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ON THE COVER: Ken Orloff's Grand Champion Marquart Charger.

Photo by Jason Toney

CARBURETOR SYNCHRONIZATION

How to detect and fix mis-synchronization

BY CAROL AND BRIAN CARPENTER

WITH THE PROLIFERATION OF the Rotax 912 80-hp and the Rotax 912 S 100-hp engines, the topic of carburetor synchronization has come to the forefront. Until about the 1980s, the popularity of Continental and Lycoming engines dominated the general aviation market; these engines used a single carburetor providing for a single source of air and fuel to the cylinders. The use of dual carburetors was primarily relegated to the area of the two-stroke ultralight market. And, even with these engines, the process of carburetor synchronization was quite simple and reliable. However, with the popularity of the Rotax 9 series engines, it has become important to understand a little bit more about how the induction system works on this amazing little powerhouse. This understanding is important from not only a maintenance standpoint but also a pilot's perspective.

The Rotax 912 is essentially two engines connected to a single crankshaft and gearbox with both the left and right sides of the engine having their own independent carburetor, ignition, and exhaust system (Figure 1). As you might imagine, having two engines trying to run a single propeller requires a bit of choreography between the right and left side of the engine to make things run smoothly. Most of us who have spent a considerable amount of time in the air can remember a time when one of the cylinders on a four-cylinder engine just quit firing, maybe from fouled spark plugs or a plugged fuel injector. Regardless of the source, if you have ever lost a cylinder, it likely got your attention.

Now imagine losing two cylinders. This is nothing short of an all-out assault on your engine and airframe. The shaking can be so violent that the fear of the engine departing the airframe becomes a realistic concern. With an engine like the Rotax 912, which has the right and left side induction systems isolated from each other, you can see the potential hazard with having one throttle wide open and the other at idle. The

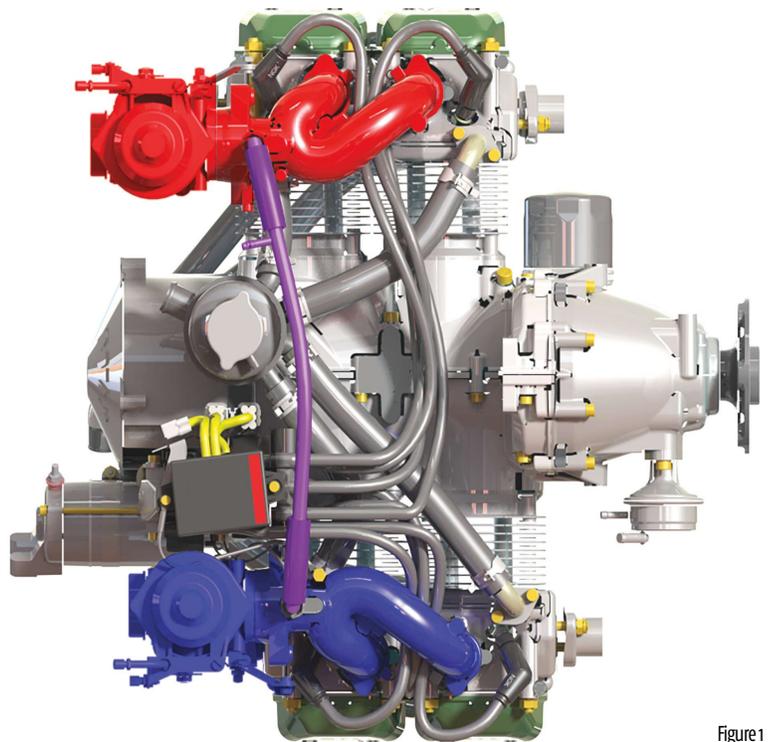


Figure 1

resulting reaction of the engine would be similar to the scenario of losing two cylinders in our previous example.

In fact, we now train pilots differently in a Rotax-powered aircraft by teaching them to advance the throttle to full in the event of a violently shaking engine, because on most Rotax-powered aircraft the throttles are spring-loaded to the full throttle position. As a result, in the unlikely event of a throttle cable failure, pulling the one remaining throttle cable back to idle when the engine starts to shake just exacerbates the problem. By advancing the throttle to full, it allows the throttle springs to bring both carburetors to the same full throttle position. This allows the engine to run smoothly and the aircraft to be flown to the nearest airport where the engine can be shut off for a dead-stick landing, a better scenario than losing the engine power entirely. Theoretically, at full throttle the carburetors are perfectly synchronized by the throttle arms hitting the full throttle stops simultaneously.

So we've identified that the Rotax 912 is basically two engines running in synchronicity at full throttle. Having one throttle cable adjusted in a slightly different position (let's say 1/8



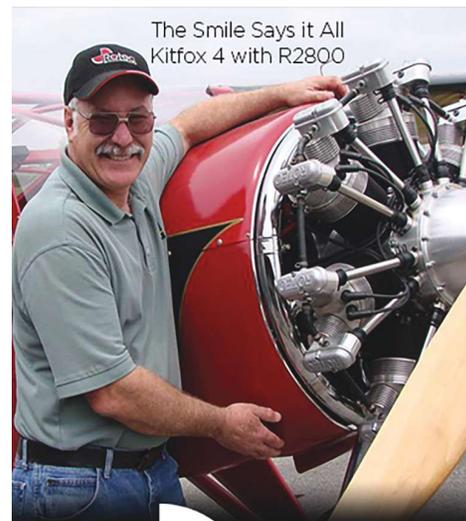
Figure 2: Clamping off the crossover (balance) hose.



Figure 3: Clamp pliers.

inch of extra cable), compared to the other throttle cable, at full throttle would result in only a miniscule differential in the manifold pressure of the two intake manifolds. However, if the throttle arms are in the idle position, 1/8 inch difference in throttle cable length would result in a massive pressure differential between the two intake manifolds. And as a result, the engine would run extremely rough. At idle a very small adjustment makes a significant change in the pressure differential. And as we open the throttle wider the pressure differential between the two manifolds decreases. The most important synchronization points are at idle and just off idle.

A balance tube, shown in purple, has been designed into the engine in Figure 1. This is a tube that runs from one intake manifold to the other. The theoretical basis for this is that if one throttle is slightly farther open, and as a result has a slightly higher manifold pressure, the fuel/air mixture will be diverted through this crossover tube to the other intake manifold equalizing the manifold pressure. When both throttles are open exactly the same amount and



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the manifold pressure is identical, there is no flow from one side to the other through the balance tube. And when there is a significant imbalance or mis-synchronization, the flow through the balance tube is substantial.

Understanding this has allowed us to develop a quick and simple field test to identify engines with poor synchronization. By taking a pair of hose clamp pliers and momentarily blocking off the rubber hose connecting the balance tube to the intake manifolds while the engine is running, we can identify a poorly synchronized engine (Figure 2). If we block off the balance tube and the engine continues to run smoothly, there is little flow from one side to the other.

However, if we block off the balance tube and the engine shakes a great deal, it is an indication that the engine is in dire need of proper synchronization. On one occasion the shaking



Figure 4: Synchromate II installed into manifolds.

was so bad after blocking off the crossover hose that the carburetor was shaken loose from the intake manifold. The absolute best vacuum hose pliers to use for this operation can be obtained from Harbor Freight. It makes a very low cost set of plastic vacuum hose pliers with a locking device. The jaws on the plastic vacuum hose pliers have a very nice rounded “V” section that fits perfectly in between the crossover tube and the intake manifold (Figure 3). Simply pinch the hose between the pipe and the manifold fitting without pinching the aluminum pipe. Now, as you might imagine, this simple test is in no way a substitute for doing a proper carburetor synchronization.

Some of the characteristics associated with mis-synchronized carburetors include:

- Overall vibration causing wear and tear on the airframe and engine.
- Rough running at idle, too low of idle speed, including engine stopping during final approach.
- Excessive wear on the gearbox resulting in an increase in the amount of steel both in the oil filter as well as on the magnetic drain plug.
- Troubles with the needle and seat within the carburetor seating properly, particularly at idle. This causes excessive fuel in the float bowls and a rich mixture. The rich mixture, in turn, makes the engine run rougher exacerbating the shaking problem.

Rotax provides a fairly comprehensive set of instructions for proper carburetor synchronization in the line maintenance manual, downloadable from www.EAA.org/sportaviation under This Month's Extras. However, the myriad different throttle linkage systems used throughout the light sport industry require that you extrapolate from these synchronization procedures and adapt them to your specific type of throttle actuation system. No matter how your linkage system is designed, the basic procedures

mt-propeller



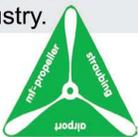
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involve installing a manifold pressure monitoring system into each of the two intake manifolds and then adjusting the carburetors to achieve an identical manifold pressure both when the throttle is at idle as well as just off idle. We use a Synchronate II (Figure 4). This is a digital synchronization tool built specifically for Bing carburetors and has the added advantage of allowing the calibration of the tool prior to each use. By disconnecting the balance tube from the engine and attaching the synchronization tool into each manifold, we can measure the differential pressure between each intake manifold. On the Synchronate II, when the digital bars are in the center position (Figure 5) the pressure in each manifold is equal. Bar movement to either side will indicate the manifold with the lower pressure (Figure 6). The challenge becomes understanding your throttle linkage system. The system should have a physical idle throttle stop normally at the throttle, which should be making contact simultaneously as both throttles hit the idle rpm adjustment stop, and this needs to occur while maintaining proper idle rpm and perfect synchronization. Now if that isn't enough, as you advance the throttle to move the throttle arm off the idle rpm adjustment stop, the cable adjustment now controls the synchronization. If adjustment of the cable is necessary to maintain synchronization in the off idle position, it will inevitably screw up your throttle cable position in relationship to the physical idle stop at the throttle. This, in turn, will allow the throttle to be pulled against the idle stop at the carburetor. Excessive force against the idle stop can cause the lightweight idle stop on the Bing carburetor to bend. This causes the idle synchronization to be screwed up, and as a result, the entire synchronization and adjustment process needs to be started over. If you are new to this process, it can be rather frustrating. Our recommendation is that you use an

LSRM (light-sport repairman with a maintenance rating) experienced with the carb synchronization process to help you through the first synchronization.

Once you become familiar with your particular airplane, have the throttle linkage set up correctly, and understand how it

works, the system is rather simple and bulletproof. Most of the problems we see related to carburetor synchronization are simply a lack of understanding about how to properly set up the linkage in relationship to the carburetors, poorly designed throttle systems, or trying to synchronize worn-out carburetors that need to be rebuilt. It is a waste of time to be synchronizing the carburetors if they are not set up and working correctly. The 912 and 912 S Rotax engines are amazing products. Once you become familiar with the nuances of their maintenance and operation, you can't help but be impressed by the elegance of the design. *EAA*

Carol and Brian Carpenter, EAA 678959 and 299858, owners of Rainbow Aviation Services, have co-authored two aviation books and team teach the Light Sport Repairman Workshops. Brian is a CFII, DAR, A&P/JIA, and the designer of the EMG-6 (an electric motor glider). Carol is an SPI, PP, LSRM, and FAAST representative.



Figure 5: Properly synchronized carburetors.



Figure 6: Improperly synchronized carburetors.

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Dan Grunloh flying near Paxton, Illinois, for WUFI.

ONE DAY, ONE SKY

World Ultralight Fly-In 2015

BY DAN GRUNLOH

ON OCTOBER 10, 2015, the worldwide virtual fly-in was held with more than 500 pilots participating in an attempt to set an official world record. The plan was for pilots of ultralights, microlights, and light-sport aircraft from all around the world to fly on that day and submit a dated picture as proof. The idea for the event and its successful implementation is an illustration of the power of community, and of social media. It happened because pilots joined together from around the world to share the fun of open-air fun flying, and they wanted somehow to fly together. The World Ultralight Fly-In (WUFI) was the result. It was conceived and executed in less than three months at a pace that stunned even its originators. To employ a frequently used term from the Internet, the idea “went viral.”

The roots of WUFI go back to 2013 when longtime GA pilot Paul Lindamood, who had taken up flying a two-seat Quicksilver, decided to reorganize the Dayton Ultralights Club. The original group established in 2000 gained notoriety when it organized a group cross-country flight of ultralights from Dayton, Ohio, to Kitty Hawk, North Carolina, and back to celebrate the 100th anniversary of flight. The new group based at the Moraine Airpark in Dayton is a non-profit club supported by donations. It began with a handful of members, and within two years it has grown to 30 active pilots and 75 members.

The club had a Facebook page, but Paul wanted something with a wider scope that would allow more people to come together in an online community. A Facebook page is somewhat limited, but a public Facebook group is a different entity with much more freedom. Anyone can join by clicking a button on the screen. Flying ultralights and open-air aircraft is reminiscent of the flying in the 1965 British comedy film *Those Magnificent Men in their Flying Machines* so he called the group Those Magnificent Men and their Flying Machines.

The new Facebook group started slowly in January of 2015, but soon more and more pilots from all around the world began to join perhaps drawn by the name, and our universal love of that film. They posted amazing pictures and stories that drew others into the group, and soon a community developed that offered advice and inspiration to fellow aviators they might never meet in person.

Three people, Paul in Ohio, Bill Esker in Arizona, and Koen Van de Kerckhove in Belgium, were lamenting the difficulty for many people to ever attend EAA AirVenture Oshkosh in Wisconsin with their aircraft. Bill had hauled his Weedhopper on a trailer 1,800 miles to attend in 2014. The distances and cost make it impossible for many. Someone said wouldn't it be great if we could all fly together, and at that moment in early July, the plan for WUFI was hatched. We all fly in the same air and the same sky all around the world anyway, so the slogan “One Day, One Sky” was born. The date was set for October 10 because October is an ideal time weatherwise in multiple hemispheres. The plans for WUFI spread quickly on the Internet as members of the Magnificent Men group passed the word to other groups and clubs. The attempt to set a new record made

news in the aviation world, and enthusiasts got coverage even in their local newspapers. The WUFI project was popular, and it drove membership in the Magnificent Men group to its present size of about 2,000 participants. A dedicated Facebook group was established solely for WUFI discussion and posting of photos.

An online interactive map collected nearly 900 locations in 22 countries around the world pinned by pilots who planned to fly for WUFI 2015. Some had bad weather and could not fly, but some pins represented a whole group of pilots in a club. I joined five members in my local EAA chapter to fly that day, and there were numerous other chapters and clubs around the world doing the same thing. Everyone who submitted proof of flight on October 10 would receive a certificate recognizing their participation in this first record attempt.

Technical problems challenged those who joined late or had not prepared. Many of our cameras or cellphones today don't apply the date stamp to the photo. Holding your expensive cellphone out into the wind stream to take a selfie adds a bit of thrill. Cameras can have errors in the internal date settings, and a few of us posted the required pictures on the wrong Facebook page. Pilots flew with newspaper clippings taped to their helmet or took pictures of their watch. Some submitted videos instead of photos (which was fine). A large group of pilots in Venezuela planned and executed a group fly-by for a video. They practiced on the ground first to get it right. The WUFI organizers worked hard to iron out any problems and contacted submitters to get missing details.

There were about 500 official recognized entries on the record attempt, but probably many more flew who did not get a picture or make an official entry. Several pilots managed to arrange their first solo flight on that day. The Facebook postings are filled with amazing stories about those 500 different WUFI flights. My time stamp from Illinois indicates WUFI founder Bill Esker was flying at almost the same time in Arizona, as were many others in the United States. It was indeed one world and one sky that day.

The threshold for participation in WUFI was the ability to post your photo entry on a public Facebook group or know someone who could do it for you. There is no talk of changing that for next year. Facebook is the best vehicle for low-cost worldwide communication. With the spread of cellphones and tablets and the ease of posting photos and videos it can quickly build a virtual community. All of us can now self-publish in real time.

Anyone with Internet access can view the amazing photos and watch the inspiring videos from around the world posted on the Magnificent Men and WUFI Facebook groups. Don't miss it. But if that is all you do, then you are missing the best part. A Facebook login requires only a minimal bit of personal information, but it makes it possible to interact with the community, post your own pictures, make new friends, and plan new adventures. Give it a try. The next WUFI is set for October 1, 2016. It will probably be much larger than this first attempt. Find links to the Magnificent Men and their Flying Machines group, the online interactive map, and the WUFI photo page at www.EAA.org/sportaviation under This Month's Extras. **EAA**

Dan Grunloh, EAA 173888, has been an EAA member and volunteer since 1981, and he has logged 1,500 hours in ultralights and light-sport aircraft. He can be reached at dangrunloh2@gmail.com.



Hector Preciado in Guanajuato, Mexico, in his Quicksilver.



Stefen Nystrom flying a SeaMax in Sweden.



A group of pilots flying for WUFI in Venezuela.



WORTH THE 37-YEAR

Wait

Grand Champion honors
put frosting on the cake

BY MARY JONES





Ken works on a fitting on the leading edge of the wing.



KEN ORLOFF, EAA 55380, had never flown a Marquart Charger when he bought the plans for the MA-5 in 1978, and little did he know it'd be 37 years before he would. But a lot happened along the way.

Ken learned to fly in 1964 while in college. His first airplane was a newly restored J-3 Cub that he and two buddies purchased for \$1,800. After selling his interest in that airplane, he restored a Taylorcraft BC-12D. Eventually he sold that to finance the purchase of a J35 Bonanza after he completed graduate school at the University of California at Santa Barbara and went to work for NASA at Moffett Field. (Ken holds a Bachelor of Science and Master of Arts in physics as well as a doctorate in mechanical engineering, with an emphasis on aeronautical engineering. He is also an airframe and powerplant mechanic with inspection authorization.)

But all along Ken knew that one day he would build an airplane. Working toward that goal, he took an aircraft welding class at a local community college while still in grad school. This was in the early 1970s and kits didn't yet exist, so Ken knew he'd have to know how to weld. His first project was a Spezio Tuholer that he built with a friend between 1972 and 1976. He said he learned a lot while building that plane, including that it wasn't a very good airplane. He decided his next airplane would be "a good one," and that's when he discovered Ed Marquart's MA-5 Charger. "I looked at lots of different plans sets, but when I saw the Charger plans, I knew Ed Marquart was a real engineer; he knew structures, and he knew how to put things together."

Ken started building in 1978, working on the wings first. "I tried to do a rib every night. I was still working at NASA and would work on the project nights and weekends, cutting and bending steel and making wing fittings." In 1979 he moved from the Bay Area to Pine Mountain Lake Airport near Groveland, California, where he built a home and hangar on the airport, and the Charger project came with him. Ken said he worked pretty hard on it until 1982. "I had the upper wing panels completed, and I'd welded a lot of small parts—rudder pedals, torque tubes, lots of fittings, and bell cranks." But life intervened, and Ken didn't work on the Charger project for several years.

In 1992, Ken was flying both a Beechcraft Baron and Bonanza for business and pleasure. His company, Orloff Consulting, provides aviation accident consulting services to plaintiffs and defendants, taking him all over the country. He decided, "If I was going to be burning that much fuel, I wanted to go high and I wanted to go fast." So he bought a Lancair IV-P kit and began building that airplane, completing it in 2002. "That took about 12 years away from the Charger project, but it's a great airplane and it flies great."

In 2003, Ken started working on the Charger project in earnest again, and he said since 2006 it's been "every night and every weekend." Ken and his wife, Lynne, were married in 2005. "I told Lynne, if I can come home from work and just get one little part made each day after dinner, it's one less thing I have to do. And we stuck to that pattern," Ken said.

That resulted in Ken getting to fly the Charger for the first time in February of 2015. At EAA AirVenture Oshkosh 2015, N171MC

had just a little more than 60 hours on it. “I flew the 40 hours off (last) spring and early summer, and we took off for Oshkosh with 43 hours logged,” Ken said. Does it fly as well as everyone told him 37 years ago? “Yes, it has very balanced controls and great flying characteristics. I can see why everyone I talked with back then loved the airplane. It’s just a nice flying airplane.”

Lynne, a school teacher turned engineer, is also a pilot, flight instructor, and the owner of a Ryan PT-22 that she’s flown to Oshkosh twice previously—53 hours round trip with 42 landings, she said—so she’s the one with the low-and-slow experience. “Ken finished planning our trip here to Oshkosh pretty quickly, and I asked him, ‘Did you plan airports that had access to restaurants for lunch? Flying in the open beats you up a bit, and we’re going to need to eat,’” Lynne said. “Well, he didn’t, but we did okay.” The trip to Oshkosh took them 16 hours over four days. “We laughed a bit about flying to Oshkosh in an open-cockpit airplane at our ages,” Ken said, “but I said, ‘I gotta do it.’”

Ken and Lynne have been coming to AirVenture Oshkosh for the past four years, each year with Ken thinking it might be the year he could bring the Charger. Lynne said, “The first couple of years, I told him, ‘Stop killing yourself. You’ve got too much to do.’ But each year he learned something and would come back home and make some changes to the plane.” Ken got lucky in 2013 to see Mark Gilmore’s Charger. “Mark Gilmore had his 2009 Grand Champion Charger here that year, and I filled my iPhone with photos of his airplane. Mark was a great help. We e-mailed often, and he answered a lot of questions.”

THE BUILDING CHALLENGES

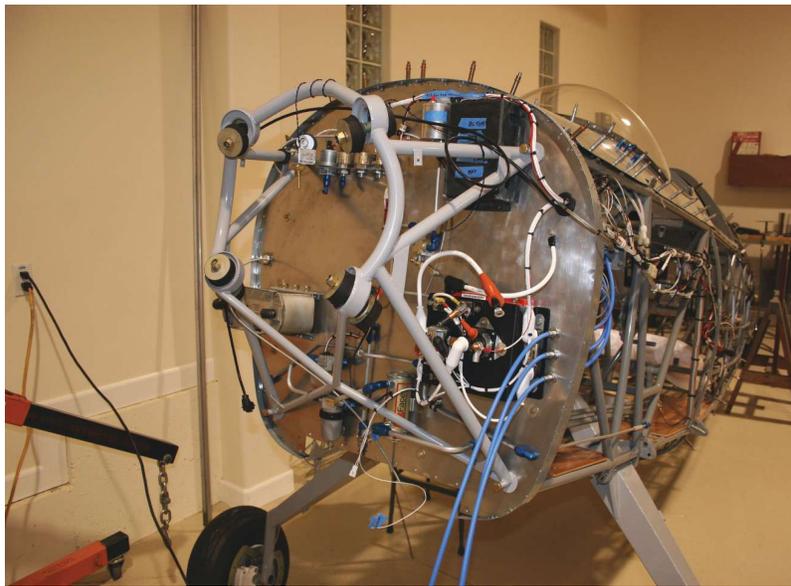
Ken said there were a lot of things on the Charger that were fairly difficult to build. “But, I always took the approach that I never thought of the whole airplane completed. I always took the one little thing that I was doing, and that was the end project. I’d do that one thing no matter how long it took me. That made the whole project easier to handle.

“There’s a lot of steel on this airplane, so my band saw was doing a lot of cutting and bending steel, but I also bought as many parts as I could from Ken Brock. His company was making Charger parts in the early 1980s, and that made life a lot easier.”

Ken identified a few of the other difficult areas. First he mentioned the area around the cockpit openings. “I had to do some fairly sophisticated bending of the 1/2-inch aluminum tubing underneath the cockpit combing. That was pretty tricky.”

He said making the cowling also was quite time-consuming and challenging. “The plans don’t really tell you anything about the cowling, so I had to design that as I went along.” That process was made a bit harder because Ken chose a different engine than the O-320 that most Charger builders use. Ken went with a Ly-Con O-360 and a WhirlWind constant-speed propeller. “I’ve had an O-360 on several of my other aircraft, and it’s just a good engine, so I wanted one on my Charger, too.”

Ken paid 30 percent of the price of an O-360 engine to Ly-Con in 2005 and received an engine core that he used for figuring out how to mount his accessories on the engine and complete the



Ken had to design the engine mount for the Ly-Con O-360.



Ken originally built fiberglass wing fuel tanks as called out in the plans, but wasn’t happy with them, so tore them out and built larger metal tanks to replace them.





Ken and Lynne flew the Charger from California to Oshkosh for AirVenture Oshkosh 2015 where it was named Grand Champion Plans-Built. The trip took 16 hours over four days.

cowling. When it was finished, Ken returned the core and then received an overhauled O-360. Lynne said one of the clever things he did was to make a Plexiglas firewall so he could see through it to figure out how to mount parts on the engine. Then, after the engine was completed, he used the Plexiglas piece as a template for the actual firewall. Ken's engine change also meant that he had to design his own engine mount.

But the hardest parts to work with turned out to be the wing tanks. Ken first had two fiberglass wing tanks as called out in the plans, but he was not happy with them. "One day I just took an air drill with a cutting wheel and started tearing those tanks out. I tore everything out spar to spar," he said. "Luckily I had kept my wing rib jigs, so I made a bunch of new ribs and designed an entire new structure for the upper wing and built aluminum tanks that are removable. They're 7 gallons each as opposed to the older ones that were 4 gallons. The nose holds 17 gallons."

Another challenge was that the MA-5 plans do not specify a maximum weight (they only spell out a CG range), nor do they offer a V_{NE} speed. Ken asked other Charger builders how they arrived at their maximum weight and was advised to take his

empty weight (1,162 pounds), add 200 pounds each for the front and rear seat occupants, plus the weight of fuel, the weight of everything he could possibly stuff in the baggage compartment, and round the number up to the next 50 pounds. For Ken's Charger, that came out to 1,850 pounds.

Ken had to get clever to determine the V_{NE} . When he was covering the wings, he figured out the rib stitch spacing so that the stitches would miss the spars and as many of the compression tubes and drag/anti-draw wires in the wing as possible. That spacing came out to be 2-3/4 inches. Then, he said, "In AC 43-13, there's a chart that helps you figure out what your rib stitch spacing should be for various V_{NE} speeds. I went to that table and found my rib stitch spacing and then found the corresponding V_{NE} , which turned out to be 165 knots." That's a number he doubts he'll ever see. "There's so much drag on a biplane."

The wheelpants also needed a bit of adjusting. "My wheelpants are the same as those used on Cessnas," Ken said. "They're low drag and have nice fairings around them, but they were for a nosewheel airplane, and when I put them on the Charger, the back ends were touching the ground so I had

to cut off the bottoms and rebuild them at an angle that is parallel to the ground.”

Ken also noted there’s a lot of carbon fiber and fiberglass on the Charger, “so the experience I gained working on the Lancair project helped with those parts.” That included the windscreen retainers, fairings on the tail, the root fairings, and the air intake scoop.

When it came time for covering, Ken decided to go with the Stewart covering system on the advice of a friend. He said working with that system was delightful. “One of the real benefits of this system is there are no fumes and the materials are nonflammable. I did the covering in my workshop with little ventilation. I had covered my Tuholer years ago, but I needed to brush up on the technique, so Stewart gave me 20 hours of video, which I watched before I began covering with the Ceconite.”

Then Ken engaged Steve Green Aircraft Painting of Medford, Oregon, to do the painting. “Steve painted my Lancair, and he is an artist. He came down and stayed with Lynne and me for three months, and we spent two and a half months spraying and sanding to get the finish to the level we wanted, and then Steve did the final coats of paint,” Ken said. “He had never worked with a waterborne system before, so it was a learning process for him, too, but he did a wonderful job.” The airplane’s colors are Idaho Snow, Tennessee Red, and Midnight Black.

One of Lynne’s contributions to the project was to pick the colors and design the paint scheme, and she worked with Scheme Designers, with a young artist named Alicia. “I was fine with doing the design, but I didn’t want to have to figure out the aspect ratio of where everything goes. Alicia was an excellent listener; I told her what I wanted, and we were able to finalize the design in one iteration with one small change.”

Lynne’s other contribution to the project was to design and oversee the interior of the Charger. For that project she worked with Tim Hallock of Aviation Design, who’s a neighbor of theirs and another person whom Lynne and Ken describe as an artist. Some of the “finesse” items they worked on together were specially designed leather headrests and miscellaneous pockets in the cockpits to hold things like Lynne’s iPad. Lynne also specified that she wanted the seat cushions to be leather on one side and vinyl on the other. She said, “Climbing in and out of the cockpit, you have to step directly on the seat, and the little rocks and stones that you pick up in your shoes on the ramp do a lot of damage to leather, which isn’t as sturdy as vinyl. So we made the cushions with vinyl on one side, and that’s the side we have facing upward when we’re climbing in and out. That does a lot to save the leather surface.”

Lynne also asked Tim to put non-skid pads on the floorboards as well. “You have to stand up and push off the floorboards to climb out of the airplane, and you can’t do that easily on that beautiful wood. You need to have something to get a grip on.” She also wanted the back of the header tank covered with leather to look more finished. “You just think about these finer details for a while and come up with solutions,” she said. No doubt Lynne’s experience flying her open-cockpit Ryan PT-22 gave inspiration to some of her ideas. Another of Ken’s clever

thoughts was to line the baggage compartment so the fabric can’t be punctured from the inside.

As for the Charger’s performance, Ken is quite happy. “There’s so much drag on this biplane that it’s only going to go so fast no matter what engine you put on it, but I’m very happy with the O-360 and constant-speed prop combination,” he said. “The biggest difference is in the climb. On our way to Oshkosh, we took off from a couple of airports with density altitudes of 10,000 feet, and the airplane just jumped off the ground. The constant-speed prop is nice because you can bring the rpm back and get really nice fuel economy. I was down around 7 gph at times.”

While this project was Ken’s to begin with, it’s clear that he and Lynne are equally proud of the final product, and no doubt that pride culminated when their Charger was named the Grand Champion Plans-Built Aircraft at Oshkosh 2015—a great honor for a lot of perseverance! *EAA*

Mary Jones, EAA 224626, is a semi-retired, former longtime editor of EAA publications.



Above: A group of volunteers helped Ken mount the wings. Below: Organizing the rear cockpit panel to accommodate modern flight instruments as well as traditional round gauges.







John Moody

— AND THE BIRTH OF ULTRALIGHTS

Celebrating 40 years

BY DAN GRUNLOH



WHEN JOHN MOODY MADE the first successful flight in an Icarus II foot-launched powered hang glider on March 15, 1975, he changed the course of human history, and he began a process that culminated in 1982 with a new set of regulations for powered ultralights called FAR 103. He was not trying to create a new category of aircraft, but a convergence of forces and fortunate timing gave us unprecedented freedom to fly here in the United States with minimal regulations. It fostered an explosion of growth and interest in aviation with tens of thousands of people becoming involved in aviation.

John came to Oshkosh for AirVenture 2015 after a long absence to celebrate the 40th anniversary of his milestone flight. He flew every day and brought living history to aviation enthusiasts at AirVenture who weren't even born at the time of his first flight. And he did it in the same 40-year-old Easy Riser design that made him famous. The highlight was a flight down the main runway and back at sunset in front of thousands of spectators gathered for the night air show.

One could argue that the hang glider and the powered hang glider were among the greatest aviation innovations because for the first time man could actually fly like a bird taking off from

level ground from a standing position. People were electrified by the sight of it. Events happened quickly after that flight in 1975. Within eight years everything had changed, and John began to be called the father of ultralights.

John, trying to raise a family as a young engineer in the early '70s, began to eye the \$80,000 Kremer prize for man-powered flight. He noted that most attempts focused on building lightweight sailplanes with pedal-powered propellers. Birds, however, fly very efficiently and long distances without propellers, and he had learned about a little known principle called the Katzmayr effect. When the angle of attack of a wing oscillates in a sinusoidal pattern (without stalling) there is a net gain in lift and a reduction in drag. Also a momentary contribution to thrust occurs when the wing pitches forward in the oscillation. The effect is known today in the world of soaring flight and has been demonstrated in models. John wanted to test a theory of man-powered flight where the pilot would be pumping up and down with the legs causing the wing to oscillate instead of pedaling in a circular motion to drive a propeller. The rigid-wing Icarus hang glider was chosen as a suitable test vehicle because of its pitching characteristics.

Two years after John's first foot-launched powered hang glider flights, Paul MacCready won the Kremer prize with a propeller-driven sailplane pedaled by Bryan Allen. By then, notions about the Katzmayr effect had been postponed, and John Moody was busy producing kits for all the enthusiasts who wanted to fly a powered ultralight. Man-powered flight was indeed a great achievement, but we didn't find tens of thousands of people adopting the practice and creating a new class of aircraft, as we had with John Moody. That's what made him the father of ultralights.

THE MOODY TIMELINE

Ultralights as we know them today might not have been possible without hang gliders because of an important quirk with the foot-launched connection. Modern hang gliding began in 1961, and the world was exposed to hang gliding in the 1960s by Bill Bennett launching on water skis. In 1971 Dave Kilbourne demonstrated ridge soaring in a foot-launched Rogallo wing hang glider in California. From the very beginning inventors tried to add power to their hang gliders, but most failed due to the poor performance of the wings of the time. When a young engineer named Taras Kiceniuk developed the rigid-wing Icarus tailless biplane hang glider in 1971, its performance was miles above anything seen before. Pitch was controlled by weight shift, and a turn was induced by wingtip rudders controlled by twist grips.

Two years later in the winter of 1973 John, at the age of 33, built an Icarus II hang glider and began to teach himself to fly from hills near Waukesha, Wisconsin. The snow acted as a cushion, and the cold dense air helped with lift. When narrating videos of his early attempts to fly, he explains that he was learning to crash first. He later tried towing and cliff launching. In the fall of 1974 he mounted a West Bend go-kart engine on the glider and on March 15, 1975, made his first successful foot-launched powered flights from a frozen lake near Milwaukee. He started with takeoff runs at low power and gradually increased the throttle setting after each attempt. John explained he didn't want to kill himself right away. The first flight was only 300 feet, but he ended up flying over a mile that first day.

On a later flight in July 1975, at a hang gliding meet in Michigan, he reached an altitude of 3,000 feet much to the chagrin of the glider pilots who could not fly because the wind was from the wrong direction. His first cross-country was a 16-mile flight from Waukesha to the Rainbow Airport near Ojibwa, Wisconsin. He had to refuel at the halfway point. By now he had switched to a McCulloch engine and added streamlined fairings to the struts, which made a big difference. Every time he flew it drew a crowd.

Immediately after he began flying at Rainbow Airport he was contacted by the FAA accusing him of flying an unregistered airplane. John said no, it was a powered hang glider. The FAA had already accepted that hang gliders were not aircraft, but it was not ready to accept powered hang gliders (even though many experimenters had already attempted it). John couldn't fight the FAA, but Jack Cox at EAA convinced him that it could be registered in the experimental experimental amateur-built category. The first ultralight was registered N65131, and John obtained a

student pilot certificate with solo endorsement. He was now ready to go to Oshkosh.

NO SEAT. NO HARNESS. NO BRAINS.

His earliest flights were made hang glider style, hanging from the armpits. It wasn't as uncomfortable as it might seem as most of the weight was on the lower back and the feet. He soon added a swing seat that was simply a board slung from two ropes. Foot-launch pilots must be able to get the gear down quickly for landing. Later a sling or hammock type seat was developed. From the beginning and right up to today John has used a mouth-held safety switch to kill the engine in case of an emergency. The first version was a little crude, and sometimes it leaked current and gave him a "tingle."

John's flights at Oshkosh in 1976 were sensational. He said from the pilot's point of view, it was like tipping a bowl up on its side. All the people would flow like water toward the fence whenever he took off. Everything was fine until he got too enthusiastic in a wingover and found himself upside down.



Unfortunately the wing entered a series of infamous tumbles. After about three revolutions he spit out the mouth kill switch to stop the engine, and the wing recovered just in time for a normal landing. He was grounded after the incident, but he later appealed and was allowed to fly again.

John had flown out of the backyard of a writer for *Popular Science* in 1976 that resulted in an article in the December issue of the magazine. That publicity along with his exposure at EAA Oshkosh got him started in the kit business. The first flights were in an Icarus II hang glider, but he soon switched to the Easy Riser, a beefier version created by Larry Mauro that had a better airfoil, used aluminum ribs instead of foam, and could be easily folded for transport. For a few years John's kit business boomed. He sold about 900 copies of the powered Easy Riser kit with prices ranging from \$1,200 to \$1,800.

SON JAMES FLYING TO SCHOOL

In the late '70s Larry Newman introduced a weight-shift ultralight called the Eagle based on a bowsprit hang glider concept with a canard for stall resistance and tip rudders for roll control. John acquired an Eagle B model and began flying it in

addition to his Easy Riser. It was so simple his 16-year-old son, James, also learned to fly it. The Eagle was kept in their backyard, and around 1980 James was flying it back and forth to high school, tying it down in the soccer field. How cool is that? John and James have continued flying the Eagle to this day. His vintage red model with the Coca-Cola logo on the sails (seen for years at Sun 'n Fun) was re-covered in blue, flown at AirVenture 2015, and was sold to a collector who flew it home!

John was not the first person to build what we now call an ultralight. There were neat little airplanes before 1975 like the Kolb Flyer that was already in the air in 1970. The key fact is that they all had landing gear. If we had asked the FAA directly for the freedom to fly our little airplanes with minimal regulations or government involvement it would likely have been refused. Instead, an explosion of hang glider interest coupled with the successful application of power maneuvered the course of events to give us the freedom of FAR 103.

A SLIPPERY SLOPE TO MORE FREEDOM

When Taras introduced his Icarus hang glider the FAA required an N number because it had aerodynamic controls (the



John Moody uses a mouth-held engine cutoff switch.

tip rudders). Rogallo wings were viewed as little more than weight-shift kites, and thus were not aircraft. Full three-axis rigid wing hang gliders like the Mitchell wing or Volmer Jensen VJ-23 were considered aircraft. The Easy Riser hang gliders were weight-shift in pitch, and they were actually hang gliders in practice. The interpretation was loosened, and the concept of foot-launch was established. Foot-launched gliders were not aircraft even if they had aerodynamic controls on the wing. Then John Moody came along and began to claim that there was such a thing as a foot-launched powered hang glider, and why not? They used the engine to launch and then could glide back to Earth. It wasn't much of an airplane; the pilot was indeed running, and suddenly the foot-launch rule for powered hang gliders seemed an expedient solution.

Enthusiasts noted that hang gliders sometimes have wheels used for landing even though they are foot-launched. It would be safer and injuries could be prevented if the powered versions could also have wheels for landing. All the Easy Risers quickly got landing gear. By now the FAA probably realized it was going to have to develop formal rules for ultralights and issued an interpretation indicating that powered ultralights with landing gear that could be foot-launched would not require registration or pilot certification. It would limit the aircraft to about 90 pounds (including fuel) and to a stall speed of about 14 mph. The operator himself didn't have to foot launch if he could show the identical model had been foot-launched successfully at least once (typically in a strong headwind with wing handlers). It was a temporary solution. By the time FAR 103 was released in 1982 we had fully enclosed three-axis ultralights with a hole in the floor that wasn't needed for actual operation.

THE FLORIDA YEARS

By 1984 the ultralight market began to move to faster, heavier aircraft, and the overall sport declined thanks to a TV documentary that focused on accidents. Lawsuits were beginning to come in as a result of inevitable injuries caused by foot-launching. John had little choice but to fold up and move from Wisconsin to Florida in search of employment. He didn't fly for about 12 years.

He purchased a vintage 1976 Easy Riser from a former customer in 2001. When the nose wheel fell off on the first test flight he discovered he could still do foot landings, and it gave him an idea for a humorous air show act. A supposed disgruntled creditor pretended to shoot at him with a shotgun (firing blanks) knocking off first a false tail and then the landing gear. After some blipping of the throttle and engine sputtering, John would land in front of the crowd engine off, on his feet as the announcer explained the origins of powered ultralights. It was a popular show until, in shifting winds in 2004 at an air show in Augusta, Georgia, he banked too steeply while trying to maneuver to land and stalled in from 100 feet.

He had two demolished ankles, several broken ribs, punctured lung, and broken pelvis. The ankles were so bad the doctors suggested he might have a more successful, less painful,



John Moody tells his story in the ultralight forums tent.



and faster recovery if both feet were amputated. They couldn't promise amputation would result in a recovery in time for the upcoming duck hunting season so John decided to take a chance and keep his feet. Through stubborn persistence he regained the ability to walk, but his foot-landing days were over.

Now retired in Florida, John couldn't readily commit to making the long haul to AirVenture in 2016, but he is likely to continue to fly at the Sun 'n Fun Fly-In as he has done for more than 15 years. For John and James it's a short trip from nearby South Lakeland Airport where he hangsars his ultralights.

John Moody was inducted into the EAA Ultralights Hall of Fame in 1999. A survey of designers, industry leaders, and veteran pilots in ultralight and light-sport aviation today would reveal that a surprising number of them began flying in an Easy Riser. From all of us at EAA and the entire ultralight community, thanks, John; you helped so many of us get into flying, and you continue to inspire others to join us. Learn more about John Moody at www.EAA.org/sportaviation under This Month's Extras. **EAA**

Dan Grunloh, EAA 173888, has been an EAA member and volunteer since 1981, and he has logged 1,500 hours in ultralights and light-sport aircraft. He can be reached at dangrunloh2@gmail.com.



My sort-of exhibit wall. Let me see now, all of my big clamps and my big hammers are visible, along with my bigger pipe wrenches and my antique blacksmithing tools (neat stuff, remember?). And, oh yeah, my brand-new-never-been-run Lawrence B-5 radial. You wouldn't want to hide that under a bench would you?

WORKSHOP PHILOSOPHIES

We don't all agree

BY BUDD DAVISSON

YEAH, I KNOW. I SPEND A LOT of time talking about workshops, so maybe the name of this editorial space, Shop Talk, is apropos. The reason I spend so much time talking about workspace considerations is because, like so many others, I have far more projects and building daydreams than my smallish shop (a narrow double garage) can possibly contain. So, I'm continually thinking about how I can more efficiently use the space I have because I keep coming up with more projects and the space isn't going to get any bigger. In the course of this kind of mental discourse I'm continually having little epiphanies in which I solve some sort of space problem or, at the very least, develop some sort of guideline that I either should follow or really wish I had followed when I set up the shop.

By the way, I gave serious thought to whether I really wanted people to see my little workshop and how I compensate. But, then I decided there are probably a lot of folks out there in the same little boat, so they might benefit. I'm not proud.

SHOP SIZES: THE MYTHICAL "DOUBLE" GARAGE

There's no reason to rehash the "what's the right size for a shop" discussion. We all know there really is no such thing as too much space. However, for those who haven't built their garage yet, there's reason to discuss what constitutes a "double garage" that really is double.

I couldn't remember the exact dimensions of the standard double garage, so, I Googled it (originally a proper noun, now a verb) and stumbled into a quagmire of discussions about the "right" dimension for a double garage. Remember, we're talking about an actual garage, not the ideal airplane-building space (30 feet by 40 feet works well for that) because most of us have to use a structure that does double duty. Eventually the airplane will be finished and the space will revert to holding nothing but cars and other stuff we don't know what to do with. In the search I came to the conclusion that there is no such thing as a "standard" garage dimension. In fact, going to the American Garage Builders site, it says a two-car garage is 18 feet by 20 feet, which I know for a fact is too narrow for standard cars or an SUV and a compact. Yeah,

they fit, but they're crowded. Ask me how I know that: Mine is 18 feet wide (but 40 feet long), and it's far too tight. The minimum should be 20 feet by 22 feet, and if there's any storage down the sides, 24 feet by 24 feet is much preferred. Adding a couple feet to both sides in the initial build won't significantly impact the cost, but the additional room will be very noticeable. If building a wider garage, a 12-, 16-, or 18-foot door will work, but wider is better. Additionally, if at least an 8- or 10-foot door is installed in the back leading to the backyard, the useful nature of the garage increases exponentially, although you then lose part of that wall for storage, etc.

TEMPORARY SPACE

Since most of us are stuck with the garage we have, inevitably there comes a time when, for a short period, we could use more space. Often it is to store finished components. Or maybe to have a separate area to blow paint or sand blast. When we start talking about modifying our existing building or fabricating structures to accommodate short sections of our build, we need to look at our local building codes to know what is likely to get us in trouble. In some cities you can't pitch a pup tent without filing an environmental impact statement. In other areas, mostly rural, you can build a Taj Mahal in your backyard and no one will care, least of all the local township. So, familiarize yourself with your local building codes before

reading the following few paragraphs. Also, if you haven't already done so, familiarize yourself with your neighbors and their attitudes toward your project. If you start building temporary shelters anywhere in sight of them and they don't know why, you run the risk of them filing complaints on you. This would apply to things like a PVC pipe structure covered in painter's clear drop cloth that you're going to use while painting or sand blasting a fuselage. The neighbors would appreciate knowing that won't be there forever.

A couple of points about building codes and possible add-on structures:

Codes aren't the same city to city.

Quite often small sheds are limited to 120 square feet, which is still very usable space. These don't usually need building permits, if they aren't permanently anchored to the ground. A structure that's 8 feet by 15 feet will hold most homebuilt wings. Build it yourself and be creative: match the dimensions to what you want to store or work on. Some cities will allow putting a 20-foot on-deck container in a backyard. They're perfect; the rent is usually reasonable, and you can buy used ones cheaper than you can build a shed. But there's a moving cost, and the neighbors may not like it.

The definition of "temporary" often hinges on whether or not the structures are movable or firmly attached to the ground, so rigging them up with small wheels of some kind may get you out of any kind of restrictions including side yard setbacks, etc.

If it has permanent electricity hooked to the main house power, the city will want an inspection. Run a heavy, homemade, Romex extension cord that plugs into the house temporarily and the city is out of the loop.

Make packing crate-type cubicles with slanted, roofing-membrane tops to store big items. Bolt or screw them together so you can easily disassemble them when finished.

For painting, sand blasting, and other super-short-term activities, think in terms of the aforementioned PVC pipe frame or 2-by-2s joined with plywood or sheet metal gussets using sheet rock screws to hold them together for easy disassembly. Stake it to the ground with DIY rebar stakes (might want to have the city's Blue Stake Crew come look for buried wires and pipes first). Cover with clear plastic sheeting. I made a paint booth in my tiny shop with plastic sheeting that's stapled to the ceiling rafters (through 1/4-inch strips to hold the staples). The sheeting on the walls has 1-by-2s stapled to the bottom for weight. The walls are rolled around the 1-by-2s and tied to the ceiling when not in use.

DIFFERENT MINDSETS AND DEGREE OF FINISH: TIDY VERSUS THE REST OF US

Some folks are just better organized than others and want tidy, well-kept shop areas. Others, like me, rate functionality far above all else. Appearance and worrying about the arrangement of the open-end wrenches are far down the priority scale. I remember a friend who built his dream workshop telling me, "We've only got so much time on Earth; don't spend too much of it building a workshop when you should be building an airplane." He had an incredibly beautiful workshop that took a couple years to build and equip. That so tired him out that he put off starting his airplane and died before he ever got to build anything in it. I think about that every time I walk into the shop: How much time do I actually have left, and how much should be spent building and how much tidying up?

Everything in my shop has "its place," but, if it's a hammer, for instance, its place will be piled with the rest of the different kinds of hammers on the right end of the second shelf from the bottom on the old set of shelves standing in the middle of the floor. That would be below the shelf that holds the series of mismatched plastic compartmented covered trays holding nuts, bolts, and electrical stuff. Below that is the shelf that holds every kind of sandpaper available, both sheet, roll, and adhesive backed. The overall looks are awful, but everything is organized enough that I spend very little time looking for what I'm looking for. The stack-and-pile system works for me, but every time one of my anal friends visits, the seeming disarray makes him break out in hives in less than five minutes. On the other hand, I actually build stuff and he thinks about building but seldom does.

SOME OF US ARE NATURALLY VISUAL: DON'T HIDE STUFF FROM US

Another big dividing factor between shop people is that some of us absolutely have to file our stuff out where we can see it. We're very visual. The instant something goes out of sight into a file drawer, it



I don't plan on using the 3-inch by 8-foot fiddleback, English walnut planks anytime soon. Ditto the practice bombs, so what better place to store them than in the overhead? Where do you keep yours?



Completely finished, painted, and ready to install panels snuggled up in the ceiling where I can't accidentally ding them. The ceiling is the ideal place to store components you don't want scratched. Bigger things, like wings, would require a temporary outdoor weatherproof crate or a 10-foot ceiling (which I have).

might as well be buried in the backyard; we'll never find it again. That's one of the primary reasons I decided not to sheetrock the walls. All of those exposed studs and the hidey-holes between them are golden storage areas in which my primary storage tools are a screwdriver bit in my 3/8-inch Milwaukee and a handful of sheetrock screws, which make hanging something instantaneous. When I'm looking for something I haven't used in a while, I know it's hanging somewhere up on this wall or that wall. And the space between the studs? It's priceless! When you give it some thought, it's amazing what you can store "in" the walls.

I consider the open ceiling and its rafters to be the equivalent of overhead floor space: It's just like the floor, but you only put stuff up there that you won't be using for a while. Stuff like 3-inch walnut planks, 100-pound practice bombs, and, more important, components of the project at hand that are finished and painted but you want them somewhere that they can't be damaged. The 14-inch ceiling rafters are perfect for that. Also—and this is important—a 10-foot ceiling will let you sling completed wings and such from the overhead. In small shops, this is a big deal!

Of course, if you're unlucky enough to live somewhere that has winter, all that wall and ceiling storage is probably better sacrificed for the installation of effective insulation. There's nothing worse than a cold shop.

By the way, not sheetrocking the walls and ceiling greatly increases the building's vulnerability to fire, and I seriously considered sheetrocking it for that reason alone. However, I decided to put in a sprinkler system instead. DIY system parts are plentiful, and the only hassle was running a cold water line in, but it was worth it for the peace of mind.

Incidentally, a side thought in my head when I'm hanging tools, etc. on the walls is that there is some shop-type stuff that I just like to look at. So, I view some of the wall areas as "look at" walls: look at what I found! It's a small exhibit of what I think is neat stuff. So, I work a little harder at arranging those. But, not much.

Yeah, I know the majority of you have tidy, orderly-as-an-operating-room workshops. But, right now I'm betting there a number of you reading this who are relieved to find that it's okay to look sloppy as long as you really aren't sloppy. There's a difference between being sloppy and being orderly-in-a-relaxed-fashion. Sloppy can breed sloppy work, which we don't want, and you spend too much time looking for things. Orderly, regardless of its form, breeds progress, completion, and good craftsmanship. And those are our goals. *EAM*

Budd Davisson, EAA 22483, is an aeronautical engineer, has flown more than 300 different types, and has published four books and more than 4,000 articles. He is editor-in-chief of *Flight Journal* magazine and a flight instructor primarily in Pitts/tailwheel aircraft. Visit him on www.AirBum.com.

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BLIND RIVET STEM REMOVAL

BY DAVID GRIFFIN, EAA 647967; TEGA CAY, SOUTH CAROLINA

FACED WITH THE challenge of removing more than 200 countersunk 1/8-inch blind rivets from a wing skin that we needed to salvage, I decided that the only possible way to drill out the aluminum rivet heads was to first remove the remains of the steel center stems. If you don't remove the steel stems, it will force the drill bit off the center of the rivet. It was not possible to reach the rear side of the rivets. I enlisted the aid of my friend Les Kanna, EAA 440272, to make a simple fitting that would be located at the end of a standard pneumatic rivet gun and help drive the stems through. The adapter was made from a 2-inch long piece of 1-inch aluminum bar drilled out at one end to fit the barrel of the rivet gun and the other to suit a rivet stem that we used as the punch.

This simple device worked real well, and I could then use a drill slightly smaller than 1/8 inch to remove the rivet without enlarging the original hole. Air pressure should be kept to less than 30 psi to avoid the device jumping and leaving marks on the skin. Use light drill pressure to avoid spinning the rivet in the hole. *EAA*



DRILLING CANOPY BOW

BY RANDY HOOPER, EAA LIFETIME 119586; HERMITAGE, TENNESSEE

I AM BUILDING THE FINISH kit of an RV-8, my current project. At this stage I'm preparing the canopy and frame for drilling rivet holes. I know to minimize stress to the Plexiglas the hole should be centered at the point where the Plexiglas and round steel tube touch.

When you clamp the Plexiglas to the steel tube you might see what looks to be a gray line running away from the clamp. This is actually not a line but an impression that appears where the two materials touch. Unfortunately, this line doesn't always present itself, so I had to come up with some other way to tell exactly where the Plexiglas touches the canopy frame. To find that point in the absence of the gray line, I cut a strip of thin paper and colored the end for contrast. To find the point of contact, slide the paper in between the clamped Plexiglas and tube as far as it will go and mark the end of the paper to indicate the point of contact. For the paper thickness I used, it came within one-half diameter of a No. 40 drill bit to the actual point of contact. The paper then allowed me to determine where to drill the hole.

LANDING GEAR • WHEELS & BRAKES

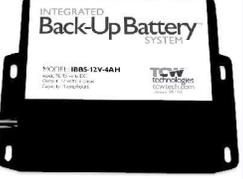


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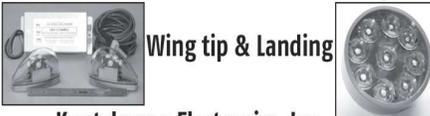
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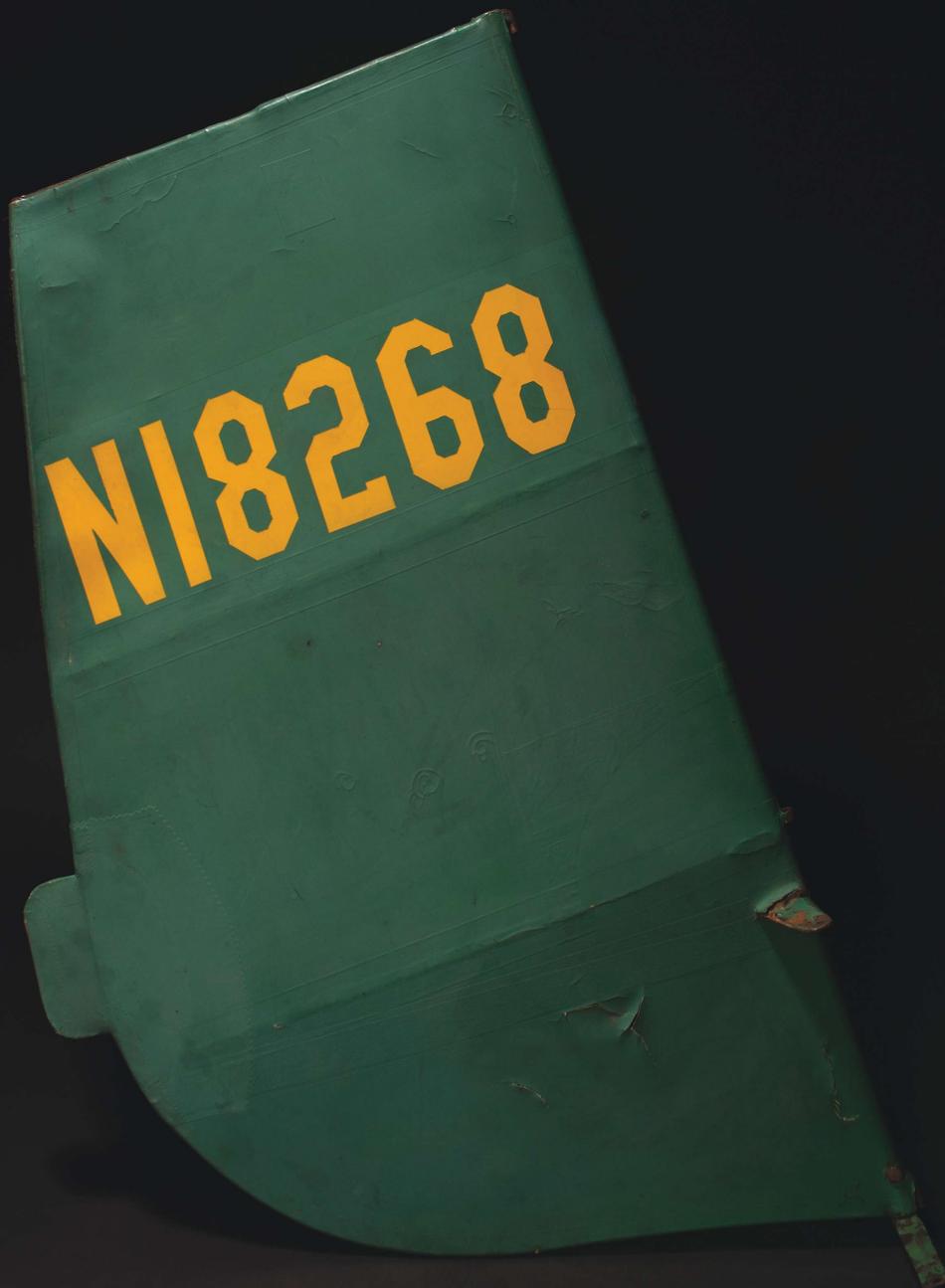
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