

SECTION 5: CONSTRUCTION MATERIALS, PROCESSES AND USEFUL INFORMATION

This section is not intended to be a complete manual on aircraft construction. We are only hitting the high points here. You should supplement this information with some of the publications listed in Section one.

5A ALUMINUM & PRIMING

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.

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 5M)

The main bar aluminum used in the RV-4&6 wing spars is 2024-T4 alloy, and is not corrosion treated. Pre assembled spars (RV-3,7,8,9 &10) are gold anodized and need no additional protection. The other bar, angle and tube used is 6061-T6 alloy and also is not corrosion treated. All aluminum bar, angle, and tube used in the RVs, especially the main spar bars, must be primed or anodized 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.

DUPONT VERI-PRIME (PRIMER #615 and CONVERTER #616S)

DITZLER DP-40/50 EPOXY PRIMER

TEMPO brand Chromate in a spray can

PRATT & LAMBERT Vinyl Zinc Chromate, EX-ER-7 and T-ER-4 Reducer

SHERWIN WILLIAMS WASH PRIMER #P60G2 and Catalyst Reducer #R7K44

MARHYDE self etching primer, available in a spray can as well as quarts

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 won't be a problem with mixing and matching the type of primers used, but we don't know for sure. They are impractical for painting the whole airplane or large skins.

Generally (not everyone will agree) it is accepted that two part epoxy primers provide the best corrosion resistance. However, they are expensive, toxic, heavy and dry slowly all of which makes them problematical for the home builder. If you can tolerate those issues and want your RV to be in good shape when your grandchildren inherit it, they may be "best" for you.

Van's Aircraft does not have an "approved" primer. We use Sherwin Williams P60 G2. This is used on the QBs and prototypes made here. The QBs 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. True, for optimum corrosion resistance, but Vans feels 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 manufacturers 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.

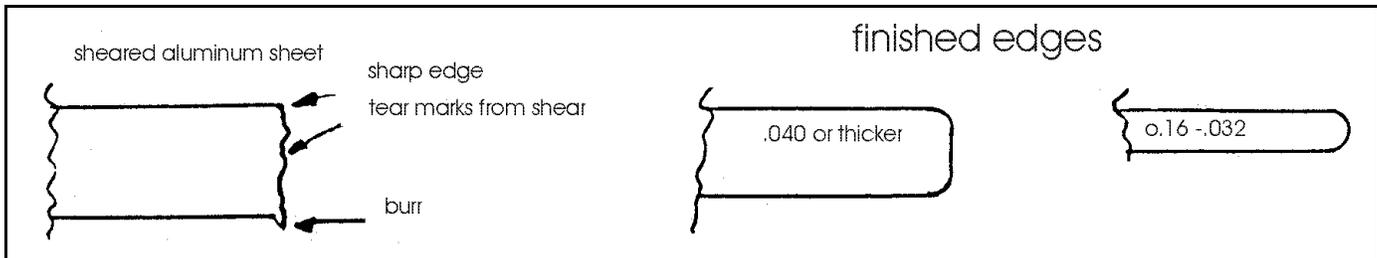
Historically, not many manufacturers primed the interior of their products, but there are still many flying 50 year old

airplanes without corrosion problems. One favorite analogy round 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 the same as the day it left the showroom, the other, looks like it is fit for the wrecking yard. Same primer/paint, different result. How do you intend to look after your airplane? How you treat it has a much greater effect than the primer you choose.

This is all that we can tell you about priming. The choice is yours, prime everything or prime nothing or somewhere in between.

5B EDGE FINISHING, HOLE DEBURRING, and SCRATCH REMOVAL

2024-T3 aluminum sheet is a relatively hard, brittle aluminum. 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.

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. This is illustrated in the enlarged drawing. 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 a burnishing (de-burring) tool. In most instances, the burnishing 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. If the sheet had been sheared, the shear marks should be removed.

Corners, particularly inside corners, must be cut with a radius to prevent cracking. 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. See fig 5-3.

All drilled holes should also be de-burred. 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 slow. 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 countersinking difficult and inaccurate. Be very careful deburring holes in .020 sheet. By the time you have deburred both sides, the hole could be enlarged.

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 not accustomed to aircraft standards. Scratches in the surface of aluminum can have the same weakening effects as rough edges, corners and holes. The alclad sheet being used is very easily scratched because of the thin layer of very soft aluminum used on the surface. Scratches within this surface 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 solution to this is to take extra care to prevent scratches, and then to sand or buff out all scratches, 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 you also remove the alclad surface of the aluminum and thus the corrosion protection. Any area that has been sanded for scratch removal must be primed.

5C MARKING PARTS

NEVER use a scribe to make layout lines or other marks on aircraft parts. The lines can cause failure of the part along the lines with the vibration of the engine. The use of an ordinary lead pencil will cause corrosion of the aluminum. We recommend that you use only 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.

5D RIVETING

Two types of rivets are used in the construction of an RV; "AN" rivets, and "blind" rivets. Blind rivets, often referred to as Pop Rivets ("Pop" is a brand name) are used only in areas where access is not available to buck standard AN rivets and where loads are light enough to be carried by them. Low strength blind rivets are used to attach the fiberglass wing and tail tips, attach baggage and seat floor skins, and to close most of the control surface skins.

Two styles of AN rivets are used; universal head (AN470) and 100° countersunk head (AN426). As a general rule, all external rivets on the RVs are the countersunk head variety, and the internal rivets are universal head. Three diameter rivets are used; AD3 (3/32), AD4 (1/8), and AD6 (3/16). 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.

Most external rivets are the AD3 (3/32") diameter. Because their smaller size requires low setting pressures, there is less chance for denting the skins and a smoother surface results. Most internal rivets are 1/8" dia., to minimize the number of rivets necessary while maintaining modest setting pressures. The 3/16" rivets are used in the main wing spar construction, and require a very high setting pressure, necessitating a heavy-duty rivet gun or a fairly large rivet squeezer. The RV-3,7,8 & 9 kits have pre assembled spars so builders don't have to set 3/16" rivets. Rivets must be the correct length. If they are too long they tend to bend over like a nail, or "cleat". If they are too short, 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 we were to rivet an .016 skin to an .032 rib, the material thickness would equal .048. If we are using a #3 rivet (3/32" diameter), 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 a AD3; 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.

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 Fig 5-2. 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.

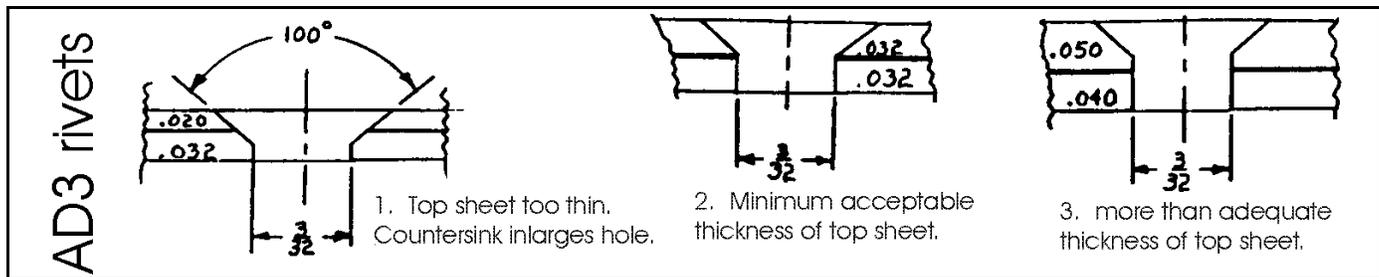
Note: There are times when the correct rivet length is not available. Depending on the application a shorter rivet can be used or a longer rivet cut to the proper length. Using a longer rivet, as is, can result in the shank being bent over like a nail. We have chosen to use a rivet that may seem too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

The pages at the end of this section illustrate the riveting process, rivet nomenclature, and some of the problems builders may encounter. Artist Tony Bingelis has managed to include a great deal of information in a small space. Those new to riveting will benefit from careful study of these drawings.

5E 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. Machine countersinking actually removes metal. This 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, depths vary depending on part shape, hand pressure and tool sharpness. Be sure to remove any vinyl coating before dimpling the parts.

For AD3 rivets, .032 is the minimum allowable skin thickness, and for AD4 rivets, .050 is the minimum thickness. Metal thicker than this is difficult to dimple, so it is common practice to machine countersink for AD4 rivets. Notice in example 1 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. In example 2, skin of minimum acceptable thickness is used. Note here that the full rivet head is supported and the original hole is not enlarged. Example 3 shows not only the fully supported rivet head, but also contact with the rivet shank.



While it is acceptable practice to machine countersink metal as thin as 0.032" for an AN426AD3 (3/32") rivet, we recommend dimpling in metal 0.040 and thinner. There are a couple of reasons. 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 in 0.032" stock makes the job easier, and certainly can be used. One example is when a sheet is sandwiched between two other thicknesses. In this case, the sheet receiving the factory countersunk 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 5-4.

Use a rivet as a gage when you machine countersink. When the rivet is flush, you are done. If there is going to be a dimpled skin riveted onto the machine countersunk surface, adjust the machine countersink tool two "clicks" deeper than flush. This will make the rivet sit about .005" below flush when dropped into the hole.

Dimple countersinking, or simply "dimpling" is done with dimple die sets such as those shown at the end of this section. The bench mounted "hand riveting/dimpling tool" covered in Sect. 3 is very useful for dimpling of rivet holes in large sheets because it holds the dies in perfect alignment and has enough reach to dimple all the skins on an RV. The dimple dies also fit a standard hand rivet squeezer, which is useful along edges and narrow pieces. Occasionally it may be necessary to use a hand block or bucking bar to support a die. In some cases, a bucking bar with a female die cut into it may be combined with a rivet (as the male "die") to do a job where nothing else will reach.

CAUTION: Although the pre-punched parts are precision manufactured, resist the temptation to simply dimple the parts without first match drilling. Drilling removes the shear marks that are left by the punch process and guarantees that the hole spacing is perfect on your parts. Removing the shear marks is important because if left alone, the skin can crack around the hole due to the stretching caused by the dimple dies. This cracking may not appear for several years after many hours of vibrations and flight cycles.

5F BACK RIVETING

When riveting thin aluminum skins to light ribs or stiffeners, it is difficult to avoid getting some slight indentations of the skin around the rivet. Particularly on shiny, unpainted aluminum, the reflection of light makes the skin look much rougher than it actually is. One way to lessen this effect is "back-riveting". This means holding the bucking bar on the factory head of the rivet and driving from the shop end with the rivet gun and a special back rivet set. Unfortunately, this procedure is difficult or impossible for most of the airframe. However, it 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. On some wing skins and the fuselage sides, this is a two person job and a large area bucking bar is required. See fig. 5-6.

5G FOLDED TRAILING EDGES

On those surfaces that have folded trailing edges the skins come partially pre-bent. This allows you room to install the stiffeners and end ribs. The plans pages have drawings that show the proper radius that needs to be achieved on the final bend. A homemade bender can be fabricated from a pair of 2"x8"s and a number of door hinges to get the final bend correct. After riveting the stiffeners in place and bending the skins, check that both sides of the skin are flat and don't have a bulge on either side. Do this with a good straight edge. Before doing the final riveting, put a dab of RTV or tank sealant at the inside of the skin where the two stiffeners overlap. This will tie the stiffeners together. A dab about the size of some chewing gum will do the job and prevent the skins from cracking at this point due to vibration. See FIG 5-5 and FIG 5-7

5H RIVETED TRAILING EDGES

The riveted type of trailing edges require some extra work. 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 is fuel tank sealant, which is also used to bond the foam ribs in the trim tab.

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 AEX for the rudder is predrilled but the AEX for the elevators is not. They must be match drilled to the skins. Refer to the plans for the proper drill angle for this procedure.) 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. Clear the holes of any sealant with a drill spun with your fingers.

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 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 control surface over and set the trailing edge rivets to the final size with a mushroom set, again checking constantly. See FIG 5-9.

A little finesse will produce a nice double flush joint, but you must constantly guard against bowing the trailing edge.

5J 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, so the curve is started by rolling the edge of the rudder skin. You will need a piece of 3/4 or 1" steel water pipe, a broomstick, or something of similar diameter, about four inches longer than the skin.

Tape the edge of the skin to the pipe along its entire length. Use vise grips or small pipe wrench clamped to the pipe as a handle and roll the skin around the pipe. Keep pressure down toward the worksurface and away from the spar to keep 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. FIG 5-8 illustrates the process.

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 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 rudder skin before squeezing. See the Leading Edge Detail on the appropriate drawing.

Except for the fiberglass tips (those come after all the empennage surfaces are built, so you may do them all at once) the control is finished.

5K 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 obviously makes the lap joint appear wider than it is, makes painting more difficult, etc. One easy method of minimizing this effect is by pre-bending the last 1/4 inch or so of the skin downward just a few degrees 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. This procedure is illustrated in the drawings at the end of this section. There are several methods of making this slight edge bend. You can use a hand seamer, moving progressively down the sheet, making a very light bend to avoid bend marks between succeeding grips with the seamer. On long thin pieces you can put the sheet on an even-edged table with about 1/4" overhang and draw a block of hardwood or plastic along the edge with just enough downward pressure to cause the slight bend as it moves. Some tool suppliers sell tools for the purpose, usually two small rollers mounted on an aluminum disc. The edge of the aluminum sheet is placed between the outboard set of bearings 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 overbending the edge and causing a worse visual effect than before. Experiment with scrap material first.

5L FORMING ALUMINUM PARTS FROM SHEET

The RV-6/6A QuickBuild Kit requires forming several ribs and bulkheads from flat aluminum sheet and can be a useful skill in the Standard kits as well. Sheet metal brakes are capable of only straight bends, so parts with flanges along curved edges must be bent over "form blocks".

Form blocks 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 doesn't 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 form block and a "tool cap". This tool cap looks very much a form block, but does not have to be exact.

Its function is to keep the part from bowing or distorting when the flanges are bent.

The form block, blank and tool cap are all aligned with tooling holes and clamped together with bolts through these holes. The protruding edge of the blank is bent around the form block with a mallet or a lead bar. Final adjustments to the flange are made with a hand seamer and fluting pliers.

5M 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 won't scratch the aluminum.

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.

5N 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. An example is shown on Fig. 5-1.

The process used to manufacture the ribs may leave them slightly bowed. Before they are installed they must be straightened. This is done by "fluting", that is, putting small creases or "flutes" along the edge of the flange with special pliers. The flutes effectively shorten the flange and pull the rib into line. Fluting diagrams for the empennage, wing ribs and bulkheads are shown on the plans where required. Otherwise the flutes are simply centered between the pre-punched holes in the flanges..

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. Approach the fluting cautiously. Flute just a little at a time until the desired flatness is reached.

Make sure that the flanges are perpendicular to the web, so that they will mate correctly with the skins. Adjust with hand seamers as necessary. If you have overdone the flutes and curved the rib/bulkhead the other way, you can gently squeeze the flutes with the seamer to straighten the ribs.

5P ALUMINUM TUBING

In RVs we use 3003 soft aluminum tubing in at least four places, the fuel vent line, the fuel lines inside the cockpit, the brake lines and the pitot line in the wing. These lines must be bent with a tube bender to avoid kinking and get

a professional looking installation. The flared ends of these lines are 37° and not the 45° that are found on automotive lines. A good quality flaring tool is necessary tool to do the proper job. Properly installed, aluminum lines will last for many years. Here's 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, 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's a little tongue on the rotary flaring tool that serves a stop. Make sure you've selected the right diameter (RVs use 3/8 tubing for fuel lines, 1/4" tubing for fuel vent and brake lines), insert the tube from the far side of the tool until it hits the stop, then tighten the clamp.

Making the flare: Swing the stop out of the way. 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.

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. What? You don't have a Standard Aircraft Handbook with the torque tables for these things? Get one. (I'll give you these for free: assuming aluminum fittings, for 1/4" tubing it's 40-65 inch-pounds, for 3/8" tubing it's 75-125 inch-pounds.) Later, you can leak test the system.

5Q STEEL

The steel used in RVs is all 4130 grade. mostly in the form of thin plate and thin wall seamless tubing. 4130 is a high strength, high carbon steel 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 in his shop. 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.

5R INSTALLING NUTPLATES

Nutplates are almost always installed with AN426AD3 flush rivets. When the structure is too thin to machine countersink for a standard rivet, you have two choices of installation. An NAS1097AD3 rivet can be used. This rivet has a smaller head and therefore takes a much shallower countersink. The second method is to dimple the structure and dimple the nutplate. In order to dimple the nutplate you must modify the dimple die so it will clear the threaded portion of the nutplate. Simply grind away that portion of one side of the die that is in the way. If you do this carefully the die will still give good service in dimpling other parts. Of course you only have to modify the female half of the die.

5S FUEL TANK SEALANT

The recommended sealant, MC-236-B2, (often called ProSeal) 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?

Working with tank sealant can be a messy proposition but it doesn't 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.

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. Then thoroughly clean all the parts (including rivets) with naphtha or MEK or an etching acid like Alum Prep 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 loaders scale or postal scale. 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, 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 splice plate).

Following are two methods for making applying sealant easier.

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. A 35cc Monoject syringe will cost less than \$1.50. Drill the end out a little larger for better flow of the thick sealant. After filling the syringe with a Popsicle stick and squeezing out the air, you now have a miniature caulking gun.

Mixed, unused sealant may be kept in the freezer up to 4 days.

5T 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, wing & empennage tips, wheel fairings, and other fairings. The typical part consists of several thicknesses of bi-directional fiberglass cloth and resin.

Fiberglass parts supplied with RVs come in two types, polyester and epoxy. The polyester parts can easily be identified by their white gel-coat surface. The epoxy parts are translucent green. 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 the 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 it will dull tools quickly. 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. Get some flocked cotton fiber and micro balloons to mix with the resin for building up and filling. Most supplies can be obtained from a local marine/ boat store or from one of the mail order supply houses like Aircraft Spruce.

PREPPING THE COWLING FOR PAINT

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. You can also use this method for the wheel fairings and other parts. The parts have a thin layer of wax (mold release) which must be removed before painting.

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. 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 surrounding foam ends. Mix a marble sized portion of polyester ("bondo") body filler -- the filler will dry fast so do not mix too much. Even though we said not to use polyester on epoxy, when used in small amounts like filling pin holes, it works OK. 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 UV Smooth Prime and Superfil. 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.

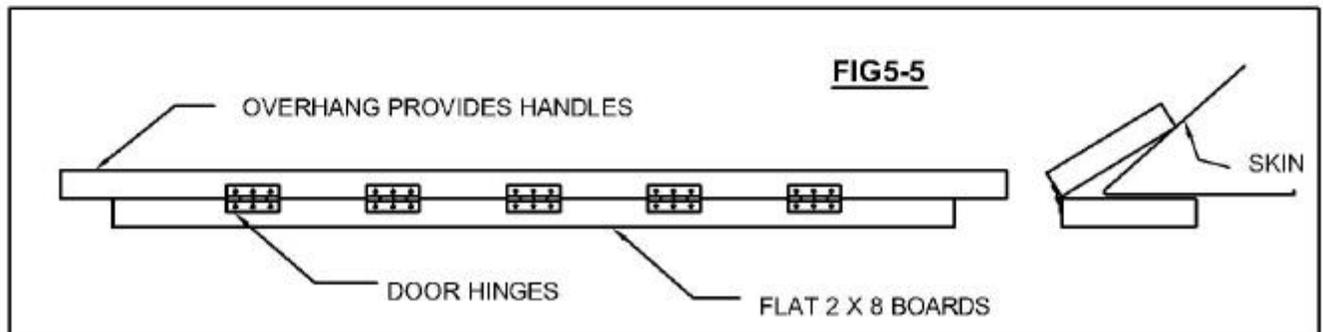
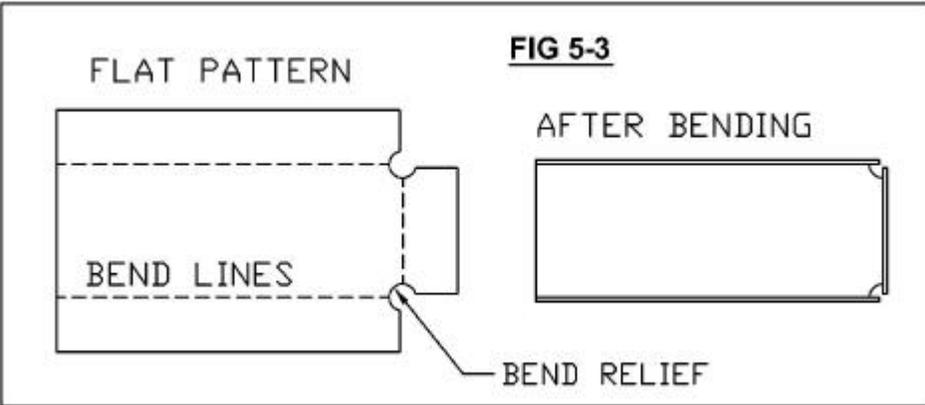
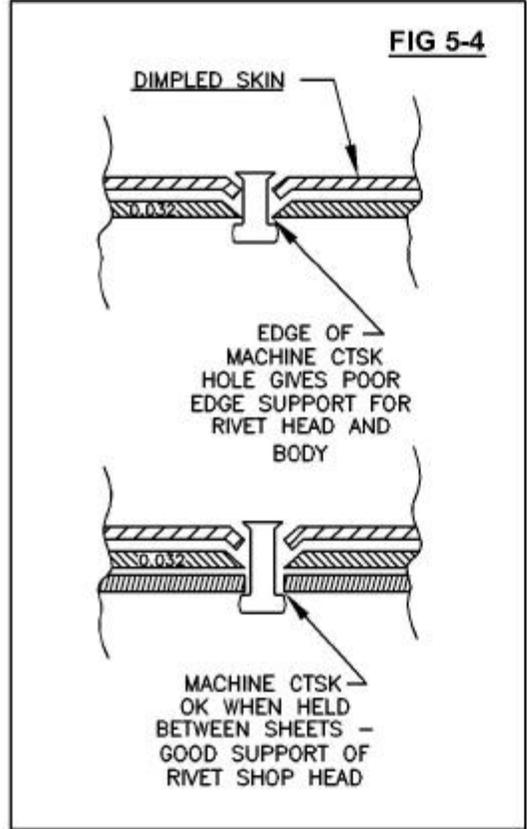
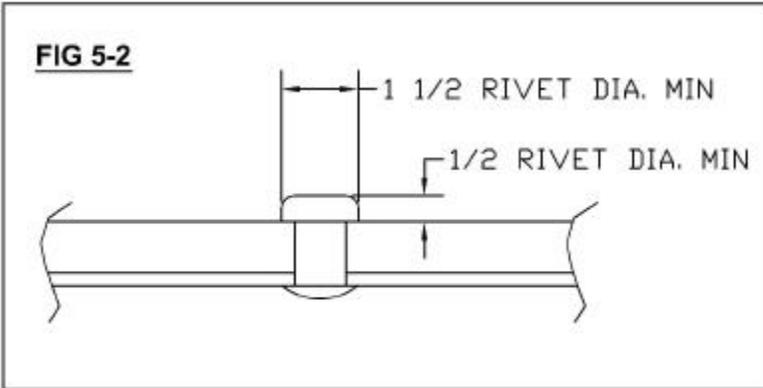
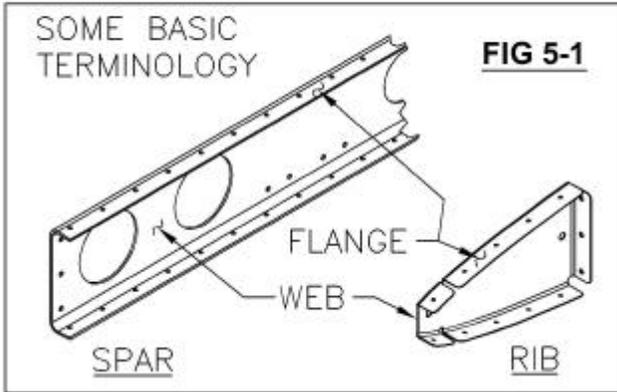
5U PLEXIGLASS TIPS

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 60° F is asking for trouble. Heat the shop to 75-80° -- 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.

Regular twist drills have tips that tend to fracture Plexiglass. Special Plexiglass drills are available from tool suppliers. Chipping on the back side of drilled holes can be eliminated by clamping a piece of wood to the Plexiglass and drilling through into the wood. 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! If a die grinder is not available an electric drill will work but you will have to make several passes going a little deeper each time until you break through. Practice on the flanges of the canopy for both the cutting and drilling operations.



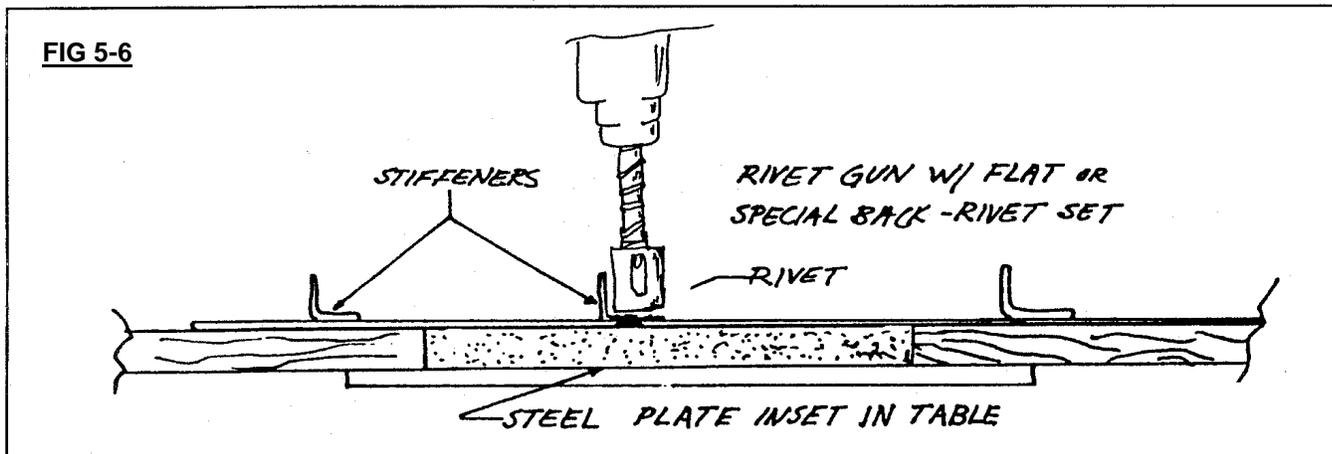


FIG 5-6 Back riveting is an easy way to get a smooth finished surface. The rivet gun is used on the shop head of the rivet. The special back rivet set has a spring loaded sleeve that helps keep the metal pieces firmly together.

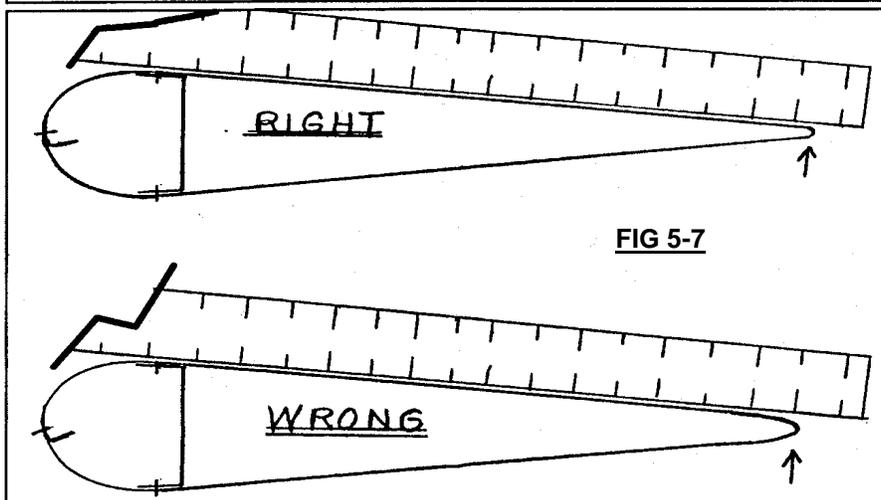
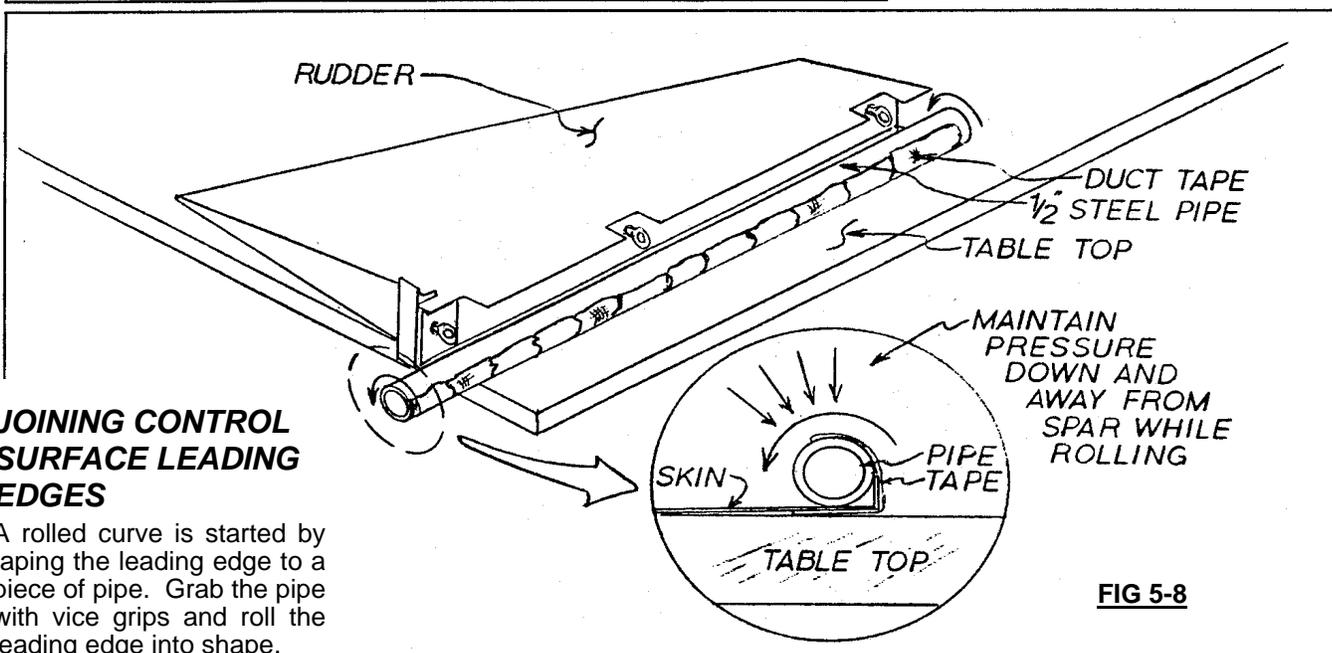
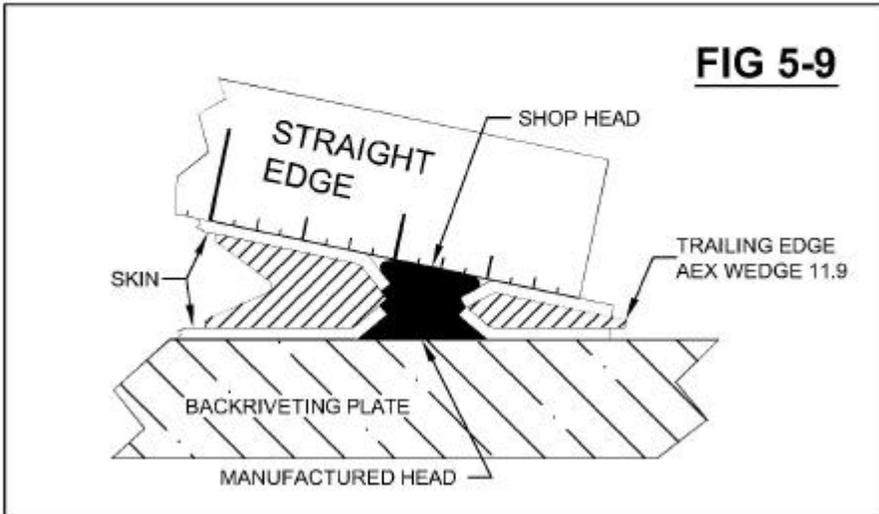


FIG 5-7 The shape of the control surface trailing edge affects the way the controls feel and the airplane flies. The home made bending brake in **FIG 5-5** is used to make the shape shown. A straight line from the spar to the trailing edge radius. Avoid bulged trailing edges.





5V NUT AND BOLT TORQUES

The importance of correct torque application cannot be overemphasized. Undertorque can result in unnecessary wear of nuts and bolts, as well as the parts they secure. Overtorque 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.

Be sure that the torque applied is for the size of the bolt shank not the wrench size.

Use a calibrated torque wrench.

Be sure the bolt and nut threads are clean and dry.

Apply a smooth even pull when applying torque pressure.

Whenever possible torque the nut, not the bolt.

When applying torque to a bolt be sure to have a washer under the bolt head and lubricate the bolt shank.

The chart below is for most of the fasteners used on RV's. Note that on the smaller bolts the torque is quite low and is in inch pounds. Do not try and use a foot pound torque wrench on these bolts. Get one 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.

AN Bolt size	Bolt size- Threads per inch	Standard nuts AN310, AN315, AN365	
		INCH Pounds	FOOT Pounds
AN3	#10-32	20-25	1.6-2.0
AN4	1/4-28	50-70	4.2-5.8
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

SOME NOTES ON DRILLING

The hardness and alloy of the material and the makeup of the cutting tool determine the speed that metal is 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. Simply put, that is the speed that the cutting tool passes through the material being cut. 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. You can use most any oil, WD-40 etc. There is no need to get sloppy, just enough to lubricate and carry off some heat. Drilling steel requires considerably more feed pressure than aluminum.

The chart below is general and you can interpolate speeds for sizes not listed. As you can see the speeds for drilling aluminum are higher than any of our hand held drills are likely to go. That's why an air drill is superior to electric drills for aluminum. It is also assumed that the drills are sharp and the set-up is rigid, as in a drill press.

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

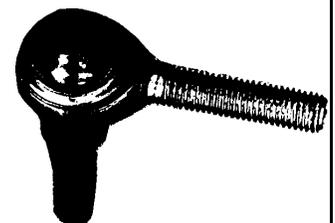
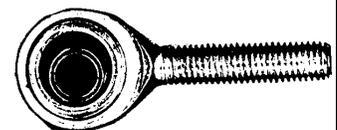
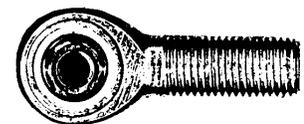
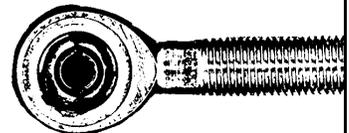
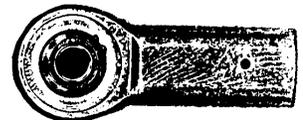
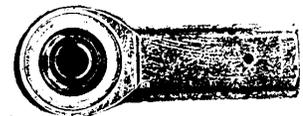
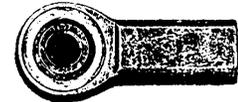
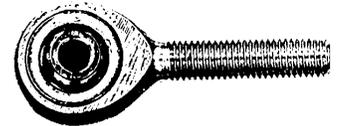
When drilling with a hand drill it is advisable to start the drill turning slowly, then increase the RPM after the drill is centered and stabilized in the hole. You can drill a straight hole by aligning the drill with the reflection in the shiny aluminum.

The small drills that we use in RV building are of the split point style and need special equipment to sharpen. You may need as many as a dozen each of #30 and #40 before the project is finished. Don't skimp on drills, when it gets dull get a new one.

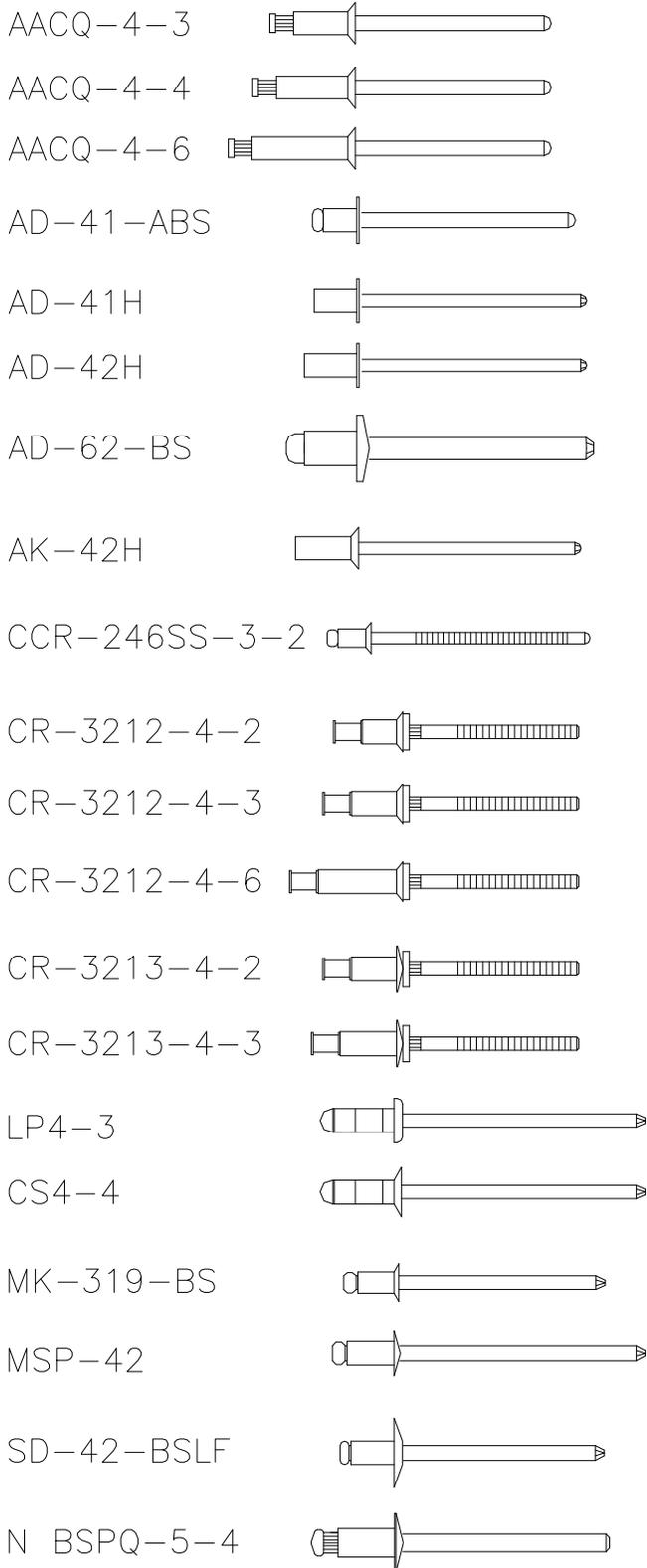
See section 9 for tips on drilling Plexiglass.

ROD-END BEARING REFERENCE CHART

Part no.	Stud	BearingHole	Length	Thickness
M3414M MM3M-12	1/4" male	3/16	1.94	7/16
MW-3M	3/16"female	3/16	1 3/8	0.31
F-3414M MW-3M-16	1/4 female	3/16	1 3/4	7/16
F-3514M MW-3M-16	5/16 female	3/16	1 3/4	7/16
MD-3616M	3/8 male	3/16	2 1/4	1/2
MD-3614M MM3M-20	3/8 male	3/16	1 3/4	7/16
CM-4M	1/4 male	1/4	1.94	3/8
CM-4S	1/4 male	1/4 stud	1.94	



5



BLIND RIVET IDENTIFICATION

SEE VAN'S CATALOG FOR COMPLETE DESCRIPTIONS

SCALE 1-1

5W ELECTRICAL WIRING NOTES

The following schematic represents the electrical system for a basic VFR homebuilt airplane. It includes a battery, starter, alternator, magneto/starter switch, fuel pump and radio. This schematic will be expanded to include other electrical devices and will be used to explain the basics, but has all of the items necessary for an aircraft electrical system.

Refer to the full page schematic for the continuing dialog.

Electricity: There are three primary units of measure or terms we must know to successfully wire our plane: 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 12 and 13 volts. When a battery is installed in an airframe and the alternator or generator is operating, the system voltage will be 13.5 to 14.5 volts. For this discussion, we will use 14V as the nominal voltage. 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 Watt (W), which is a measure of power being consumed by a circuit. Items such as lights are typically rated in watts.

Now that we are electrical engineers, we can start determining the size of the breakers and the size of the wire to use.

As determined from the chart below, the landing light will require about 8 amps to operate at its rated output of 100 watts. For practical purposes we can round this up to 10 amps (never round current down). Thus we will need a 10A breaker for the 100W landing light. Be careful with the taxi light though. It will require its own breaker, or we can increase the size of our lighting breaker, or we can wire it so the landing and taxi lights can never operate at the same time. On the schematic we have provided for a separate breaker. This is a safety precaution. Occasionally when a lamp burns out, it will short out (as opposed to going to an open circuit) and draw a lot of current. This will cause the circuit breaker to trip to keep from burning out the wire going to the landing light. If both taxi and landing light were on the same breaker, both lights would now be inoperative, but being wise, we provided a separate breaker for the taxi light and will at least have some light to find the tarmac, even if it is pointed in the wrong direction. The next step in wiring the light is to determine the size of wire to use. In this installation, the light is mounted in the wing and the distance from the battery through the switch and breaker out to the wing is about 15 feet. Referring to the chart at the lower left corner of the schematic (*Wire length vs. wire size*) we can see that a 16 gauge wire can carry 10 amps of current 10 feet, slightly short of the 15 feet we need. The next size wire is 14 gauge which can carry 10 amps 16 feet. Bingo... this is the correct size wire. This same scenario can be used to determine the size of wire for most of the installations. A larger size wire (14 ga. is larger than 16 ga.) can always be used but a smaller size wire should never be used. Keep in mind one thing, the breakers are installed to protect the wiring, not the appliance (radio, strobe, light, etc.). If you decide to use the next size larger breaker for a little extra margin for the light, then you should go back to the chart to determine what size wire to use. If a short did occur in the light and a 15A breaker was installed, our 14 gauge wire might melt the insulation or burn into two pieces before the breaker opened. Not a pleasant thought!

Radios. The schematic indicates a radio master which allows us to turn all the radios off for startup and shutdown, thereby protecting them from any voltage spikes which may occur. After the switch, there are two circuit breakers. One protects the wiring going to the NAVCOM and Intercom and the second breaker protects the wiring to the GPS, transponder, and altitude encoder. All of the equipment could safely operate directly off the switch, since the 20A breaker would protect the wire, but two breakers are incorporated allowing smaller wire to be used for power to the radios and to allow some of the equipment to continue to operate if a short occurs at one of the pieces of equipment. If the two breakers are used after the switch, it is not necessary to have the 20A breaker associated with the switch and a less expensive switch could be used.

In determining the size of the breaker and wire we can look at the radio specifications. This example uses a King KXI 55. The current requirements are 0.7amps in the receive mode and 8.5 amps in the transmit mode. The intercom only requires 0.1 amp. The most current required is going to be 8.6 amps for the combination of the radio in the transmit mode and the intercom. This would round up to a 10A breaker. Since the radios are within 5 feet of wire length from the battery, the chart on the schematic indicates we can use either 18 gauge or 16 gauge wire. This wire would go from the 10A breaker to the radio. The short segment from the switch/20A breaker to the smaller breaker should be a 12 gauge wire. The main breaker located at the switch should be at least equal to the sum of the two smaller breakers or larger. As an example, if a 10A breaker is used at the switch and a fault occurs at the NAVCOM, then the 10A switch/breaker will trip before the 10A breaker protecting the NAVCOM, thus interrupting service for all the COM equipment.

The alternator circuit is a fairly simple piece of the electrical system. The alternator is rated by the amount of current it can produce. When the engine is operating, the alternator is providing all of the electricity used by the equipment

on board, and any excess current is routed through the ammeter to the battery where it is stored (charges the battery). The wire and circuit breaker going from the alternator to the bus bar (see description of bus bar later in this article) and then to the battery must be large enough to carry this current. Typically a switch is not placed between the alternator and the battery because of the potential for high currents. The mechanism for disabling the alternator is the switch going to the regulator. This is a low current circuit which controls the output of the alternator, with the ability to disable the alternator and/or change the output voltage. When disabled, the alternator current output will drop to zero amps and the system voltage will drop from 14V to 12V as provided by the battery.

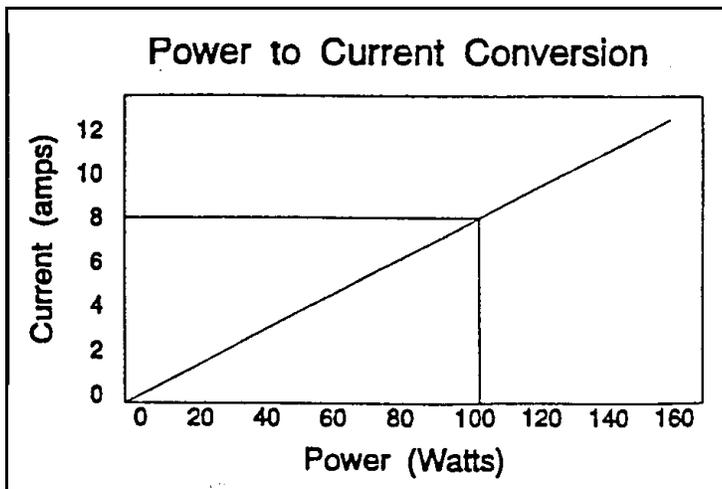
Ammeter vs. voltmeter. Some pilots prefer the ammeter while some prefer the voltmeter as the instrument of choice to monitor the electrical system. The ammeter when wired as shown on the schematic will indicate a charge condition when the alternator is operating and excess current flows to the left through the meter and into the battery. If the alternator is not producing electricity (either turned off or the engine is not operating) and a landing light is turned on, current will flow out of the battery, through the ammeter from left to right and on to the light with the meter indicating a discharge condition. The ammeter thus gives an indication of current flowing into or out of the battery. The voltmeter indicates the voltage on the bus bar, or electrical system. The battery alone will give a reading of 12 to 13 volts. When the alternator is operating, the voltage will indicate between 13.5 and 14.5 volts. From the voltmeter, one can determine whether the alternator is operating, but the actual amount of current flowing into or out of the battery cannot be determined. If it is determined that a voltmeter will not be part of the installation, just leave it out. If it is determined that the ammeter will not be used, then a jumper must be provided from the master relay to the bus bar in place of the shunt as shown on the schematic.

Relays are electrically controlled switches capable of conducting a lot of current. Typically there are two types used on aircraft. The master relay is a continuous duty relay with three terminals. Two of the terminals are large where the large currents used for starting the engine will flow. The third terminal is a control terminal. The Master Switch is connected to this terminal and grounds the terminal to activate the relay. Note that the two large terminals should not be re-versed (i.e.: the battery connection must be to a specific terminal) or the relay will not operate when the Master Switch is turned on. The second type of relay is an intermittent duty relay (starter relay). This type of relay is only rated for intermittent duty, such as operating the starter. The starter relay comes in many configurations. Typically there are two large terminals which carry the large currents for the starter motor and one or more smaller terminals. The large terminals on this relay are reversible. One of the smaller terminals will be the control terminal. 12V must be applied to this terminal to activate the relay. On some versions of this relay, the ground for the coil is through the case and on some varieties, a second terminal will need to be wired to ground for the relay to operate.

Radios again. Antennas are connected to the radio via coaxial cable. Be sure to use the proper impedance cable (i.e. 50 ohms RG-58, not 75 ohms). The antenna must be mounted on a metal surface (ground plane) for proper use as a transmission antenna with the braid of the cable connected to the ground plane adjacent to the antenna installation. Corroded or broken connections at the antenna end, either the center conductor or the ground braid) can cause transmission problems, while the receiver functions normally. When stacking radios vertically, cooling may be required since the vertical heat flow is impeded from radio to radio. -Some radios use the NAV antenna as the COM receiver antenna, so both antennas must be installed for COM operation, even if the NAV function will not be used.

Anti-collision/strobe - These lights should be placed where they will not interfere with the pilots vision. A strobe should flash between 40 and 100 times per minute. Strobes are rated by joules of energy (20 joule min.) with candle power as a measure of light leaving the tube. Strobes use a power pack to convert the aircraft 14 volts to 350 volts as required by the flashtube. Strobes and anti-collision lights must have individual switches to disable the light if the light is reflected back into the aircraft by fog or clouds, thus temporarily blinding the pilot.

Wiring - Stranded wire is preferred over a solid conductor. Solid conductor (a single strand of wire) 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 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.

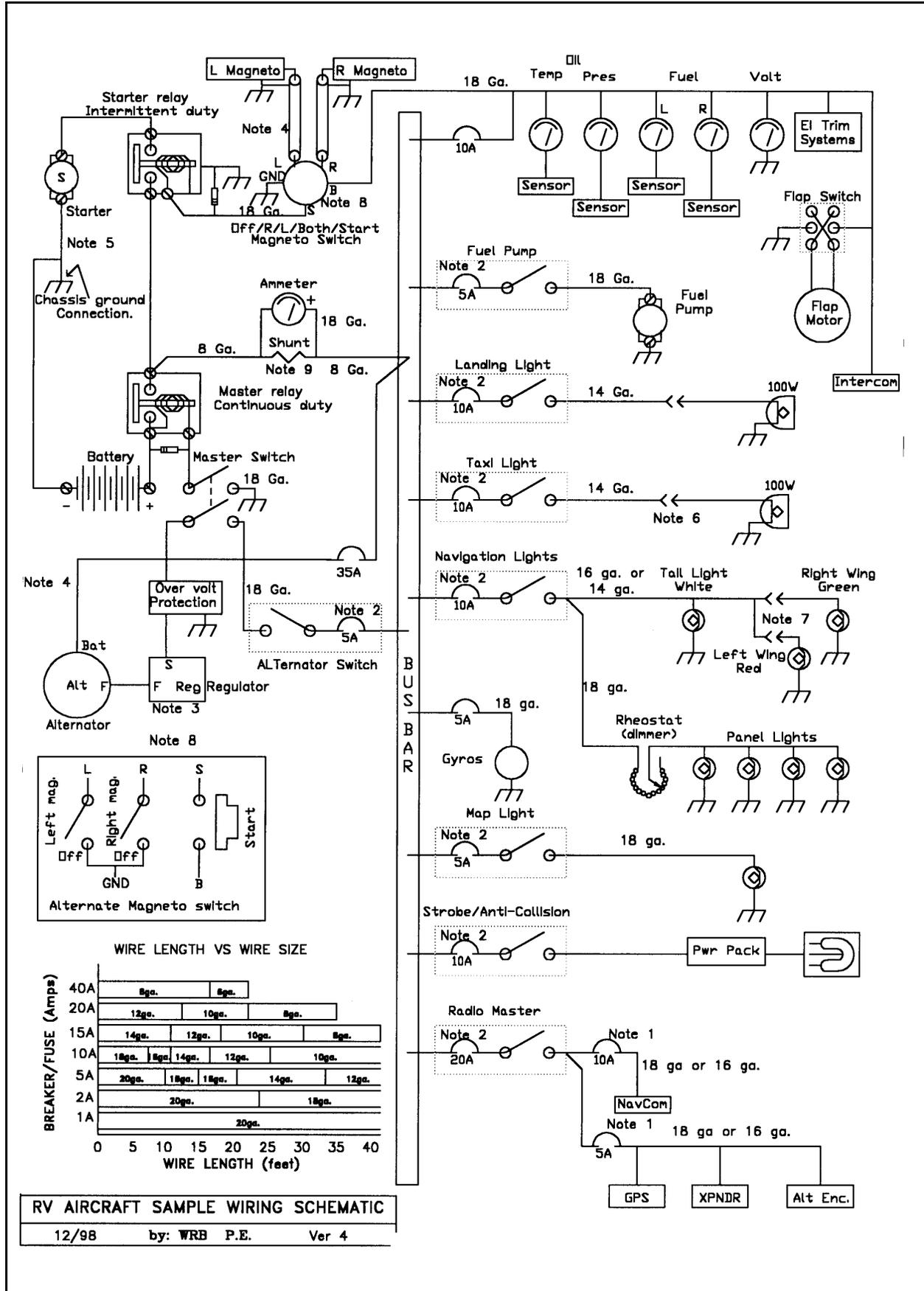


The following numbers correspond to points on the schematic for additional information:

1. Circuit breakers protect the wiring, not the appliance.
2. Either breaker switches as shown or individual switch and circuit breakers (or fuses) can be used.
3. The voltage regulator should be placed near the battery, or at least in the same temperature compartment as the battery. As the battery changes temperature, a different voltage is required to charge it. If the regulator is at the same temperature as the battery, it will regulate the voltage to properly charge the battery.
4. Shielded wire to eliminate noise pick-up from electrically noisy devices. This is optional. Plain wire can be used and an automotive type condenser used at the terminal where the noise is created.
5. The same size wire that is used to connect the battery to the starter must be used from the negative battery terminal to the engine case. Ideally it will be in two sections, the first from the battery to the airframe at the firewall and the second from the firewall (using the same bolt to connect both ends to the firewall) to the engine case. This connection to the firewall will be the airframe ground where all the returning current from the lights, radios, etc. will return to the battery.
6. 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).
7. Quick disconnects or a terminal block can/should be provided at points where there may be a need to separate the wires at some point in the future. However, each such joint is a source of failure, is extra expense, and is extra weight.
8. Either a mag switch/starter switch combo can be used, or individual switches as shown in the box on the left side of the schematic. If individual switches are used, a placard will be required informing that the start procedure is to use only the LEFT MAG (the mag with the impulse coupling). Once the engine has started, the right mag is turned on.
9. The shunt type ammeter is the preferred type. All the current (other than the starter) from/to the battery flows through the shunt. This creates a small voltage drop which is measured by the meter. The advantage of this system is the shunt is placed in the vicinity of the battery or the bus bar. The entire current is not required to route up through the meter.

The bus bar shown on the schematic is a common connect point for the distribution of power in the plane. Some installations may use a piece of copper bar stock connected along the breakers, while another installation may jump wires from point to point. Another method would be to use a long screw on a switch, circuit breaker, or even an insulated bolt as a common point for the distribution of power.

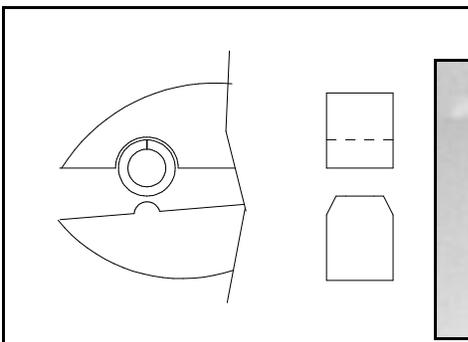
The best method for wiring the plane is to use the back of one of the pages of the plans and create (draw) a custom schematic. This schematic should have all the appliances (radios, instruments, lights, etc.) placed on the schematic similar to the way they will be installed in the plane. Then start by transferring the connections from the sample enclosed schematic to the custom schematic, add all of the additional wires such as mike, headsets, PTT (push to talk switch), altitude encoders, etc. From each radio, draw all connectors as they appear on the radio and show each wire connecting to the correct pin. From this layout, the wire size can be documented, cable routing can be determined and a neat and professional wiring job can be accomplished.



Electrical Connections

There are several types of pliers that can be used for crimping ring terminals to wires. Before we discuss the pliers, let's look at the nature of the terminal.

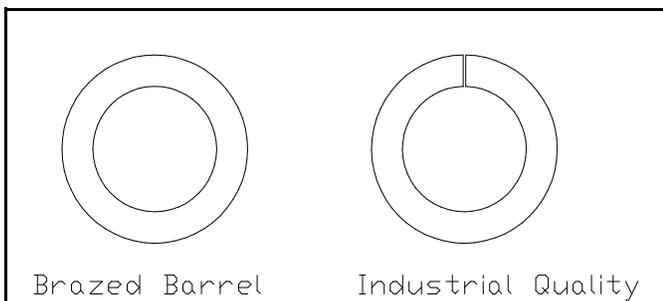
The most common terminal to be used on an aircraft will be a ring terminal. This is a device, which has a ring on one end and a barrel on the opposite end. The barrel is used to attach the wire and the ring block, switch, meter, alternator, etc. The hole for the screw (stud size) comes in various sizes. The most common sizes used on our aircraft will be for a #6 screw (terminal blocks, switches, some instruments), #8 screw (instruments, circuit breaker switches), #10 screw (AN3 bolts), 1/4" bolt, 5/16" bolt (battery terminals, master and starter solenoids, and the starter).



on the opposite end. The barrel is used to attach the wire and the ring block, switch, meter, alternator, etc. The hole for the screw (stud size) comes in various sizes. The most common sizes used on our aircraft will be for a #6 screw (terminal blocks, switches, some instruments), #8 screw (instruments, circuit breaker switches), #10 screw (AN3 bolts), 1/4" bolt, 5/16" bolt (battery terminals, master and starter solenoids, and the starter).



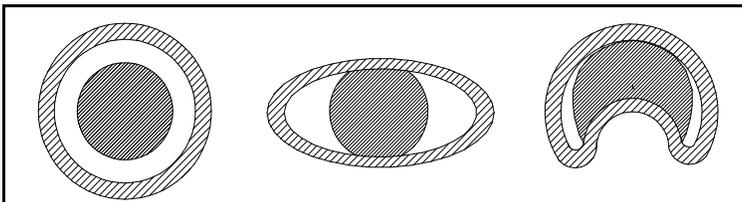
Likewise the barrel comes in various sizes for the wires. The most common will be for wire sizes (AWG) 22-16, 16-14, 12-10, 8 for the alternator and the 2 gauge battery wires. Smaller barrels will accommodate more than one wire size, whereas the larger barrels are designed specifically for one wire size. 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.



insulation, which is the terminal type used in most of our applications. The larger terminals for 2 gauge wires are usually not insulated.

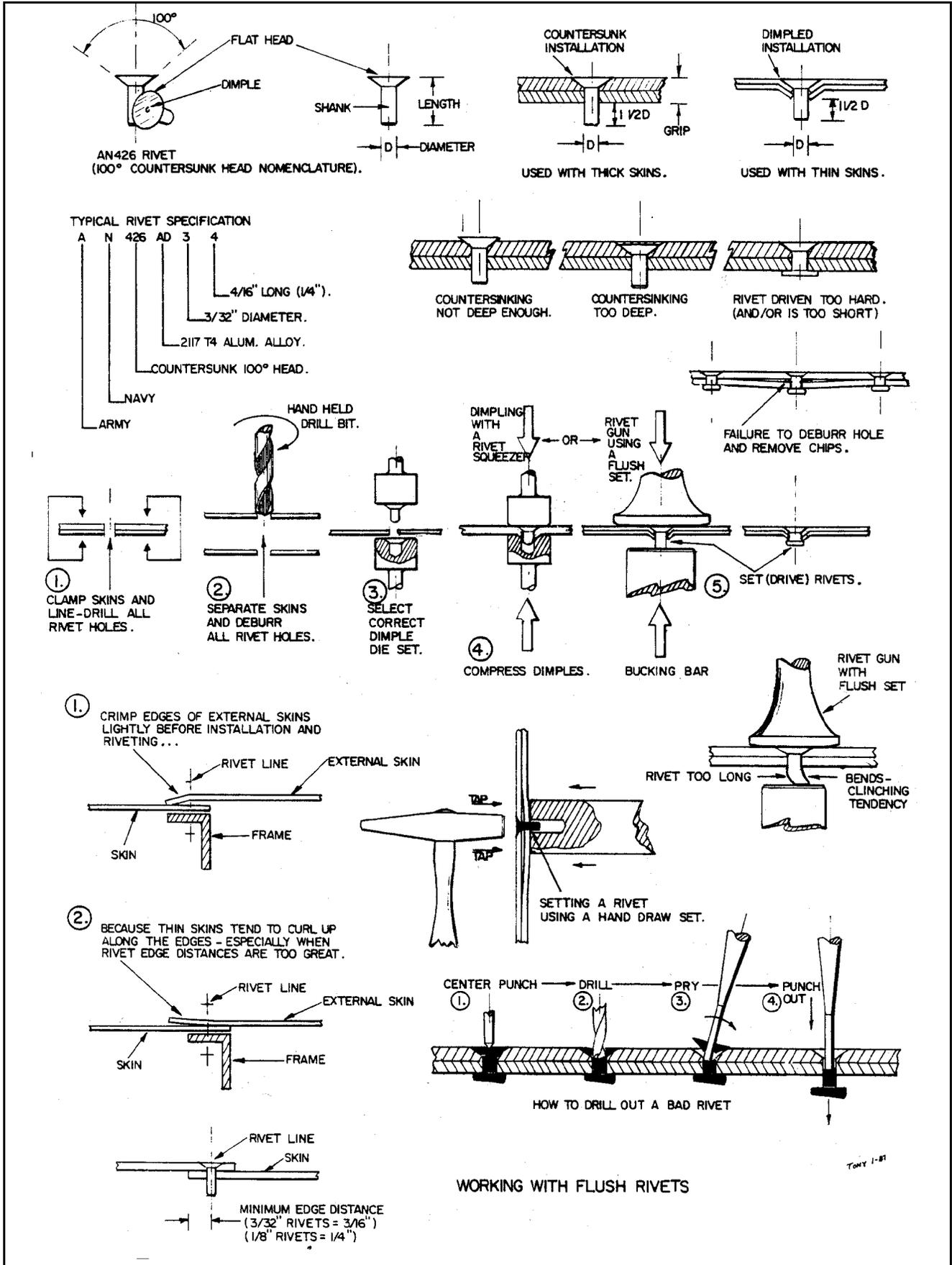
The industrial quality barrel will be a folded or rolled barrel as shown and the higher quality barrels will be a continuous barrel that has been brazed at the seam. When crimping, it is important to note where the seam is to ensure that the crimp will not cause the barrel to spread open.

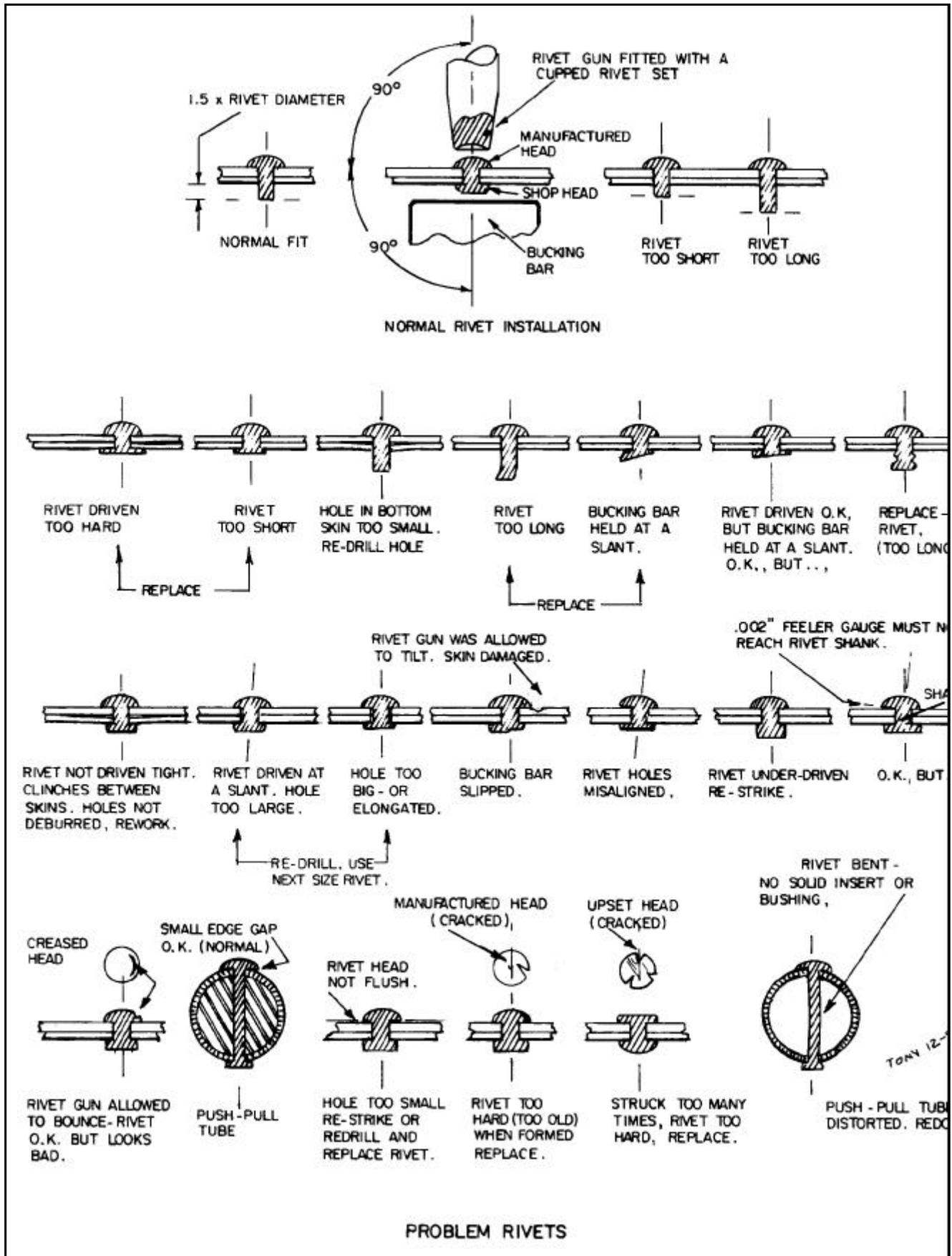
There are several types of crimpers on the market. Most of them are of the lesser quality which tend to distort the barrel when the crimp is made by flattening the barrel (view "B") from its original round shape. During this flattening process, the industrial quality barrel will tend to spread the seam and not grip the wire strands equally. Even the brazed barrel when flattened will provide a lesser quality crimp. The lump of wire centered in the crimp will limit the compression of the barrel while the strands of wire around the perimeter of the wire bundle will not be compressed. The crimper that works the best is a crimper that indents the barrel on one side, maintaining the round shape on the opposite side. This type of crimper lends itself to the industrial terminal by not distorting or opening the seam if the crimp is performed on the side opposite the seam as shown in view "C" above. 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. Soldering of the barrels is generally not recommended as this will form a rigid point and the wire will typically break right at the end of the solder. The only time solder would be used is on the smaller wire sizes (22 gauge and smaller) where it was questionable if the wire was securely crimped. Then the wire should be securely tied into a bundle near the solder joint where it can not vibrate.



right at the end of the solder. The only time solder would be used is on the smaller wire sizes (22 gauge and smaller) where it was questionable if the wire was securely crimped. Then the wire should be securely tied into a bundle near the solder joint where it can not vibrate.

The crimper as depicted works the best. There are some light weight crimpers that have the same die characteristics in the handle aft of the pivot point that will work, but the best is a crimper with the squeezing jaws forward of the hinge point and close to the hinge point giving a lot of leverage for a good crimp. This is not an expensive ratcheting crimper, but one that is in a reasonable price range. The units made from stamped metal are not as good as the crimpers made from forged steel.





The manual now changes from general information to specific building instructions for the empennage of 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 like available help, available space, or just personal preference, you might well alter some procedures with good results. It does not mean, either, that you should simply follow the instructions blindly, one step at a time, without thinking ahead.

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.

The empennage is a logical place to begin building. It consists of several independent structures, so even a major mistake on one surface may be corrected inexpensively. It also gives a good introduction to techniques and materials that will be encountered throughout the project. The methods of joining skeletal parts and attaching skins are typical of the entire airframe.

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