COMPOSITE MATERIALS EDUCATION

DON'T SKIP THIS SECTION. Every hour you spend in this preparation section will save you five when you really start building your aircraft.

INTRODUCTION

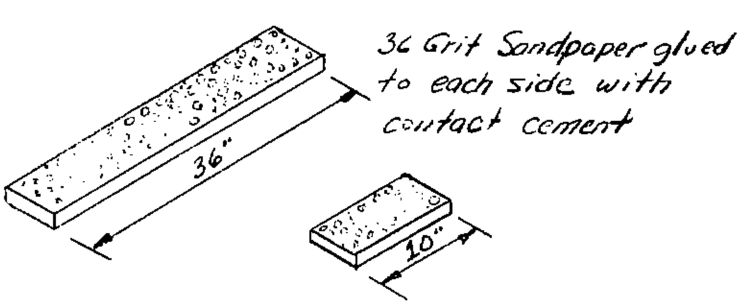
In this section you won't build any part of your airplane. What you will do is learn how to build your airplane the right way. The construction techniques may be radically different from anything you've done before (including building boats, surfboards, airplanes, and gocarts), and you should assume there is only one correct way to do it. We've discovered many wrong ways of doing things and have written the plans to keep you from repeating our mistakes. We insist that you do things our way. If you have a better idea, suggest it to us; we'll test, and if it really is a better idea we'll publish details in the Quickie Newsletter.

This section will teach you all of the techniques required to build your airplane, show you what special tools you need, and how to use them. The educational samples that you will build in this section are designed to give you experience and confidence in all of the techniques that you will use in the construction of your airplane. The steps in construction of each sample are arranged in sequence (as are the steps in construction of the actual aircraft parts) and you should follow the sequence without skipping any steps. You will learn the basic glass layup technique used throughout the aircraft, special corner treatments, foam shaping/cutting, and joining methods. A summary of these techniques is provided on yellow paper for you to tack up on your shop wall.

THE FOLLOWING TOOLS ARE ONES YOU MAKE:

Sanding Blocks

These are required in many areas during construction and for finishing. You may also use a "soft block", which is a block of the blue-white or orange styrofoam wrapped with sandpaper.



Much elbow grease is saved if you replace the sandpaper often.

Long Straightedge

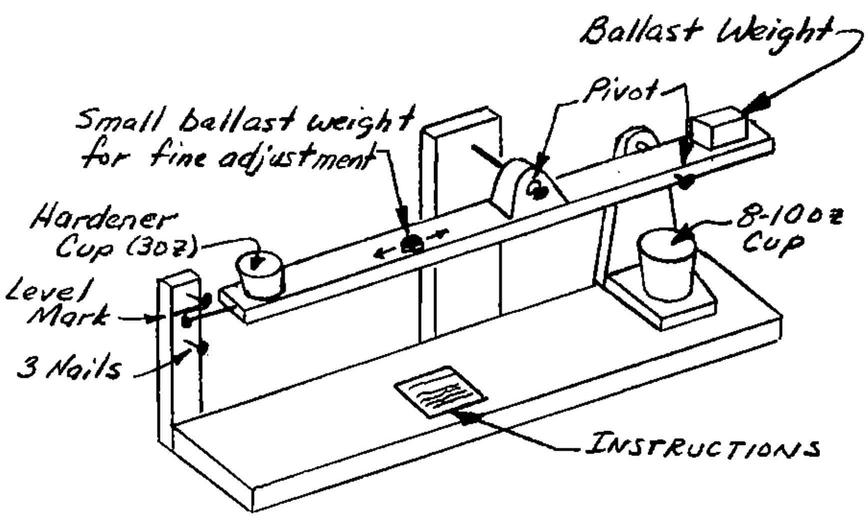
This is not absolutely required, but is quite handy when jigging or checking the straightness of flying surfaces. It is merely a 6-ft or 8-ft 1x3 or 1x4 piece of lumber that is hand-selected to be "eyeball straight". You can get it one of two ways: (1) Order it from Aircraft Spruce & Speciality Co., or Wicks Aircraft Supply - they plane them perfect from dry lumber. (2) Sort through the lumber (dry fir or redwood) at your local lumber yard until you find one that looks straight when you eyeball it from one end. Mark it and hang it on the wall so it doesn't end up as part of a shelf!

Epoxy Balance

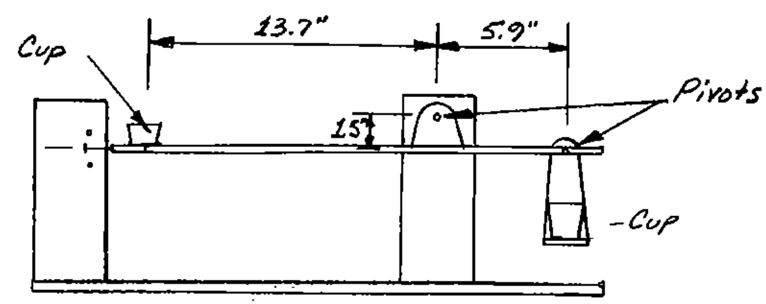
Devices which automatically ratio the correct amount of resin and hardener and dispense it with the pull of a lever are available from Aircraft Spruce & Speciality Co., and Wicks Aircraft Supply, for approximately $150. These save time and epoxy. You can ratio the epoxy by building the following simple balance - don't skip steps!

Follow each step exactly every time you mix epoxy.

1. Place both empty cups as shown (wet the hardener cup).
2. Adjust ballast weight to level mark.
3. Fill resin cup with desired amount of resin - 1 to 6 oz.
4. Add hardener to hardener cup to balance scale on level mark.
5. Pour the hardener into the resin cup and mix.



Pivots - metal tube bushings in wood. Loose fit on nails. The 1/8" dia brass tube available at hobby shops is excellent for the bushings. MUST BE FRICTION-FREE.

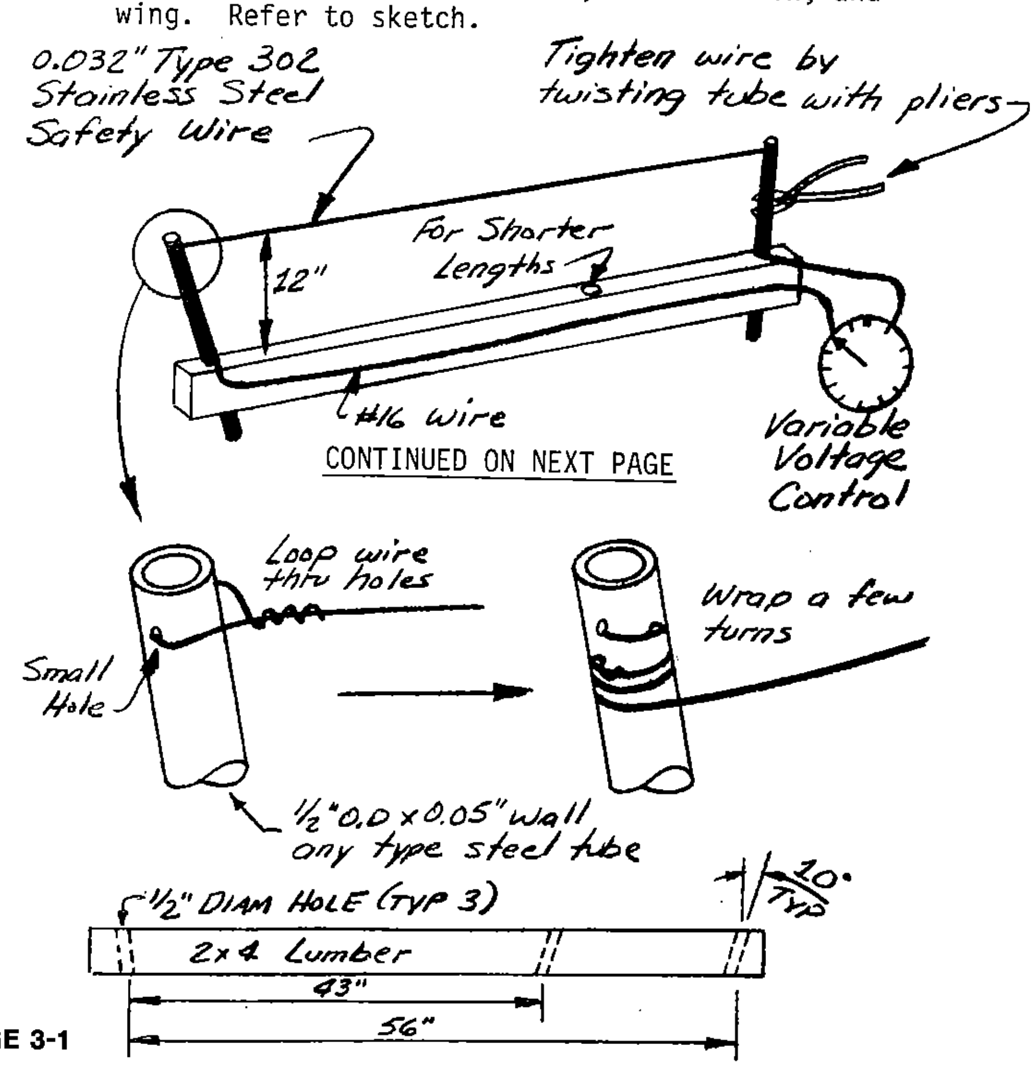


These ratios result in a 43-part hardner to 100-part resin mix.

RATIO BALANCE FOR RESIN/HARDENER
1. Place both empty cups as shown. (Wet the hardener cup).
2. Adjust ballast weight to level mark.
3. Fill resin cup with desired amount of resin - 1 to 6 oz.
4. Add hardener to hardener cup to balance scale on level mark.
5. Pour the hardener into the resin cup and mix.

Hot Wire Cutter

You will need a hot wire cutter to carve all the foam cores for the canard, vertical fin, and wing. Refer to sketch.



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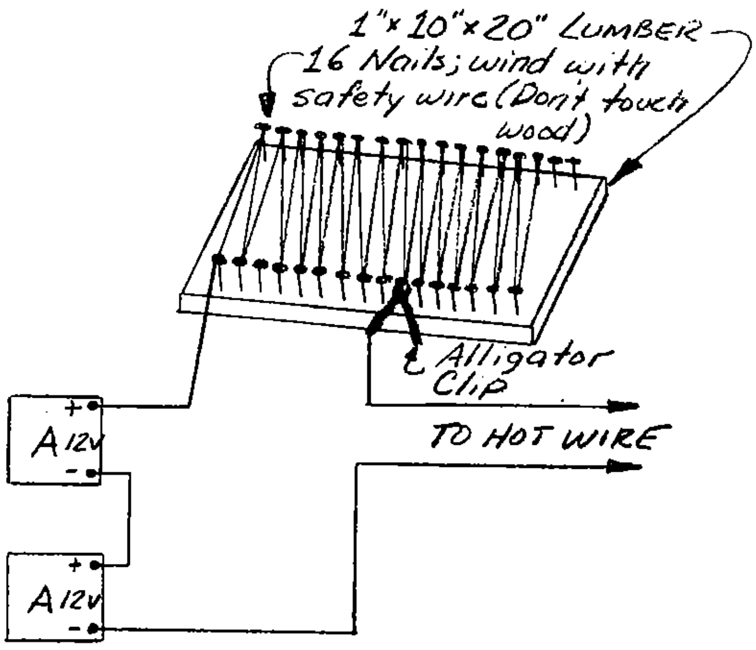
The variable voltage control can be obtained from Aircraft Spruce and Specialty or Wicks Aircraft Supply, or you can substitute any controllable power supply to include the 14 to 20 volt range with at least 4 amp capability. An alternative is to borrow two 12-V battery chargers or auto batteries and lash up the following device. The "A" blocks represent either a battery or a 12-V dc battery charger with a 4 amp capability.



Note: Alligator Clip: move to right to cool wire, move to left to heat wire.

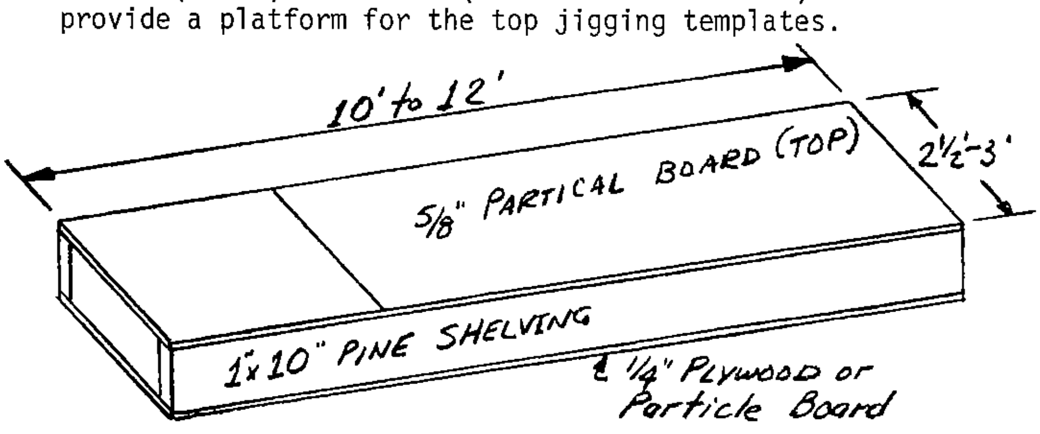
The cutter should only be used on the blue-white or orange styrofoam. A hazardous gas is emitted if you try to cut urethane.

You can substitute .025 nicrome wire which can be run at a lower current (about 2 amp) but nicrome wire is difficult to find. Adjust the current to obtain a wire temperature which will allow the wire to cut the foam at a rate of one inch every four to six seconds when pulled with a light load (less than ½ pound). This can be checked with a small scrap of foam. If temperature is correct, the foam will have smooth hairy surface. A cratered surface means too much heat. If the wire is too cold, the cutter will have to be forced hard, causing the wire to lag. Lag should not exceed ½ inch over the top and bottom of the wing and not over 1/8 inch around the leading edge. If the wire is too hot, it will burn away too much foam, making the part too small and will result in ruts in the foam if the wire is inadvertently stopped during cutting. The wire should be tightened until the wire starts to yield. Check this by tightening the wire while plunking it, listening to the sound. The pitch will increase until the wire yields.

Jig Table

You will need a table to jig and build the wings and canard. It should be at least 2 ft by 10 ft. Any larger than 4 ft. by 12 ft. will just get in the way. Use a little care in making a flat, untwisted surface. The following is a sketch of the one we made and it works fine. The box design makes it stiff in torsion. Set it up with the top 35 to 39 inches above the floor. Don't get carried away with surface finish, since you are going to be gluing blocks to it with Bondo and chiseling them off several times.

When building the wing and canard, which are nearly 17 ft long, one can extend the jig table with lumber (2x4's) and Bondo (see section on Bondo) to provide a platform for the top jigging templates.



JIG TABLE

MATERIALS

The materials, processes, and terminology used in the construction of your Q2 are recent to homebuilding. This section is devoted to familiarizing you with the language, materials, and techniques used in these plans. This information is basic to the construction of your airplane. You should study this section and be sure that you understand all of it before continuing.

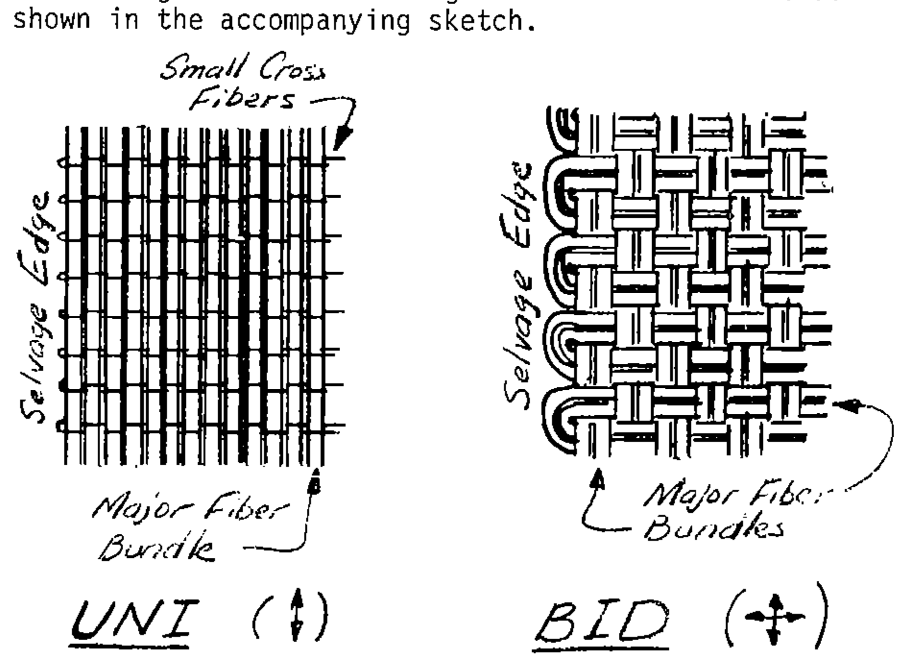
There are five basic materials that you will be working with: fiberglass cloth, epoxy, microspheres, flox, and foam. Each material, its properties, and uses, will be discussed in detail. Basic processes using these materials will also be discussed.

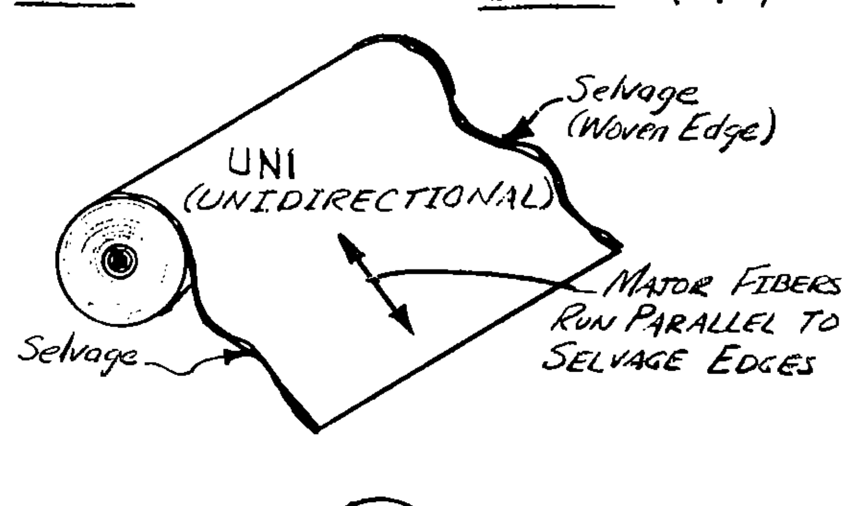
Fiberglass Cloth

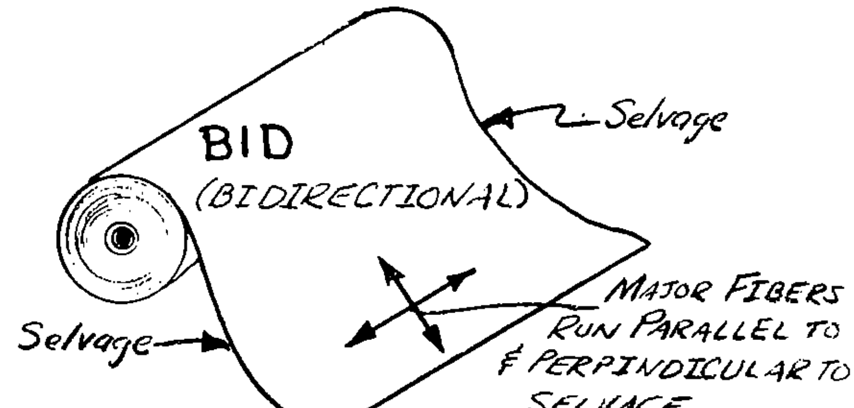
The most basic structural material in your Q2 is glass cloth. Glass cloth is available commercially in hundreds of different weights, weaves, strengths, and working properties. The use of glass in aircraft structures, particularly structural sandwich composites, is a recent development. Very few of the commercially available glass cloth types are compatible with aircraft requirements for high strength and light weight. Even fewer are suitable for the handlayup techniques used in the Q2. The glass cloth used in the Q2 has been specifically selected for the optimum combination of workability, strength, and weight.

The glass cloth in your Q2 carries primary loads, and its correct application is of vital importance. Even though doing your glass work correctly is important, this doesn't mean that it is difficult.

Two types of glass cloth are used, a bi-directional cloth (5277BID), and a unidirectional cloth (5177UND). (Use the full part number for ordering your cloth, but for simplicity the plans will use only BID or UNI designations). BID cloth has half of the fibers woven parallel to the selvage edge of the cloth and the other half at right angles to the selvage, giving the cloth the same strength in both directions. The selvage is the woven edge of a bolt of fabric as shown in the accompanying sketch.







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UNI cloth has 95% of the glass volume woven parallel to the selvage giving exceptional strength in that direction and very little at right angles to it.

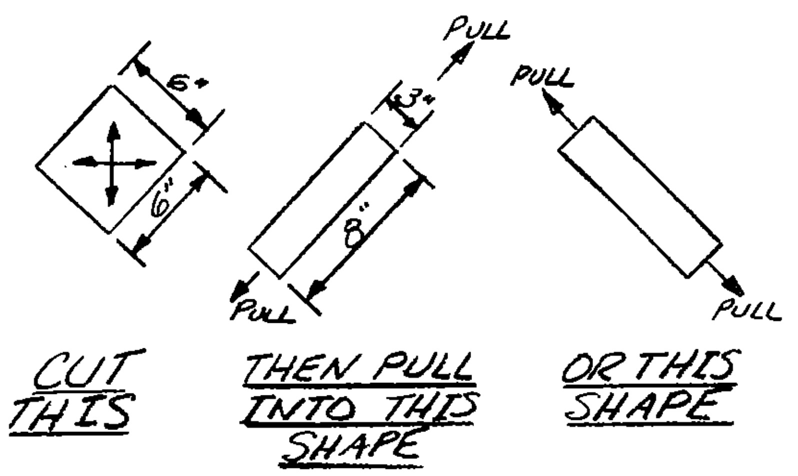
BID is generally used as pieces which are cut at a 45-degree angle to the selvage and laid into contours with very little effort. BID is often applied at 45 degree orientation to obtain a desired torsional or shear stiffness. UNI is used in areas where the primary loads are in one direction, and maximum efficiency is required, such as the wing skins and spar caps.

Multiple layers of glass cloth are laminated together to form the aircraft structure. Each layer of cloth is called a ply and this term will be used throughout the plans.

Marking and cutting the plies of glass cloth is a job that you will repeat often in the construction of your Q2. Glass cloth should be marked, cut, and stored in a clean area with clean hands and clean tools. Glass contaminated with dirt, grease, or epoxy should be discarded. A clean, smooth surface is needed for marking and cutting. The area used for storing and cutting glass cloth should be separated from the aircraft assembly area because otherwise it will be exposed to foam dust, epoxy, and other things which can contaminate the cloth. You will need a good sharp pair of scissors, a felt-tipped marker, a fairly straight board, and a tape measure for marking and cutting. The small amount of ink from marking and numbering plies has no detrimental effects on the glass cloth.

In each step the size, type, and fiber orientation of each ply is given. Take the list to your glass cutting table, roll out a length of the appropriate cloth, straighten the selvage, mark all of the plies, and cut them.

Now is a good time to stop reading long enough to go and cut a square ply of BID and see how easy it is to change its shape by pulling and pushing on the edges as shown in the sketches. Cut a square with the fibers running at 45° and pull on the edges to shape the piece.



It helps if you make fairly straight cuts, but don't worry if your cut is within ⅛ inch of your mark. As you cut BID, it may change shape, just as the square ply that you are experimenting with does when you pull on one edge. Plies that distort when cut are easily put back into shape by pulling on an edge. Rolling or folding cut plies will help keep them clean and make it easier to maintain their shape. If several plies are called for, it may help to number them before cutting. Save your clean scraps and make an effort to use them for smaller plies. If the cloth is spotted with epoxy, throw it away.

When cutting long strips or large pieces of 45-degree BID, always roll or fold it so it keeps its shape when handled. When it's applied, it can be set on one end of the part and rolled onto it. If you pick up each end, it will distort and not fit the part properly.

The fiber orientation called for in each lamination is important and shouldn't be ignored. UNI is characterized by the major fiber bundles running parallel to the selvage and being much larger than the small cross fibers which run at right angles to the selvage. In BID the cross fibers are the same size as those running parallel to the selvage, giving BID an even "checkerboard" appearance. BID is commonly used for plies cut at 45° to the selvage. Your tailor would call this a "bias" cut. The 45° cut makes it easy to work wrinkles out of a ply locally, without having to chase it to the far edge. The 45° cut also makes it possible to make a ply slightly longer than originally cut by pulling on the ends, or wider by pulling the sides. The 45° orientation isn't critical; you don't need to measure it. Your eyeball of a rough diagonal (45° ± 10°) is adequate when either cutting or laying up the cloth.

EPOXY

In recent years the term "epoxy" has become a household word. Unfortunately, "epoxy" is a general term for a vast number of specialized resin/hardener systems, the same as "aluminum" is a general term for a whole family of specialized metal alloys. Just as the "aluminum" pots and pans in your kitchen, the "epoxy" in your Q2 is vastly different from the hardware store variety.

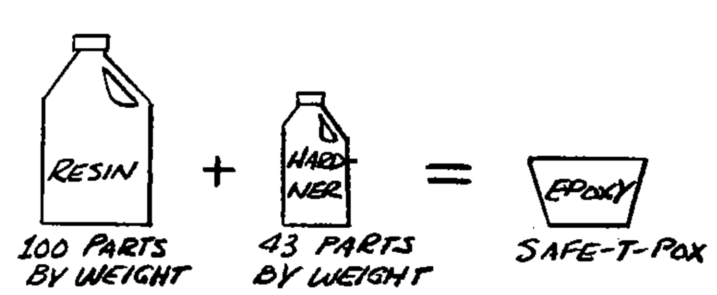
Epoxy is the adhesive matrix that keeps the plies of load-carrying glass cloth together. Epoxy alone is weak and heavy. It is important to use it properly so that the full benefits of its adhesive capability are obtained without unnecessary weight. A large portion of your education in composite structural work will be spent learning how to get the full strength of an epoxy/glass mixture with the minimun weight. This section will discuss the terminology and techniques for working with epoxy resin and its hardener.

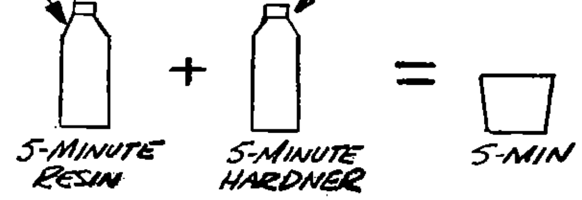
An "epoxy system" is made up of a resin and a hardener tailored to produce a variety of physical and working properties. The mixing of resin with its hardener causes a chemical reaction called curing, which changes the two liquids into a solid. Different epoxy systems produce a wide variety of solids ranging from extremely hard to very flexible. Epoxy systems also vary greatly in their working properties, some are very thick, slow pouring liquids and others are like water. Some epoxy systems allow hours of working time and others harden almost as fast as they are mixed. A single type of resin is sometimes used with a variety of hardeners to obtain a number of different characteristics. In short, there is no universal epoxy system; each has its own specific purpose and while it may be the best for one application, it could be the worst possible in another use.

The epoxy systems used in the construction of your Q2 are tailored for a combination of workability and strength, as well as to protect the foam core from heat damage and solvent attack. These systems are very low in toxicity to minimize epoxy rash. The epoxies are not similar to the common types normally marketed for fiberglass laminating. Two different systems are used in the Q2: a normal curing system, and a 5-minute system. The very fast curing (5-min.) system is used much like clecos are used in sheet metal construction (or clamps in woodwork); for temporary positioning. Five-minute is also used in some areas where high strength is not required, but where a fast cure will aid assembly.

Safe-T-Pox will cure to a firm structure at room temperature within one day. Complete cure takes 14 days.

The Q2 epoxy systems are called Safe-T-Pox and 5-MIN.





Any foam bonding where parts are small and the fast cure allows the next step to be done soon. Also used as a temporary joint for jigging.

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The working and strength characteristics of an epoxy system are dependent on the resin, the hardener, and on the amount of each in a given mixture. Epoxy systems are engineered for a specific ratio of resin and hardener. It is quite important that the proper mixture be obtained. An accurate balance or ratio pump must be used to accomplish this. A drawing of an inexpensive ratio balance is included in these plans. The mix ratio accuracy is particularly important with Safe-T-Pox. The 5-Min. can be adequately rationed by merely pouring a blob of part A in a cup and adding a blob of part B that looks the same volume before mixing. Never eyeball estimate Safe-T-Pox, always carefully use the balance or pump.

Epoxy resin and hardener are mixed in small batches, usually 6 ounces or less, even in the largest layup. The reason for small batches is that, in large batches, as the hardening reaction progresses, heat is generated which speeds the reaction, which causes even more heat, which ends up in a fast reaction called an exotherm. An exotherm will cause the cup of epoxy to get hot and begin to thicken rapidly. If this occurs, throw it away and mix a new batch. The small volume batch avoids the exotherm. For a large layup, you will mix many small batches rather than a few large ones. With this method you can spend many hours on a large layup using epoxy that has a working life of only a few minutes. If the epoxy is spread thin as in a layup its curing heat will quickly dissipate and it will remain only a few degrees above room temperature. However, in a thick buildup or cup, the low surface area to mass ratio will cause the epoxy to retain its heat, increasing its temperature. This results in a faster cure causing more heat. This unstable reaction is called an exotherm. Exotherm temperatures can easily exceed the maximum allowable for foam (200°F) and damage the foam-to-glass bond.

Unwaxed paper cups are used for mixing and ratioing resin and hardener. Convenient 8-oz cups for resin are provided. The hardener cups are the 3-oz unwaxed bathroom paper cups. Don't use waxed cups; the wax will contaminate your epoxy.

If you are using the homebuilt balance, follow this procedure. Place the resin (8 oz) cup on the right cradle. The resin cup can be either a new clean cup, one with a little uncured epoxy left in the bottom, or a clean cup from a previous layup with hard epoxy in the bottom (smooth, not lumpy). Now, take a clean 3-oz hardener cup - pour a splash of hardener into it then scrape the hardener back into the container. This gives the hardener a wet surface, so its remaining hardener will not be counted in the balancing. Now, place the wet hardener cup on the scale, check that it swings freely and balance it perfectly by moving the small weight. Epoxy is then poured into the 8 oz cup (6 oz or less). Hardener is then poured into the 3 oz cup at the other end of the balance until the arm is level. When ready to mix, pour the hardener into the resin cup and mix completely. If you have the ratio pump, you simply put one cup under the spout, pump out the amount that you want, and mix.

Mixing is done by stirring with a stick, being careful not to spill any. If you spill part of an unmixed cup, the ratio of resin and hardener may be inaccurate and it shouldn't be used. Mix each cup for at least two minutes. You should spend 80% of your mixing time stirring the cup and 20% scraping the sides to assure complete mixing. Do not mix with a brush. The bristles can soak up the hardener, changing the ratio. Use a tongue depressor or wood stick.

The working temperature has a substantial effect on the pot life and cure time. Very hot conditions will cause the cure to speed up. In cold working conditions the cure will be delayed and if it is cold enough, epoxy may not cure at all. Working temperatures must be between 70° and 90°F. A range of 75 to 80°F is best. Be sure to get a wall thermometer (approx. $1.50 at any general store) to check the temperature of your work area. At 75°F, 5-Min must be used within four minutes, and Safe-T-Pox must be used within 20 minutes.

Cold epoxy results in increased time required to do a layup, since it takes longer to "wet" and to squeegee the cloth. A layup at 65° may take almost twice the time as at 75°F. On most layups (except for joining foam cores) its best to have 75 to 80°F room temperature and 80 to 90°F epoxy. Resin and hardener can be kept warmer than room temperature by keeping it in a cabinet with a small light bulb on. DO NOT store your resin or hardener on a cold floor if you plan to use it within the next several hours. If you let your shop get cold between working periods, keep some resin and hardener in the warmest place of your house for use on the next layup.

Save your mixing cups, as they can be used as a quality check of your epoxy. After a day or two take a sharp knife point or scribe and scratch the surface of epoxy in the cured cup. If the epoxy cured properly, the scribe will make a white scratch mark. If the epoxy hasn't cured, the scribe will make a dull ridge, indicating a soft surface. If this occurs, the epoxy has not cured, either due to inadequate time or temperature, or bad mixing, or bad epoxy.

MICROSPHERES

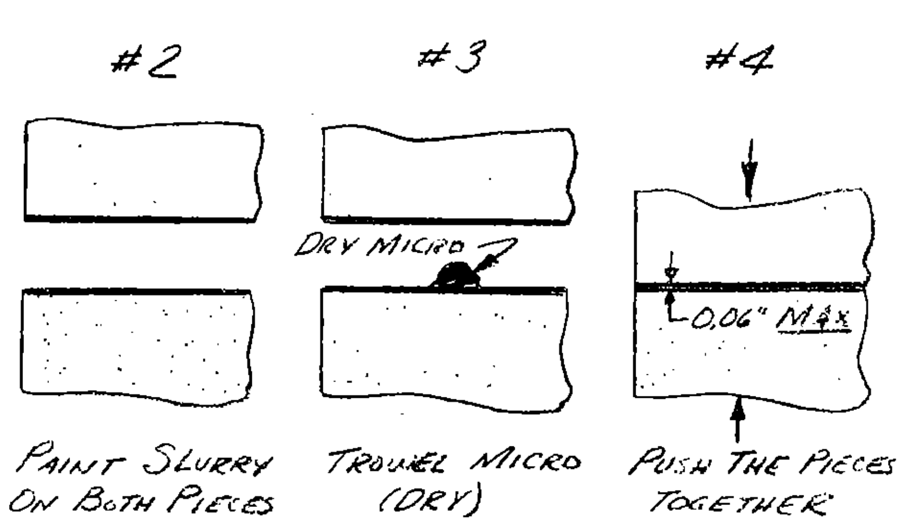
Microspheres are a very light filler or thickening material used in a mixture with epoxy. Micro, as the mixture is called, is used to fill voids and low areas, to glue foam blocks together, and as a bond between foams and glass skins. The glass bubble-type supplied is lighter than most common types. Microballoons must be kept dry. If moisture is present it will make them lumpy. Bake them at 250°F; then sift with a flour sifter to remove lumps.

Micro is used in three consistancies; a "slurry" which is a one-to-one by volume mix of epoxy and microspheres, "wet micro" which is about two-to-four parts microspheres by volume to one part epoxy, and "dry micro" which is a mix of epoxy and enough microspheres to obtain a paste which will not sag or run (about five parts-to-one by volume). In all three, microspheres are added to completely mixed epoxy.

You do not have to accurately mix the microspheres; just dump them in until the desired consistancy is obtained. Micro slurry is used to paint over foams before glass cloth is applied over them. Slurry is almost the same viscosity as the pure epoxy and is runny enough to apply with a brush. However, the easiest way to apply slurry is to pour it onto the surface and spread it out evenly using a squeegee. When skinning urethane foam use a full thick coat of slurry. Inadequate slurry on urethane can result in a poor skin bond. Wet micro is used to join foam blocks, and, while it is much thicker than slurry, it is still thin enough to sag and run (like thick honey). Dry micro is used to fill low spots and voids and is mixed so that it is a dry paste that won't sag at all. In all three micro types, you don't measure, just add microspheres until the desired consistancy is obtained. Use micro only as specifically shown - never use micro between glass layers.

Always use the following method to join foam blocks. This is extremely important.

1. Check that the foam blocks fit closely together. If there are voids over 1/16 inch, sand to fit, or fill the void with a sliver of foam.
2. Paint a light coat of micro slurry on both surfaces. If joining foam to fiberglass, paint pure mixed epoxy (no microspheres) on the fiberglass surface and micro slurry on the foam surface.
3. Refer to the sketch and trowel wet or dry micro in the center of the joint. Thus when joined the micro is pushed outward expelling (rather than trapping) air. If the fit is excellent use dry micro.
4. Push the two pieces together, wiggling each to move the micro toward the surfaces. Be sure the micro is no thicker than 0.1 inch at any place, to avoid exotherm. Wipe off any excess. Do not be concerned if the micro does not completely reach the surface. That void can be filled immediately before skinning the part.



FLOX

Flox is a mixture of cotton fiber (flocked cotton) and epoxy. The mixture is used in structural joints and in areas where a very hard, durable buildup is required. Flox is mixed much the same as dry micro, but only about two parts flock to one part epoxy is required. Mix in just enough flox to make the mixture stand up. If "wet flox" is called out, mix it so it will sag or run.

When using flox to bond a metal part be sure to sand the metal dull with 220-grit sandpaper and paint pure mixed epoxy (no flox) on the metal part.

BONDO

Throughout these plans the term "Bondo" is used as a general term for automotive, polyester body filler. Bondo is used for holding jig blocks in place and other temporary fastening jobs. We use it because it hardens in a very short time and can be chipped or sanded off without damaging the fiberglass. Bondo is usually a dull gray color until a colored hardener is mixed with it. The color of the mixture is used to judge how fast it will set. The more hardener you add, the brighter the color of the mixture gets, and the faster it hardens. This simple guide works up to a point where so much hardener is added that the mixture never hardens. Follow the general directions on the Bondo can for fast setting Bondo. Mixing is done on a scrap piece of cardboard or plywood (or almost anything), using a hard squeegee or putty knife. A blob of Bondo is scooped out of the can and dropped on the mixing board. A small amount of hardener is squeezed out onto the blob and then you mix to an even color. You will mix the blob for about one minute. You will then have two to three minutes to apply it before it hardens.

Be sure to clean the board and putty knife off before the Bondo is completely hard. MEK will clean Bondo off your putty knife and squeegee if it isn't completely hardened.

PEEL PLY

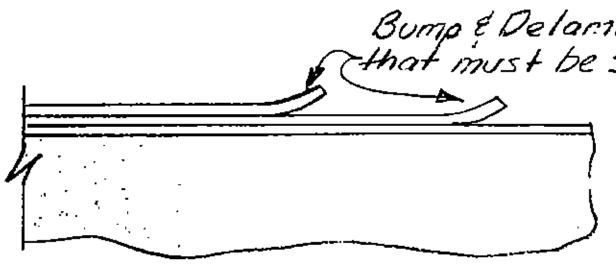
Peel ply is a layer of 2.7oz dacron fabric which is laid up over a fiberglass layup while the fiberglass is still wet, and is later removed by lifting an edge and "peeling" it off. The most convienient form of dacron to use is "surface tapes", normally used in covering fabric aircraft. These are available in rolls. You will need at least one roll, 2" wide. Peel ply is used for two purposes:

(1) Peel ply any area that will later be structurally attached to another fiberglass layup. Once the dacron is peeled off, the surface is ready for another layup, without sanding. If you do not use peel ply, you will have to sand the surface completely dull (no shiny spots). This sanding is hard, itchy work and ruins the strength of the outer ply of fiberglass.

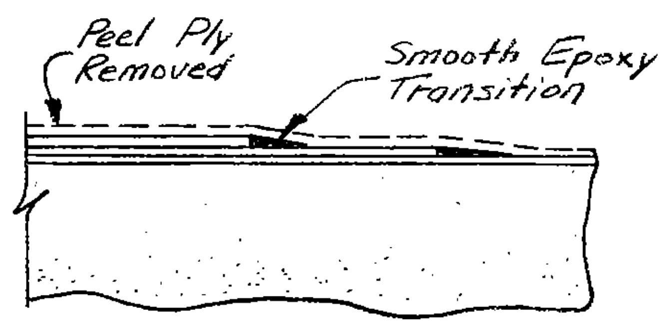
Note that to peel ply the trailing edge overlap area, the peel ply is the First ply made to the foam core, Lay a strip of dacron down on the overlap notch and secure it with tacks or staples so it doesn't move when you layup the skin.

(2) The second use for peel ply is to transition the area where the top ply of a layup terminates on the fiberglass surface.

Refer to the adjacent sketches. If the top ply edge is laid up bare it results in a rough edge that can delaminate if a little dry. Sanding the rough edge is hard, itchy work and usually results in damaging the adjacent surface. If the edge is overlaid with a strip of dacron during the layup (lay on the dacron and wet out by stippling or squeegeeing) it will make the edge lay down flat and will form a wedge of epoxy to smoothly transition the edge. After cure, peel off the dacron. The result is a beautifully transitioned smooth edge with no delamination tendency. Use this method in all places where a cloth edge terminates on the surface.



NO PEEL PLY



WITH PEEL PLY

EXAMPLE: PEEL PLY ON LEADING EDGE

FOAM

Three different types of rigid, closedcell foam are used. A low density (nominally 2 lb/ft3) blue-white or orange, large-cell styrofoam is used as the foam core of the wing, canard, vertical stabilizer, and control surfaces. The blue-white or orange foam is exceptional for smooth hot wire cutting of airfoil shapes. The large cell type used provides better protection from delamination than the more commonly used insulation-grade styrofoams.

Low density 2 lb/ft^3 green or light tan urethane foam is used because it is easy to carve and contour, and is completely fuel proof. The urethane used is Urethane 210 or equivalent.

The white styrene modified urethane foam is used in medium density (4-6 lb/ft^3) where higher compression strength is required.

Do not substitute foams for those supplied by Quickie Aircraft Corporation. For example, the Q2 blue-white or orange styrofoam has great glass surface peel strength than the standard blue styrofoam sold by some distributors. Also, we considered using the "fire resistant" BROWN urethane instead of the green 2 lb urethane, but found its physical properties, fatigue life, and fuel compatibility to be much lower than the urethane supplied to Q2 builders. Do not confuse styrofoam with white expanded polystyrene. Expanded polystyrene is a molded, white, low density, soft foam, which has the appearance of many spheres pressed together. This is the type used in the average picnic cooler. It disappears immediatley in the presence of most solvents, including fuel, and its compression and modulus is too low.

All three types of foams, urethane, styrene modified urethane, and polystyrenes are manufactured in a wide variety of flexibilities, densities and cell sizes. Getting the wrong material for your airplane can result in more work and/or degraded structural integrity.

Since sunlight can damage foam, avoid exposure of foam to the sunlight by keeping it covered.

END OF SECTION

CONSTRUCTION TECHNIQUES

HOT WIRE CUTTING

The airfoil-shaped surfaces of your Q2 are formed by hot wire cutting the orange or blue-white styrofoam of 2 lb/ft3 density. The hot wire process given airfoils that are true to contour, tapered, proerly twisted, and swept with a minimum of effort and the simplest of tools. The details for making your hot wire saw were shown earlier.

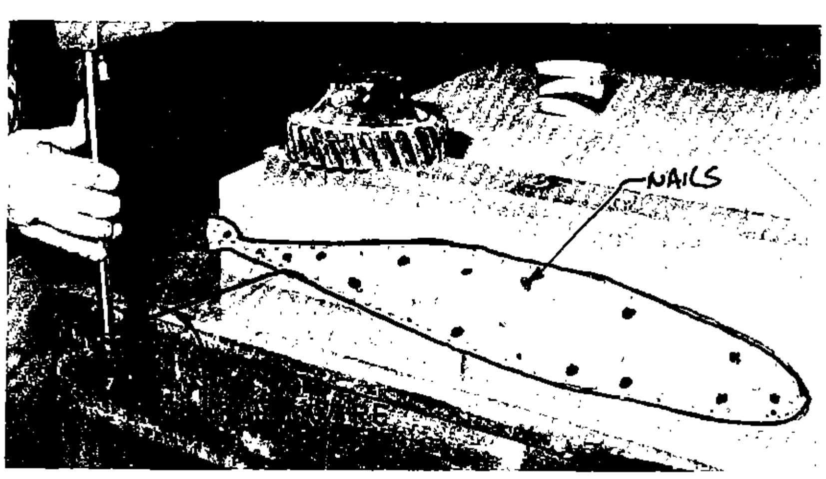
The hot wire saw is a piece of stainless steel safety wire, stretched tight between two pieces of tubing. The wire gets hot when an electricial current passes through it and this thin, hot wire burns through the foam. By making smooth steady passes, the hot wire gives a smooth, even surface. The foam offers little resistance to the hot wire's passage. To get a smooth accurate cut, a template is required. Templates are made from thin plywood, sheet metal, masonite or formica. A variable voltage control is used to supply the electrical current that heats the wire.

The blue-white or orange foam used in your flying surfaces was selected for a combination of reasons and its hot wire cutting ability was one of them. Other types of foams are readily hot wire cut, but some (white expanded polystyrene) have poor physical properties and others (urethane) give off poisonous gases when hot wire cut. Use only the recommended materials!

Hot wire templates can be made from 1/16 to 1/4 inch plywood, formica, or masonite or .032 to .064 sheet metal. It is important to have smooth edges on the templates. A rough edge may cause the wire to hang up and burn into the foam excessively. Templates are required on both ends of the foam being cut. The size, shape, and orientation of the two templates is varied to taper, and twist the foam core as required. The planform (span and sweep) is set by squaring up the foam block before the templates are used. In general, the trailing edge of the wing is the reference.

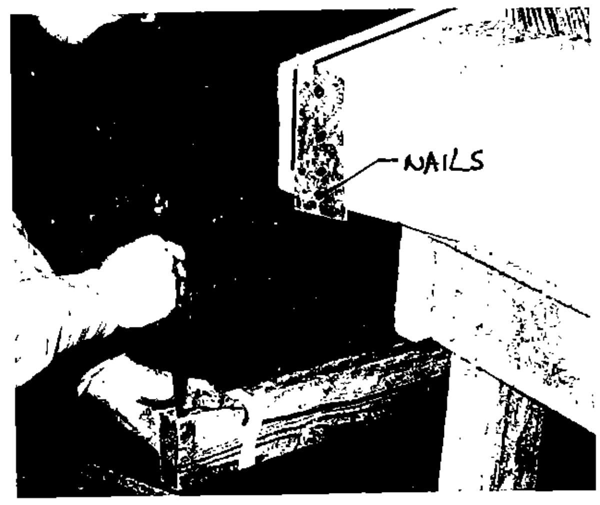
Full-size template drawings are provided in the plans. To make your templates, just glue the template drawings to a piece of plywood or sheet metal and trim to the contours shown. There are a number of markings on each template which aid in the alignment and cutting of the foam core.

Each template has a waterline (W.L.) marked on it which is used to align the twist of the foam core. Each template's waterline is leveled using a carpenter's bubble level. This assures that the relative twist at each template is correct. The template is then nailed to the foam block to obtain the correct planform.

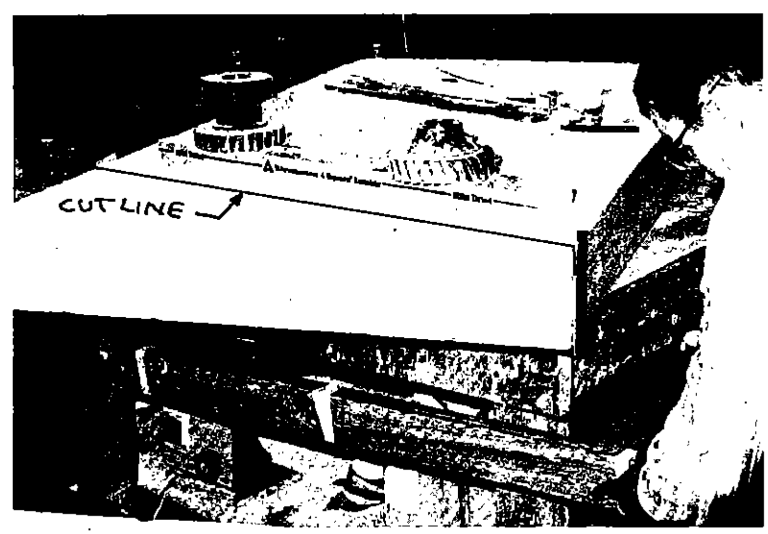


Each template has numbered marks running from the trailing edge around the leading edge and back to the trailing edge. These are called "talking numbers." When the foam cores are cut into their airfoil shape, the talking numbers are used to assure that each end of the hot wire is co-ordinated to obtain the correct, tapered airfoil. The person calling the numbers should be at the largest template. A typical cut would sound like this: "Resting on the tab 1/4" from the foam, moving forward, entering foam now - one, half, two, half, . . ., 34, half, 35, half, 36, coming out of the foam and pausing on the tab, wire's out." As the cut is made, the person on the small rib follows the numbers, passing over them as he hears them called out. Pause marks are indicated in places where it is necessary to pause for a couple of seconds and let the hot wire's center lag catch up with the ends.

Preparing a foam block for an airfoil cut is begun by trimming the rectangular foam block to the basic dimensions for the correct planform. These "trim" cuts are made using two straightedged trim templates. The templates are held against the foam by nails through the template into the foam. Enough nails should be used to hold the template firm so that it won't move when the hot wire is held against it.

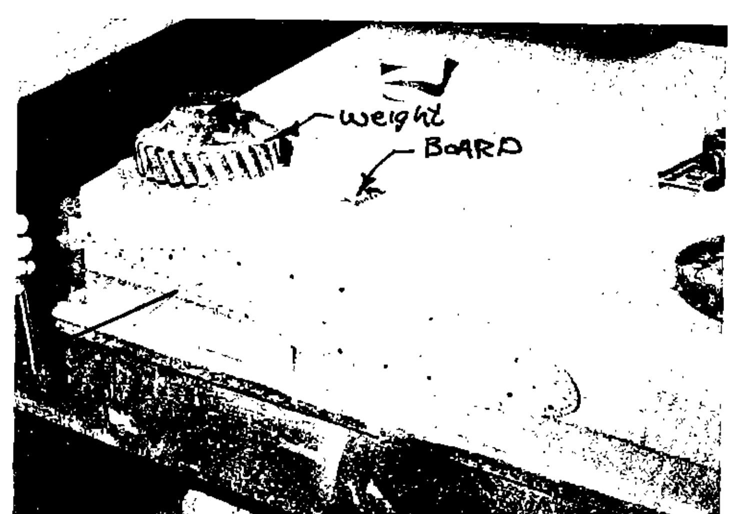


Cutting straight down along template with a hotwire.



Note the diagonal cut being made by correctly positioning the vertical templates and passing the hotwire downward along them.

Each template must have holes for nails to hold the templates to the foam; four penny nails are good for this use. The holes in the templates should be a close fit for the nails. Be careful not to angle the nails so that the hot wire can catch on them! Some rib templates are used several times, for both inboard and outboard, requiring you to transfer the talking numbers, pause marks, trim line, and waterline to the opposite side of the template.

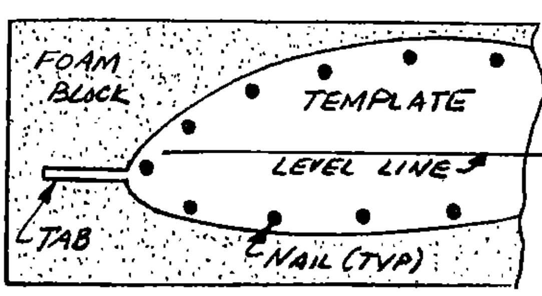


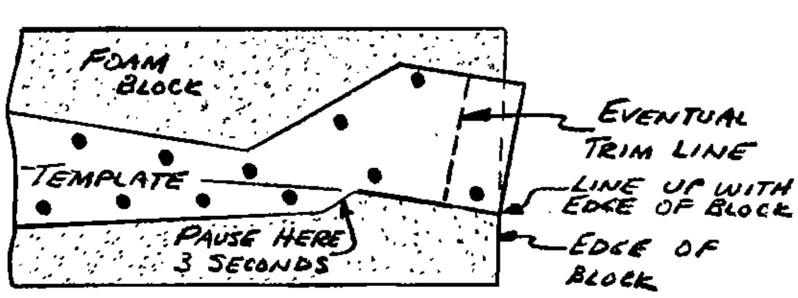
Support the foam block well; don't overhang the block past the edge of the jigging table.

CONTINUED ON NEXT PAGE

The use of the hot wire saw is a simple thing if your equipment is set up properly. Proper wire tension and wire temperature should be maintained for good cutting. The wire tension should be tightened after the wire is hot by twisting one tube with a pair of pliers. The wire should be as tight as possible. The wire should be hot enough to cut one inch of foam in four to six seconds without having to force the wire. A wire that is too hot will burn the foam away excessively. To cool an over-heated wire, simply turn your voltage control to a lower voltage setting. If you use a battery charger, you will have to add length to the wire. To warm up a cool wire, just increase the voltage setting or, with the charger, shorten the wire. Although the foam offers only mild resistance to the hot wire, a long cut will cause the middle of your wire to lag behind the ends. Wire lag can cause problems in tight curves like the leading edge of an airfoil. To reduce lag there, the cutting speed is reduced to about one inch in 8 to 10 seconds. The airfoil templates have notations in the areas where reduced speed cutting is necessary and pause marks where it is necessary to allow the lag to catch up completely.

The most common hot wire error is wire lag which causes a bow in the leading edge. The following method solves this problem and thus we recommend you use it for cutting the canard and wing. Use the tabs on the templates at the waterline at the leading edge by cutting the core in two passes: one from the leading edge up over the top to the trailing edge, the other from the leading edge (under the tab) down under to bottom to the trailing edge. The thin "flash" of foam left on the leading edge due to the thickness of the tab is easily removed with your butcher knife. The result is a perfectly straight leading edge. Care must be taken to assure that both ends simultaneously approach the template at the leading edge. Use the following vocal commands "wire is moving toward the tab, now resting on the tab 1/2 inch from the template (confirm both ends in that position), moving toward template 1/4 inch away, 1/8" away, on the template, moving up (talking number), Y (talking number) . . .". When approaching the trailing edge overlap notch (see sketch) slow down and pause 3 seconds in the notch to assure a full, sharp, accurate surface for the skin overlap.





The hot wire should be guided around the templates with light pressures. Pushing too hard against the template may move them or flex the foam block which results in an under cut foam core.

The correct set-up is just as important as using the correct tools and materials. Foam is a fairly flexible material and an improper set-up can cause deflection. The foam block should be well supported at each end, so that it doesn't sag and doesn't move around while being cut.

You need clearance for the hot wire cutter to pass by the table and the weights used to hold the foam steady.

Foam is manufactured in sizes that are often too small to get a complete core from a single block. It is necessary to use two foam blocks to get the size required for the wing cores. These blocks have to be joined using an epoxy/microsphere mixture. The hot wire won't cut through the micro joint, so all of the hot wire cutting is done with the blocks temporarily joined. Nails or blobs of 5-min epoxy are used for temporary foam joints, but the hot wire won't cut through these. Thus, they have to be placed carefully so that the wire doesn't have to pass through them.

Don't be overly concerned if you don't make perfect foam cuts: ridges on the foam core from inadvertently lifting the hot wire off the templates are easily faired in with a sanding block. A less-than-perfect leading edge can be blended in by sanding after the foam core is assembled. Gouges in the foam can be smoothed and filled with dry micro to contour after applying the glass skins. The foam is too expensive to throw away because of a minor gouge.

A finished foam core may warp out of shape after it is removed from the original rectangular block. This is due to internal stresses in the foam from the manufacturing process, and is no cause for concern.

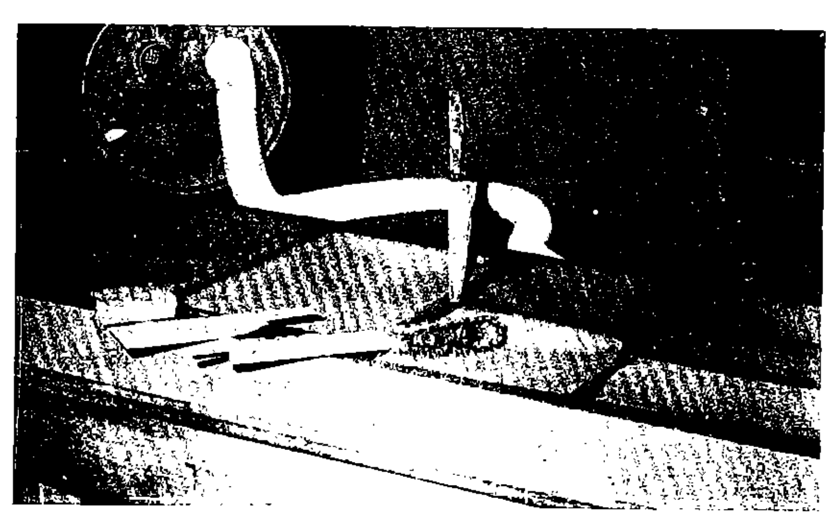
A warped core is simply weighted into the jig blocks and shimmed straight prior to glassing. Once the skin has been installed, the foam is held firmly in position by the sandwich structure.

URETHANE FOAM SHAPING

One of the real treats in the construction will be shaping and contouring urethane foam. Urethane is a delightful material that shapes with ease using only simple tools. A butcher knife, old wire brush, sandpaper, and scraps of the foam itself are the basic urethane working tools. A vacuum cleaner is convenient to have handy since working urethane produces a large quantity of foam dust.

The knife is used to rough cut the foam to size. The knife needs to be kept reasonably sharp; a sander or file is an adequate knife sharpener since it's a frequent task and a razor edge isn't necessary. Coarse grit sandpaper (36 grit) glued to a board is used for rough shaping.

Inside contours or "dishing" is done by using a ragged old wire brush to rough out the bulk of the foam and following up with a scrap foam piece to smooth the surface. The foam scrap conforms to the shape of the surface resulting in a very smooth contour.



Outside contours are roughed out with a sanding block and finished using a foam scrap. Dry micro and flox are used to fill voids and pot fasteners in a number of places. All foam shaping should be finished before any micro filling is done, because the filler is much harder than the foam and this makes smooth contouring very difficult. Your best carving template is your eyeball; an occasional check on the depth of a contour is about the only measurement necessary.

Keep your shop swept reasonably well. The foam dust can contaminate your glass cloth and your lungs. Use a dust respirator mask while carving urethane. Try not to aggravate the better half by leaving a green foam dust trail into the house.

GLASS LAYUP

The glass layup techniques used in your Q2 have been specifically developed to minimize the difficulty that glass workers have traditionally endured. The layups that you will do will be on a flat horizontal surface without the molds, vacuum bags, and other special equipment that are common in glass work. The layups that you do will all cure at room temperature; no ovens or special heating is required. If you have suffered through a project that requires you to build more molds and tools than airplane components, then you are in for a real treat.

The techniques that you will use are quick but they still need to be done correctly. 90% of the work that you will do is covered in the next few paragraphs so make sure that you read and understand this section very well. If you learn these basics, your airplane will be easy. If you skip over this information, you will probably end up frustrated.

STEP 1: PERSONAL PREPARATION

Before you get started with a layup, plan ahead. Some major layups take several hours and before getting your hands in the epoxy, it's a good idea to make a pit stop at the restroom.

Do not start a large layup if tired; get some rest and do it when fresh. It's best to have three people for any large layup; two laminators and one person to mix epoxy. Be sure that the shop is clean before you start.

Take the recommended health precautions (discussed later in detail) using gloves or barrier skin cream. Get your grubby, old clothes on or at least a shop apron. Make sure that your tools are clean from the last layup and ready to use. Your working area should be between 70°F and 90°. Best results are obtained at 75 to 80°F. Below 70°F the epoxy is thicker making it more difficult to wet the cloth. Above 90°F, the possibility of an exotherm is greater.

STEP 2: CUT FIBERGLASS CLOTH

The fine points of glass cutting have been covered earlier. Remember that there isn't any requirement to cut accurate dimensions. Cloth dimensions are given well oversize. You scissor trim them as you go, while laying the cloth up. It is a good idea to keep two pair of scissors: one clean and in the glass storage area, and one in the shop that gets epoxy on it. After cutting, roll or fold the material; keep it clean and handy for the layup.

STEP 3: PREPARE SURFACE

The only difference between layups over different materials is in surface preparation. The layup over foam will be covered here since you will be doing more of it, and other surface preparations will be covered separately.

The foam surface is prepared by leveling uneven areas with a sanding block and brushing or blowing any dust off the surface. Use compressed air or vacuum to remove dust.

Now is the time to accurately check that the foam core is the correct size, shape and contour. Refer to the section views of the part - be sure your core looks exactly like that on the section view. Lay a 12 inch straightedge spanwise on all critical areas of the flying surfaces and be sure you don't have any high or low places or joggles. Measure any areas that involve fiberglass buildups to check for correct depth. Build up is 0.009 inch per ply for UNI and 0.013 inch per ply for BID.

STEP 4: MIX EPOXY

Mix epoxy when you need it, not before. Micro, dry micro, and flox may be required at various stages of the layup. Mixing and composition details were covered earlier. Apply a coat of micro slurry to the foam surface before the first glass ply is laid over it. The slurry can be poured on the foam and spread thin with a squeegee. Fill any dings or gouges in the foam core with dry micro prior to applying the slurry.

STEP 5: LAY ON THE CLOTH

Lay on the cloth in the specified orientation. Pull the edges to straighten the cloth out and to remove wrinkles. Maximum strength and stiffness is obtained if the fibers are not wavy or wrinkled. If the cloth is to be applied around and/or into a sharp corner, you will find the job easier to do if the fiber orientation is at 45° to the corner. Don't get depressed if the layup looks like a hopeless mess at

this point. Press on with patience and things will work out fine. To remove wrinkles, study the direction of fibers, follow the fibers to the outer-edge of the cloth and pull on the outside edge. Pushing a wrinkle off the part is incorrect. Once the part is free of wrinkles use a squeegee and make light passes from the center outwards to smooth the cloth.

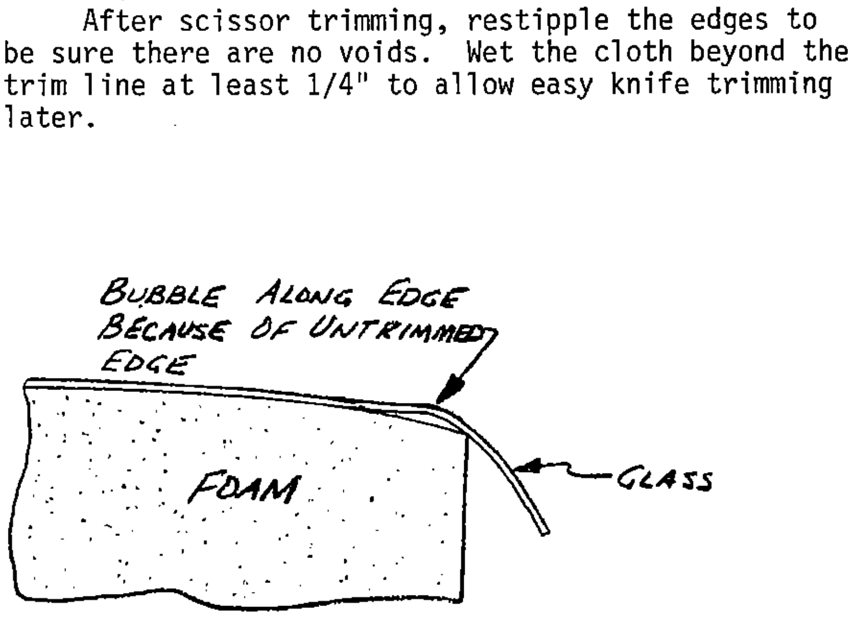
STEP 6: WET OUT THE CLOTH

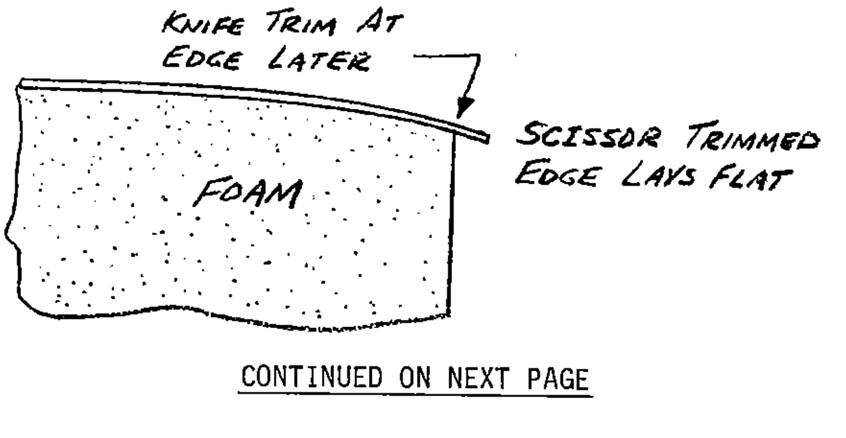
Do not use micro between plies of cloth. Wet out the cloth by pouring on a thin coat of epoxy. This may not be necessary if there is enough epoxy under the cloth to be brought to the surface. This is done by "squeegeeing", which involves drawing the squeegee over the cloth. This brings excess epoxy up from below to wet out the cloth, resulting in a weight savings as compared to adding more epoxy on top. REMEMBER, epoxy adds no strength beyond what is needed to wet out the white color of the cloth and fill air voids; any further addition of epoxy is only dead weight.

Where multiple plies are required, the first plies may be laid up wet and the excess resin brought up by squeegeeing to help wet out the middle plies. To do this, pour epoxy onto the part and move it around the surface with a squeegee. Your work will go much faster if you make the layup too wet, then remove excess epoxy with many light passes with the squeegee. Do not squeegee too hard, as this can starve the surface of micro and introduce air. Continue to inspect for air (tiny white flecks or bubbles) and stipple (a vertical stabbing motion with a paint brush) or squeegee in more epoxy to remove the air. A handy squeegee can be cut from the flexible plastic found on a coffee can lid. You may also find a paint roller handy for spreading around the epoxy. The final plies are ambitiously stippled and additional epoxy is applied sparingly. When in doubt - squeegee it out.

As you wet out each ply, scissor trim to within 1/2" of any overhang (trailing edge, etc.). This ½" will be knife trimmed after the layup cures. If an overhanging ply isn't trimmed, it lifts the edge up and makes a bubble.

After scissor trimming, restipple the edges to be sure there are no voids. Wet the cloth beyond the trim line at least 1/4" to allow easy knife trimming later.





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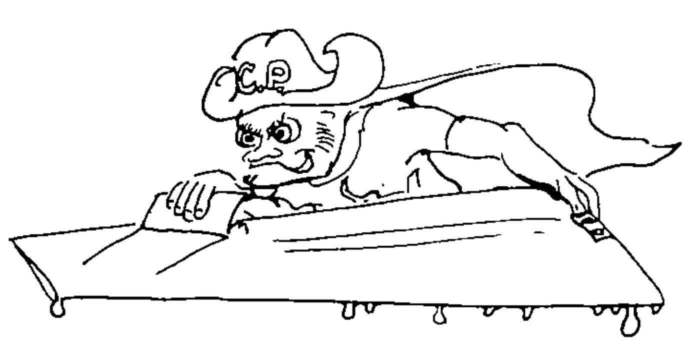
STEP 7: SQUEEGEEING

Squeegee out excess epoxy. This involves drawing a plastic or rubber squeegee over the layup as shown. Plastic squeegees (scrapers) are available at any paint store and included with the kit. If excess epoxy exists, it will be pushed off the edge of the piece. Remember, excess epoxy is much better on the floor than on the airplane. It is possible to squeegee too hard and make the layup too dry. If this occurs, the surface will appear white, indicating the presence of air. If this occurs, wet the cloth by painting on a little epoxy and stippling it down into the layup. The best quality layup is obtained if each layer of a multilayer layup is squeegeed. The excess epoxy which is pushed off the edge can be recovered and returned into the cup. This is easily done by catching the epoxy on the squeegee and scraping it on the side of the cup.

The finished layup should appear smooth and green so that the weave of the cloth is clearly visible, but not so dry that any area appears white in color. If you've done an excellent job, the weight of resin will be about 2/3 of the weight of cloth used.

To check if there is too much epoxy in the layup, pull a squeegee across the surface, stopping before you reach the edge. Lift the squeegee up and look for a large "ridge" of epoxy where the squeegee stopped. The ridge under the top ply indicates that the layup is too wet and you should spend time with the squeegee to remove epoxy off to the sides.

Don't hesitate to use your stippling roller or brush on an area after squeegeeing. Some places are not suited to the use of a squeegee and the dry brush or roller must be used to expel the excess epoxy. On a given layup, about 1/2 of your time should be spent squeegeeing or stippling.



STEP 8: GENERAL INSPECTION

After you have finished the layup, take a few minutes and give it a good general inspection for trapped air, dry glass, excess epoxy, and delamination. It is much easier to correct these things while the layup is wet than to repair the cured layup. Also, have someone else inspect it. Usually a different person can find air flecs or bubbles that are missed by one inspector. Carry a good light around for the inspection. Glance the light off the surface at variour angles to look for airflecks. If any air is visible, stipple it out. Be sure the overlaps on the edges are perfect. If, due to a sharp corner etc, you have a problem eliminating an air bubble, use one of the following two methods:

(1) Lift the cloth up off the foam, trowel some wet micro into the troublesome area, add more epoxy as you stipple the cloth back down.

(2) Add excess epoxy over the bubble, cover the surface with saran wrap (thin plastic wrap), then push firmly outwards to force the air out to the sides. The saran wrap will seal the surface to keep air from being drawn in. This method will force the cloth to stay down even around a sharp corner.

STEP 9: PRELIMINARY CONTOUR FILL

Certain areas, like along the trailing edge (see cross section views) require a dry micro fill. It is preferred to apply this fill within 2-3 hours of finishing the fiberglass layup. However, where the micro filler obscures the structure underneath, FAA inspection should be completed before dry micro filling. Areas like the trailing edge where the structure can be inspected from the other side should be filled while the layup is still tacky (within three hours of the layup). If you wait until the layup cures, you will have to sand the fiber-glass surface to a dull finish before applying the micro. So, mix up a "dry" micro mix and trowel it into low areas while the lay-up is still wet, and save the work of sanding where feasible.

STEP 10: CLEANUP

Brushes can be used two to four times if after each layup they are washed with soap and water. Wipe excess epoxy off with a paper towel. Wet the brush and work soap into all fibers by mashing it into a bar of soap (Lava brand is best). Rinse with hot water and repeat 3 times. Be sure they are dry before next use. We generally use a cheap brush (approximately $2.00 to $4.00 per dozen) and discard after two or three layups. Clean squeegees the same way.

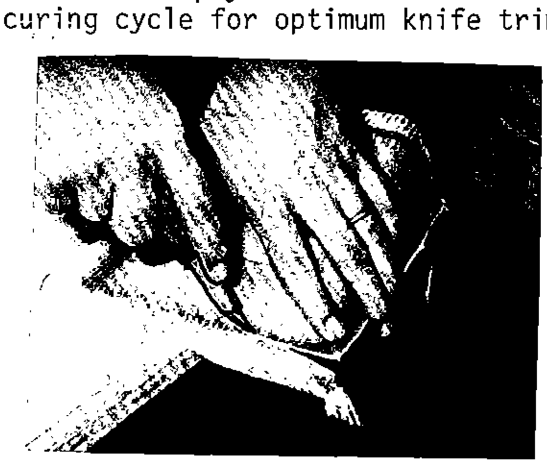
If you use skin barrier cream (Ply No.9), the epoxy and cream will wash off easily with soap and water. When you get epoxy on unprotected skin, Epo-cleanse is used to remove the epoxy. Both of these products are available. Once you are sure your skin is clean, wash again thoroughly with soap and water, even if your hands were protected with plastic gloves. If you get epoxy on tools or metal parts, clean them with acetone or MEK before the epoxy cures.

The only good way to protect your clothing is not to get epoxy on anything that you care for. Use a shop apron and don't make layups in good clothing. A surplus flight suit or other cheap coveralls are a good investment.

You may feel that layups are messy work after your first experience with them. However after you've done several, you will have learned not to wipe your hands on your clothing (keep a roll of paper towels handy), not to scratch your ears, eyes, etc. during the layup. If your tools and work area are clean and organized well and you are disciplined with the epoxy, the job can be less messy than working with other materials.

STEP 11: KNIFE TRIM

When a layup is wet, you can only scissor trim to within about ¼ inch without disrupting the fibers in the ply. An easy clean trim can be obtained by waiting three to five hours after the layup. At this time, the laminate is firm enough to support the cloth from fraying, yet soft enough to cut easily with a sharp knife. This "knife trim" stage is the optimum time for edge trimming with ease and accuracy. Take a sharp, single-edge razor blade or X-Acto knife and trim the edges with a motion downward toward the edge. Experience will help you determine the correct time in the curing cycle for optimum knife trimming.



In the plans, when "knife trim" is called for, this assumes the three to four hour wait, even though not specifically stated. Don't fall apart if you miss the knife trim stage and have to trim the fully cured glass. If you wait until the layup is completely set, then saw along the edge with a coping saw, dremel, bandsaw, saber saw, etc. Smooth the edge with a sanding block. When trimming a cured edge, be careful of the "needles" (sharp protrusions of glass-frayed edges supported with epoxy).

The needles can be avoided by returning three hours after the layup to make the knife trim. Knife trim time varies with temperature: about six hours at 60 degrees and one hour at 90 degrees.

OTHER SURFACES

Surface preparation (step 3 of the basic glass layup) varies with the material that you are laying up over. The layup over foam was covered in detail in step 3. To prepare a cured glass surface for layup, the cured surface must be sanded to a completely dull finish with 36 to 60-grit sandpaper. If any of the glossy surface remains, an incomplete bond results which is weak. Better yet, use peel ply as described later. Micro slurry should not be applied to glass surfaces being bonded; this weakens the joint. Wood requires no special preparation for bonding but should be free of grease, oil, paints, and varnish. Sand wood surfaces with 36-grit sandpaper before layup. Metal bonding is not relied upon for strength but metal surfaces should be free of oil and grease and, except for bolts, nuts, and other fasteners, metal surfaces should be dulled by sanding with 220-grit sandpaper, and coated with epoxy before setting in place. Cured micro surfaces should be sanded dull but be careful not to obliterate surrounding foam surfaces while doing it. In practice you may be glassing over several types of material in the same layup and you will be using most of these surface preparation techniques together.

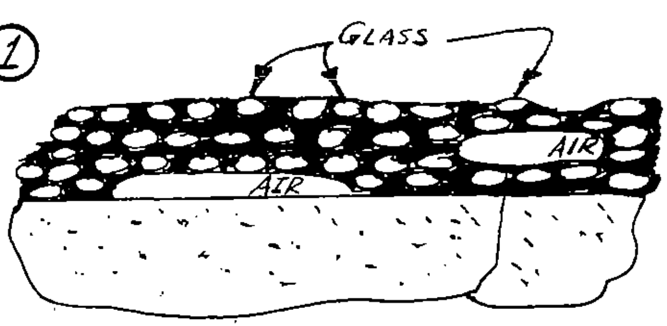
ATMOSPHERIC CONDITIONS

Temperature has the greatest effect on the working properties of your epoxies. 75 degrees farenheit is an ideal temperature. The range from 60 to 90 is acceptable with the precautions mentioned in the section on EPOXY. Humidity has a lesser effect on these materials than it does on aircraft dopes and some paints. Humidity will only create problems if it is over 75%. Don't undertake a layup if it is pouring down rain outside or, if you notice a cloudy "blush" on the wet epoxy surface, or any evidence of whiteness in the epoxy due to moisture.

RECOGNITION OF A DRY LAYUP

One of the most important things you must know is how to inspect for the presence of air within a layup. Air leaves somewhat crystal-like flecks of white areas, noticeably different than the white color of the microballoons. The presence of air is shown in the adjacent sketches in 3 forms: (1) A bubble or large void at the foam surface or within the laminate, (2) small bubbles of air scattered throughout an area, or (3) inadequate filling of the outer ply. Make a layup of 3 ply BID in a 6-inch square over a scrap piece of foam, trying to achieve these 3 types of dryness. Let it cure with the defects. This will be a handy sample to use to instruct others who will help you inspect.

(1)



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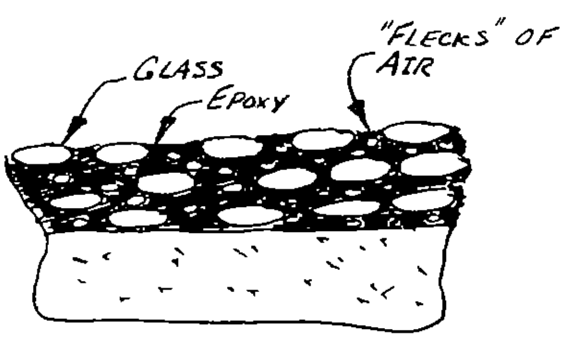

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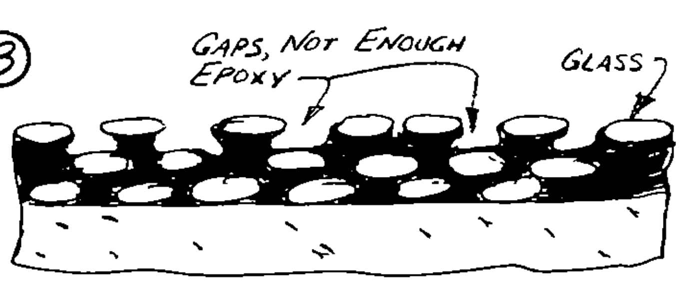
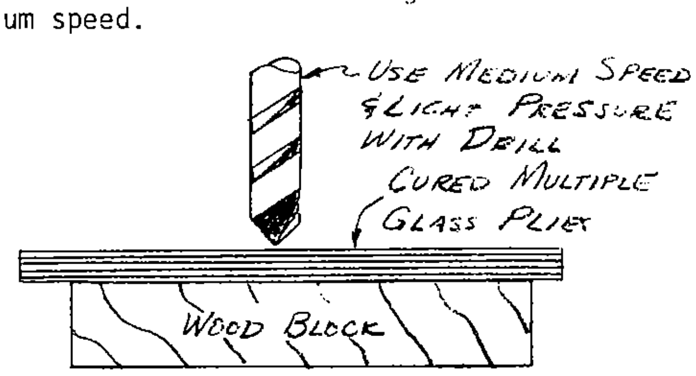
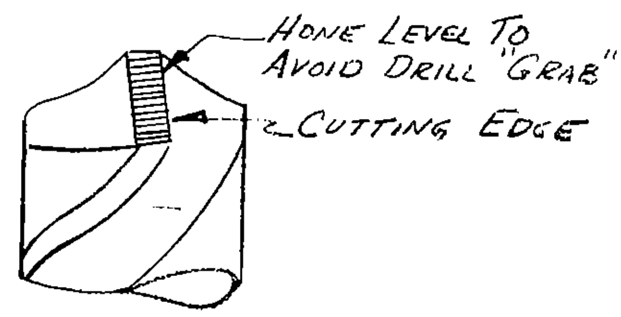


DRILLING, GRINDING, & SAWING

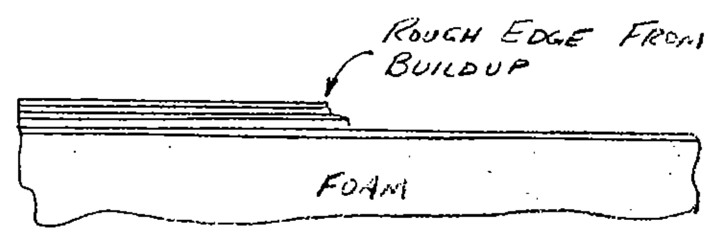
Drilling through cured glass tends to tear the surface plies on the back side. Backup a glass layup with a wood block for drilling as shown and drill at medium speed.

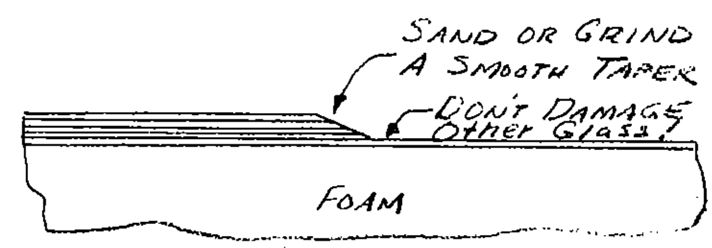


Using a small hone, grind the cutting edges of your drill bit flat as shown (not undercut). This will keep the drill from grabbing into the glass. Don't over-do it, just make a couple of light passes with the hone.

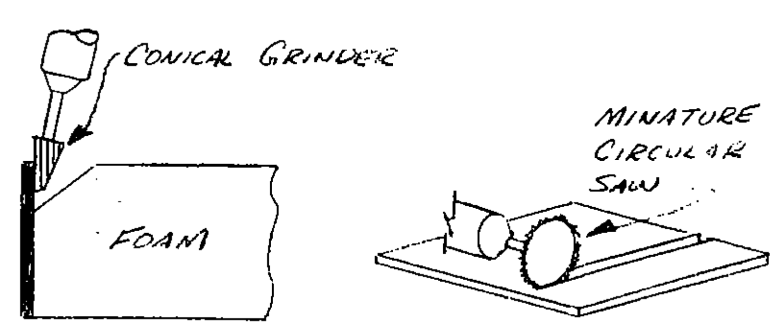


In several places rough, cured glass surfaces occur where overlaps or thick buildups are done. These rough edges should be smoothed as shown using a grinder or sanding block.



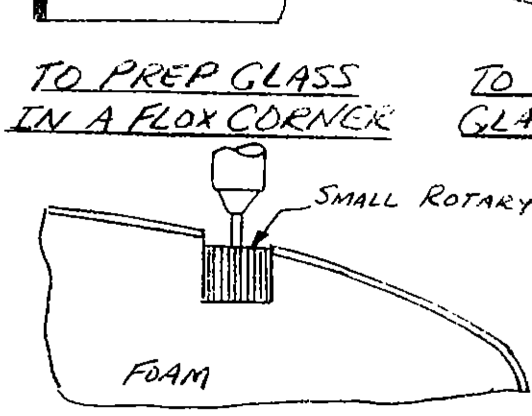


The Dremel (Moto Tool) or Home Shop (Weller) is a very versatile tool with many uses in the construction of your Q2. The kits usually have a nice selection of bits, cutters, grinders, stones, and mandrels for every concievable use. The three types of bits shown here are the most useful for your project. Don't throw the others out, as your next door neighbor might be able to use them on his supersonic ornithoper project.



TO PREP GLASS IN A FLOX CORNER

TO CLEAN UP GLASS EDGES



TO COUNTERBORE
TO GRIND

RIVETING

A pneumatic riveter is not required. The few hard rivets used can be set with a hammer, using your vise as backup. The 'pop-type' rivets are pulled with a low-cost hand puller available at any hardware store.

CUTTING THE UNI SPAR CAPS

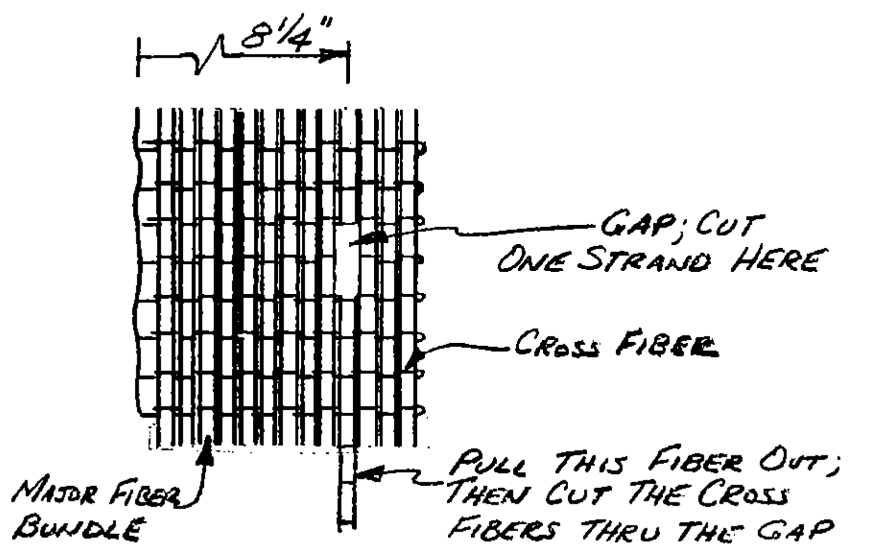
The spar caps used in the main wing, vertical tail, and canard, are strips of UNI cloth that you will cut from the roll provided in the kit.

Begin by unrolling the roll on a long, flat surface. The example to be used here will be a spar cap A that is 8" wide by 50" long. You would measure a 8-1/4" wide piece (to allow for frazzling of the edges) by 50" long, with the fiber orientation running along the 50" edge.

The technique is one of finding the one strand that is at the edge of the 8-1/4" width, cutting it, and then pulling that whole strand the length of the spar cap to remove it. You will now see a clearly visible gap in the UNI cloth where that one strand used to be. Now, using an Exacto knife or razor blade, cut all of the cross fibers along that gap, thus severing the spar cap from the rest of the roll.

Carefully mark the cap with a centerline (in this case at the 25" point, mark it with the letter A and roll it up to keep dirt out of the fibers.

When you next unroll it, you will probably find that the edges are frazzled. As long as you don't reduce the width below the original callout (in this case 8") you may pull off strands that are frazzled. Be carefull to only pull loose one strand at a time or else the whole spar cap will start coming apart!

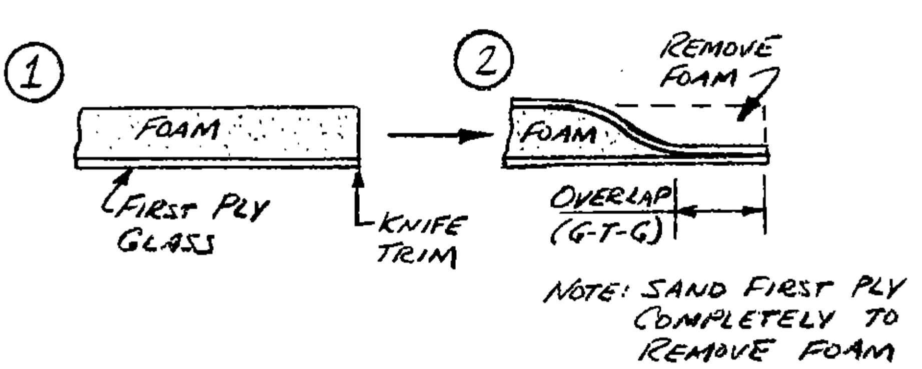


GLASS-TO-GLASS

In order to improve the rigidity of a part, you will occasionally be asked to perform a glass-to-glass layup, sometimes abreviated as GTG.

The example shown here is a glass-to-glass layup on a bulkhead. Begin by glassing one side of the bulkhead as usual. Next, having turned the bulkhead over after curing to prepare the other side for glassing, you will remove foam with a smooth transition so that your next layup will butt up against the previous glass layup.

The amount of "overlap" necessary varies with the loads. On bulkheads, use a minimum of 3/8", on the trailing edges of ailerons and elevators use ¼" minimum, and on the trailing edges of the wing, use 3/8" minimum.



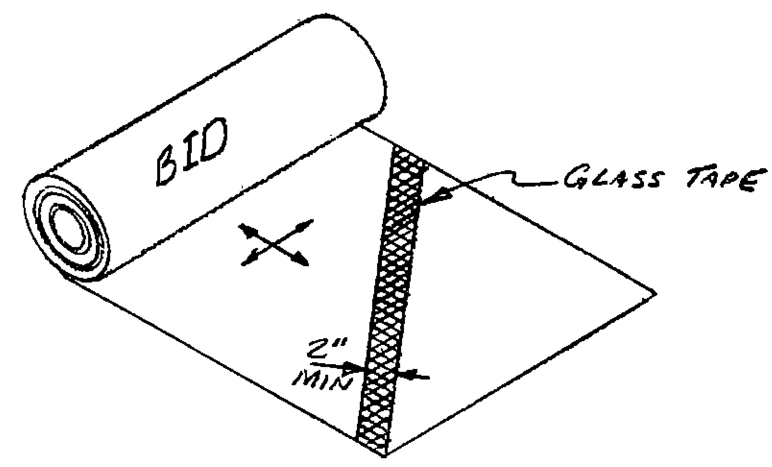
PHENOLIC BONDING

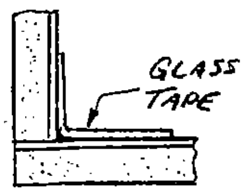
Before bonding phenolic to any surface, be sure to sand the phenolic dull (i.e. to remove the shiny surface) immediately prior to doing the layup. This avoids getting grease from your hands, etc. in the layup, which might cause poor adhesion and subsequent failure of the layup.

TAPES

Quite often during the construction of your Q2, you will be asked to use glass tapes to join two pieces together.

A glass tape is a strip of BID cut at 45 degrees which is used to lap up onto both surfaces that are being joined. For proper strength, the tape should be at least 2" wide.





QUALITY CONTROL CRITERIA

INTRODUCTION

One of the unique features of the glass-foam-glass composite construction technique is your ability to visually inspect the structure from the outside. The transparency of the glass/epoxy material enables you to see all the way through the skins and even through the spar caps. Defects in the layup take four basic forms: resin lean areas, delaminations, wrinkles or bumps in the fibers, and damage due to sanding structure away in finishing. Resin lean areas are white in appearance due to incomplete wetting of the glass cloth with epoxy during the layup.

DRYNESS CRITERIA

Pick any 6"x6" square in the layup in the critical area. Assess carefully if any evidence of air in the layup is present (white flecks, bubbles, air at the foam face). If the dryness is more than 10% of the area, the part MUST be rejected. Reject or repair any evidence of dryness or voids in the trailing edge or leading edge overlaps. Better yet, do an adequate inspection with good light before cure when it's easy to fix. If in doubt on overlaps be sure to stipple in enough epoxy.

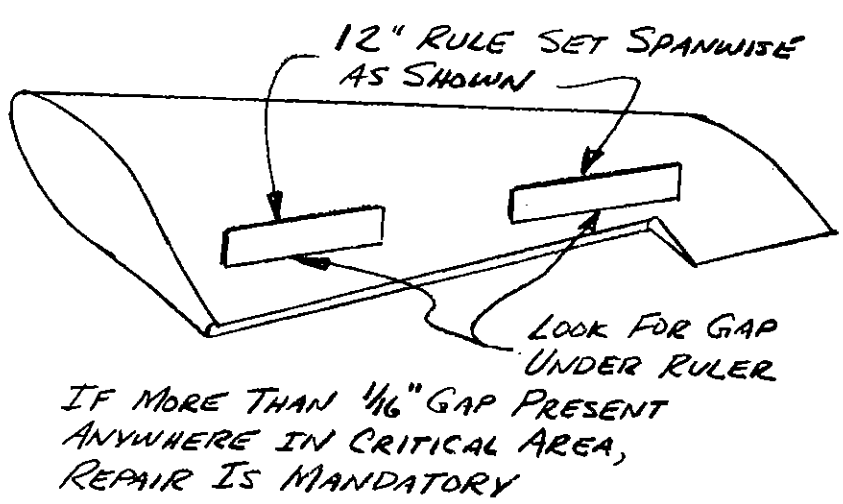
Delaminations in a new layup may be due to small air bubbles trapped between plies during the layup. The areas look like air bubbles and are distinctly visible even deep in a cured layup. Small delaminations, or bubbles up to 2-inch diameter, may be filled with epoxy by drilling a small hole into the bubble and filling the void with epoxy.

When making a layup, do not be concerned if the brush occasionally sheds a few bristles; these do not need to be removed. If the bristle count exceeds about 10 per square foot, change your brush and remove bristles.

Occasional sanding through the weave in the first skin ply is not grounds for scrapping the part. Care should be exercised in areas, such as the skin joints, not to weaken the structure in pursuit of an optimum finish. An excess of resin (wet) will make your airplane heavy and does weaken the layup, but usually not enough to reject the part for strength reasons.

BUMP/JOGGLE/DIP CRITERIA

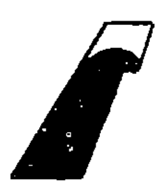
The best way to check this is to lay a 12-inch straightedge on the part spanwise. Move it all over the surface in the critical areas. If you can see 1/16" gap in any area, the part must be repaired. It is best to repair or beef up lumpy areas even if they meet this criteria. Better yet, do a good job in core preparation and use your squeegee well in the layup to avoid the lumps in the first place.



The following is a listing of the "critical areas"; the portions of the Q2 that must meet all the inspection criteria:

1. Entire canard.
2. All portions of the fuselage within 10" of the engine mounts, canard, and wing.
3. All control surfaces.
4. All flying surfaces in the shaded areas shown, plus all overlaps at L.E. & T.E.

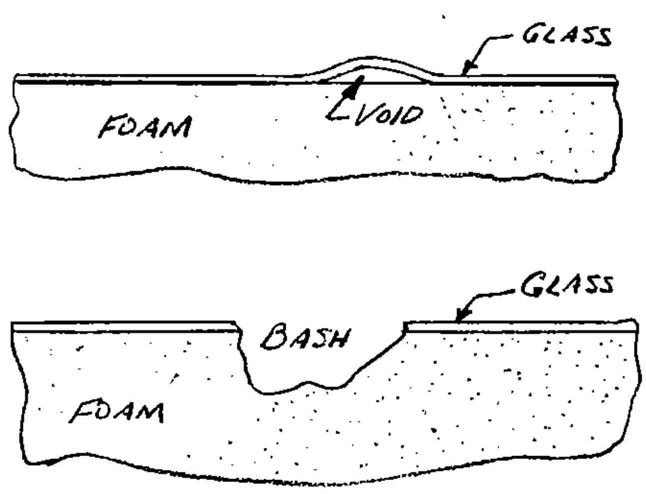
WING (TOP & BOTT)



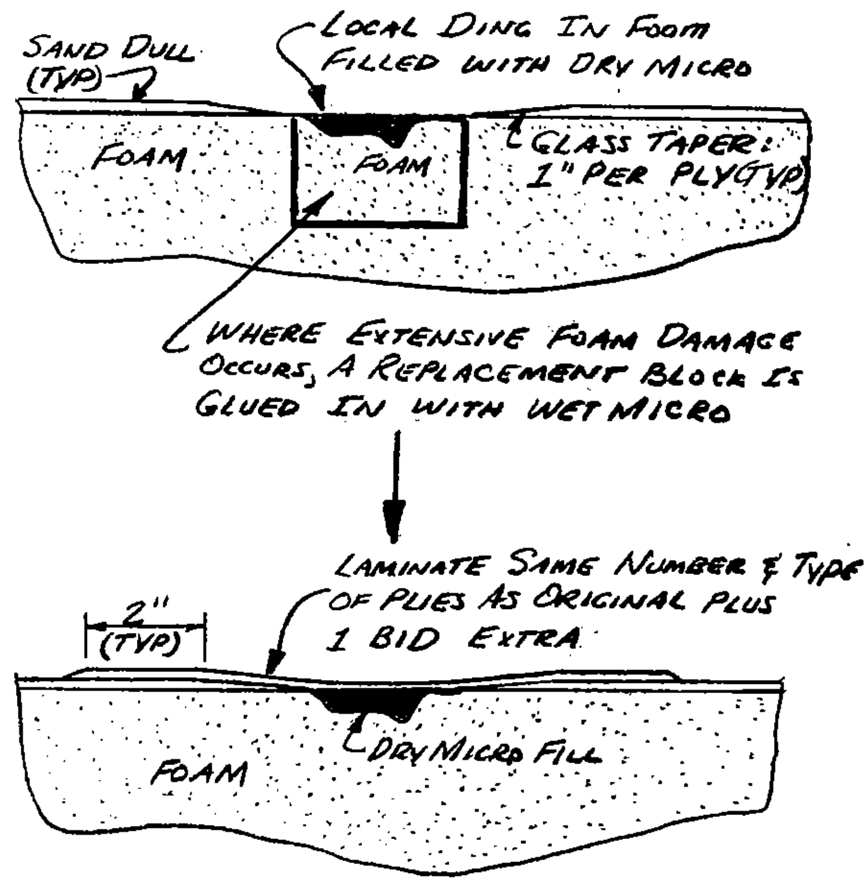
VERTICAL FIN

Major wrinkles or bumps along more than 2" of chord are cause for rejection in the wings, canard and vertical fin, particularly on the top (compression side). This does not mean you have to reject the whole wing - anything can be repaired by following the basic rule: remove the rejected or damaged area and fair back the area at a slope of 1" per ply with a sanding block in all directions. By watching the grain you will be able to count the plies while sanding. Be sure the surface is completely dull, and layup the same plies as you removed, plus one more ply of BID over the entire patch. This will restore full strength to the removed area.

Use this method to repair any area damaged for any reason - inadvertent sanding through plies during finishing, taxiing a wing into a hanger, etc.



TYPICAL DEFECTS



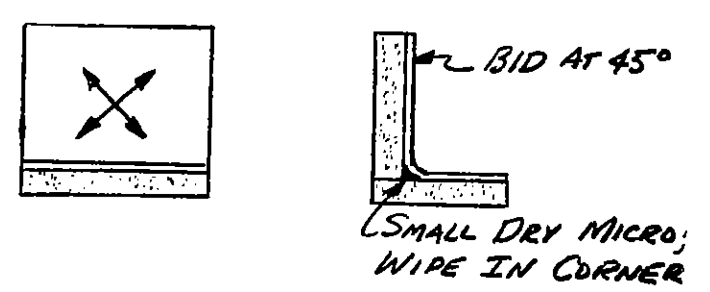
TYPICAL REPAIRS

CORNER TREATMENTS

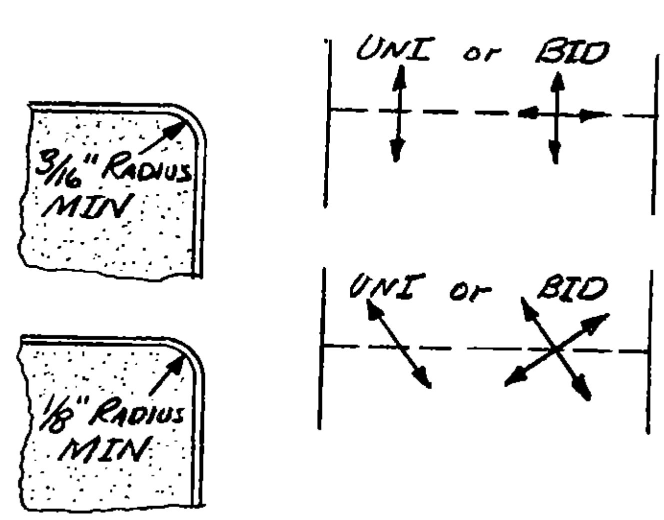
A variety of structural corners are employed in the construction.

There are two basic types of corners: one where the glass fibers are continuous around the corner, and the other where a structural filler is used and glass is bonded to the filler. The corner with the glass fibers running completely around it is used where maximum strength is required.

Inside corners can be laid up quite abrupt and only a very slight wipe of dry micro is needed to get the glass to lay into it. BID cut at 45° is used on this type of corner.



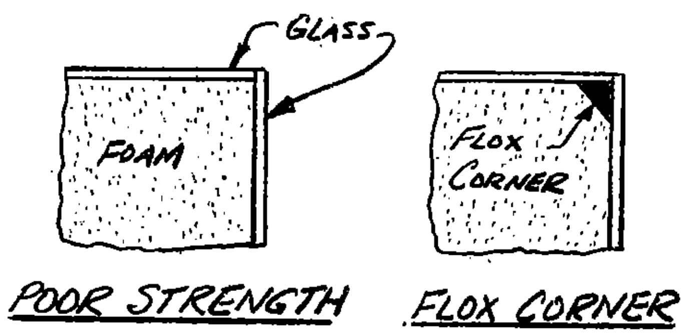
Outside corners require a radiused edge. Where the glass fibers run directly around the corner a minumum radius of 3/16 inch is required. Where the fibers run at an angle to the radius, only a 1/8 inch radius is needed.

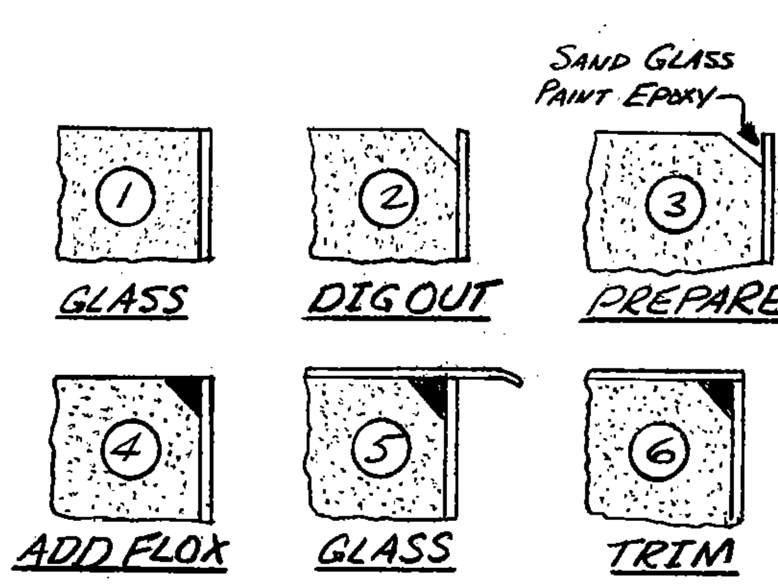


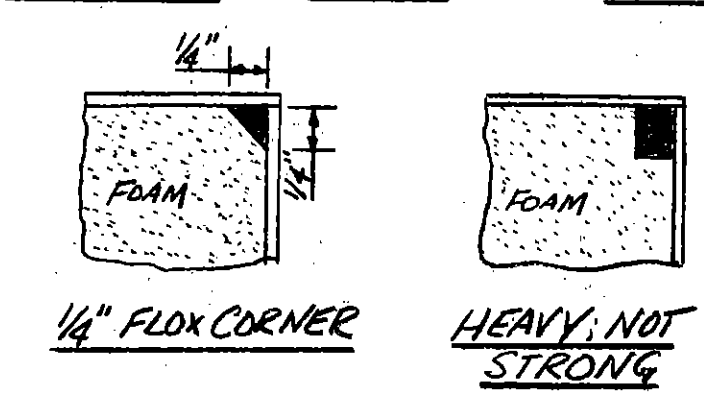
FIBER ORIENTATION

CONTINUED ON NEXT PAGE

In some areas a sharp corner is desirable and maximum strength isn't required. In these areas a flox corner is used. A simple unsupported glass corner has very poor strength. To strengthen this corner, a triangle of flox is used to bond the glass plies together. The flox corner is done just before one glass surface is applied for a wet bond to one surface. The other glass surface has to be sanded dull in preparation as shown.







HEALTH PRECAUTIONS

SKIN PROTECTION

If you work with epoxy on your bare skin, you can develop an allergy to it. This "sensitization" to epoxy is an unpleasant experience and is to be avoided. You generally have to get epoxy on your unprotected skin to become sensitized. If you use a protective barrier skin cream like Ply No. 9, or disposable plastic medical examination gloves, the allergy can be avoided. The barrier skin cream also allows you to clean up with soap and water after a layup.

The Safe-T-Pox epoxy systems are very low toxicity. However, a few people (about 1 percent) may be sensitive to epoxy. These people can get some help by using doctor prescribed anti-allergy medicines and/or by using elaborate masks/multi-gloves, etc, to reduce exposure. Remember to always use skin protection and never let epoxy come in contact with bare skin, even if you have no reaction to it. Sensitivity is accumulative, such that you may later develop an allergy unless you protect your skin.

DUST PROTECTION

Sanding or grinding fiberglass and foams creates dust that can be harmful to your lungs. Use a dust respirator mask for these operations. Disposable dust masks are available at most paint stores.

VENTILATION

Mix and work your epoxy in a ventilated area. If your shop is not ventilated, set up a small fan to move a small flow of air in or out. Do not hotwire urethane foam.

HEAT DEFORMATION AND CREEP

Several builders have had flying surfaces warp or bend due to being poorly supported until fully cured. Do not hang or support them at each end for long periods as they may "creep" or slowly deform. Store them leading edge down with support in at least three places. Your surfaces can be better protected against "creep" if you post-cure them. Sailplane manufactures do this by putting the entire airplane in an oven at 160°F. You can do it as follows: After you have painted on the black primer put the wing or canard out in the sun. Be sure it is well supported in at least three places along its span. At noon a black surface can reach 140 to 180°F. giving it a relatively good post-cure. After the post-cure, the structure is more stable for warping or creep. If you have a wing or canard that is twisted wrong, apply a twisting force in the opposite direction before and during the post-cure (weights applied to boards,Bondoed or clamped to the surface can be used). Remove the force only after the surface has cooled. A 200 ft-lb torque (50 lb weight on a 4 ft arm) applied twice, once while the top surface is post-cured and once for the bottom, surface, can twist your wing or canard over one degree. The twist correction will be permanent and will stay as long as the surface remains cool (below the post-cure temperature). This is generaly referred to as the heat-deformation characteristic of the epoxy. If it is room-temperature cured only, it will soften above 140°F. But if post-cured it will not soften until over 160°F. Heat for post-curing or for intentional deforming can be applied by other means such as heat lamps, hair dryers or electric radiant heaters (household type), however this is generally not recommended, since it is too easy for the homebuilder to get the part too hot and ruin the part. The foam is damaged above 240°F. If you want to use these heat sources, do so by applying the heat very slowly and checking the temperature often by placing your hand on the surface. If you can hold your hand on the surface five seconds without pain, the temperature is okay-three seconds is too hot.

AIRCRAFT MEASUREMENT REFERENCE SYSTEM

To ease the engineer's task of defining where things go in these odd-shaped gadgets called aircraft, a fairly standard system of references has been developed. Fortunately the Q2 is so simple that an eleborate measurement system is not necessary. It is, however, convenient to use the standard terminology for reference occasionally and you should be familiar with its meaning.

The three basic references are called butt lines, fuselage stations, and water lines. Don't blame us for the absurd names, we didn't set the system up. All three are given in inches from some arbitrarily chosen reference, so, fuselage station 100 is found 100 inches away from fuselage station 0, and similarly for butt lines and waterlines. Being as lazy as anybody else, we abbreviate these as FS, BL, and WL.

Fuselage stations (FS) are used to define the location fore and aft on an airplane. To make things easy, fuselage station 0 is generally located near the nose of an airplane and measurements are made aft. Fuselage stations are the most commonly used of the references and later on you will make a reference mark on your airplane to use as a permanent FS reference point.

Waterlines (WL) are used to define vertical locations. Waterline 0 is generally found near the ground and measurements are made up from WL 0.

Waterlines are utilized in many places to position components or templates relative to each other by leveling reference waterlines with a carpenters level.

Butt lines define positions inboard and outboard. Butt line 0 is the vertical centerline of the airplane and measurements are taken to the left and right of BL 0. Since left and right depends on which way you are facing, it is standard practice to define left and right as the pilot would while seated in the cockpit.

Using these three references, any point in an airplane can be described with a fuselage station, butt line, and waterline. Fortunately, your Q2 is so simple that we don't need to locate very many things this way. When you start on your 4/5 scale replica of a B-1 Bomber, this reference system will be real handy.

SURFACE FINISHING

INTRODUCTION

Finishing the composite airplane is more important than simply obtaining an attractive paint job. The finish on a composite aircraft serves to protect the structure from deterioration due to ultra violet radiation (sunlight). The finishing materials also give the airplane its final aerodynamic shape. Using the proper materials and techniques, the finishing process is pleasing (both esthetically and aerodynamically), and provides for long maintenance-free service. Use of sub-standard materials can limit the life of the finish, result in an overweight airplane, and even limit the service life of the airframe. Sanding is done frequently during the finishing process and extreme caution must be exercised to avoid damaging the structure. A poorly executed finishing job can destroy the structural integrity of the airframe. Even the finished color of the composite aircraft can effect its structure. The finishing process is as important to the structure of the composite airplane as basic materials and techniques used in fabrication are. Proper techniques must be adhered to for safety as well as to obtain an attractive airplane.

The Q2 is sensitive to weight growth. You may easily add 50 pounds during the finishing process if you try to finish the entire aircraft to sailplane standards (smooth, wave-free surfaces).

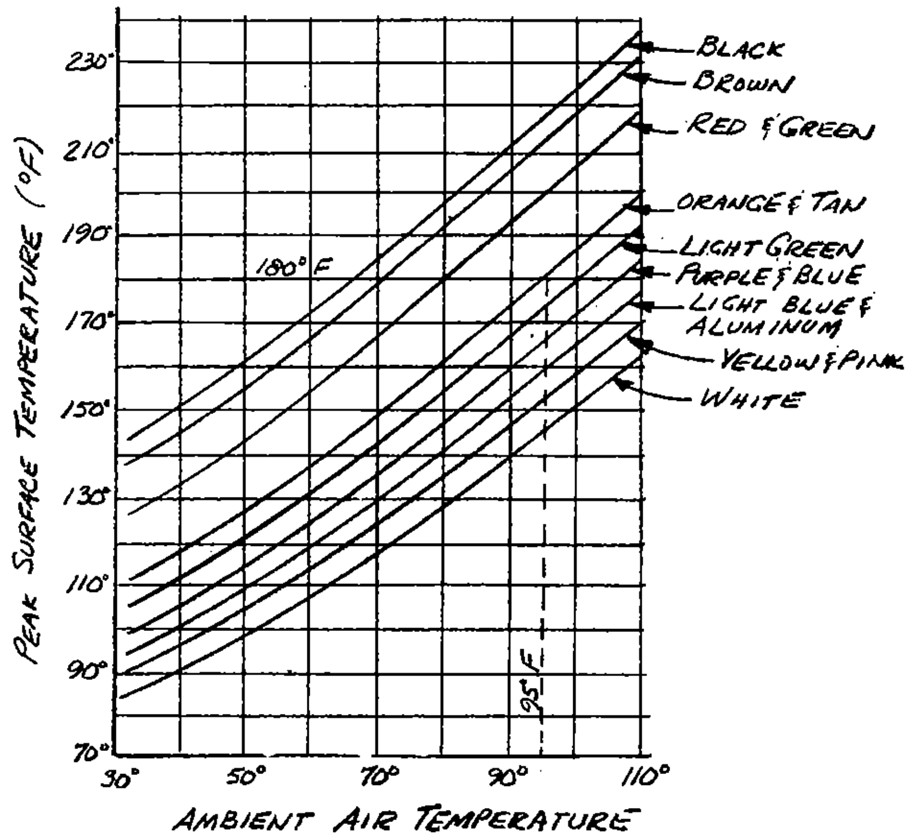
There is one part of the aircraft that must be finished to a smooth and wave-free surface - the canard. We have found that unless the canard is smooth and wave-free, serious degradation of performance and flying qualities results. This section will tell you how to obtain a smooth and wave-free finish on the canard.

The rest of the airplane, in order to keep it as light as possible, should be sanded with very little filling, then primed. and then painted. This will allow some of the fiberglass weave to remain showing, but your Q2 will still look good.

Remember, build it light and finish it light; every pound of weight that you save during the construction and finishing will make the aircraft much more fun to fly in the coming years.

FINISH COLORS AND HEAT

The materials used in amateur-built composite airframes are predominately epoxy resin systems with fiberglass reinforcement over a variety of plastic foam cores. The epoxies and the foams are all sensitive to high temperatures. Some epoxies, cured at elevated temperatures, retain their physical strength to temperatures not found outside an oven. Others, including most room temperature curing epoxies such as the Safe-T-Pox system, soften and loose their rigidity at only moderate temperatures. The common plastic foams are also heat sensitive and tend to soften and (some) swell with moderately elevated temperature. Elevated temperatures could potentially cause a softening of the fiberglass load bearing material, a swelling of the foam core, and general distortion of the airframe. To achieve elevated temperatures you would have to bake your airplane or find some other means of heating it. The sun is a potential source for this heat. In still air, on a hot sunny day it is possible to obtain surface temperatures that approach 250°F. The color of the surface determines how much solar heat it will absorb. White surfaces absorb very little (10%) of the sun's heat while a black surface (95% absorbsion) will heat up tremendously. The accompanying graph shows the relationship between color and surface temperature. White has been choosen as the standard color for fiberglass sailplanes to preclude any possibility of excess temperature due to solar heating. The same criteria apply to the Q2, and white is recommended. Trim colors in less-critical areas such as the fuselage, vertical tail, and the underside of wings and canard, can be other than white. Dark trim colors are definately not recommended on the upper surface of wings and canard! If you would like further information on the subject read the September 1975 issue of Soaring magazine.



COLOR CURVE

(REF: SOARING: SEPT 75)

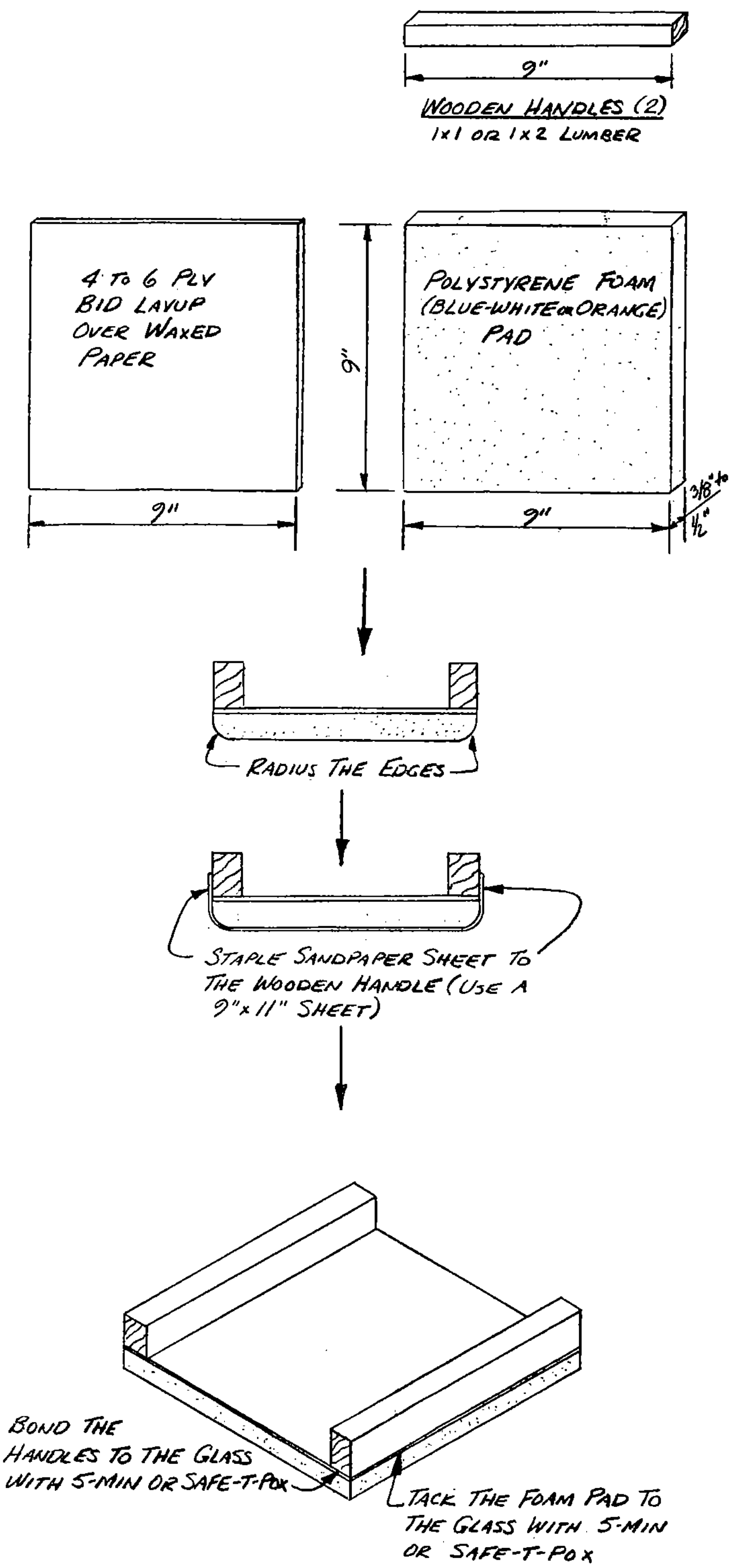
TOOLS AND MATERIALS

The tools and materials used in finishing the composite airplane are simple and straight foreward. A low density microsphere/epoxy mixture (dry micro) is used for coarse filling requirements. Automotive type polyester body fillers (Bondo) are very heavy and not recommended as a primary aircraft finishing material. Medium to light surface filling (less than .030") is done with a light weight polyester spray (or brush) filler/primer called Feather-Fill. Feather-Fill is noteworthy for its ability to fill medium thicknesses in a single spray or brush coat and for its easy sanding to a smooth surface. Dupont 70S dark gray laquer primer/surfacer provides an effective ultra violet radiation barrier with its 15% carbon-black content as well as an excellent finish sanding surface in preparation for the finish paint. The actual finish paint type is largely a matter of the builder's personal preference. Automotive finishes in laquer, enamel, acrylic laquers, acrylic enamels, and the polyurethanes are all acceptable. We find the acrylic laquer is easy to work with, easily patched, and readily polished to a high gloss.

The enamels and acrylic enamels are low cost and easy to apply; however, they are not readily repairable if chipped. The polyurethane finishes offer the best gloss for the longest life, but they are high cost and virtually impossible to repair. There is a polyester paint, known as Prestek, commonly used in sailplane circles to achieve a glass-smooth finish, but it is heavy, requires a tremendous amount of work to get a high gloss finish, and chips easily (brittle).

Sanding will occupy a large percentage of the time spent finishing the composite aircraft. Sandpaper in 36 to 60-grit, 100-grit, 220-grit, and 320-grit roughnesses will be used. Standard 9"x11" sheets are the most versitile. Use a good quality aluminum oxide, or silicon carbide sandpaper. Don't waste your money on the cheap flint-type sandpapers. Power sanders are not recommended; it is too easy to damage the structure while using them. Hard (wood) and soft (foam) sanding blocks and the sanding spline shown will be your primary finishing tools. A paint spraying setup will be desirable for feather fill, U.V. barrier primer and finish painting. Some hand brushing of feather fill and U.V. primer can also be done.

The sanding spline is a finishing tool common to the sailplane industry. It is an easy tool to make and does an excellent job of contouring. You may find it handy to make two, one for coarse grit sandpaper and one for medium or fine sanding. The spline is an easy tool to use but it may require your close attention at first. The spline is always held with handles parallel to the leading edge of an airfoil surface (wing, canard, etc.) as shown in the sketch. The sanding motion is on a diagonal to the leading edge while the spline's handles are held parallel. This takes a little getting used to but becomes second nature after a little practice.



SANDING SPLINE

THE FINISHING PROCESS

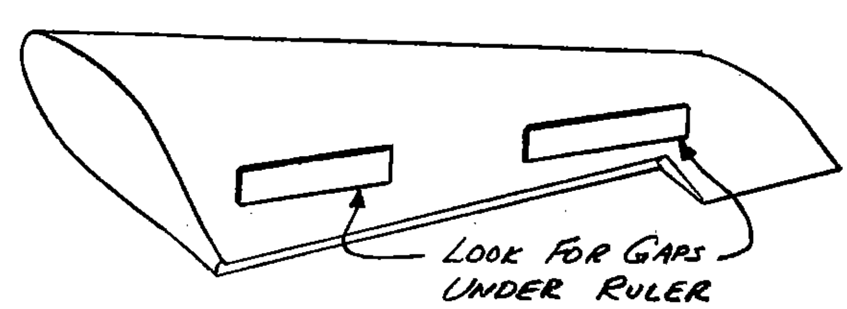
Finishing the composite airplane is a five-step operation. Repairs or rework of structure must be completed first, before the obscuring finish is applied, and final structural inspections must be complete. Second, coarse contour filling is done with microspheres/mixed with epoxy (dry micro) as required in areas requiring .03 inch to .20 inch of fill. Any exceptionally gross filling (over .20 in) is also accomplished at this stage using a foam filler. The initial contour sanding begins with the cured microsphere filler, and exceptional caution must be exercised to avoid damaging the structural skins while sanding. Third, featherfill is applied to fill medium sized surface defects up to .03 inch, and as a general fill of the glass surface weave. The fourth step is the application of an ultra violet barrier primer. Fifth, the final finish paint is applied.

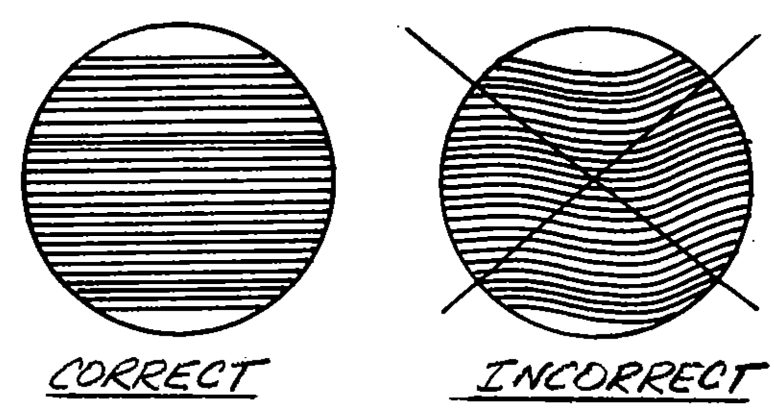
The following sketches are descriptive of the finishing process and its potential pit falls. The sketches use an exaggerated scale to show details more clearly.

STEP ONE: INSPECTION/REPAIRS

Before you begin finishing, the entire structure must be airworthy. You can hide poor workmanship from your own eyes and from the inspector who will finally approve your first flight, but you can't fool mother nature! All structure must be sound before finish materials are applied. The following sketches are a review and clarification of the quality control criteria found in Chapter 3. Each airplane must have a thorough inspection and required repairs completed as the first step in finishing.

The best way to inspect the structure for bumps or dips is to place a 12" ruler on the wing or canard span-wise, as shown. Gaps under it approaching 1/16" height must be repaired.





UNI FIBERS SHOULD BE STRAIGHT, NOT KINKED, DISRUPTED, OR CROOKED

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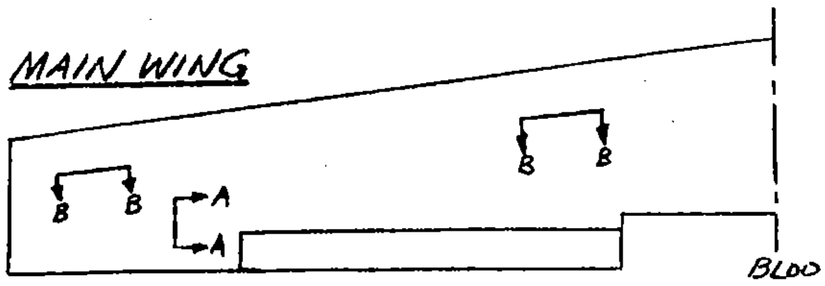

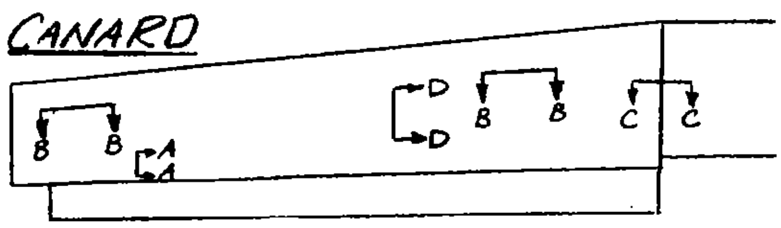

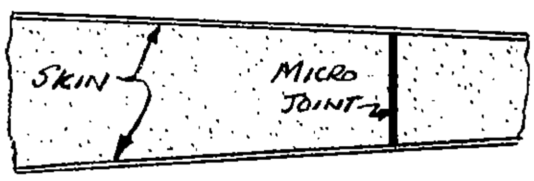

SECTION A-A
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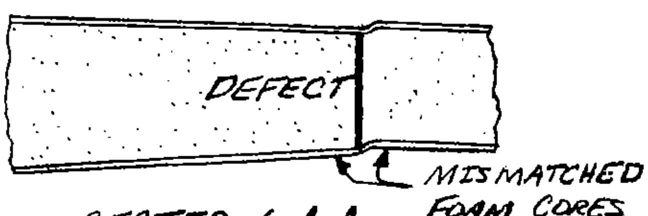

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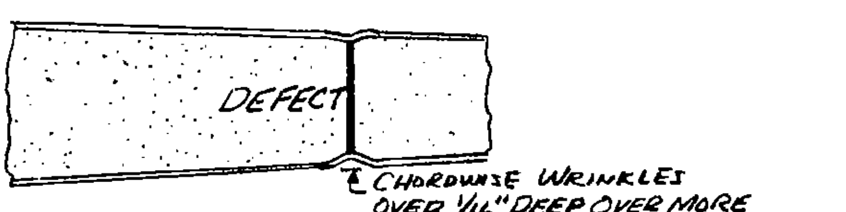

SECTION A-A
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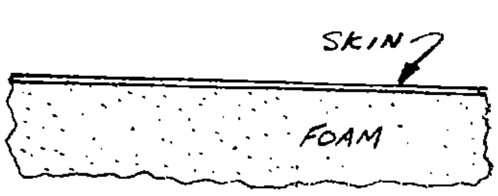

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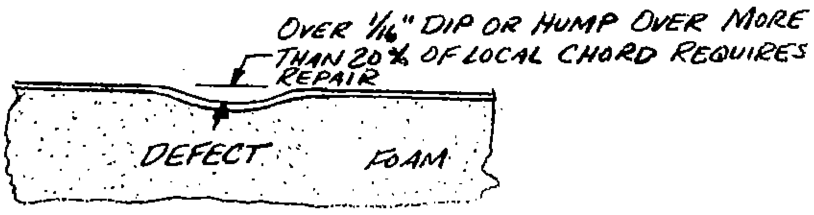

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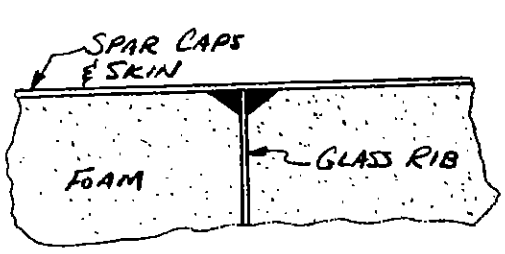

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SECTION C-C
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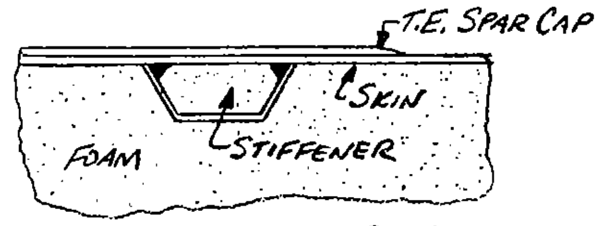

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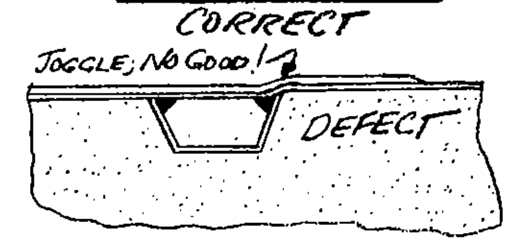

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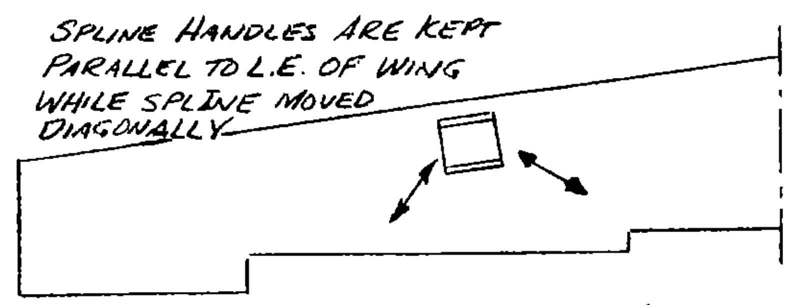
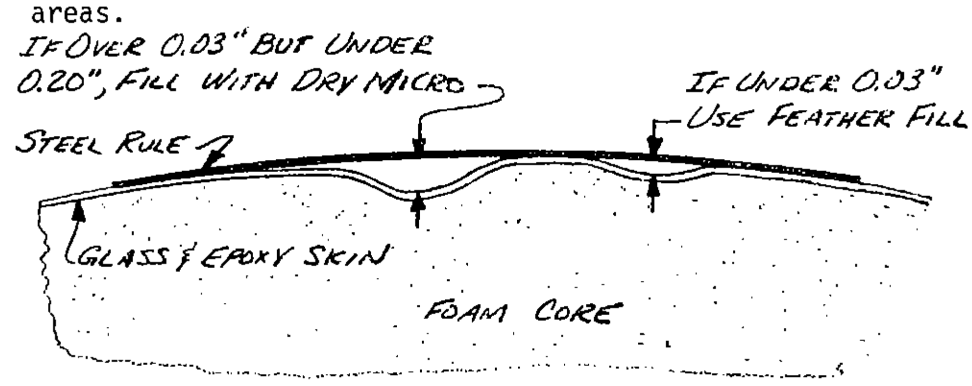


SPLINE MOTION

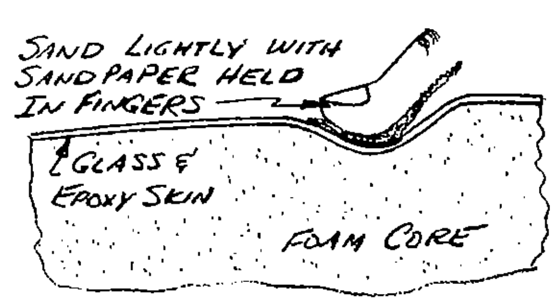
STEP TWO: COARSE FILLING

You must be extra cautious in this step or you may destroy your structure. When you take a peice of sandpaper and start grinding on your composite structure it's like using acid to clean a metal wing spar. It must be done carefully!

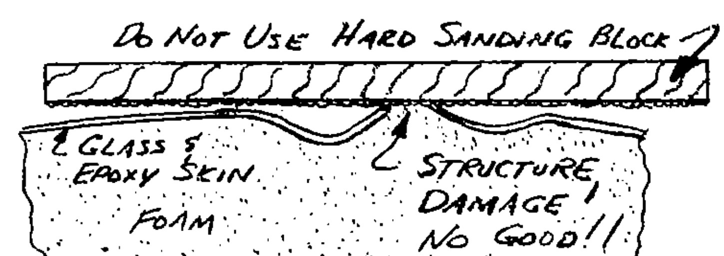
Start by determining which areas require micro filler as shown using a flexible yard stick and a scale. Prepare the areas to be filled by hand-sanding lightly. Do not try to use a sanding block or spline on these areas.



INSPECTION



PROPER SANDING



IMPROPER SANDING

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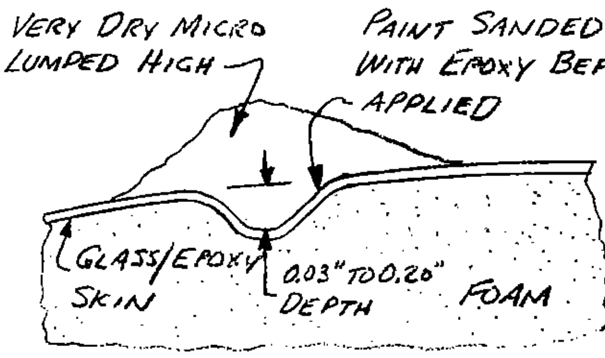
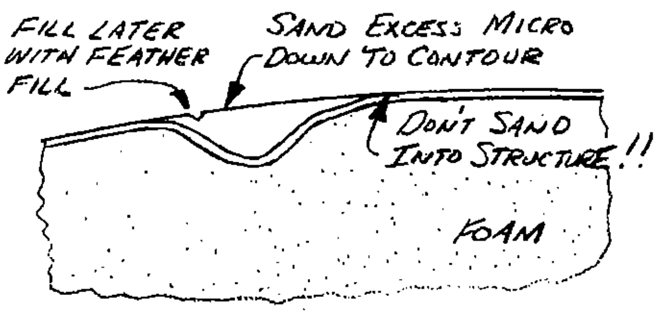
Paint a thin coat of epoxy over the area to be filled. Dry micro is then lumped over the area. The fill must be high, such that material is sanded away to bring the area into contour. The micro should be mixed very dry (lots of microspheres) to save weight. Let the micro cure at least 24 hours.

Sand the micro overfill into contour using a hard sanding block, or spline with coarse (36 to 60-grit) sandpaper. Exercise extreme caution while sanding. A few careless strokes with coarse paper can ruin your structure!

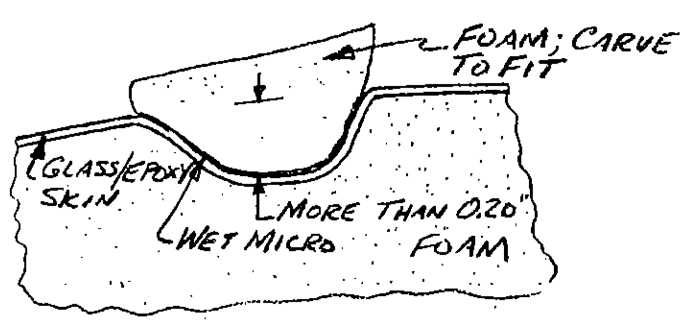


0.03" TO 0.20" FILL

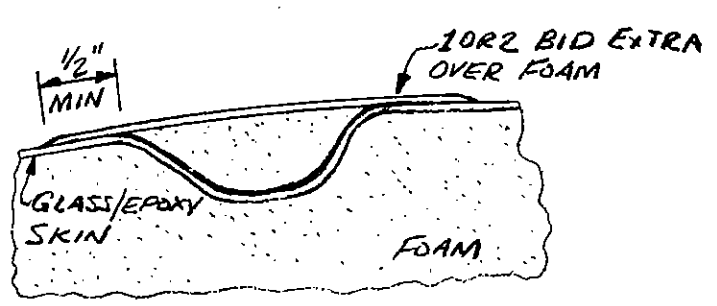


SANDING

NOTE: USE A HARD SANDING BLOCK, SOFT BLOCK, OR SPLINE WITH COARSE 36-60 GRIT SANDPAPER.



OVER 0.20" FILL



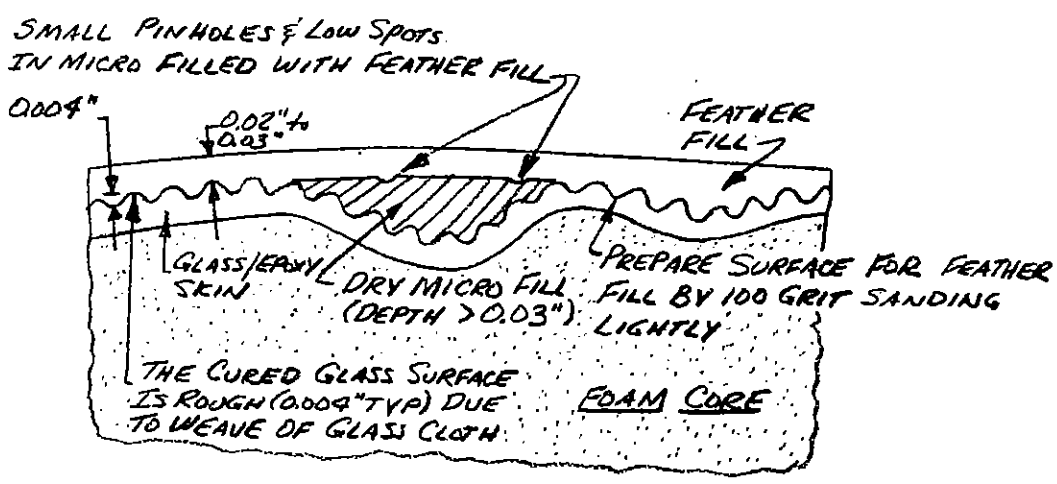
SANDING/GLASSING

STEP THREE: FEATHER FILL

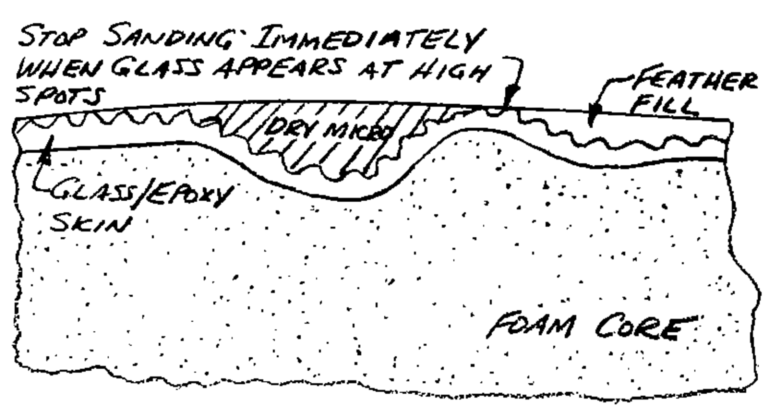
Sand the surfaces lightly by hand or with a soft foam sanding block in preparation for feather fill. A spray or brush coat of feather fill will build up .02" to .03" thick, fill the glass weave and any medium sized out-of-contour spots. Feather fill will require several hours curing time before it can be sanded. The cured feather fill is sanded to contour using a spline or soft block and 100-grit sandpaper. Again, extreme caution must be exercised not to damage the glass structure in pursuit of a good finish. The contouring must stop immediately when the highest glass peaks begin to be visible as the feather fill is sanded away.

If you find that you have underestimated the fill required or just have a thin coat, don't hesitate to use a second coat of feather fill. A well prepared surface generally won't need more than one coat. When you have finished contouring the feather fill, the surface should be basically smooth and fair. The primer to follow is not intended to be contoured heavily, just smoothed with finer sandpaper for a smooth finish while leaving a substantial ultra violet barrier.

After you have filled and contoured, reinspect for sanding damage; it is an easy thing to do! Remember, you are only allowed to sand into the first skin ply in local areas no greater than 2 inches in diameter and all of these areas must total less than 10% of the surface area. Wherever there is only one ply, or where the UNI cloth is crossed for strength (e.g. the canard and wing skins), no sanding of the ply is allowed, except for "scuffing up" the surface. Be Careful!



APPLICATION



SANDING

STEP FOUR: PRIMER

The ultra violet radiation barrier is provided by the heavy carbon black content of the dried primer (Dupont 70S). The primer gives the whole surface a flat black color and the sanding should never remove it completely, exposing the light gray feather fill below. The primer is sprayed on, allowed to dry, and sanded lightly to achieve a smooth surface. The first primer coat is sanded using 220-grit and the second coat very lightly wet sanded with 320-grit. When complete, the primer is very smooth, dark, and ready for finish paint.

STEP FIVE: FINISH PAINT

Follow the manufacturer's directions for the type of finish paint that you have chosen.

COCKPIT INTERIOR

It is not necessary to fill the glass weave, although some very light sanding may be done to smooth the surfaces. Apply one coat of the Dupont 70S primer to the interior glass surfaces for ultra violet protection prior to painting the interior.

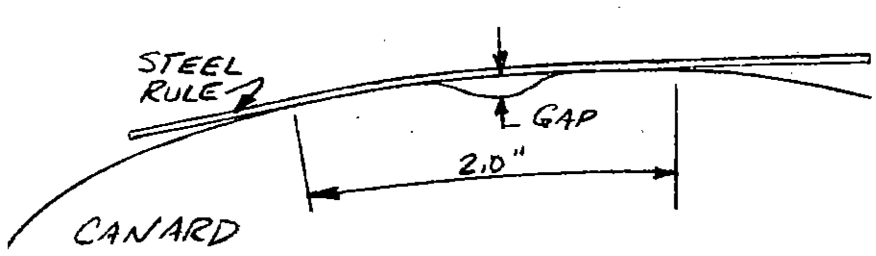
A light color (light grey, green, or blue, etc.) is recommended on the cockpit interior to avoid high heat buildup when the aircraft is parked in the summer sun with the canopy locked. Automotive trunk paint may also be used. Its "speckled" appearance will hide the weave of the glass cloth.

CANARD SURFACE SMOOTHNESS IS CRITICAL

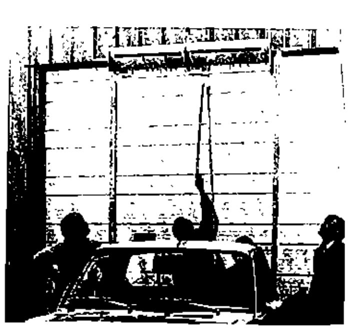
During the Quickie program we built and installed a canard that resulted in very poor low-speed performance. Stall speed was 10 mph higher than predicted and tuft tests showed stall angle-of-attack over three degrees lower than extimated. We later traced the problem to a wavy upper surface; the canard must be smooth.

Of course, the big question is "how smooth"? The best way to check this is with a steel pocket ruler, the flexible kind that's only .02" thick, or with a plastic drafting ruler. Hold the ruler as shown in the sketch, pushing it to the surface with two fingers 2 inches apart. If the surface is a smooth curve between your two fingers the ruler will lay down following the curve with no gaps. If the surface is bumpy or wavy the ruler will touch the surface only in 3 or 4 places. Take a feeler gauge to measure the gaps between the ruler and your surface. If you have a gap of more than .005 inch, your surface is too wavy. Check this in several places from the leading edge back to 50% chord. The bad Quickie wing had gaps of about .012 inch. After refinishing with gaps of less than .005 inch, its stall angle of attack increased from 8 deg. to 12 deg!

The best time to use the ruler and check for smooth surface is when sanding the Featherfill with the spline. Recheck after sanding the 70S black primer. It will not change when white paint is sprayed on.



CANARD WAVINESS TEST



AMATEUR-BUILT Q2INSPECTION CRITERIA

1.0 SCOPE

This document has been prepared to assist inspection personnel by providing recommended acceptance criteria and acceptable repair practices for the Q2 amateur-built composite sandwich structure.

2.0 BACKGROUND INFORMATION

2.1 DESIGN CRITERIA

The materials, methods, and practices employed by the amateur builder in the construction of the Q2 type are new to light aircraft construction and may be unfamiliar to the inspection personnel involved with the licensing of amateur-built aircraft. Structural design criteria for the Q2 exceed F.A.R. part 23 requirements. In-house component testing of the primary flight structure has been conducted to 200% of design limits. Detail documentation of test data is on file at Quickie Aircraft Corporation. The aircraft is considered to be a utility category aircraft. Q2 builders are being supplied with a complete owner's manual which specifies all placards, operating limitations, normal and emergency operations, flying qualities, maintenance sp cifications, inspection procedures, and initial flight test procedures.

2.2 STRUCTURAL APPROACH

The basic structure throughout the design is a composite sandwich of load bearing fiberglass skins separated by a light-weight foam core. While the materials and processes are tailored to the amateur builder, the structural layout is very similar to the honeycomb composite structures stilized in military and transport type aircraft and fiberglass sailplanes. Loads are carried by epoxy/"E"-type fiberglass lamina. Foams of various types and densities are employed as a form (upon which the load bearing material is shaped) and as local buckling support. In no instance are foams used to transmit primary loads, as is the case in some other amateur-built designs.

2.3 INSPECTION TECHNIQUES

The transparent nature of the fiberglass/epoxy material allows for visual inspection of primary structure from the outside prior to finishing. Defects in the structure, as described in paragraph 3.0, are readily visible even in the deepest laminate.

2.4 INSPECTION SEQUENCING

The external visual inspection capability provided by the materials allow inspection of all primary structures at any point before finishing. All primary structures are at the surface, eliminating the requirement for "pre-cover" or "closure" inspections. Opaque filler materials are used throughout the airplane in finishing, and inspection must take place before any areas are obscured. Some areas may have opaque materials applied to one surface where the structure is inspectable from the opposite side (wing trailing edge for example).

3.0 DEFECTS

3.1 VOIDS

Interlaminar voids in a new layup may be due to small air bubbles trapped between plies during the layup. These void areas look white and are distinctly visible even deep in a cured layup. Interlaminary voids up to 1 inch in diameter do not require repair, as long as they do not consist of more than 5% of the surface area.

Interlaminar voids (airbubbles) up to 2 inches in diameter are acceptable when repaired as follows: A small hole is drilled into the void and epoxy is injected into the void area. Small voids such as this may occupy up to 5% of the laminate surface area.

Voids greater than 2 inches in diameter should be repaired as shown in paragraph 4.

CONTINUED ON NEXT PAGE

3.2 LEAN AREAS
Areas where the epoxy/glass matrix is incomplete because of inadequate wetting of the cloth with epoxy (lean areas) are speckled whitish in appearance. The fully wetted laminate will have a consistant transparent greenish appearance. Epoxy lean areas are acceptable, as long as the white speckled area is less than 10% of the surface area. White to green ratios greater than 10% require rejection or repair as shown in paragraph 4.

3.3 RICH AREAS
Resin richness primarily adds weight to the laminate. While some degradation of physical properties does occur, a overly wet (rich) layup is not grounds for rejection.

3.4 INCLUSIONS
Bristle paint brushes are used throughout the layup process. As a brush begins to deteriorate it will shed some bristles into the laminate. The bristle inclusions, up to 20 bristles per square foot, are not cause for rejection. Occasional inclusion of small woodchips or other small foreign objects is not grounds for rejection.

3.5 FIBER DISRUPTION
In all instances, it is good practice to have the glass fibers lying flat and without wrinkles. Major wrinkles or bumps along more than 2 inches of chord are cause for rejection in the wings, canard, and vertical fin, particularly on the upper surfaces (compression side). Disruptions greater than 2 inches require repairs per paragraph 4.

3.6 FINISHING DAMAGE
Damage to the external structure by sanding in preparation for surface fill and paint can occur. Occasional sanding through the weave of the first skin ply is not grounds for rejection. Sanding through areas greater than 2 inches in diameter completely through the first ply or any damage to interior plies must be repaired in accordance with paragraph 4. A damp rag passed over the sanded surface will make the plies show up to determine how many plies have been sanded away.

3.7 SERVICE DAMAGE
Damage to the glass structure will be evidenced by cracked paint, or "brooming" of glass fibers. Both of these indicators are clearly visible. If either type of indication is present, the paint and filler should be sanded away, bare laminate inspected, and repairs made per paragraph 4 as required. Where surface damage has occured it is also likely that local foam crushing has been inflicted.

3.8 DELAMINATIONS
Delamination of glass/epoxy lap joints is evidenced by physical separation of plies. These defects are easily visible and easily repaired. The leading and trailing edges of flying surfaces (wing, canard, vertical fin) should be free of delamination.

3.9 MULTIPLE DEFECTS
Where multiple types of small defects occur in a laminate (voids, fiber dislocations, and lean areas for example), they should not exceed a total of 10% of the surface area of the laminate, or 20% of the wing chord at any one spanwise position.

4.0 REPAIRS

There are seldom single defects so massive that a major component must be scrapped. The repair procedures described here may be applied throughout the QUICKIE and Q2 composite sandwich structures.

4.1 SMALL VOID REPAIRS
Voids up to 2 inches in diameter may be repaired by drilling a small hole into the void and injecting the void full of epoxy. A vent hole opposite the injection point is required to allow air to excape.

4.2 LARGE DEFECTS
Excessively large voids, lean areas, finishing damage, fiber disruptions, major fiber wrinkles, or service damage may be repaired using this procedure. Remove the rejected or damaged area by sanding or grinding the taper the glass laminate on a slope of approximately 1 inch per ply in all directions. The plies are visible as the sanding is done. The tapered glass edges and surrounding two inches of glass surface must be sanded completely dull. Damaged underlying foam should be removed and the void filled with a dry microsphere/epoxy mixture or a replacement foam piece. The damaged area is then laminated over using the same type and orientation of glass plies removed, each ply lapping onto the undamaged glass at least one inch. The whole repair area is covered with an additiona bi-directional glass ply.

4.3 DELAMINATIONS
A delaminated joint should be spread, the mating surfaces sanded dull, gap filled with flox (epoxy/flocked cotton mixture), then clamped shut while it cures.

5.0 MATERIALS

Since a wide range of similar appearing materials exists which exhibit substantial differences in physical (structural) properties, Quickie Aircraft Corporation has established a distribution system to provide the amateur builder with proven acceptable materials. Quickie Aircraft Corporation strongly discourages the substitution of materials. Homebuilder substitutions for the basic structural materials constitutes major structural modification to the Q2 design, and could adversely effect flight safety.

6.0 APPLICABILITY

These acceptance criteria are different from and, in some cases, much looser than for similar structures found in sailplanes and other contemporary composite structures. These criteria apply only to the QUICKIE and Q2 structutes. Design safety factors in excess of three enable somewhat relaxed acceptability criteria compared to other similar structures.

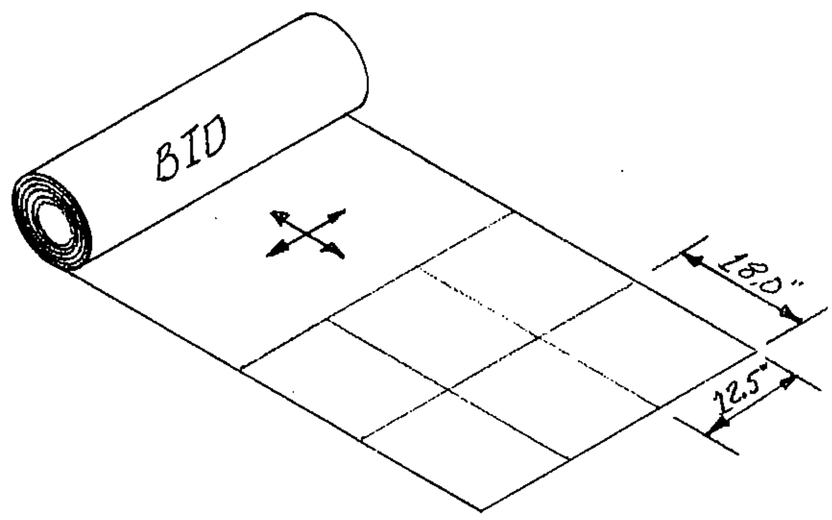
END OF SECTION

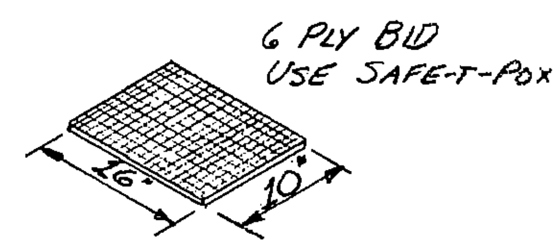
PRACTICE LAYUPS

FLAT LAYUP

The first practice layup that you will make is a layup of six BID plies onto a flat surface. This is intended to give you experience in the techniques of glass/epoxy work and to give you a check on your workmanship. You should be able to complete this layup in about half an hour.

Protect your work bench by taping waxed paper over an area about 24" by 24", (or, find a piece of metal and wax its surface). This will keep the epoxy from bonding to the table top. Cut six plies of BID that are about 12½ inches by 18 inches.





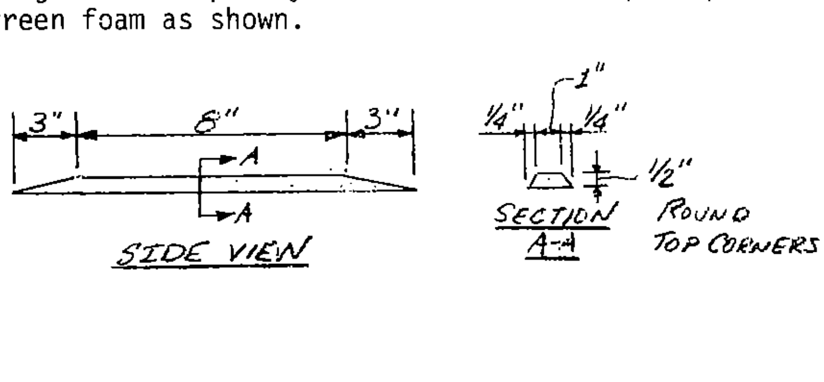
Laminate the six plies on top of the waxed paper. Try to do your best job of stippling and squeegeeing so that the plies are completely wetted but not full of excess epoxy. Let the layup cure to knife trim, about four hours. Carefully mark a 10 inch by 16 inch rectangle and knife trim the layup to that size using a sharp razor blade or trim knife. Allow the layup to cure completely. If you forget the knife trim, cut the cured piece with a coping saw or band saw.

Take the cured 10"x16" piece to your post office, or any accurate scale, and ask them to weigh it for you. Your laminate should weigh between 10½ and 12½ ounces. A 10½ ounce layup is about as light as can be done without voids (white areas). A 12½ ounce layup has too much resin, and if you make all of the layups in the airplane this wet, your Q2 may be as much as 50 pounds over weight. An 11 ounce layup is just about perfect. Save this piece; it will be useful to check future layups against.

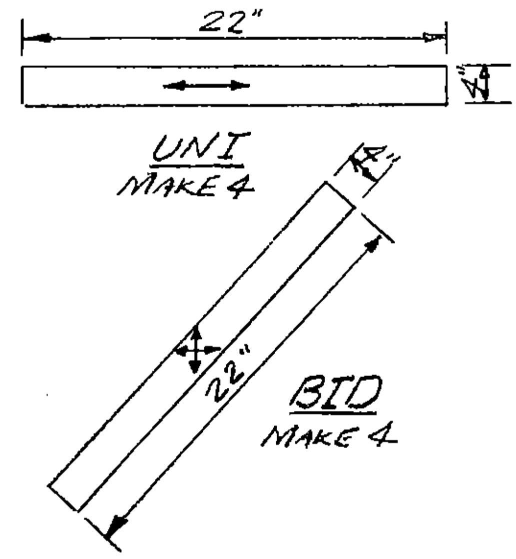
CONFIDENCE LAYUP

The second practice layup is one intended to give you confidence in the strength of your work. This layup is a sample of composite sandwich structure and is typical of the load carrying structures in your Q2. When this layup is finished, and completely cured, you will subject it to a simple load test, and thus demonstrate the strength of your workmanship.

First, tape a piece of waxed paper about 30 inches long to the top of your work table. Shape a piece of green foam as shown.



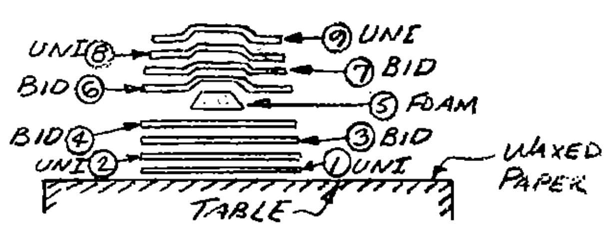
Go to your glass cutting area and cut the glass plies shown.

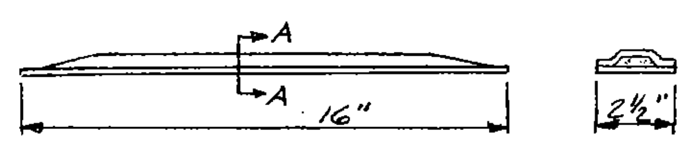


Lay up two plies of UNI, two plies of BID, paint the foam with micro slurry, and press it in the center. Then lay up the other BID and UNI plies.

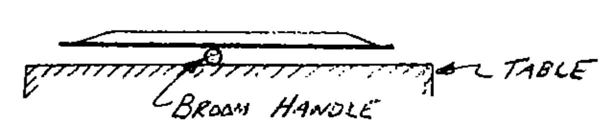
Be careful to work all air bubbles out of the corners. The best way is to stipple with the brush. The glass is oversized so that it can be trimmed to exact dimensions later. Trim to the dimensions shown after curing 24 hours, using a coping saw or band saw.

Allow the piece to cure for four days at room temperature before the load test.



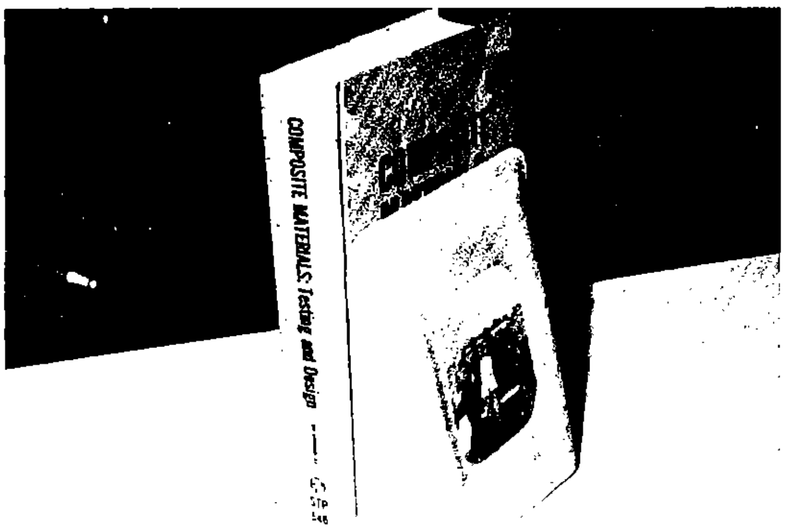


Now for the test: lay a broom handle or piece of tubing on the work bench and try to break the sample by putting all of your weight on the ends. A 200 pounder will stress the sample more than any part of your airplane is stressed at 10 g's.



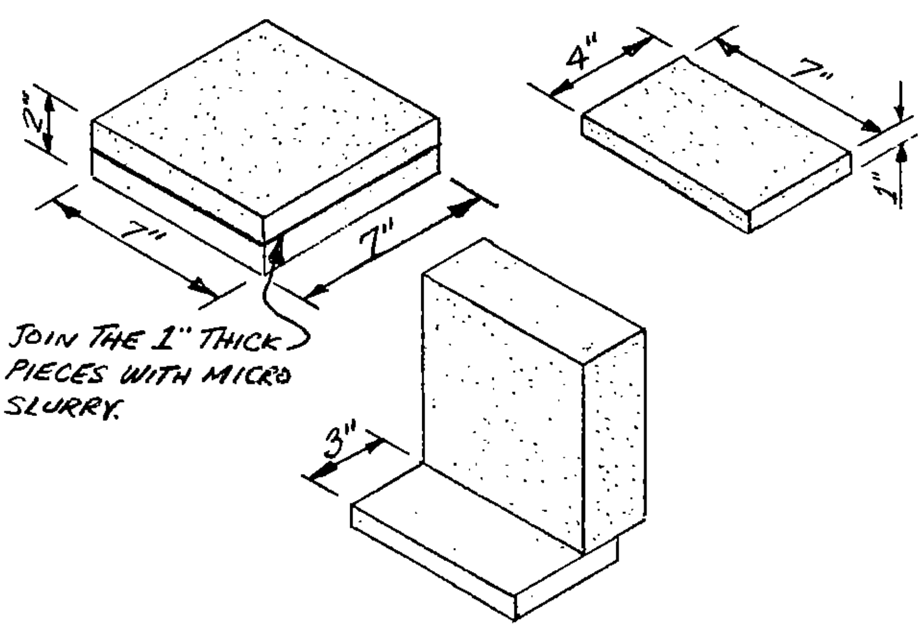
BOOK END

The last practice part that you will make before starting on your airplane is a book end. It takes three layups to make the book end and involves most of the operations that you will need to learn, to build your airplane.

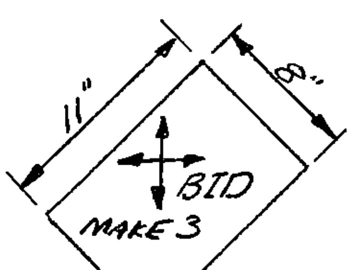


Cut the 3 blocks of green urethane foam (2lb/ft3) as shown.

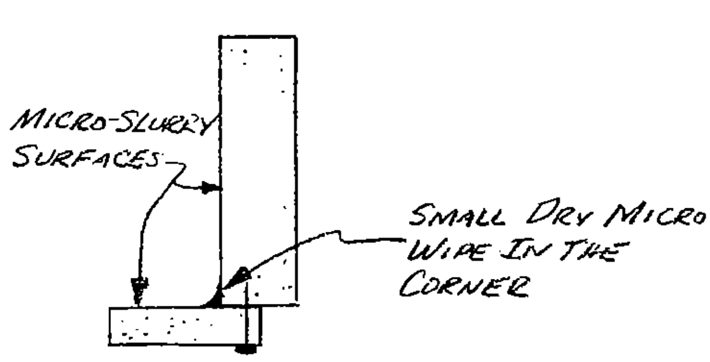
Nail them together.



Cut three plies of BID as shown.

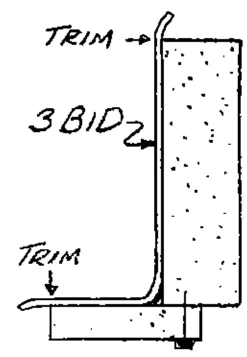


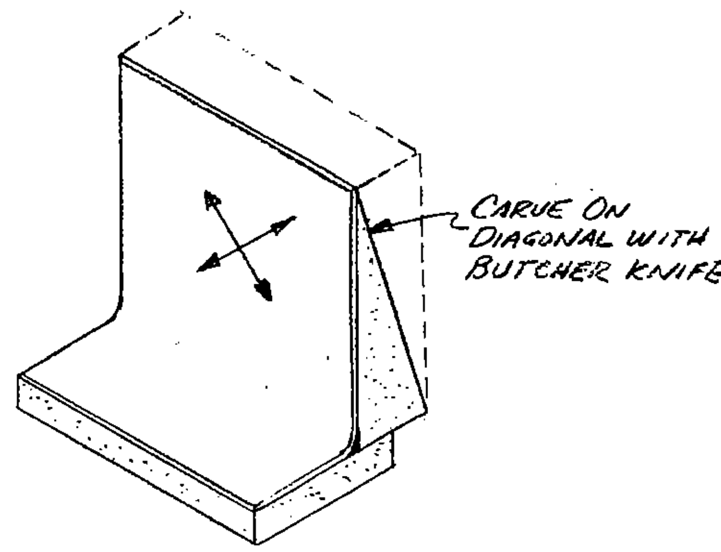
Mix 4 oz. of Safe-T-Pox epoxy; using about 1 oz, make a small batch of micro slurry and coat the foam as shown. Make dry micro from the leftover slurry and a small radius with it as shown.



Lay up the first ply of BID as shown.

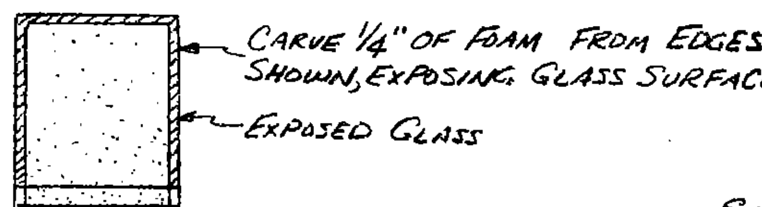
Using plain epoxy (no micro), lay up the other two plies and allow to cure. Note how the 45° fiber orientation allows the glass to lay down completely into the small radius.

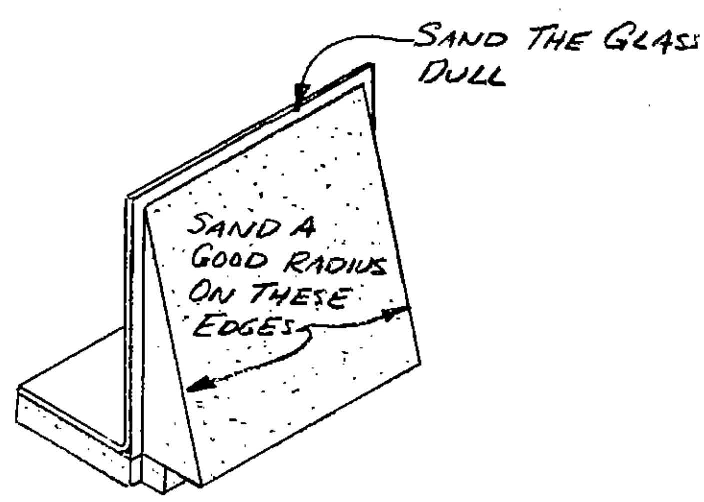




Knife trim along the foam edges.

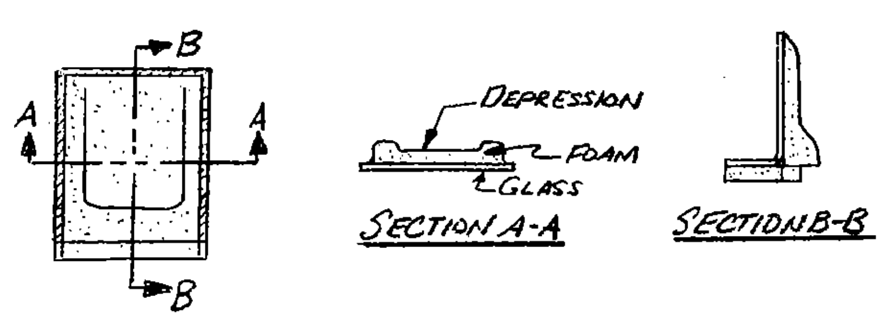
After the first layup has cured and the edges have been trimmed, the thicker foam block is carved and contoured as shown.



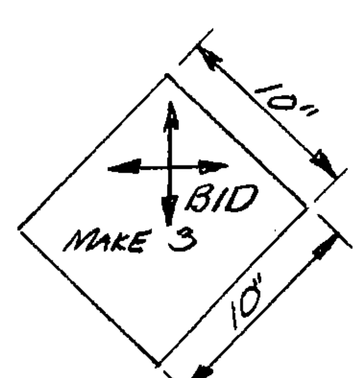


Put a generous radius on the foam edges and sand the ¼" wide glass edges dull for glass to glass bond. Use your wire brush to rough out a depression in the middle of the block.

Finish smoothing the depression by rubbing it with a scrap of green foam. Radius the corners of the depression. Blow or brush all of the foam dust off the surfaces.



Cut three plies of BID as shown.



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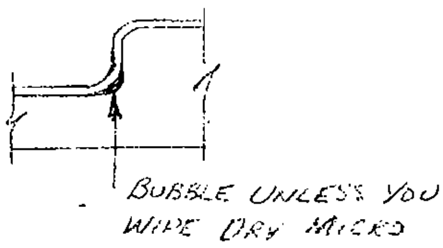
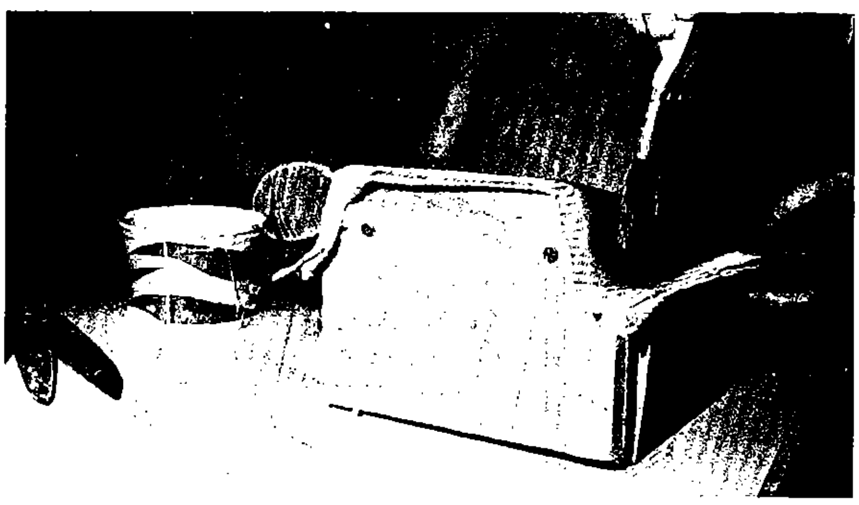
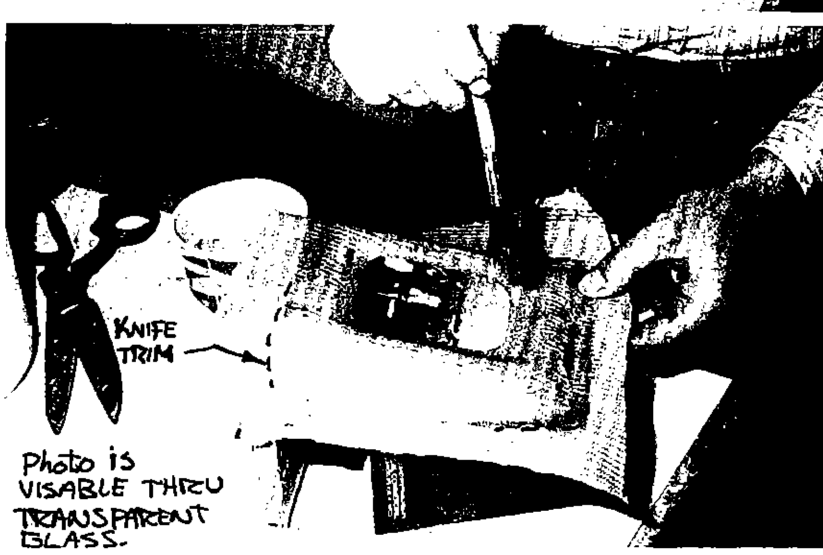
Mix Safe-T-Pox, make a small batch of slurry, and save the remaining epoxy. Slurry the foam surface and apply two plies of BID to the contoured surface. Start the layup in the center and work out toward the edges. If you have trouble getting the glass into the depression corners without bubbles, lift the plies and wipe in a little dry micro. You will then find that it will lay smoothly in without voids (see sketch). This depression is sharper than any in your airplane and is intended to give you a feeling of how sharply you can form the cloth.

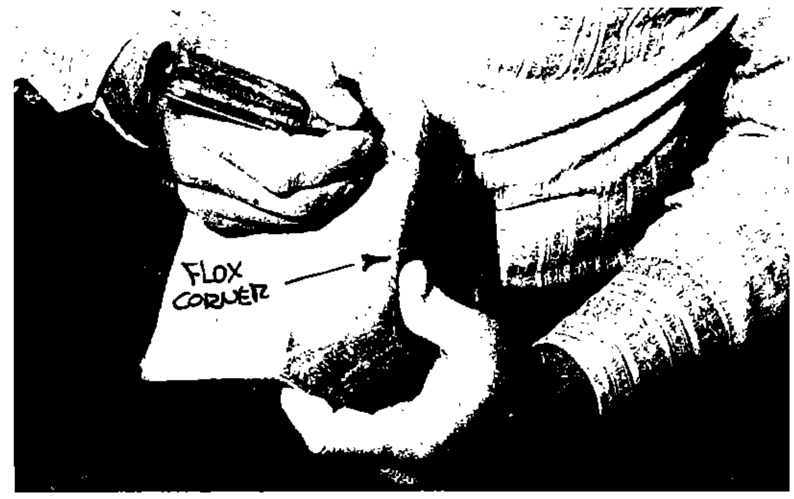


Before laying the third BID ply down, place your favorite photo in the depression, and then lay the third BID ply over it. Scissor trim the excess glass cloth. Allow to cure and knife trim the edges. The lower edge is trimmed flush with the bottom of the foam block.

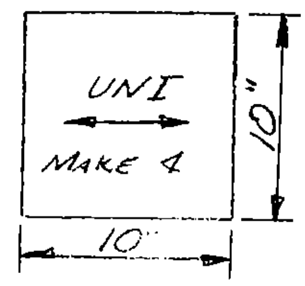


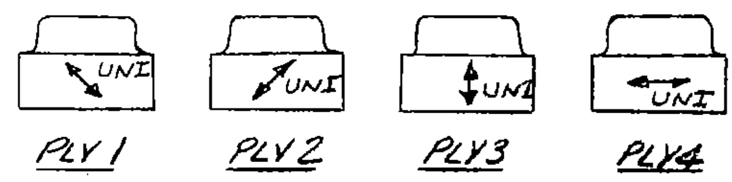


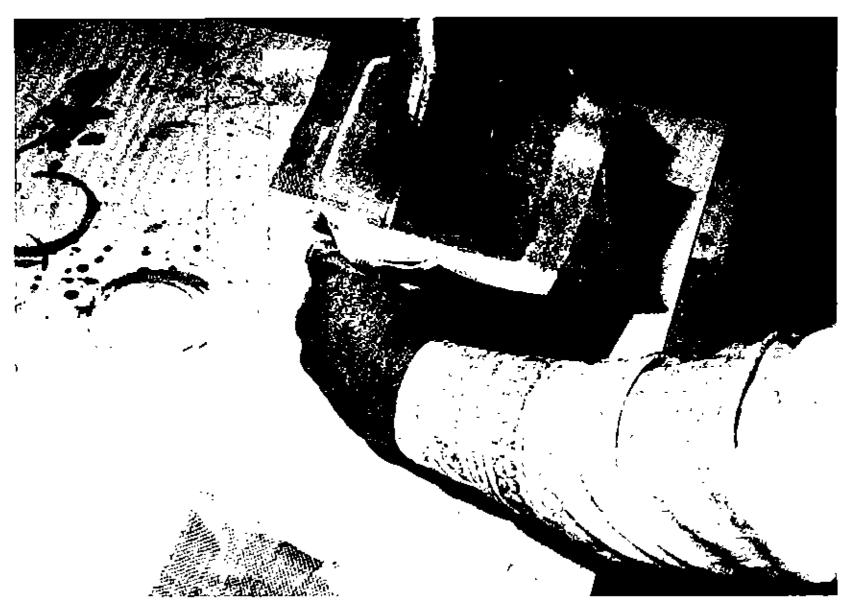
Wait until the second layup is fully cured. Remove the 1 inch foam block with a butcher knife and sanding block. Remove foam for a ¼" flox corner and sand the glass surface dull.



Mix Safe-T-Pox, a small batch of flox, and a small batch of micro slurry. Fill the corner with flox and slurry the foam. Lay up the four UNI plies with the orientation shown.





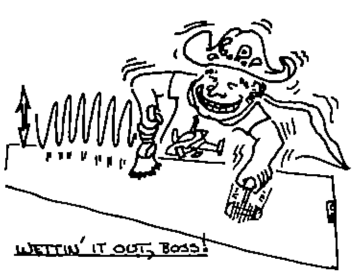


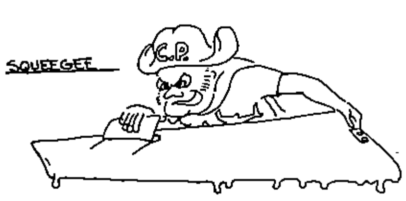
Knife trim the edges. After 12-hour cure, sand the edges with 100-grit sandpaper as required for smoothness and good appearance.

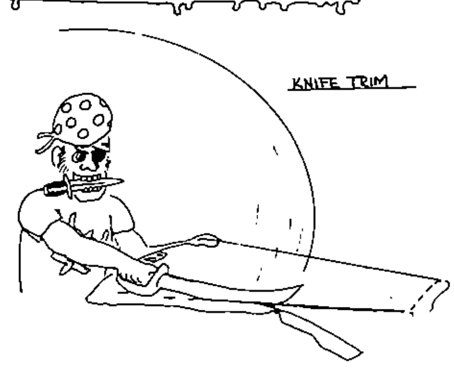
It may at this time seem a bit ridiculous to use three layups, about four hours work, and two days cure, just to make a book end! But remember, this book end was not designed for ease of construction; it was designed instead, to let you get a first hand exposure to the following operations before starting on your airplane; glass cutting, foam preparation (slurry), BID and UNI layups, flat surfaces, corners, and compound curves, flox corner, knife trim, concave and convex foam carving, glass to glass surface preparation, and sanding edges. So, use this experience to your best benefit and spend the curing time studying the plans. Even if you're experienced in glass layups, the book end is a worthwile project to get familiar with the workability of this BID and UNI weave cloth.

EDUCATION SUPPLEMENT

Rip this page out of your plans and staple it to the wall of your shop. While it is a handy reference, it's still a good idea to read all the words in the education chapter once in awhile. Don't skip the details - they're all important.



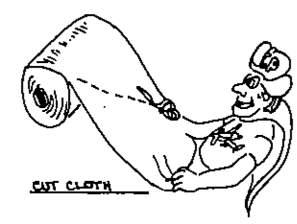


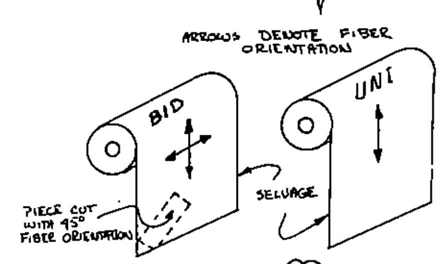


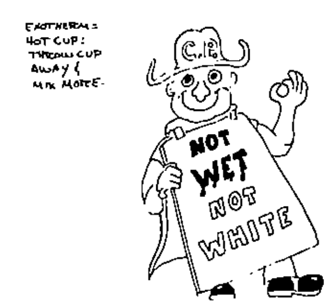
BASIC LAYUP PROCEDURE

1. PREPARATION: Ply 9 or gloves on hands, shop temperature 75° + 10°.
2. CLOTH CUTTING: You can get by with just a standard pair of good fabric scissors, but the job is much easier with the large pair of industrial scissors (Weiss model 20W). They're $25 (gulp!) but worth it in the long run.
3. SURFACE PREPARATION:
   FOAM - Hot-wire-cut surface needs no preparation. Sand ledges or bumps even, fill holes or gouges with dry micro immediately before the layup. Brush or blow away dust.
   GLASS - Always sand completely dull any cured glass surface (36-grit or 60-grit sandpaper). Resand if it has been touched with greasy fingers.
   METAL - Dull with 220-grit sandpaper.
4. MIX EPOXY: Follow all mixing steps shown on your epoxy balance. Mix two minutes, 80% stirring and 20% scraping the sides and bottom. Don't mix with a brush.
   . Micro Slurry - Approx equal volums of mixed epxoy and microspheres
   . Wet Micro - Enough microspheres for a "thick honey" mix.
   . Dry Micro - Enough micro so it won't run.
   . Wet Flox - Thick, but pourable mixture of epoxy and flocked cotton.

   APPLY TO SURFACE:
   Layup Over Foam - Brush or squeegee on a thin micro slurry layer (thick over urethane).
   Layup Over Glass - Brush on a coat of epxoy.
5. LAY ON CLOTH: Pull edges to straighten wrinkles. If working alone on a long piece, roll the cloth then unroll it onto the surface.
6. WET OUT: Don't slop on excess resin; bring epoxy up from below with a vertical "stab" of the brush ("stippling") or a squeegee action. Start in center and work out to sides. Most of the time of a layup is spent squeeging. Stipple resin up from below or if required, down from above. "NOT WET, NOT WHITE."
7. SQUEEGEE: If you have excess resin, squeegee it off to the side. Use squeegee with many light passes to move epoxy from wet areas to dry areas.
8. PRELIMINARY CONTOUR FILL: Save sanding by troweling dry micro over low areas while the glass layup is still tacky. This is done at trailing edges, spar caps, or over any low areas. The low places are overfilled with micro then sanded smooth after full cure.
9. KNIFE TRIM: Save work of sawing and sanding edges by razor trimming the edges at the "knife trim stage," which is about 3-4 hours after the layup.
10. GENERAL INSPECTION: Take a good look for dry glass, excess resin, bubbles, and delamination before walking away from your wet layup.
11. CLEANUP: If you've used Ply 9 skin barrier, you can get all epoxy off your hands with soap and water. Epocleanse is also excellent for removing epoxy and it returns natural skin oils. Brushes - rinse twice in MEK and wash with soap and water. Throw away after two to four uses.







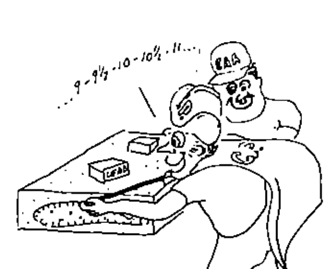
URETHANE FOAM SHAPING

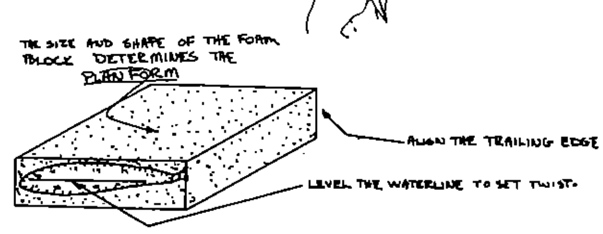
BASIC TOOLS: Sharp butcher knife, sanding block, surfoam file, wire brush and blocks/scraps of urethane. Use a dust mask. Hack away, have fun.

HOT WIRE CUTTING STYROFOAM

Hot wire tool has a lengths of 56".

Wire must be tight. The adjustable voltage control is best, but the job can be done with 2 12-volt, 6-amp battery chargers or 12-volt car batterys. Foam block must be well supported and weighted. Templates must be nailed on tight. First cut the basic block to size; this determines the planform size and shape. Level the template level lines; this determines correct twist. Set hot wire temperature for about 1" travel through the foam in about 4 to 6 seconds with light pressure. Do the actual cutting at about 1" every 6-7 seconds (8-10 sec. around the leading edge). Practice on scraps first.

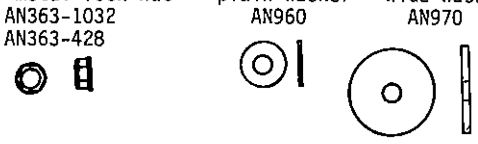




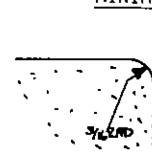
HARDWARE SKETCHES

AN3 3/16" dia bolt AN4 1/4" dia bolt	AN509 flush head screw	AN525 washer head screw

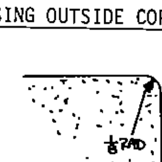
all metal lock nut AN363-1032 AN363-428	plain washer AN960	wide washer AN970



MINIMUM RADIUS FOR GLASSING OUTSIDE CORNERS



Fibers at 90° - 3/16" radius



Fibers at 45° - 1/8" radius

QUALITY CONTROL CRITERIA/REPAIRS

See the Education section

END OF CHAPTER