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IT TOOK ME over five years to build Tailwind N447A, during which time there were a number of major events or milestones which will always stand out in my memory. A couple of these come readily to mind, one of which was the assembly of the ribs onto the spars of one of the wings, creating my first major assembly, and the second of which was the rollout of the skeleton fuselage into the driveway for installation of the wings, the first time the project actually began to look like an airplane.

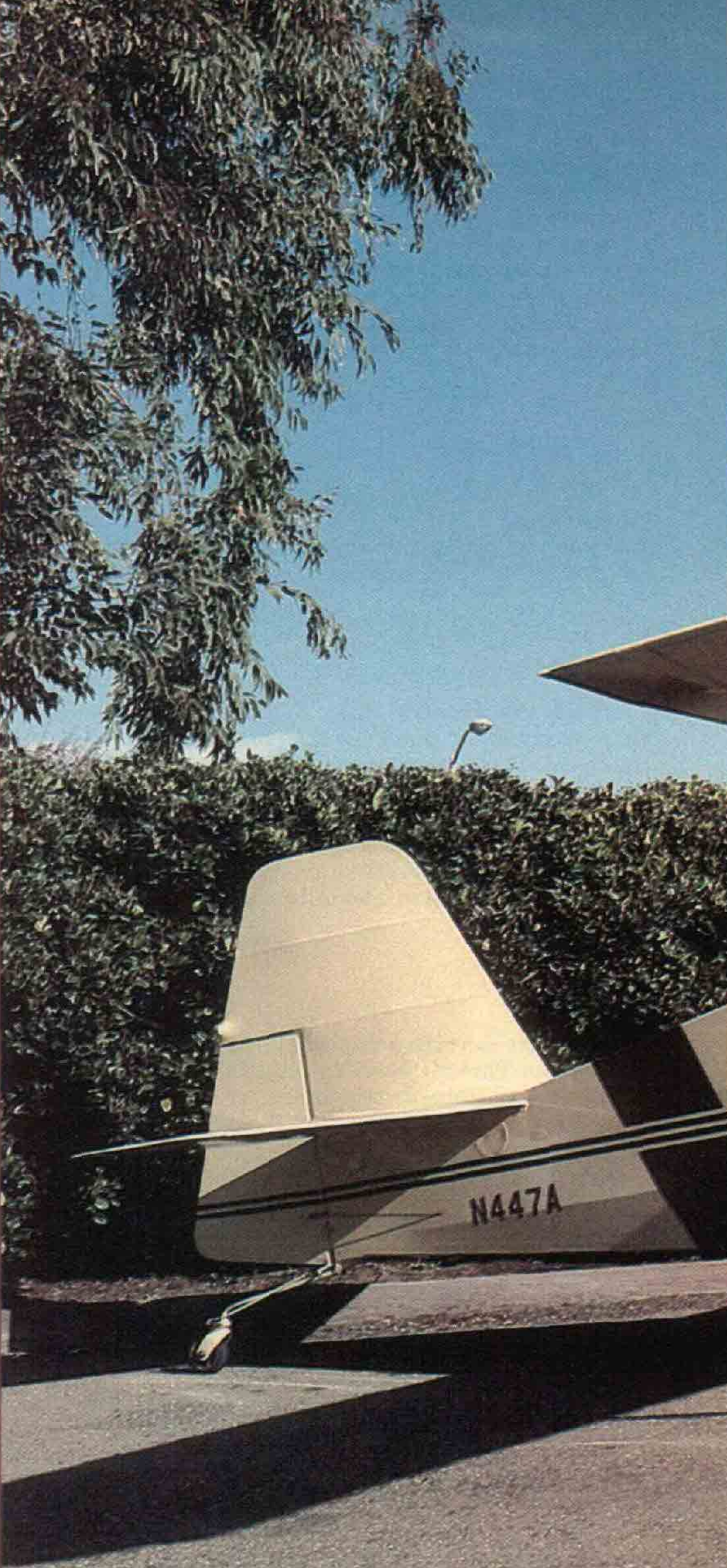
There were a number of other milestones, of course, but the one which will always be the most vivid in my mind is actually a series of events and a period of time starting at the beginning of April, 1983, and ending with my arrival at Oshkosh four months later. I still have difficulty believing how much was accomplished in that short period of time.

By the beginning of April, the completed fuselage was installed in my hangar at the Hayward airport, waiting for the wings, flaps, and ailerons to be covered, finished, and installed. At this point, I had serious doubts about being able to complete the airplane and comply with the FAA requirements in time to make the fly-in. The knowledge that I would miss it by only a couple of weeks at the most, however, is what gave me the increased determination not to miss it at all. Somehow or rather, the idea of waiting 11½ months to go to Oshkosh '84 seemed terribly unattractive and anticlimatic. Two, three, or perhaps even six months would be all right, but 11½ months, too much.

The wings were finished and installed by the middle of May. The flaps and ailerons were finished and installed three weeks later. Their installation did not go without incident, however, with two problems being encountered. It took longer than expected to adjust the flap and aileron control linkage and to achieve proper freedom of movement. Secondly, I accidentally jammed a screwdriver completely through one of the flaps. I couldn't tolerate the idea of a patched up flap on my brand new airplane, so I took it home and did the covering and painting job over. This cost me a week and brought me up to the middle of June. At this point, all that remained to be built were wing fairings, covering the junction of the wing to the fuselage. This small but exasperating job took me two weeks, although the time was somewhat concurrent with the work on the flaps and ailerons.

Now came the paperwork. A weight and balance was performed, with everything coming out satisfactorily, and an appointment was made with the FAA for the preflight inspection. The inspection also came out satisfactorily and I was given a test period of 25 hours, since I had a certificated engine and propeller combination. The following Sunday, June 26th, the airplane was successfully flown for the first time and was in the air a total of well over two hours, on a flight from Hayward to Hollister, followed by a number of other short flights in the Hollister area.

I was now down to four short weekends in which to fly off the 25 hour test period and obtain the final FAA inspection and airworthiness certificate, before the opening weekend of the Oshkosh convention. At this point, my good friend, Bill Hartman (EAA 112891), entered the picture. He had been following my progress from the beginning, and having flown his own homebuilt Quickie to Oshkosh a couple of years earlier, now sensed the same unattractive and anticlimatic feelings he knew I was having about waiting 11½ months for Oshkosh '84. He offered to help me fly off the 25 hours, and between the two of us,



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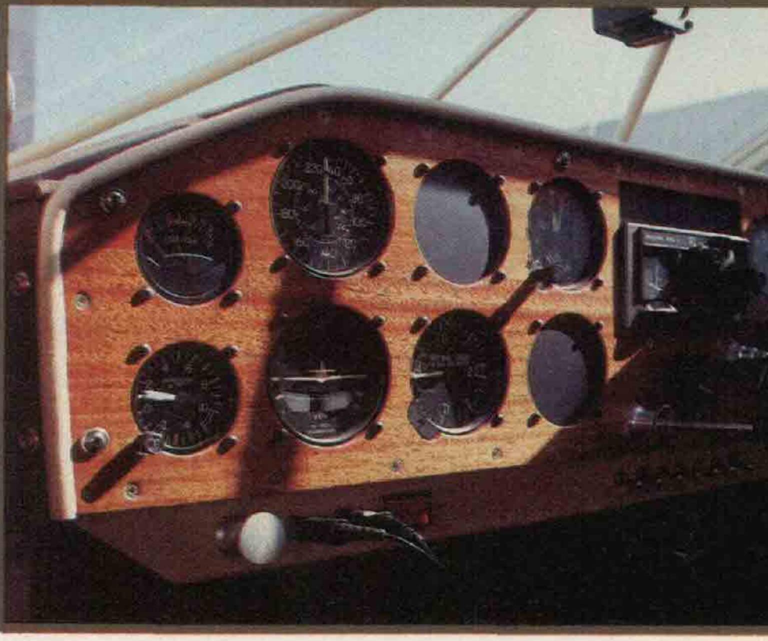
we were able to easily accomplish this by the end of Sunday, July 10th. Needless to say, the fact that the airplane performed well was a big help.

It now looked as if all the frantic work and planning of the last couple of months might actually pay off. On Friday, July 15th, the airplane had its last inspection and was given the final airworthiness certificate. The next day, I was able to attend EAA Chapter 62's annual Hollister fly-in by simply rolling my airplane out the hangar door. After all those years, my first fly-in was quite a thrill indeed. Less than two weeks later, I was enjoying the main event at Oshkosh '83. Bill Hartman and I flew the Tailwind there in a day and a half, 12½ hours of flying time, no difficulties, arriving early Friday afternoon, July 29th.

And so ended a project that had had its germination almost thirty years earlier, when Steve Wittman was demonstrating his first Tailwind to the pioneers of the EAA. To this day, I have saved an old file folder packed with information and magazine articles about the Tailwind, along with a piece of correspondence from Steve, himself, dated sometime in 1956, detailing the flying characteristics of the airplane and describing the various materials and parts he was making available to early builders. My situation at that time, however, did not permit any airplane building and my interest fell dormant for many years. It never really went away, though, and it was startled back into the forefront in the middle 70's by a cover article in Air Progress magazine on Burt Rutan's Vari-Eze. If Burt's plans had been available at the time the article was printed, I would probably be flying a Vari- Eze now. As it turned out, however, they weren't available for a year or so, during which time I once again became captivated by the Tailwind. Somehow or rather, I wanted to build an airplane utilizing the more traditional A & P skills, such as welding, sheet metal work, woodworking, fabric, and so forth. Looking over all the new designs which had come onto the scene since my original



association with the EAA in the middle fifties, my choice quickly narrowed down to two, the Thorp T-18 and the Tailwind. Based on my personal preference for high wing airplanes made of tubing, fabric, and wood, I reaffirmed my original preference for the Tailwind.

Newer members of the EAA are perhaps not aware of the fact that the Tailwind was once the darling of the homebuilder crowd, much like the T-18 and Mustang II were in later years and the Long-EZ, Glasair, and Quickie II are today. The Tailwind has the distinction of being the first of the high speed, two place, enclosed cabin designs available to homebuilders and is still being built in reasonable numbers today.

There is a lot to be said for Tailwinds. I happen to think that the airplane is beautiful, although I can readily understand how younger Star Wars enthusiasts might disagree with this. It is fast, comfortable, and inexpensive to own and operate. It is also inexpensive to build, when compared to the prices of some of the current kits so popular today. It is a straight forward machine, where either the pilot or his 80 year old grandmother can walk over, open the door, get in and sit down, with no difficulty. No gymnastics required. Its flying characteristics are excellent, thanks to Steve Wittman's genius, and if well built and maintained, its safety and reliability are the equal of most factory planes. Tailwinds are not hangar queens. Once finished, they remain finished, not needing the constant rework, adjustments, and other fiddling around that so many of the current designs seem to require. I personally know of two airplanes pushing 25 years of age, each with over 2000 hours in the air and each flying with its original cotton fabric. Neither of these airplanes has ever required any more maintenance or attention than one might expect to lay on a Cessna 152. I could go on and on, but so much for the sales pitch on Tailwinds here. Suffice it to say, I have never had the slightest inkling of regret over my decision to build one.

I started my airplane in the fall of 1977, after receiving a shipment of $500 worth of wood from Aircraft Spruce and Specialty Company. My shop area consists of a two-car garage of the railroad variety, one car behind the other. Since we keep a car in the garage, my work area was limited to a space about 10' by 20', not too large but large enough to get the job done. Early on, I had decided to build the wings first, since they could be stored flat in the rafters, leaving all the work space available for the building of the fuselage later on. During the summer, before ordering the wood from Aircraft Spruce, I had constructed a sturdy, permanent 4' by 8' worktable, with the idea of temporarily expanding it to 16' in length later on. A rib jig was constructed, with holes drilled in several of the gusset areas, so that the ribs could be knocked out of the jig from behind, in the event they got stuck. The individual truss pieces and gussets were all mass produced, slightly oversized, and placed in individual containers. The gussets, as a matter of fact, were cut to size, with the exception of the edge which protruded above the cap strip. These edges were later ground down carefully to the level of the cap strip on the disc sander. I found it expedient to steam bend the top cap strips in the area forward of the spar opening, to make them easier to work with.

The ribs were produced at the rate of about one per evening, using Aerolite two-component adhesive. This adhesive is very easy to use, since the paste component is painted onto one surface and the very thin activator is swabbed onto the other. What actually occurred each evening was that one rib was constructed in the jig by installing the cap strips and then carefully fitting the slightly oversized truss pieces into place by grinding their ends down on the disc sander. Gussets were then installed and the rib put aside for the evening for adhesive curing. The rib from the previous evening was then completed by having gussets installed on its reverse side. Speaking of installing gussets, I found it easy to handle the little ¼ inch aircraft nails by placing a pinch of them onto a plastic coffee can lid and then picking them up individually with a pair of stamp collector's tweezers.

All of the ribs are identical, with the exception of one root rib per wing, the one immediately adjacent to the fuselage. These root ribs are smaller and required a second rib jig of completely different and smaller dimensions from the first.

The Tailwind wings are plywood covered and are miracles of simplicity, lightness, smoothness and strength. They contain no metal parts whatsoever, with the exception of the three attachment brackets, two located where the spars join the fuselage and the third located midspan for the lift strut. The tremendous strength and rigidity of the wing is achieved by the fact that the plywood is all at once bonded to the ribs, both spars, the leading edge and the trailing edge. There are no nails or other attaching devices holding the plywood to the substructure, only adhesive.

Wilson Werhan

As I mentioned before, the earliest sense of accomplishment in building my airplane was when I initially slid the ribs onto the finished spars, thereby creating my first major assembly. Quite a thrill, which my wife and son also enjoyed.

Many articles have been written about the application of plywood to wing structures, most of which seem to make the procedure sound extremely difficult. I did the job alone and found it quite simple, although I must admit that in the interest of adhesive pot life, I asked my son to apply adhesive to the plywood while I applied it to the structure. I had previously fitted the plywood carefully to the wing, holding it in place with wooden taper pins tapped through the plywood into the hinge holes in the trailing edge spar. All the necessary nailing strips were made, with ½ inch aircraft nails pre-set into them, so that there would be no delay in their installation. With this preparation accomplished, it was no problem repositioning the plywood with the taper pins and clamping it down firmly into place with the nailing strips. See Figure 1. Since in my case the leading edges of the wings were installed after the top and bottom sheets of plywood, the forward edges of the plywood were left protruding to be trimmed later.

Speaking of adhesive potlife, I used two-component epoxy to bond the plywood, not only because of its proven strength, but also because its potlife would allow me plenty of time for application and installation. Since my employer manufactures polyamide curing agents for epoxies, my adhesive was a home brew consisting of Shell Epon 828 epoxy resin mixed with VERSAMID 140 curing

Figure 1

agent in a proportion of 60:40 respectively.

The bottom sheets of plywood were installed first, if for no other reason than to make it easy to lay out and cut the holes for the lift strut attach brackets. At this point, a VOR antenna was installed in one wing, screwed to a wooden block which was bonded to the bottom plywood, and the pitot tube apparatus was installed in the other. This apparatus consisted of a small block of aluminum, screwed to a piece of plywood, which was in turn bonded to the spar. The block of aluminum was drilled and tapped to accept a 90 degree pitot tube installed from the bottom of the wing, and the nylon tubing running from the block through the wing into the cockpit. See Figure 2. There were a lot of other details to be taken care of before the installation of the top plywood, but they didn't take very long. One interesting suggestion I followed was to use ½ inch shoe-dye swabs to apply spar varnish in the restricted areas between the gussets on the ribs.

From looking at pictures of Tailwinds, it can be seen that there is a sharp sweepback of the wing leading edge right next to the point where the wing joins the fuselage. This sweepback creates a nonstructural, triangular area forward of the spar, which presents some minor difficulty in covering. It has been done many ways in the past, with fabric or plywood, but I elected to utilize Vari-Eze technology here, by filling the entire area with green urethane foam and then covering it with several layers of fiberglass reinforced epoxy. This was a fairly simple procedure and allowed me to get the shape I wanted.

The protruding forward edges of the plywood sheets were shaved back flush with the wing structure and then the leading edge strip was applied with adhesive and countersunk screws. It was simple matter then to contour the leading edge strip to its proper curvature, flush with the plywood. This procedure was very simple and produced a beautiful, hairline joint between the leading edge and the plywood cover.

So much for the wings, which now went up into the rafters for a couple of years, not to be taken down again until they were installed on the fuselage structure. The first wing took nine months from the start of the project, but the second one only took three, primarily because most of the parts were already fabricated, but also because I had come quite a way on the learning curve with the assembly of the first one.

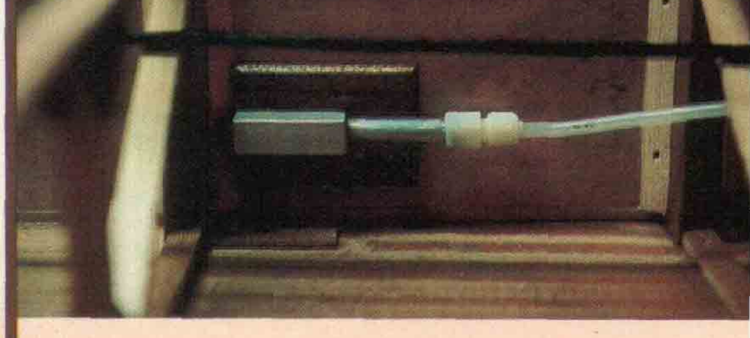
I should stop a moment here to bring into this story my very helpful friend and advisor, Ralph Korngold, EAA 2208, who is, as a matter of fact, the builder and former owner of one of the 2000 hour Tailwinds mentioned earlier. Ralph is a retired A & P, with innovative and fabrication talents way beyond the average home builder, and for that matter, most of the people in the aircraft trades. His first Tailwind, with the catchy N number 4130X, remains to this day one of the best examples ever built. Not only did Ralph teach me everything I know about airframe work, but he also responded to my endless questions over the years with hundreds of helpful hints and items of advice.

An added dividend from building my wings before the fuselage was the fact that I was able to carry on some welding practice for quite a few months before I had to commence welding in earnest. I had taken 10 hours of instruction at a commercial welding school, but had not learned anything about welding thinwall aircraft tubing. The school was more attuned to teaching shipyard workers and bridge builders. I did learn the basics, however, and Ralph helped me perfect my technique to the point where I thought it would be acceptable.

Steve Wittman offers plans for two versions of his Tailwind, the W-8 and the W-10. The W-8 is basically the original version, while the W-10 is the new aircraft with the lengthened fuselage and beefed-up tubing for heavier engines, such as Continental O-300, Lycoming O-320, and Oldsmobile aluminum V-8. Having read an article years before about Steve's six cylinder O-300 powered airplane and his high regard for that engine, I decided then and there that this was for me. My first reason was that I simply prefer the sound and smoothness of a six cylinder engine over a four I found out later on, however, the O-300's are inexpensive to buy, inexpensive to repair, very reliable, and not that much heavier than a four cylinder Lycoming. The only dimensional problem with the engine is its length, with the consequent increase in forward moment arm, which Steve solved by eliminating the four inch prop extension and lengthening the fuselage seven inches aft of the cockpit. At Oshkosh in 1982, I was very pleased to see that I wasn't alone in committing myself to this engine, when in taxied three brand new O-300 equipped Tailwinds built by close friends in nearby Baraboo, one of which became a double trophy winner at the fly-in.

Getting back to my project, with the wings safely out of the way, it became time to start in on the fuselage. The work table was temporarily lengthened to 16' and the fuselage sides drawn out in pencil. The longerons and various pieces of tubing were then laid down on the penciled drawings and tack welded together. This entire procedure, followed by the assembly of the two sides into the fuselage box section by the addition of the various horizontal tubes, is all straight forward procedure known to any builder of a tubing airplane and presented no problems whatsoever. After the job was all tack welded from tailpost to fire wall, it was a pretty sight, indeed, with the longerons having lovely curvatures from front to rear. After completion of the finished welding, however, the picture was quite different, with the longerons having lost their curvature and being straight from cluster to cluster. One unattractive thing quite often seen on Tailwinds is the sucking- in of the longerons between the clusters by the

Figure 2



tautness of the fabric. I was determined to avoid this if possible and followed Wittman's advice to bow out the longerons well beyond their proper curvature before installing the fabric. I bowed them out about ¾ of an inch, which worked out to be just about right.

After completion of the basic fuselage structure came the seemingly endless period spent on the installation of controls, mounting brackets, pads, and so forth, necessary in any airplane. In the Tailwind design, there are several places where short pieces of tubing, welded onto the fuselage, are used as bearings to hold such things as the rudder pedal shafts and the flap actuating torque tube, to name a couple. Welding short pieces of tubing, sometimes no more than ¾" long, presented me with several problems. The tube could go out of round, become filled up with weld scale, or have its edge burn away from the heat of the weld. Ralph Korngold sovled these problems years ago by devising what he calls weld washers, which are steel cork-like end caps, which are clamped in both ends of the short piece of tubing. The steel caps act as heat sinks to keep the edges of the tube from burning away, they exclude some oxygen to cut down on the weld scale inside, and they also maintain tube roundness. Ralph described and illustrated these weld washers in an old EAA publication "Custom Aircraft Building Tips", Volume Two. In installing these little bearings, I went one step further by welding the little tubes onto saddles, made from scrap tubing, which could then be more easily welded to the fuselage later on. In this manner, I was able to clean up and test out these bearings before their actual installation. See Figure 3.

Tailwind engine mounts are complicated affairs, since they not only support the engine, but also incorporate the sockets for the spring steel, rod type landing gear legs. These sockets provide the sweep-back and spread-out of the landing gear, and in doing so, present something of an alignment problem to the builder. On top of this, the engine mount for the Continental O-300 is a cradle type, considerably more complex than the ordinary rear attachment type. I found it best to build the landing gear portion of the mount totally separate from the cradle and then mate the two sections together. This worked out fairly well. I had heard a lot of stories about distortion of the landing gear socket tubes during the welding process, so I dreamt up a simple fixture to hopefully eliminate this problem. See Figure 4. This fixture consisted of a ½ inch bolt with a lot of washers spaced on it, which would slip inside and maintain the roundness of the landing gear socket while the welding was taking place. It completely eliminated all distortion and was easily removed after the tubing had cooled down.

Speaking of the spring steel landing gear, I had these made by Harmon Lang, who advertises his services in the back of Sport Aviation. They were very reasonably priced and nicely done. They come straight, however, and need to have the axle portions bent out at the proper angles to provide the correct camber of the wheels. Wittman suggests an angle for this bend and I found it to be satisfactory. I must confess I was concerned about the actual bending of this rod, since it was over ¾ inch thick at the bend point. I made a wooden template, which I could hold next to the rod during the bending process and which would show me when I had reached the correct angle. I was very relieved when the job went quite smoothly and easily. These landing gear legs have to be heat treated after the home bending process, to give them the necessary springiness and resistence to further bending. Since some distortion can easily occur during the heat treating process, it is best to advise the heat treater to place the legs horizontally head-to-toe in the oven so that if any distortion occurs, both legs will point fore or aft together, rather than in opposite directions. Hanging of the legs in the oven is not advisable, since this can change the angle of the axle.

Five inch Cleveland wheels and brakes were obtained from Aircraft Spruce at a reasonably attractive price. I did not consider the price of tailwheels to be attractive, however, so I fabricated my own out of .090 steel, incorporating a bronze bearing with a grease fitting and accommodating a five inch industrial caster wheel with a solid rubber tire. See Figure 5. This tailwheel has worked out very well up to this point and has not exhibited any tendency to shimmy. It was also quite simple and fun to build.

Figure 3

The tail surfaces were straightforward and easy to fabricate. As shown in the plans they have sharp corners, but I went to a little extra trouble and rounded these corners off for a smoother appearance. On the Tailwind, the horizontal stabilizers are cantilevered out from the sides of the fuselage and are not braced with any flying wires or supports. They have a tubular spar, which in turn slips over another tubular spar, this latter one being welded crosswise into the fuselage, protruding out either side. The welding of this spar into the fuselage was the most difficult weld in the whole airplane, since the spar is made of two pieces of heavy-wall tubing, one inside the other, and is located in the fuselage in an area consisting of .028 tubing. Bringing the spar material up to welding temperature without burning away the surrounding fuselage tubing was the problem.

With the completion of the fuselage and controls, I had finally reached the second exciting milestone in the building of my Tailwind, this being the rollout and installation of the wings onto the fuselage. I had already fabricated the lift struts and installed the wing-attach fittings on the fuselage, using jigs. In the Tailwind design, the lift struts attach at the fuselage end to short stub-ends welded to the bottom longerons. I had decided that I wanted a tiny little bit of dihedral to offset the optical illusion of drooping wings, seen on some aircraft with no dihedral at all. After the roll out of the fuselage and the attachment of the wings with hardware store bolts, the lift struts were installed and the fuselage stub-ends fitted and tack welded to the bottom longeron to give the desired dihedral angle. I had help in manipulating the wings from my wife, son, and daughter-in-law, and after the job was finished, we all sat around for quite awhile taking pictures and admiring the project. See Figure 6.

The flap aileron arrangement on the Tailwind is both efficient and interesting, being based on concentric torque tubes, actuated from inside the fuselage. There is no apparatus inside the wings and there are no control cables involved. The leading edges, or spars, of these control surfaces are fabricated from 1¼ inch tubing, held to the trailing edges of the wing by U-shaped hinge-bearings. In the case of the flap, the spar protrudes into the fuselage and is actuated in torque tube fashion by a bell crank. The aileron spar has a smaller ¾ inch tube welded to its inboard end which then passes right down the middle of the flap spar and ends up inside the fuselage, where it is also actuated in torque tube fashion by another bell crank. These two bell cranks are connected to the stick and flap level by pushpull rods with Heim ball ends, which bring about a very smooth acting system with no annoying slack. The flap spar is supported totally by three hinge-bearings attached to the trailing edge of the wing, but the ¾" aileron torque tube has to be supported in bearings inside the flap spar. I used teflon bearings on the outboard end and in the middle, but used an Oilite bearing on the

Figure 4

inboard end inside the fuselage. Surprisingly enough, when I fully tightened the bell crank clamp around the flap torque tube, I compressed it and the Oilite bearing to the point where the aileron torque tube was binding badly. The Oilite bearing is ¼ inch thick, but still compressed. I had to ream it out to .770" before I finally got free movement of the ailerons. I still can't believe the power of the Dutchman-type clamp on the bell crank. This, incidentally, was the basic time consuming problem I mentioned earlier, in connection with installing the flaps and ailerons on the airplane.

One thing I forgot to describe was the method I devised to insure straightness and concentricity when welding the ¾ inch torque tube into the inboard end of the aileron spar. As can be seen in Figure 7, I machined two thick washers, which were welded onto one end of the torque tube, about three inches apart, and which would just fit snugly inside the spar. The inner washer was then welded to the open end of the spar and a pin passed through both tubes midway between the washers as a safety measure.

At this point in the project, I found myself effectively finished with the Wittman plans. Having constructed all the truly important aerodynamic and structural assemblies, such as the wings, fuselage, tail surfaces, and controls and control surfaces, all in strict accordance with the plans, I now found myself in a position to venture forth on my own. This venturing forth was voluntary in some cases, such as the doors and the seats, but was a necessity in a lot of other cases, where various components of the aircraft are left to the builders discretion. These components include the gas tank, instrument panel, cowling and other sheet metal, wiring, engine installation with its associated plumbing, and a number of other things. Although there are a lot of useful photographic references to these items in the plans, there are no details.

Being an admirer of Ralph Korngold's wooden doors on his 4130X, I decided to copy them and construct mine of wood also. There is much to be said for the wooden doors, since they are easy to build, light, and provide easy attachment for hinges, door latches, exterior sheet metal, and so forth. I penciled in full size plans on the work table and laid out the ⅝ inch by ⅝ inch spruce pieces in a manner similar to building the fuselage sides. These pieces were glued together and then dowelled for extra rigidity. During the glueing process, one corner of the door, I don't remember which, was elevated to provide the necessary warp in the finished door. The door opening in the fuselage is not flat. One huge gusset, to become the "upholstery" on the inside of the door, was then applied to the framework with adhesive, making it extremely rigid. Door closure hardware was devised and installed at this point and then sheet metal screwed and glued to the outside of the framework, creating the finished door. There were some decorative strips applied to the inside of the doors, to give a "woody" wagon appearance, and that was it.

The mahogany instrument panel of the Sorrell Hyperbipe was the inspiration for my wooden panel. I found the panel very easy to make, cutting the holes with a fly cutter, stopping just short of cutting all the way through and then flipping the panel over to complete the hole from the backside. Bezel rings from junk instruments were used as drill guides for the screw holes, making the result extremely accurate. After all the holes and other openings had been cut in the piece of mahogany, which incidentally is 3/16 inch five ply aircraft plywood, it was found to be quite flexible. I added 90 degree aluminum to both the top and bottom edges, giving it all the rigidity it needs. The bottom aluminum piece, as a matter of fact, has several bends in it and acts as a lower extension of the wooden panel, for switches, a circuit breaker, and the primer. After this lower metal panel was finish painted, the switches installed in it were labelled with rub-on transfer lettering, purchased in a sheet from Aircraft Spruce. A coat of varnish was then sprayed over the metal panel to encase the lettering, which could otherwise be rubbed off. The entire panel is mounted on four inch stand-offs, welded to the cross piece between the door posts. This places the panel four inches aft of the door opening, much like most modern automobiles. As in the case of the doors, the wooden panel was very simple and quick to make, particularly since I did not have any accidents with the fly cutter. You can be certain I was very careful with that thing, when I got close to the end of the job. The wooden panel is not only good looking, but it also has a certain amount of shock absorbing capabilities.

I have always been an admirer of the racey appearance of George Pereira's Osprey amphibian. One day, while looking at his airplane, I was impressed by a couple of its interior features and decided to copy them. The first was his collection of small mahogany knobs, used throughout the cockpit. The second feature, the more important, was the design of his seats, being classic buckets made from welded steel tubing with webbing in between. I tack welded together a mock-up seat from junk tubing and gave it an extended comfort test one evening by placing it in the airframe and showing myself photo slides of past fly-ins for a couple of hours. The mock-up seemed comfortable enough, see Figure 8, so I built two permanent seats along similar lines, using soft aluminum pop riveted to the framework for the cross webbing. These one-piece seats pivot forward at the front only, thereby exposing the belly of the fuselage for inspection and cleaning. Pieces of foam of varying thickness were covered with upholstery and velcroed to the webbing in two separate assemblies, the bottoms and the backrests. The back rests lean against the forward edge of the baggage compartment floor for support. The seats are not adjustable and were designed for my six foot height, so cushions have to be used for shorter people. This is a disadvantage, of course, but worth putting up with to save all the weight and bother of adjustable seats.

The material used for the seat upholstery, as well as all the interior trim and the baggage compartment, is a fabric from DuPont called Cordura. This is a nylon fabric which looks exactly like canvas and comes in various colors. It is about as thick as canvas, but is light weight, water-proof, and extremely durable. It is used primarily in luggage, but interestingly enough, also used in Christen Eagles.

Since completing my Tailwind, many people have asked me if I did all the work myself, such as welding, sheet metal, and painting. The answer to this question is yes I did, with three major exceptions. The sewing of the upholstery was one exception, although I designed it myself. The other two exceptions were the nose bowl, more about that later, and the aluminum gas tank. With the extremely complex shape of the tank, square at the front, round at the back, with a cut-out for the radio and several tubes running through it for controls and wires, I decided to hand the job over to a sheet metal expert. I constructed a reasonably accurate cardboard mock-up, covered with very accurate dimensions and impaled with dowel sticks, where the tubes were supposed to be, and took the mock-up out for bids. The first shop with a reasonable bid, promising me two week delivery, did absolutely nothing with the mock-up for one month, except make excuses about how busy they were. I finally realized that they felt they had bid too low and didn't want the job at all. I then went to an A & P with a shop of his own, who gave me a higher bid, but who delivered the finished tank a couple of weeks later as he said he would. The tank has a mechanical, Cessna-type fuel gauge in it and has two outlets on the bottom. One of these outlets has a three inch high standpipe on the inside above the bottom of the tank, while the other outlet is flush with the bottom. In this manner, and with a three-way fuel valve, I have a Volkswagon type reserve system, giving me three gallons or so in the event the main supply should run out. It shouldn't be allowed to run out, of course, but then there is always the possibility of a fuel leak or perhaps even some forgetful moments.

This is an appropriate time to mention the fuel plumbing system, which as originally conceived and installed, brought on the only significant functional problem I have

Figure 5

Figure 6

had with the airplane so far. I had installed a light weight but bulky fuel valve from a Cessna 210 in a bracket welded to the diagonal tube just behind the fire wall and had plumbed from the tank outlets to the valve inlets with 3/8 inch aluminum tubing with flared ends and AN fittings. The bulky valve and curves in the tubing created a situation where there was a small loop higher than the outlet of the tank. This loop trapped air and prevented smooth fuel flow, until such time as it was entirely purged of air and filled with solid fuel. I discovered this the first time I test-ran the engine in the airframe, when I found that it would run perfectly for two or three minutes and then quit. Disconnecting the fuel line at the carburetor, I could clearly see a lot of air bubbles coming out along with the fuel.

In discussing this problem with Molt Taylor one afternoon in his shop in Longview, Washington, Molt advised me that he did not like hard tubing between gas tanks and the airframes. He went on to recommend the use of Weatherhead Barb-Tite push-on brass fittings, with neoprene fuel hose. I followed his advice by replacing my beautiful but bulky fuel valve with a Weatherhead 6749 valve and by installing the low profile Barb-Tite fittings with neoprene hose. This provided me with a totally downhill flow of fuel, which solved the starvation problem once and for all. I might add here that it is impossible to pull the hose off one of these Barb-Tite fittings without cutting it. I know. I installed one of my two hoses a little too long and had to replace it. I might also add that before I abandoned my original fuel valve and hard tubing, I duplicated the configuration with a common rubber device found in most American bathrooms and discovered that water would not flow. I had thought that if the tank were higher than the carburetor, fuel would flow, but I discovered this is not the case. Actually, I should have known better, having siphoned a lot of gasoline in my life.

The fiberglass nose bowl on my Tailwind is the same as the one Steve Wittman has on his O-300 powered airplane and comes from a mold owned by Bill Hansen, of Minneapolis. As I understand it, Bill and Steve worked together many years ago to develop this nose bowl for the O-300 installation, in an attempt to eliminate the prop extension and still retain good streamlining.

At Oshkosh '77, I decided that I intended to copy Wittman's proven cowling design, since his airplane had been flying successfully with it for many years, and that I would therefore need one of the Hansen nose bowls. Bill is in the business of transforming large highway buses into motor homes and is extremely busy all the time, working very long hours. He agreed to make me a nose bowl readily enough, but subsequently had a problem actually getting around to it. It so happens that my employer is located in Minneapolis and that I travel there from time to time on business. On one of these trips, I called Bill in advance and asked him if I could stop in

Figure 7

during an evening and make the nose bowl myself, under his supervision, and he quickly agreed. As it turned out, however, Bill's "supervision" consisted of his actually laying up the nose bowl himself, while I stood and watched. In any event, I carried it home to San Francisco on my return trip. The edges were unfinished and there was no flange for the cowling sheet metal, but these shortcomings didn't lessen my relief of finally having the thing in my possession.

The Wittman plans call for the use of ⅜ inch steel channel as a substructure for the windshield glass. This substructure consists of three parallel channels, commencing at the firewall and sweeping up to the cabin roof, at a rather rakish angle. I substituted ⅜ inch .035 square tubing for the channel, since it looks better from the inside and could be drilled and tapped to take machine screws rather than nuts and bolts. Lexan polycarbonate sheet was used for the windshield and side windows, rather than Plexiglas, since Lexan can be fastened tightly with countersunk screws, without the danger of expansion cracking. Lexan is very susceptible to solvents and solvent vapors, however, particularly in areas of curvature or stress, so one has to be careful about that.

One of the more exciting and satisfying assemblies of the airplane to build was the engine cowling. As a matter of fact, I should include here all the sheet metal assemblies such as the cabin sides, belly pan and roof. A considerable amount of engineering and pre-planning was required before this work could be started, since the plans do not include any details on these assemblies. Most of the planning involves the development of the attachment apparatus for the various sheetmetal components. In order to clear the upper engine mount bolts, as an example, it was necessary to elevate the bottom of the windshield and spread out to the right and left the upper edges of the cabin at the firewall.

This was accomplished by riveting aluminum angles to the top and both sides of the firewall, which itself was fastened permanently to the front of the fuselage. These aluminum angles were fitted with a multitude of anchor nuts for holding down the fuselage side panels and lower windshield. The bottom of the firewall was bent back 90 degrees and fitted with anchor nuts to hold the forward edge of the belly pan. Aluminum channels, fitted with anchor nuts, were installed in the fuselage tubing, parallel to the direction of flight, about three inches inboard from each of the lower longerons, to provide a fastening point for the sides of the belly pan and the bottom, wrapped-around edges of the side panels.

A word or two here about anchor nuts. Ralph Korngold must be a stockholder in the Tinnerman Company, since he is really enthusiastic about these fasteners when used as anchor nuts. As most readers know, these nuts are made from stamped spring steel, and unlike the ESNA or distorted bore type, do not wear out. They can be used over and over again, with no loss of efficiency, something very important to a home builder fitting up a lot of new sheet metal parts. On the other hand, they do not have any prevailing torque, which means that loose screws can vibrate out with no hindrance. Prevailing torque or not, my experience with the Tinnerman anchornuts has been one hundred percent perfect so far, without the loss of the first screw. I was concerned about the loss of screws on my way to Oshkosh this year, since a lot of them are painted and I had forgotten to bring along a spare supply.

The process of engineering and fabricating all of the many atachment points for the various sheet metal parts of the airplane was a great deal more lengthy and complicated than I have described here so far. As a matter of fact, it took me hours and hours. When it was finished, however, I was able to build the various sheet metal components with little or no difficulty, if you can discount the time spent on the tremendous amount of handwork involved.

The handwork was generated by two things, the first being the fact that all the rivets and screws in the sheet metal are countersunk, with each hole requiring dimpling and the dimpling sometimes involving two or three layers. The second thing was the fact that all the attachment holes and anchor nuts were in existence when the sheet metal was laid down on top, meaning that all these holes had to be "found" through the metal. This was done with homemade point-headed screws, which leave a small mark when inserted under the metal and bumped with a rubber hammer.

In my cowling design, the nose bowl is held in place in front of the engine by an upper sheetmetal deck, fastened to the nose bowl in front and to the firewall at the rear, and by a trough surrounding the carburetor heat box, fastened once again to the nose bowl at the front and to the firewall at the rear. I made these two pieces out of .032 aluminum, fitting them into place after I had cantilevered the nose bowl into its proper position with wooden stringers. Once the upper deck and the trough were fabricated and installed, the entire structure was extremely rigid and suitable for fitting the remaining four pieces, two on the top, which open up like the hood of an old fashioned car, and two on the bottom, which are semi-permanent.

These four pieces of aluminum, .025 in thickness, took a little doing since they are square at the firewall and round at the nose bowl. I was able to form the square end of these pieces by pressing one edge down into the space between a couple of wooden vee blocks clamped to the edge of the workbench, using a piece of ½ inch steel tubing as the tool for doing the pressing. The two wooden blocks were clamped like a vee on the table, but also had cham-

Figure 8

fered edges to allow the metal to be more or less formed down in the gap with the ½ inch tube. A couple of pieces of sheet metal were ruined in this operation, but I finally got the results I wanted.

There are a couple of inexpensive sheet metal tools I purchased from U. S. Tool or ATS, I don't remember, which I found to be almost indispensible during my sheet metal work. The first was a Whitney-type punch and the second was a rivet squeezer, with a couple of dimpling die sets. In the first case, the Whitney punch almost guarantees that the hole in the sheetmetal is going to be exactly where the center punch mark is, as compared to twist drills, which can very easily wander off, in thin stock. In the second case, the rivet squeezer speeds up the dimpling and riveting process by a factor of about 10X, at least in the case of a beginner like me. Where the line of rivets is close to the edge of the metal, there is simply nothing like a rivet squeezer for neat and uniform results.

The well known company, 3M, makes a metal sound-deadening insulation, consisting of ¼ inch thick foam, coated on one side with an extremely tenacious pressure sensitive adhesive and on the other side with aluminum foil. Although this sound deadening material is extremely expensive, I used it on the fuselage sheet metal panels with excellent results. Not only does the material impart a wood-like deadness to the metal panels, but it also gives the panels a sizeable amount of plywood-like strength, necessary in a few cases where very thin material was used.

While on the subject of insulation, I might add that the firewall, .016 stainless, was covered on the backside with heavy, woven asbestos material, received as a sample from a friend at Johns Manville in Denver. On top of this asbestos material, in between the fuselage firewall tubes, were bonded ⅝ inch foam rubber panels covered in upholstery material. This dual firewall insulation has been extremely effective from the heat point of view, with the temperature down by the rudder pedals being no higher than anywhere else in the cabin. The only other insulation used in the airplane was an additional piece of the ⅝ inch foam installed on the back side of the fabric luggage compartment, in an attempt to cut down on the trumpet effect of the rear fuselage.

After the cowling had been completed, I had occasion to run a compression check on the engine and found it to be seriously below acceptable levels in several cylinders. My engine had been purchased in the middle of 1977 right out of its original Cessna 172 home, where it had seen almost no activity for the previous 10 years or so. Its owner had been honest in telling me that it needed a top overhaul, but I had harbored the hope that I might get 50 or 75 hours out of it before taking it down. In this manner, I would not be doing taxi testing and initial flying on a brand new, tight engine. No such luck however, after my running the compression check. I made the decision to major the engine completely and undertook this operation, under the close supervision of the late George Holmes, an AI and EAA member, during the winter of 1981-82.

After the engine was secured back in its mount, I carried out the very enjoyable work of wiring the airframe and plumbing the engine. In connection with the wiring, I looked over several proposed diagrams and found the one contained in the Cessna 150 manual to be the closest to what I wanted. After all, everything was just about the same as a Continental powered 150, right down to the fact that I had the same alternator. I therefore purchased a 150 manual and copied the wiring diagram exactly, to the last diode.

The battery is installed on the cross-member at the rear of the baggage compartment in a specially designed aluminum container I made up one evening, after observing the prices of factory battery boxes in the various supply catalogs. My box is totally enclosed and lined with epoxy impregnated fiberglass to make it corrosion resistant and leakproof. See Figure 9. The battery, itself, is a manifolded type with its little rubber tube running into the bottom of a plastic bottle, mounted nearby, with a hole in its top for venting. There is no overboard battery drain. So far, I have found no liquid collecting in the bottom of the bottle. For those who might be concerned about the possibility of hydrogen gas collecting in the fuselage, I can point out that a great many Volkswagen Beetles had the battery installed under the back seat inside the very airtight body, with no adverse effects.

Figure 9

At this point in the project, the engine installation required the fabrication of two more very important assemblies, the first being the baffles and the second being the exhaust system. When I purchased my engine out of the 172, I received it "firewall forward", meaning that I got the baffles, exhaust system, propeller, and even the engine mount. This made it possible for me to easily copy the baffling system used by Cessna and developed over a number of years of building 170's and 172's. The Cessna baffling would not fit properly under my cowling, so it was necessary for me to build all new parts, in the exact same manner as the old, with the exception of the dimensions fitting the cowling. Since my O-300 is getting a much faster ride that it did in the 172, I braced the baffles in many places to give them rigidity to withstand the higher air pressures. This extra rigidity has served the baffles well, with no cracks or failures having been noticed so far. While on this subject, there is a controversy concerning the aluminum alloy which should be used for baffles. Some people claim that the softer alloys are less prone to cracking, while others disagree with this. The Cessna company fabricated their baffles from 2024 T3 and I followed suit, since they came to me after 2000 hours and almost 20 years, in fairly good condition.

There is a company in South San Francisco by the name of Sanderson Headers, in the business of manufacturing exhaust systems for speedboats and race cars. This company generates a reasonable amount of scrap .049 mild steel tubing in their manufacturing process and throws it all into a large bin in the back yard. With Sanderson's permission, I was able to pick up a pile of 1½ inch tubing, straights, bends, and other shapes, out of which I fabricated my exhaust system. I bought some inexpensive paper convoluted tubing in the local auto supply store and mocked up the exhaust system with this material, to get a good idea as to how it should be laid out. As I ended up, each bank of three cylinders has three pipes into one, with each side having its own individual tail pipe projecting out the bottom of the cowling. Each exhaust manifold has two expansion joints and a separate tail pipe, creating a situation where there are supposedly no stresses being generated during the expansion and contraction process.

The exhaust system has worked well up to this point, with only one small leak at one of the cylinder flanges, which I was able to correct by further tightening of the exhaust flange nuts. The right and left hand tail pipes are connected to each other, by means of a ⅜ inch tube inside the cowling, making the entire exhaust system more or less of a box structure. This was a hint I got from Steve Wittman, who told me it would eliminate the independent shaking of the individual manifolds during engine startup and shutdown.

The completion of the exhaust system brought me up to the point where I was ready to commence the fabric covering process. Before I get into a few details on that, however, I would like to use a few short paragraphs to describe several features of my airplane, which some readers might find interesting.

One of these features concerns the fuel cap. The Tailwind fuel tank is behind the firewall and under the windshield. Most Tailwinds have a fuel filler cap and pipe which project up from the top of the tank and protrude through the lower windshield. In most cases, there is a fuel cap standing an inch or so above the level of the windshield glass, which to me seemed very unaerodynamic. Some people have devised elaborate and interesting aluminum trap doors, revealing the fuel cap down inside, similar to the fuel door on an automobile fender. This did not seem practical in my case, since the tank top appeared to be too close to the windshield glass, so I used a piece of marine hardware, consisting of a flange attached to a 2 inch filler neck, with a screw-in cap. I connected the 2 inch neck to a similar 2 inch neck projecting up from the gas tank top, with a piece of stout rubber hose, much the same as on most automobiles. The flange and cap are, of course, located on the outside of the windshield glass, but protrude only ⅛ inch above its surface. They are made out of polished stainless and are very attractive.

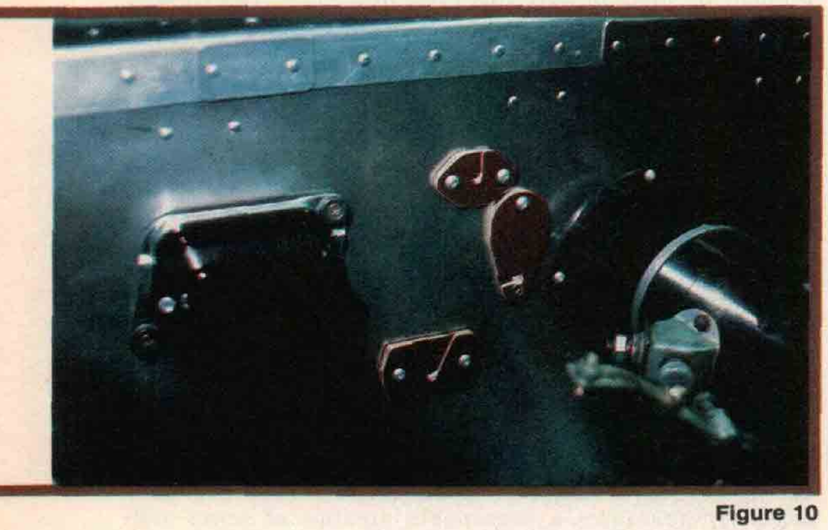


Figure 10

How to seal up the several holes in the firewall, for wires, cables, and so forth. Ralph Korngold introduced me to a great way to handle this problem, involving the use of a couple of overlapping pieces of ⅛ inch thick Micarta sheet, drilled together with holes for the cable or wire and a couple of attaching screws. After the overlapping pieces are drilled one on top of the other, the cable or wire holes are then slotted out to the edge of the piece of Micarta, one hole slotted to the right and the other hole to the left, so when they are brought back together, there is still only a round hole in the center. Much like a pair of wire stripper pliers, which when closed down, still have a small hole for the wire. I used "pop" rivnuts, available in the hardware store, to hold these devices onto the firewall. When finished, the thickness of the Micarta gives a good bearing surface to the cable or wire, keeping it away from the nearby sharp sheetmetal. See Figure 10.

One modern material I found intriguing for use on my airplane was $^3/_{16}$ inch nylon tubing for the brakelines. I believe this material is recommended by Burt Rutan for the Long-EZ. Because of its flexibility, its use eliminates the requirement for heavy, flexible hydraulic lines between the master cylinders and the fuselage, along with a number of AN fittings on either end of the fixed aluminum tubes. Brass fittings are manufactured for this $^3/_{16}$ inch tubing, with ⅛ inch pipe thread ends suitable for attachment to the master and brake cylinders. I fabricated a rectangular block of aluminum into a drilled and tapped bulkhead fitting, locating it above the master cylinders and inside the engine compartment. See Figure 11. Loops of nylon tubing go upward from the master cylinders to this bulkhead fitting, with further runs of tubing going from the bulkhead fitting down the gear legs directly to the wheel cylinders. One word of caution in using this nylon tubing. The available small brass inserts must be put into the bore of the tubing, before insertion into the brass fittings, otherwise the tubing will be crushed when the fitting is tightened, possibly spoiling the seal and creating a leak.

In the Fall of 1982, I was ready to commence the fabric covering process, something I had been looking forward to for a long time. I had earlier decided to use the Stits process, not so much for Ray's fabric, but primarily for his coatings. Although I realize there are a lot of strong arguments praising the virtues of non-tautening butyrate dope, I for one prefer the more modern technology of making coatings from resins which have no tendency to tauten in the first place. After all, the tautening of aircraft dacron fabric, whether it be Ceconite, Stits, or "just plain dacron", is a function of the heat of a steam iron, rather than the tautening of coatings.

Although I agreed with Ray on the subject of his coatings, I did not agree with him concerning his directions for applying fabric adhesive and bonding fabric to the metal structure. Taking a hint from one of the Christen Eagle construction manuals, I found it much better to paint the adhesive onto the structure in a couple of slightly thinned-out coats, coating the entire assembly and then letting the adhesive dry. The fabric could then be clamped into place on the structure and the adhesive underneath wetted out with MEK liberally painted onto the fabric to penetrate through to the adhesive, underneath. If the MEK were painted on in four or five inch lengths at a time and then rubbed vigorously with the fingertips before evaporating, the adhesive could be felt turning to liquid and coming up through the weave of the fabric, making an excellent bond. I found this method to totally eliminate all of the rush caused by the rapid drying of the adhesive. It also eliminated puckers, pleats, and so forth, which I experienced at the beginning. Almost the entire fabric application was carried out in this manner, including the pinked tapes. There is no better way to keep a pinked tape straight and to keep the little "pinks" stuck down onto the fabric.

The vertical fin was covered first, totally independent of the fuselage. The next piece of fabric was the top panel of the fuselage, which was split where it meets the leading edge of the vertical fin and then baseball stitched back together again under the fin. The remainder of the fuselage was done with three more pieces, the two sides and the bottom.

Envelopes were made for the rudder and two elevators, with the sewn seams being along the trailing edges and the adhesive joints being at the leading edges. I did these three surfaces twice, being dissatisified with the adhesive-only job done first, since the trailing edges showed finger-tip impressions in the adhesive and were unsightly. The ailerons and flaps were simple wrap-around jobs, also having no adhesive on the trailing edges.

The wings of the Tailwind, although covered with thin plywood, have a couple of open bays at each wing tip which require fabric. I did the wings spanwise with Stit's new HS-90X fineweave fabric, which is light enough for the plywood and yet strong enough for the open bays. The fabric was butt-jointed at the leading edges and covered with a three inch tape.

I would like to pass on a couple of personal experiences in spraying with Stits coatings. In the first place, I found 35 PSI to be adequate with my Binks Model 7 gun. Any more pressure than that and the paint, particularly the silver Polyspray, just bounced off the fabric and filled the room with dust. I also found that the Polyspray required retarding, with three or four ounces of Stits retarder per gallon, to get any sort of flowout. Without the retarder, the finish was extremely sandy and required an enormous amount of work to smooth down. Using the retarder, the finish came out almost glossy.

I elected to use the Aerothane two-component polyurethane finish coating on my airplane, since I know these urethanes to be the highest gloss, most UV and weather resistant coatings known to man at this time. They have a distinct disadvantage of not being easily repairable, but I decided to live with that. In addition, the Aerothane seemed to be quite susceptible to runs, more so than automotive urethanes such as Imron, and this caused some difficulty. Ray's advice in this connection is to spray a light wet coat, something which struck me as a non-sequitor, since how does one spray a coat that is at once light and wet? After much frustration, I finally got the answer from a painter friend, who told me to adjust the material flow way back, so that only a minimal amount of paint was coming out of the gun, and then to get the wetness by slowing up the movement of the gun over the surface of the work. In other words, a minimal amount of paint being given a little extra time to build up the desired wetness. This simple explanation, which even Ray Stits likes, indeed worked miracles for my Aerothane painting technique.

Some people balk at the expense of urethane coatings, running upwards of $60 a gallon, with the high price being primarily caused by the expensive isocyanate curing agent. It should be pointed out, however, that these coatings go a very long way and are basically one-shot operations, consisting of a tack coat with a couple of "light, wet" cross coats, after a few minutes set-up time. If the job is done properly, it is over after the first operation. In the case of the lacquer type coatings, they are half the price but much thinner, requiring many separate coats with a lot of sanding in between to achieve the sort of thickness necessary to allow rub-out to a decent gloss. In attempting to achieve the gloss, it is possible to get carried away with the number of coats being applied and run the cost up way beyond that of the urethane system. I bought four gallons of Aerothane for my Tailwind and have about ¾ gallon left over, having finished the entire airplane, sheet metal, as well as fabric.

Just a couple of other short notes about the finishing of the airplane. All of the metal was primed with two-component epoxy coatings. In the case of the steel, I used Fuller O'Brien's Mira-Plate, matching the color as close as I could with that of the exterior. On the aluminum, I first used the Amchem Alodine cleaning and conversion system, applying each part vigorously with Scotchbrite pads and then priming with Dupont Corlar light gray primer. The Corlar is a flat, sanding primer, whereas the Mira-Plate is a glossy color, acting not only as a primer, but also as a finish coat where the tubing shows. There was no problem with adhesion between the Mira-Plate and the Stits fabric adhesive.

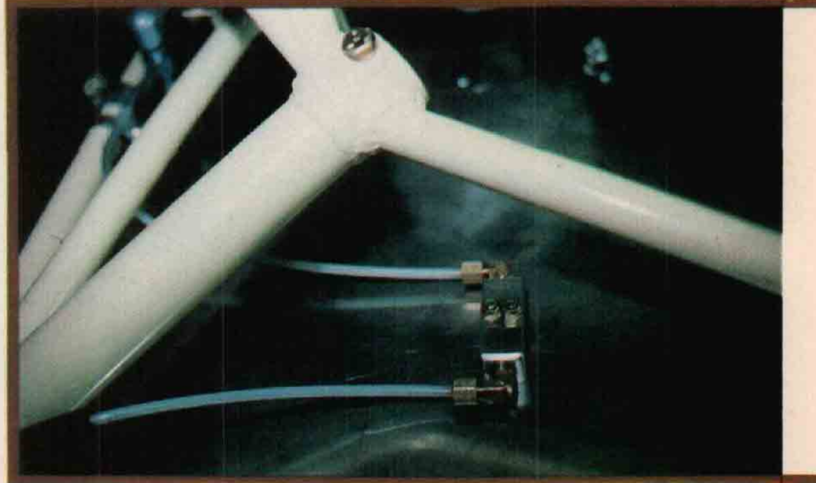


Figure 11

The striping on my airplane is conservative, with the masking being done with 3M fineline plastic coated tape. This tape is incredible and really excels at what its name implies. Pulling it off takes almost as much care as putting it on. I pulled it off 180 degrees to itself, as soon as the striping paint was dry to the touch but not yet hard, so as to avoid lifting any of it off the polyurethane surface. I am thankful to say I had no accidents along these lines and was quite happy with the finished results.

And so, with those few comments on the striping tape, I find myself back at the point where I began this article. Shortly after the striping was finished, Don Stiewel (EAA 146919), one of my biggest boosters during the entire project, helped me load the fuselage onto a flatbed trailer for the 30 mile trip from my home in San Francisco to my hangar in Hayward, on the other side of the bay. This departure of my Tailwind from its womb, never more to return, was quite an event for me but thankfully went smoothly enough without incident. It was at this point, as I related earlier, that I found myself in a race with the calendar to get the airplane completed in time for Oshkosh, '83.

As I sit here late in 1983 on a Sunday afternoon, having flown my airplane for an hour or so earlier in the day, I still find it hard to believe that the project is finally completed and that I have actually spent 60 or so hours speeding along in the air at 165 mph in my own homemade airplane. The human mind seems to magnify the anticipation of major events to a much greater degree than their actuality, a phenomenon which I have indeed observed recently. Even on my first flight, thrilling as it was, I had to stop and remind myself occasionally that here I was, 10,000 feet over Hollister, California, in my own homemade Tailwind N447A, after more than five years of building and almost 30 years of anticipation. It has been an enormously satisfying experience for me and I guess I will never totally get over it.

TAILWIND