various sources including the Iowa State University Press, and Van's Aircraft, Inc.

STALL TESTING:

We mentioned testing of mild, power off stalls during the initial test flight. After more confidence in the aircraft is gained, the pilot should proceed to perform stalls entered from all anticipated flight conditions. All types of stalls should be practiced; departure (climbing) stalls, approach (gliding) stalls, stalls with varying degrees of bank, stalls at minimum and maximum weights, cross-control stalls, and accelerated stalls. Stalls at every imaginable attitude and from every imaginable entry condition. The object is not only to gain familiarity with stalls from every conceivable flight condition, but to become comfortable with recognition of and recovery from these stalls. Not comfortable in the sense of being careless, but comfortable in the sense of being confident in your ability to control any situation. Practicing many and varied stalls will heighten your awareness of attitudes and flight conditions to be avoided because of the severity of the stalls which might result from them.

Except for accelerated stalls and secondary stalls, approach each slowly (a deceleration rate of 1 mph per second is recommended) while correcting for P-Factor (for power stalls) with the rudder. Allow the speed to bleed off until you feel a slight buffet. Note the airspeed and recover with a smooth forward movement of the stick as power is added. Maybe simply relieving back pressure on the stick when the stall occurs would be sufficient for your airplane. Stalls entered from steep bank or climb attitudes will require more aggressive recovery control application. But remember, at some loading conditions, an RV has light elevator forces, and over controlling can easily occur, and secondary stalls can be encountered.

After gaining familiarity with stalls with instant recovery, delayed recovery can be practiced. Starting with wings level, 1 G stalls, delay the recovery by a count of 1,2,3, etc. seconds. The only purpose of this is to gain further experience with handling qualities in extreme conditions and to determine your ability to control the aircraft in a prolonged stalled mode. While one should always recover immediately at the first warning of an accidental stall, intentionally holding the airplane in a stall will provide the pilot with a greater experience base.

Another bit of wisdom to remember is that the airspeed systems can be inaccurate at the high angles of attack experienced at stall speeds. Indicated stall speeds can be in error by 5 mph, possibly even more. However, the readings are relative and you can believe that your gauge will indicate the same stall speed consistently, if the stall is approached at the same rate and G-load every time.

While practicing stalls, the pilot is not only gaining familiarity with that specific airplane for his piloting benefit, but is also evaluating that airplane's stall characteristics against an ideal. The ideal is that when a stall is encountered, the nose tends to lower, or can easily be lowered by an easing of stick back pressure or by a forward stick pressure. In most RVs, there is little advance stall warning in the form of pre-stall buffet. The buffet which does occur does so within just a mph or two of the fully developed stall. The other characteristic being evaluated is a laterally uniform stall—or what is often called a straight forward stall. Airfoil irregularities, wing incidence misalignment, and wing twist can cause one wing to stall at a higher speed than the other. This obviously will cause one wing to drop when the stall occurs. This is not uncommon for RVs, and if the extent of wing drop is slight, no more than 10-15 degrees, it is of little consequence. Sometimes an asymmetric stall can be corrected by altering the angle of incidence of one wing by re-drilling off-center an oversize rear spar attach hole. This method will have limited success because structural constraints limit the extent of oversize hole which is acceptable. Consult with service personnel at Van's Aircraft before attempting this.

Another cause of asymmetric stall is airfoil irregularity caused by landing lights in the wing leading edge. The "lip" which usually occurs between the wing skin and the plexiglass lenses causes a disrupted airflow which acts as a spoiler, reduced lift, and causes that wing to stall prematurely. If this is suspected, smooth tape can be placed over the offending edges before re-testing. If this is found to be a factor, a re-work of the landing light installation could minimize the misfit and thus the stall asymmetry. A small stall strip on the opposite wing can also be used to achieve a balanced stall. Very few RV pilots have added stall strips to their wings. Whether this is because there is no need or because of lack of knowledge about the potential benefit, we do not know.

SPIN TESTING:

"A spin is a condition in which an airplane rotates because one wing is deeper in stall than the other. A spin is a highly complex dynamic maneuver that is still not fully understood, even by the experts."

Flight Testing Homebuilt Aircraft, by Vaughn Askew.

Accidental spins can result from a variety of conditions in which asymmetric wing lift is induced. Spins normally are caused by improper rudder usage coupled with a stall (including accelerated stalls) Out-of-coordination rudder produces a yaw which in turn causes asymmetric wing lift which drives the rotation. Avoid these conditions, and accidental spins won't happen. Since this utopian condition cannot be guaranteed, a degree of spin investigation training is suggested.

Intentional spin entry should be initiated from a power off stall with full rudder in one direction and full elevator following the initial stall break. Typical spin behavior for an RV is that if control pressures are released immediately following spin entry, recovery will be automatic and almost immediate—no more than 1/2 spin revolution. If spin rotation is held for approximately one full revolution, recovery can be accomplished quickly through application of anti-spin control (opposite rudder, stick centered). If pro-spin controls are held until two full revolutions have been completed, the spin will be fully developed. Recovery techniques will vary.

For RV-3s, 4s, and 8s, the most effective recovery technique is as follows:

- Power off.
- Elevator centered. (or stick free)
- Full opposite rudder.
- Recover from dive as soon as rotation stops.

Recovery time (time to stop rotation) will vary depending on C.G. position and other factors. Step #2 is best accomplished "hands-on stick" rather than stick-free because while in spin rotation, the outside aileron will sometimes float up, thus driving the stick out of center.

(As an example, here is what we found when spin testing the prototype RV-6. Remember, this is one individual airplane! Our results and yours may vary significantly.)

Testing was performed up to the limit load (1375 lb. aerobatic gross) and C.G. (25% aft of leading edge) with satisfactory recoveries being easily affected.

For prototype RV-6 and RV-6A aircraft, spin characteristics and recovery procedures were found to be as follows:)

The prototype RV-6 & RV-6A aircraft exhibited good spin resistance. Forceful pro-spin (full up elevator and full rudder) control pressures were necessary to induce a fully established spin. Good spin recovery was evident during the first two rotations. Simply releasing the controls during the 1st rotation stopped the spin, and opposite rudder and forward stick caused a quick recovery during the second rotation. After two turns, the rotation rate increased and stabilized between 3 and 4 turns with a high rate of rotation of about 180 degrees/second. Once past approximately 2 spin rotations, the spin had stabilized and if the controls were freed, the RV-6 would continue spinning until anti-rotation control inputs were applied. One reason for this is that in a fully developed spin, the elevators float up and remain there hands-off. Recovery procedure consists of the following:

- Power to idle.
- Apply full opposite rudder, (opposite the direction of rotation)
- Center the ailerons and elevator. (Because of the up elevator float, forward stick pressure is needed to center the elevators.
- Hold the above control positions until rotation stops, then use the elevator to recover to level flight. 1 1/4 to 1 3/4 rotations are usually required for rotation to stop.

Because of the high rotation rate and the positive (rather than automatic) spin recovery technique required, Van's Aircraft Inc. recommends that pilots of RV-6/6A and RV-7/7A aircraft limit their intentional spins to two turns or less, and that recovery from incipient accidental spins be initiated immediately upon recognition. **The RV-9/9A is not intended for spins at all.** Learn the conditions that lead to accidental spins, how to recognize the onset of a spin, and how to immediately and subconsciously stop an incipient spin. Then, fully developed spins, and the need to recover from them, will become less probable.

Spin testing, like other forms of limit testing, should only be attempted while wearing a parachute and after memorizing escape procedures. Memorize anticipated recovery techniques and act deliberately and calmly throughout the entry and recovery from the spin. Perform intentional spins in progressive steps, starting with immediate recovery, recovery after 1/2 turn, recovery after one turn, etc. Also, begin spin testing with forward C.G. loadings and proceed to more aft loadings as satisfactory recoveries are experienced.

All homebuilt RVs should be individually tested because small variation in configuration can sometimes greatly affect spin characteristics. This is particularly true for any variations in vertical surface areas forward of the aircraft center, and for changes which may affect airflow over the forward surfaces and/or the tail surfaces. For example, spin testing of prototype RVs has shown that spin characteristics differ noticeably with wheel and gear leg fairings installed or removed. The vertical area of these components, located forward of the center of rotation of the airplane, causes a destabilizing effect that degrades spin recovery. There are after-market gear leg fairings being marketed which are wider than those tested and supplied by Van's Aircraft. Because spin testing has shown that small changes such as this can cause a noticeable change in spin recovery, builders are advised to use caution when making changes such as this to their RVs.

One often cited example of how small alterations can affect spin characteristics is the Beechcraft Musketeer. The early production airplanes had an engine cowling with a rather abrupt transition (squared off) from its top to side surfaces. A later version had a reshaped cowl that had a smoother transition between the top and side cowl surfaces. The result was that while in a spin mode, the cross flow over the cowl now produced more lift and held the nose up, inhibiting spin recovery. As with all other areas of testing; don't make any assumptions! Recommended spin test altitude is between 6,000' and 8,000' AGL to allow plenty of altitude margin for recovery.

Inverted spins were not tested because the prototype test aircraft were not equipped for inverted flight.

Van's Aircraft Inc. does not consider spins to be a recreational aerobatic maneuver, and recommends that they not be casually undertaken.

Propeller Evaluation: Your propeller should load the engine sufficiently in level flight that the engine, at full throttle will not exceed its redline limit. Nor should the engine exceed redline rpm during takeoff. Sometime these requirements are hard to meet with the same prop (see the discussion of fixed pitch props in Section 11.)

Airspeed Calibration: Air speed indicator systems, particularly in homebuilt airplanes, are often inaccurate. Sometimes very inaccurate! Note that we refer to the air speed indicator system, not just the air speed indicator instrument itself. The system comprises five components: Dynamic pressure source (pitot tube), instrument, static pressure source, air lines, and an indicator.

The location of the pitot tube relative to the air pressure areas around the airframe is of great importance. The ideal location is one where the true air velocity relative to the airframe can be measured. The pitot tube cannot be located at any point on the fuselage because it is within the influence of the propeller disc. The only exception would be mounting it above the tip of the vertical stabilizer. This location is fine except for high angle of attack flight, as in landing attitude, where fuselage and propeller airflow disturbances cause significant inaccuracies.

The ideal pitot location would seem to be forward of the wing, in undisturbed air. But, within the first 6 to 12 inches forward, the airflow is already affected by the approaching wing, and this location results in pressure errors as much as 10% high. It is necessary to locate the pitot tube least 1/2 the wing chord length forward of the leading edge to eliminate pressure errors. This is why we see the large pitot "stinger" on factory prototype and test airplanes.

Since long leading edge pitot tubes are impractical, a compromise position is sought. This usually becomes some experimentally derived point under the wing. The pitot tube shown on the plans is located for easy manufacture and maintenance, and has proven to be a quite accurate pressure source. Use of pitot tube designs or locations other than this could result in less accurate airspeed readings.

The airspeed indicator itself could be out of calibration due to age or manufacturing inaccuracies. Any instrument repair shop can check and re-calibrate air speed indicators. However, one primary object of this sub-chapter is to alert pilot/builder that an accurate airspeed indicator does not in itself guarantee correct indicated airspeed readings.

The static source must be located in an area of neutral or ambient pressure; an area where the shape of the airframe has caused the airflow to be neither above or below atmospheric pressure. Cabin air pressure is not neutral as might be thought. Canopy and door air leaks, air vents, etc. cause cabin pressure to vary enough to result in errors of 5 mph or more if used as the air speed static source. Production aircraft often use an experimentally located static source point on the aft portion of the fuselage where airflow pressure recovery provides atmospheric pressure. The static opening at this location is also less prone to ice formation than elsewhere. The recommended RV-static source point and system components is shown in an earlier chapter of this Construction Manual or on the drawings.

The fourth system component is the lines for both the pitot and static air. Pressure requirements for either are minimal, so practically any aluminum, plastic, or rubber line can be used. Airtight sealing of the lines is important because

any leakage can compromise an otherwise accurate system. One method of checking a pitot system for leaks is just a clear plastic tube partially filled with water and slipped over the pitot tube. Elevating the open end of the tube will cause the water to flow inward (but not into the pitot tube) and build a slight pressure in the system. If the lines are airtight, the water level will remain the same. If the water level slowly returns to a balanced condition, then the system has a leak.

Such an airspeed indicator system installed in a RV should provide reasonably accurate airspeed readings; certainly accurate enough for initial test flying. Most pilots will want to calibrate their airspeed indicator readings for the purpose of documenting performance data and performing limit testing. One simple method of doing so is to fly alongside another airplane and compare airspeed readings. This would be fine IF the other airplane's airspeed system was guaranteed to be accurate. But, it probably isn't, even though it may be an expensive, late model airplane.

We recommend performing the airspeed calibration through time/distance calculations. All that is needed is a ground course of known distance, preferably about 5 miles in length, and a stopwatch. Fly both directions over the course at a steady indicated speed, power setting, and altitude. Time each run with the stopwatch. Compute the speeds for each run, add them together, and divide by two to get the average ground speed. Do not calculate the average speed from the total distance divided by the overall time. The effect of any wind will result in an erroneously low speed.

A sample calculation is shown at the end of this section. We have intentionally factored in a strong wind to illustrate the effect of averaging individual speeds rather than computing speeds from the elapsed round trip times. (Performing speed calibration testing during windy conditions is usually futile because the turbulence associated with winds will make it impossible to maintain steady airspeed and get accurate results.)

Use a flight calculator to compute true indicated airspeed from the indicated airspeed reading (factored for temperature and altitude) and plot this speed against the calculated ground speed. Repeat this procedure for indicated airspeeds vs. timed ground speeds at 10-20 mph intervals from near stall speeds to max.cruise speeds. From this, an airspeed calibration curve can be drawn and corrections made for any indicated airspeed.

An Alternate Calibration Method: Loran and GPS have given the test pilot another valuable tool in more ways than intended. Nearly all lorans provide a ground speed readout. For rough speed checks, this groundspeed readout can be recorded for two way runs at given power conditions. However, the groundspeed readouts usually fluctuate over a range of several mph, and are therefore not a precise calibration tool. However, lorans also provide continuous position reports in the form of Lat./Lon. coordinates. These coordinates can be used just like visible ground markers for a speed check course. All that is required is that the speed calibration runs be made on North or South headings. Each degree of latitude equals 60 nautical miles. Thus, every minute of latitude equals 1 nautical mile and each 1/10 minute (finest reading on most lorans) equals 1/10 nautical mile. Runs can be of any length desired. 10 nautical miles is a convenient figure, corresponding to 10 minutes latitude. Runs of this length are more accurate than short runs because any variation in time starting or stopping the watch is averaged over a longer time. For instance, if the course were only a mile long, a 1/2 second error in timing a 200 mph run would cause an error of over 5 mph. The same 1/2 second error made in timing a 10 mile run would cause an error of only 0.5 mph.

Some of the advantages of using loran (GPS) for speed checks is that the altitude is not important. The invisible mile posts are at 8,000' altitude as well as at the surface. Thus, speed checks can be made at normal cruise altitudes where full throttle can be maintained for extended time periods, and where smooth air is available at almost any time. Indicated airspeeds can be checked against timed ground speeds and against loran ground speed readouts.

An actual sample of an RV-6A test flight and computations from is included at the end of this section.

GPS tests for airspeed calibration

GPS is a more valuable tool for use in calibrating airspeed systems than is loran, primarily because of its greater accuracy and more consistent ground speed read outs. GPS ground position reports could be used for speed computations as described above for loran. However, GPS ground speed reading have been found to be so accurate that they can be used interchangeably with zero wind true air speed. Thus, if the air mass was perfectly stable (no wind), GPS ground speed and true airspeed would be the same. However, there is almost always some wind, particularly at altitudes where convective turbulence is not a problem. Thus, flying a multiple heading pattern is an easy and accurate means of canceling wind effect from ground speed read outs.

The commonly accepted procedure is to fly a box shaped pattern on the prime headings of 90, 180, 270, and 360 degrees. (fly heading rather than track) Record the ground speed readings for these heading and compute the average. While this would seem a simple procedure, carefully flying is necessary to arrive at accurate figures. The airplane must be flown precisely and the atmosphere must be very stable (no vertical movement). Even at higher altitudes where the air is generally smoother, there is often minor turbulence, wind shear, or waviness which makes it difficult to hold a constant altitude and indicated air speed. For example, it is common to experience smooth waves in the atmosphere, with low vertical velocities—you can't feel any bumpiness but you can see the altimeter (or VSI) alternating, up and down. Under these conditions, constant trim changes, and thus airspeed changes, are necessary to maintain level flight altitude. A simple calculation showed that a 100 fpm vertical component would cause a true airspeed variation of about 2.5 mph in an RV. Thus, flying from the positive to the negative phase of the wave would show a 5 mph variation.

Similarly, assuming that the atmosphere were perfectly stable, when flying at 200 mph, a pilot error of 1/2 degree pitch attitude will cause a 150 fpm climb or descent rate and several mph speed variation. Thus, great care must be taken to find smooth air and fly precisely in order that truly accurate speeds be recorded. It is a good idea to fly the speed box more than once to check consistency and obtain averages if speed variation occur.

LIMIT TESTING

Limit testing of a homebuilt, particularly a high performance one such as the RV, is an endeavor to be approached with caution and preparation. What the pilot is doing is challenging the airframe to withstand the limit loads he is imposing on it, or in a sense, daring it to fail. Most homebuilder/pilots are not daredevils and would just as soon not do limit testing. However, as it is the best available means of verifying design limits, it must be done if all future flights are to be made with confidence. With proper preparation, limit testing need not be as frightening and dangerous as it might appear. Particularly during this phase of testing, the pilot should wear a parachute and familiarize himself with its operation. Also, emergency egress of the airplane should be reviewed and memorized. Limit testing should be done at altitudes of at least 5000 ft. above ground, preferably around 8,000 ft. Along with careful planning, altitude can be a lifesaver. While the thought of structural failure or loss of control is not at all appealing, it is far better that it be encountered during controlled testing than under conditions where no options exist (low altitude, no parachute, etc.). By assuming and preparing for the worst, limit testing can be done with reasonable confidence. Flight testing of the RV prototypes proved to be routine and uneventful. With thoughtful construction and preparation, testing of homebuilt RVs should be the same. Limit testing categories include FLUTTER TESTING, G-LOAD TESTING, and SPIN TESTING. (Spin testing is also classified under Stability testing, so has been included in that section of this chapter)

FLUTTER TESTING

Flutter in an aircraft structure results from the interaction of aerodynamic inputs, the elastic properties of the structure, the mass or weight distribution of the various elements, and airspeed. The word “flutter” suggests to most people a flag's movement as the wind blows across it. In a light breeze the flag waves gently but, as the wind speed increases, the flag's motion becomes more and more excited. It is easy to see that if something similar happened to an aircraft's structure the effects would be catastrophic. In fact, the parallel to a flag is quite close.

Think of a primary surface with a control hinged to it (e.g., aileron). Imagine that the aircraft hits a thermal. The initial response of the wing is to bend upwards relative to the fuselage. If the center of mass of the aileron is not exactly on the hinge line, it will tend to lag behind the wing as it bends upwards.

In a simple, unbalanced, flap-type hinged aileron, the center of mass will be downward. This will result in the wing momentarily generating more lift, which will increase its upward bending moment and its velocity relative to the fuselage. The inertia of the wing will carry it upwards beyond its equilibrium position to a point where more energy is stored in the deformed structure than can be opposed by the aerodynamic forces acting on it.

The wing “bounces back” and starts to move downward but, as before, the aileron lags behind and is deflected upwards this time. This adds to the aerodynamic down force on the wing, once more driving it beyond its equilibrium position and the cycle repeats.

At low airspeeds, structural and aerodynamic damping quickly suppresses the motion but, as the airspeed increases, so do the aerodynamic driving forces generated by the aileron. When they are large enough to cancel the damping, the motion becomes continuous. Further small increases in airspeed will produce a divergent, or increasing, oscillation, which can quickly exceed the structural limits of the airframe. Even when flutter is on the verge of becoming catastrophic, it can still be very hard to detect. What makes this so is the high frequency of the oscillation which is typically between 5 and 20 HZ (cycles per second). It will take only a very small increase in speed to remove what little damping remains and the motion will become divergent rapidly.

Flutter testing of factory prototypes has resulted in establishing a NEVER EXCEED SPEED (Vne) of 210 statute mph for the RV-3,4 and RV-6/6A, 230 statute mph for the RV-7/7A/8/8A. and 210 statute mph for the RV-9A. This speed was determined through flutter testing at a speed of 20 mph above Vne. (FAA certification criteria require flutter testing up to Vne plus 10% or about 20 mph) The flutter testing performed consisted of exciting the controls by sharply slapping the control stick at various speed increments up to this level. Under all conditions, the controls immediately returned to equilibrium with no indication of divergent oscillations indicative of flutter. This testing was performed on factory prototype aircraft, and the flutter free flight operation of subsequent amateur built RVs has substantiated published Vne.

The “slap-the-stick" method of exciting the controls for flutter testing is potentially dangerous and requires a very skilled pilot trained to recognize the subtle control responses which indicate the onset of flutter. For this reason, it is suggested that amateur builders do not perform flutter testing of their RVs. Rather, the airplane should be constructed in strict conformity to the plans with particular attention paid to the control system--- trailing edge radii, skin stiffness, control linkage free-play, and static balance in particular. Maintaining conformity with the prototype (plans) will provide an adequate level of assurance against control surface flutter. Any design changes to the control surfaces, control system, or primary structure could invalidate the testing which has been done, and require that testing be re-accomplished.

G-LOAD TESTING

As with flutter testing, G-load testing should be conducted systematically, progressing gradually to higher and higher levels. 6 G's is the highest level recommended in testing. This is the maximum load the structure is designed to be able to withstand indefinitely. While the actual calculated breaking strength is 9 G's, the structure is designed to withstand this load for only 3 seconds. Approaching this load level could permanently weaken the structure even if failure does not occur. The margin between 6 and 9 G's is reserved to compensate for the effects of airframe deterioration through aging, fatigue, material flaws, or construction errors. G-loads of over 6 should never intentionally be applied to an RV structure.

MAXIMUM G-LOAD:

The structure of the RV-4 and RV-6/6A have been designed to withstand aerobatic design loads of plus 6 Gs and minus 3 Gs at an aerobatic gross wt. of 1375 lb, or 1600 lb for the RV-7/7A/8/8A. The RV-9/9A structure had been designed to withstand utility design loads of +4.4/-1.8G at a utility gross weight of 1600 lbs. Flight testing to the positive G limit can be done by putting the airplane in a tight turn and applying elevator back pressure. Do this progressively; increasing the load by 1G increments until the load limit is reached. Between each loading acceleration, relax and look over the airplane. Move the controls to assure that everything is normal.

For operational gross weights above this figure, aerobatic maneuvers should not be performed. This also assumes that the RV was built in strict conformity with the plans. Any variation in materials used, dimensions of primary structural parts, or workmanship standards, can cause a loss of strength and cause the actual limit load to be less than the design limit load.

The 3 G design limit for negative loads also has a built-in 50% margin. Thus the breaking strength would be -4.5 Gs.

If the RV being tested is equipped with inverted fuel and lubrication systems, negative G testing should also be done. A parachute should be worn while conducting load testing.

MANEUVERING SPEED: 134 mph statute for the RV-4 and RV-6/6A, 142 for the RV-7/7A8/8A, 118 for the RV-9/9A. By definition, maneuvering speed is the maximum speed at which full and abrupt controls can be applied. It is also the minimum speed at which limit G-load can be produced. Thus, at any speed in excess of this, full control application could result in G-loads in excess of design limits. The maneuvering speed is function of clean (no flap) stall speed. For utility category aircraft like the RV-9/9A, it is 2.1 (the square root of 4.4) x stall. For aerobatic category aircraft, it is 2.45 (the square root of 6) x stall. Because RVs have low stall speeds, maneuvering speed is low relative to cruise and Never Exceed Speed.

Based on the same formula used to determine maneuvering speed, full control application at Vne would produce a G-load of about 15. From this it should be very obvious that at any speed above maneuvering speed, the pilot becomes the limiting factor: he can impose destructive loads on the structure through excessive control application. ***Because of its high ratio of top speed to stall speed, the RV is more susceptible to pilot-induced overstresses than are most other contemporary aerobatic airplanes.***

GROSS WEIGHT: See Section 14.

AEROBATIC OR UTILITY GROSS WEIGHT: See Section 14.

FLAP SPEED: On the RV-4/6/6A/7/7A/8/8A, 110 Statute for 20º and 100 mph statute for full 40º flap deflection. On the RV-9/9A, it is 100 smph for 15º and 90 smph for 32º.

AIRSPEED INDICATOR MARKINGS

SPEEDS IN STATUTE MILES PER HOUR	RV-4	RV-6/6A	RV-7/7A/8/8A	RV-9/9A
Bottom of White Arc: (Approx. Indicated stall speed with full flaps)	54	55	58	49
Top end of White Arc: (Max. speed with full flaps)	100	100	100	90
Bottom of Green Arc: (Approx. indicated stall speed without flaps)	58	59	64	56
Top end of Green Arc: (Max. structural cruise speed)	180	180	193	180
Blue Line: (Maneuvering speed-Max. permissible speed at which full control can be applied. Speed at which full elevator control would impose loads exceeding limits)	134	134	142	118
Yellow arc: (caution range, to be flown only in calm or light turbulence conditions)	180-210	180-210	193-230	180-210
Red Line: VNE IAS (Maximum permissible speed under any condition)	210	210	230	210

AEROBATICS

Note: The RV-9/9A is NOT designed or intended for aerobatics.

Note: Aerobatic maneuvers as defined by the FAR's include bank angles greater than 60 degrees relative to the horizon and nose-up/nose-down pitch angles of 30 degrees relative to the horizon. These maneuvers must be performed above a minimum altitude of 1500 feet AGL and all participants in the aircraft must wear a parachute.

RV airframes are stressed for aerobatics up to a gross weight of 1050 lb.for the RV-3, 1375 lb for the RV-4/6/6A, and 1600 lb. for the RV-7/7A and the RV-8/8A with the "Dash One" wing (included in all RV-8/8A kits shipped since January, 2001.) Earlier RV-8/8As with the original wing have an aerobatic gross weight of 1550 lbs.

This means that they have design strengths of 6 positive and 3 negative Gs (plus a 50% safety factor) at up to this weight. The key word is WEIGHT. RV structures have a certain amount of strength and are capable of carrying a given load at given G load. If the weight increases, so does the stress. As the empty weight increases, the useful load decreases —less fuel and pilot/passenger load can be carried within the aerobatic weight limit. For this reason, a heavy 2-seat RV may become a single place aerobatic airplane because it cannot carry two people and remain under the aerobatic gross weight limit. We expect that the empty weights of many RV-4s and RV-6/As will be over 1050 lbs. because of optional equipment installed. These will definitely be single place aerobatic airplanes. Some RVs have been built with such high empty weights that when flown by a pilot weighing much over 200 lb., are no longer structurally qualified to perform aerobatics at all. Check the specific aerobatic gross weight given in Section 14. Always remember, RVs are ***not*** indestructible. Like all other airplanes, they have been designed with finite limits which must be observed. As a homebuilt, any individual airplane may have different limits which in all probability will be lower than design limits.

For or those wishing to do aerobatics in their RVs, aerobatic testing should be done during the later portion of the flight test period. We suggest that aerobatics be approached cautiously, and only after becoming thoroughly familiar with control responses, handling qualities, and performance capabilities. The pilot should also have received formal aerobatic training in other aircraft. Most RVs are capable of easily performing basic aerobatic maneuvers. This capability is due to their relatively high power loading and to their aerodynamic cleanliness which produces the speed (energy) needed. But, because of this, excessive speed build-up can occur very quickly, and should be a primary concern when attempting and practicing aerobatics. As an example, one does not enter a split-s maneuver from anything near cruising speed (like you see fighters doing in the old movies) because there is no way to complete the maneuver without exceeding speed and/or G-Load limits. The safe entry speed for a Split-S is around 100-110 IAS. The point is that RV aerobatics are not the same as Pitts or Citabria aerobatics. Speed builds very fast when pointed downhill.

Elevator stick forces are relatively light, so it is not a good idea to turn the controls over to a passenger for the purpose of aerobatics. Nor is it a good idea to apply control forces similar to those you may have become accustomed to in some other aerobatic airplane, say, a Citabria or a Stearman. Over stressing could easily occur. This is why you should be thoroughly familiar with the flying and handling qualities of your RV before attempting aerobatics. Because of its light controls, the RV is a pilot-limited airplane. In other words, it is the pilot's responsibility to avoid over stressing the airplane.

Aerobatic Entry Speeds: Refer to the section on maneuvering speed when contemplating aerobatics. Remember that the maneuvering speed is defined as the highest speed at which full and abrupt controls can be applied without exceeding the design strength of the airplane. This does not mean that it is the highest permissible aerobatic entry speed. It just means that for any speed above the maneuvering speed, control inputs must be limited to less than full—and less than that needed to produce 6 Gs. Because of the wide speed range (top speed/stall speed) of the RVs, entry speeds for some maneuvers can also vary over a considerable range. For vertical maneuvers like loops, Immelman turns, and horizontal eights, the entry speeds have an inverse relationship to the Gs required to complete the maneuver. An entry speed near the low end of the speed range will require a higher G pull-up than for an entry speed near the top of the speed range. The entry speeds listed below are presented as general guidelines, as starting points for aerobatic testing. Differing airframe weights, engines, propellers, and pilot preferences will determine the ideal entry speeds.

- Loops, Horizontal Eights: 140-190 mph.
- Immelman Turns: 150-190 mph
- Aileron Rolls, Barrel rolls: 120-190 mph
- Snap Rolls: 80-110 mph
- Vertical Rolls: 180-190 mph
- Split-S: 100-110 mph

Note: All speeds are statute mph.

Please note that the recommended entry speeds for snap rolls are relatively low. One definition of a snap roll is that it is an accelerated stall with heavy yaw input. Because the RVs have good stall characteristics and good spin resistance, they also resist easy snap roll entry. Entered at speeds below 100 mph, snaps tend to be slow and wallowing. At above 100 mph, high G loads are required. For this reason, most RV pilots avoid snap rolls and concentrate on looping and rolling maneuvers more suited to the performance and handling qualities of these planes.

RECORDING FLIGHT TEST DATA

All pertinent data obtained during flight testing should be recorded in the aircraft log and/or flight manual. This should include data about limits reached, limit speeds, acceleration (G-loads) limits, etc. This is particularly important if testing limits were lower than suggested in this text. There will be a natural tendency for future pilots of this airplane to assume that it has been built and tested to the same standard as the prototype and other RVs. If an individual RV has not been flight tested to the design limits, a clear record of the test limits should be available. An "AEROBATICS PROHIBITED" placard should be prominently displayed on the instrument panel. Remember, though your RV may look like all others, it is really a one-of-a-kind airplane because you built it, and it is not identical to any other. Well recorded data will eliminate the need for assumptions on the part of future pilots. We can do without assumptions in this business.

A placard stating "This Aircraft is amateur built and does not comply with the federal safety regulations for standard aircraft" must be visible in the cockpit of your airworthy RV. As the pilot, it is well to reflect on this thought because you are a passenger also. The federal safety standard were developed for good reason. Just because amateur built airplanes are not required to comply with all safety regulations and design standards does not exempt them from suffering the possible consequences of non-compliance. Perhaps it is better for the builder to think of the intended wording as "has not been shown to comply" rather than "does not comply". Then, do everything possible to comply with the highest "self imposed" standards of workmanship and airmanship.

We will close by leaving you with a few quotes borrowed from the FAA Advisory Circular, AMATEUR-BUILT AIRCRAFT FLIGHT TESTING HANDBOOK.

"The laws of aerodynamics are unforgiving and the ground is hard." *Michael Collins.*

"The object of the game, gentlemen, is not to cheat death: the object is not to let him play." *Patrick Poteen, Sgt., U.S. Army.*

"Leave nothing to chance." *Tony Bingelis*

"Know your airplane, know it well, know its limitations, and above all--know your own limitations." *Bob Hoover*

"It is critically important that a test pilot never succumb to the temptation to do too much too soon, for that path leads but to the grave." *Richard Hallion.*

"Always leave yourself a way out." *Chuck Yeager.*

"One can get the proper insight into the practice of flying only by actual flying experiments." *Otto Lilienthal (1896)*

"Keep your brain a couple steps ahead of the airplane." *Neil Armstrong*

"A superior pilot uses superior judgment to avoid those situations which require the use of superior skill. *Old Aviation Proverb*

"Go from the known to the unknown--slowly!" *Chris Wheal, test pilot.*

AIRSPEED CALIBRATION RUN #1

Conditions & Data: 8,000' MSL 42 deg. F. 156 IAS
2675 RPM 20.5" Man. Pres. Sensenich 68x78 prop
E6B computations show that:
156 mph IAS at 8,000' and 42 deg. F. = 178 mph True Indicated AS. (ie: no calibration for system errors)
Run #1 from north to south:
Start 45° 41.0' Lat.
Finish 45° 31.0' Lat.
Distance = 10 NM time = 3 minute 55 seconds = 235 Seconds.
Speed (knots)=Dist/time=(10 NM/235 sec) X 3600 sec/hr = 153.2 NM/Hr.
Speed (mph) = speed (NM/Hr) x 1.15 = 176.2 mph
Run #2 from south to north:
Start 45° 31.0' Lat.
Finish 45° 41.0' Lat
Distance = 10 NM time = 3 minutes 52 seconds = 232 Seconds.
Speed (knots)=Dist/time=(10 NM/232 sec) X 3600 sec/hr = 155.2 NM/Hr.
Speed (mph) = speed (NM/Hr) x 1.15 = 178.5 mph
Average speed = (176.2 + 178.5) / 2 = 177.35 mph True airspeed.
(from above) True Indicated Airspeed = 178.5 = Approx. 1 percent calibration error.

AIRSPEED CALIBRATION RUN #2

Conditions and Data: 1000' MSL 76 deg. F. 171 IAS
2650 RPM 24" Man. Press.
E6B computations shown that:
171 mph at 1000' msl and 76 deg. F. = 177 mph True Indicated AS. (ie: no calibration for system errors)
Downwind leg: 3 miles in 55 seconds.
Speed (mph)=Dist/time=(3 miles/55 sec) X 3600 sec/hr = 196.4 mph.
Upwind leg: 3 miles in 75 seconds.
Speed (mph)=Dist/time=(3 miles/75 sec) X 3600 sec/hr = 144 mph.
Average speed = (196.4 + 144)/ 2 = 170.2 mph.

This sample shows a TIAS of 177 as opposed to a true calibrated speed of 170.2, or an airspeed indicator reading of about 4% high.

Erroneous calculation would be:

Average speed = (distance 1 + distance 2)/(time 1 + time 2) = (3 miles + 3 miles)/55 sec+75 sec) X 3600 sec/hr = 166 mph.

TEST RUNS USING LORAN OR GPS MAY BE USED TO CALIBRATE THE AIRSPEED SYSTEM

NOTES