TSUNAMI

by ***JACK COX***

The May 1983 issue of **Sport Aviation** contained an article (page 47) on a new homebuilt Unlimited air racer with a real tongue twister for a name — "Tsunami", the Japanese word for "tidal wave". Since most of you live well east of the Pacific rim's seismic activity and, thus, aren't regularly exposed to terms such as "tsunami", the phonetic spelling is "sue-nom-ee". You wouldn't believe how many other incorrect (and hilarious) ways we've heard it pronounced in the last three years!

Tsunami was big news for the EAA world in 1983 because it was the first totally original **homebuilt** Unlimited racer since 1939. As such, it appeared to finally answer the question so many had asked since the World War II surplus fighter had taken over Unlimited air racing in 1946 . . . "What if you took a Rolls-Royce Merlin engine and built the smallest, lightest and sleekest airframe around it you could possibly dream up . . .?"

The article's good news was that Tsunami was no mere hypothetical question — metal had already been cut and some components, like the outer wing panels, were, indeed, already completed. A good portion of the article was devoted to the people behind the project, with emphasis on the fact that it was doubtful if a more uniquely qualified team could have been assembled. The owner of the airplane, its financial backer, engine builder and, of course, prime mover was John Sandberg, a Minneapolis industrialist (who now lives in Reno, Nevada). Tsunami's designer was Bruce Boland, a Lockheed aerodynamicist and structures engineer, who was ably assisted by Pete Law, a Lockheed thermodynamicist who would design the airplane's carburetor, water injection and cooling systems. A third member of the team was Ray Poe, enticed out of retirement from Lockheed by the challenge of creating

Rafe Tomsett

The Future Is Here In Unlimited Air Racing

the world's fastest piston engined, propeller driven airplane. Ray, with the expert assistance of Tom Emery who would join the group after the 1983 article was written, would become the principal builder of the airframe. Significantly, the team of Boland, Law and Poe had been a sort of technological brain trust for air racing ever since the modern era began at Reno in 1965, lending their expertise to about every Unlimited that had taken the checkered flag in subsequent years. Both Darryl Greenamyer's legendary Bearcat and the Griffon powered Mustang, the Red Baron, Reno winners and world absolute speed record holders, had strong Boland/Law/Poe involvement. Tsunami, however, was their opportunity to put all their knowledge, experience and skills together to create the race of their . . . and, vicariously, about everyone else's dreams.

Tsunami would be a very simple, strictly conventional airplane . . . one that borrowed heavily from the racers of the past. It would be an all-metal, Rolls Royce Merlin powered machine that in layout combined the best features of the P-51 Mustang and the pre-World War II Heston Napier Type 5 racer. It would have a span of 27.5 ft., a length of 28.5 ft. and a frontal area of just 9.8 sq. ft. — compared to 12.6 for a Mustang. The projected empty weight was a little under 4,000 pounds and the gross was calculated to be 5,100 pounds. It would be a taildragger, utilizing a Piper Aerostar main gear fitted with Learjet wheels and brakes and a tailwheel liberated from a P-51H. The Merlin engine would turn a special propeller consisting of an Aeroproducts hub and four shortened T-28 blades. Behind it would be three fuselage tanks, one holding 50 gallons of high octane racing fuel, another holding 45 gallons of water for the spray bars that help cool the radiators and the third one holding 45 gallons of water and methanol to be sprayed into the induction system to prevent detonation (the so-called "ADI" — anti-detonation injection). Behind the tanks, almost back in the Gee Bee position, would ride the pilot under a small sliding canopy . . . and, behind him, the Siamesed oil and coolant radiators fed air by a smaller version of the Mustang's belly scoop. The big vertical fin would double as the oil tank, providing some surface cooling.

The idea behind the Tsunami was to have such a small, light and clean airframe that a simple, essentially stock Rolls Royce engine could be used to get the desired performance — rather than the souped up, very highly stressed, very short lived Merlins used in the typical Mustang racer. The airplane was to be used to race at Reno and to break the 3 kilometer land plane absolute speed record of 499 mph set in 1979 by Steve Hinton in the Red Baron, and the seaplane record of 440.681 mph set in 1934 by Italian Francesco Agello in a Macchi-Castoldi MC-72. A pilot to be named would race the airplane but owner John Sandberg would try for the absolute speed records. Although highly experienced, John was flying on a Private pilot's license and wanted the world's speed records to be held by a "non-professional" pilot.

Two things in the 1983 article would go awry. When **Sport Aviation** visited the Tsunami shop in February of 1983, the expectation was that the airplane would be completed and flown that summer and would be ready to race in September. For a variety of reasons that proved to be a wildly optimistic time table — off, as things would transpire, by a full three years! There were unforeseen problems, of course, such as the fact that in midstream the entire project, with all its tooling and equipment had to be moved to a new shop, but a lot of the delay stemmed simply from the need to do a lot of detail design and, often, redesign of the basic structure to accommodate the various systems . . . **while construction was in progress**. This was an entirely new airplane and the learning curve was quite steep on it. If another one were built, it would go much, much faster, of course.

The other variable encountered during the course of construction can be expressed in one word — "Dreadnought". Frank Sanders' big R-4360 powered Hawker Sea Fury erupted onto the racing scene in 1983 and pushed the speed/endurance equation to a new, higher level than it had ever been before. No longer was it possible for the hot Merlin powered racers to spring to an early lead, then back off a bit to save their engines for the remainder of the 8 laps of racing. The Dreadnought's enormous Pratt & Whitney radial cranked out so much brute horsepower and was so reliable that it could go full bore for the entire race, and anyone who hoped to beat it would have to do the same thing. This forced John Sandberg and his crew to re-evaluate their plans to use a simple Merlin with a single stage blower in favor of an all-out race engine. The idea still was to be able to win at relatively modest (by racing standards) power settings . . . but the ante had been raised by the Dreadnought. To put this talk of power in some perspective, the Packard built Merlins used in the P-51 produced normal rated power at 2700 rpm and 46 inches of manifold pressure. Take-off power was 3,000 rpm and 61 inches. The throttle quadrants had a stop or "gate" that could be bypassed to get a "wartime emergency" output of 67 inches. Reno race crews are understandably closemouthed about their actual performance numbers, but it is common knowledge that the very fastest Merlin powered racers turn as much as 3,900 — possibly 4,000 — rpm and pull up to 120 inches of manifold pressure! Needless to say, few, if any, have ever flown an entire 8 lap race at that power. The problem these days is that the R-4360 powered Dreadnought has set a qualifying record of 452 mph around the Reno race course pulling just 74 inches and 3,000 rpm . . . and, apparently, can run that hard for as long as is necessary. It's simply a matter of cubic inches — 4,360 in the big 28 cylinder Pratt & Whitney radial versus 1,650 in the V-12 Packard/ Rolls Royce. This is the arena into which the Tsunami has been thrust . . . attempting to do with aerodynamic finesse what the Dreadnought does with brute, bludgeoning force.

And . . . this was the year.

The airframe components were constructed in a small rented shop near the Van Nuys, CA airport but the plan was to transport them across the LA basin to the Chino, CA airport for assembly at Steve Hinton's Fighter Rebuilders' shop. This was particularly appropriate, because last year it was announced that Steve would be Tsunami's race pilot. Now, he would also be its test pilot.

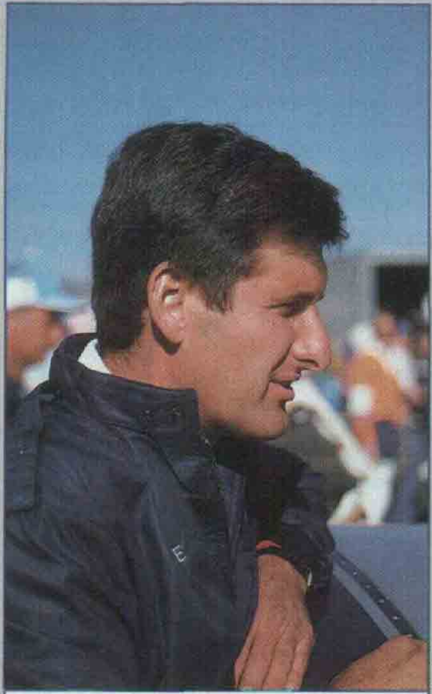
The fuselage was moved to Chino in May and the rest of the airframe in June . . . at which point Steve put 8 people to work six days a week assemblying the airframe, making and installing the various systems, fairings, gear doors, etc., etc. This was in addition to Ray Poe and the after work hours and weekend time of Bruce Boland and Pete Law . . . plus John Sandberg who practically moved in with Steve Hinton's family during the succeeding three months until Reno. Finally, on August 9, the engine was fired up for the first time in the airframe and on Sunday, August 17, the racer was flown for the first time.

The first flight, while certainly a milestone, ultimately came to be overshadowed in the minds of the Tsunami crew by the events that transpired over the next 21 days . . . the amount of time they had to get the airplane to the Reno Stead race site ready to do battle with the likes of their across ramp rival, the Dreadnought. That huge hairy beast had been sitting in a corner of the Sanders' shop ready to race and with its new pilot, Rick Brickert, fully checked out since late May!

Three weeks later at Reno I had the opportunity to interview most of the Tsunami principals. The story of their 21 day ordeal is perhaps best told in their own words and from their own viewpoints. Since it all began with the first flight, we'll start with the man in the front row seat, the pilot, Steve Hinton.

STEVE HINTON

Steve Hinton has been on the Unlimited air racing scene for so long and has been so much in the forefront of the events of the past decade that it comes as somewhat of a shock when we remind ourselves that he is still just 34 years old. Just 34 . . . yet he has been the Unlimited National Champion twice, has been the holder of the world's absolute speed record (499 mph) for piston engined airplanes since 1969, has survived the horrendous crash of the record holding Griffon powered Mustang, the Red Baron, and has developed one of the world's most successful warbird restoration shops, his own Fighter Rebuilders, located on the Chino, CA airport adjacent to Ed Maloney's Planes of Fame Museum. It was through Maloney (who is his father-in-law today) that Steve was introduced to the world of warbirds and big time air racing. He, Maloney's sons and a seemingly never ending stream of youthful airplane crazy volunteers literally grew up spending every moment of their spare time rebuilding, maintaining and flying the museum's fabulous collection of largely World War II fighter aircraft. An airline pilot for a time, Steve would ultimately formalize the famed "Chino Kids" system into a business so successful that it is his sole occupation today. Fighter Rebuilders is the major contractor for the restoration of Planes of Fame aircraft and does restorations for private individuals as well. Normal production is 3 to 4 warbirds per year. Over the past four years, Steve and his 10 employees have turned out like new reincarnations of Thunderbolts, Mustangs, Corsairs, a TBM and a B-25, among others. The R-4360 powered Supercorsair in which he won the Unlimited national championship last year, was built up from a fuselage of a Corsair that had not flown since World War II . . . and parts and pieces scrounged from all over the world . . . modified to clipped wings, the big Pratt & Whitney engine and its special cowling, plus all the spray bars and other systems necessary for racing in just four months!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STEVE HINTON

". . . it's like flying a Wildcat with a Bearcat rudder."

Steve gets the job done in record time by literally throwing manpower at the task at hand. Aircraft restoration is among the most labor intensive of mankind's endeavors, and he meets the problem head on. This is precisely what was done to the Tsunami once its major components were delivered to the Fighter Rebuilders shop.

"What we did was we injected 8 guys 6 days a week on the airplane," Steve told me. "It was a lot of finishing up — we reskinned the bottom of the wing, did the final assembly, put in all the systems, the wiring, hydraulic — built all that stuff and the gear doors, fillets, etc. — put it all together and flew it. We were able to get it done quickly because we had experienced workers and the really top design guys in people like Bruce Boland and Pete Law to work with. They would come up with an idea and everybody would kind of brainstorm it and we'd come up with an application. Believe it or not, we go around the museum and look at the airplanes there to see how things were done — and you'd be surprised how the lights come on. In our systems — hydraulic valves, linkages, etc. — we've got SBD parts, Corsair parts, Mustang parts in the Tsunami. It kinda simplifies things to have off the shelf parts, so that if you ever have a problem with something, you don't have to go back to the shop and build the part — you just replace it."

Commenting on the first flight, Steve said, "There were no major problems. The angle of incidence on our horizontal stabilizer wasn't at the optimum position, so I had to fly it with a little forward stick pressure, but that was easy to fix. Later, as we progressed up through the performance envelope, we found the rudder to be 'way too light. We've made a number of modifications to stiffen it up and we are pretty close to being happy with it. The ailerons and elevators stiffen up real nice at speed and the rudder's pretty light — it's like flying a Wildcat with a Bearcat rudder on it. We're trying to get the control harmony up to where it all feels the same, so it makes it a little easier to fly. One day we took off and the electric trim motor broke . . . that was a little interesting . . . but I've never really had a nasty minute with it. It's been a great airplane, it's easy to fly. When we got up into our higher speed range, above 300, and began doing our flutter testing, we weren't happy with our aileron control system so we redid that — went from cables to pushrods . . . in about a day of actual fabrication work. The airplane stalls nice, shows no nasty habits at all. Stalls at 95 knots, clean. Accelerated stalls depend on the Gs, naturally, but it does the same thing every time. That's a real tribute to the guy (Bruce Boland) who designed the thing. It's really nice."

Asked how it handled on the ground, Steve replied, "People always ask me that — they think it looks really terrible (meaning Tsunami appears short coupled), but it's really easy — flies a lot like a Navy fighter except for the touchdown speed. By that I mean it has a lockable tailwheel and you steer it with the rudder and when you slow down, with the brakes. It has a high enough wing loading and such an effective rudder that it handles a crosswind nicely. It lands a little fast because we don't have flaps on it yet, but that's no problem."

At the time of our interview, Steve had practiced on the Reno race course and had qualified, but had done no actual racing. I asked how the airplane felt and reacted on the pylons.

"It feels good — it turns real good. It's like a big airplane — you can back the airspeed up if you want to. If you pull a lot of Gs, it'll really slow down, so you've just got to watch how you fly it. It's more fun to be real tight, fly 90 degree turns and stuff, but when you watch the airspeed indicator, you realize that's not the way to do it."

I asked, given his limited time in Tsunami, how it compared to the Red Baron.

"Well, despite what you can hear about the Red Baron, if it were here at Reno today, it would still be the one to beat. To me, it had all the desirable qualities of a real way overpowered race plane. I'm still learning as I go with this one (Tsunami) . . . you know, I ran the Red Baron in 5 or 6 races and felt real good in it . . . and I'm sure I'll feel the same way with this after we've had time to develop it more. I just can't think of any nasty habits it has . . . which is really something with it right out of the box."

I also asked how hard he had run Tsunami to that point. Steve just smiled and said he'd seen 90 inches and had been over 500 mph . . . in fact, had been over that mark right over the top of the Reno Stead airport the evening before . . . but he hoped to be able to tell me more about performance after the racing was over that coming Sunday evening.

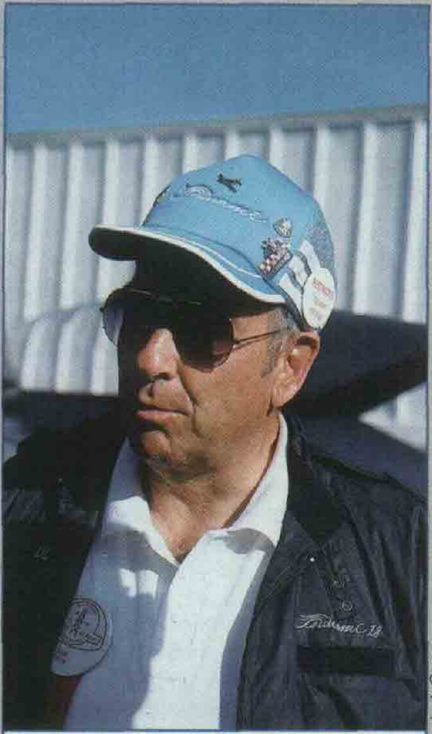
BRUCE BOLAND

Then it was the designer's turn. Bruce Boland, as many will recall from the profile on him that appeared with the 1983 Tsunami article, is a native of Brooklyn, NY who got his engineering degree and headed west to go to work, ultimately, in Lockheed's "Don't Ask What I Do" department. He got involved with air racing soon after it was established at Reno and, with fellow Lockheed employees Pete Law and Ray Poe, became a sort of "have gun, will travel" problem solving authority, called upon at one time or another by almost everyone in air racing to help make their racers go faster. Name a winning racer of the past and odds are that the Boland/Law/Poe involvement was a key factor in its success . . . and walk among the airplanes in the Unlimited pits at Reno today, reading the "credits" painted on them and count how many times Bruce and Pete are included as aerodynamic and systems consultants.

Recalling the 1983 article, I asked Bruce what changes had been made during the construction of Tsunami . . . from the original concepts of three years ago.

"The first thing I can think of is the elimination of the oil tank from the vertical tail. At one point we were going to use the same design philosophy as the Supermarine S6B and use the vertical fin as a combination oil tank and oil cooler. Once we got into the program, however, we realized it was an impractical concept — for two reasons. The expansion and contraction of the skins would eventually cause a fatigue problem, and, on a more mundane level, we simply couldn't get bucking bars inside

Two views of the unpainted Tsunami taken the weekend of its first flight by EAA Foundation Director Jimmy Leeward. An air racer in his own right, Jimmy was the winner of this year's Unlimited Silver Race at Reno in his modified Mustang, the Leeward Air Ranch Special. His son, Dirk, also raced, making the two the first father/son duo in Unlimited air race history.



Jack Cox

BRUCE BOLAND

"That's what's fun about this airplane - we're trying a lot of different theories to see if they really work . . ."

to rivet the internal baffles. Also, we realized that if we ever had a leak, it would be a bear having to remove the whole tail to repair it. So, we ended up using a conventional oil tank that for C.G. considerations eventually ended up right behind the firewall. Otherwise, the airplane was completed and flown essentially as it was originally conceived. There were some changes after it was flown and before we brought it to Reno."

Some of the "changes" Bruce referred to that came after the first test flight were actually adjustments of various components, but we'll deal with them all together.

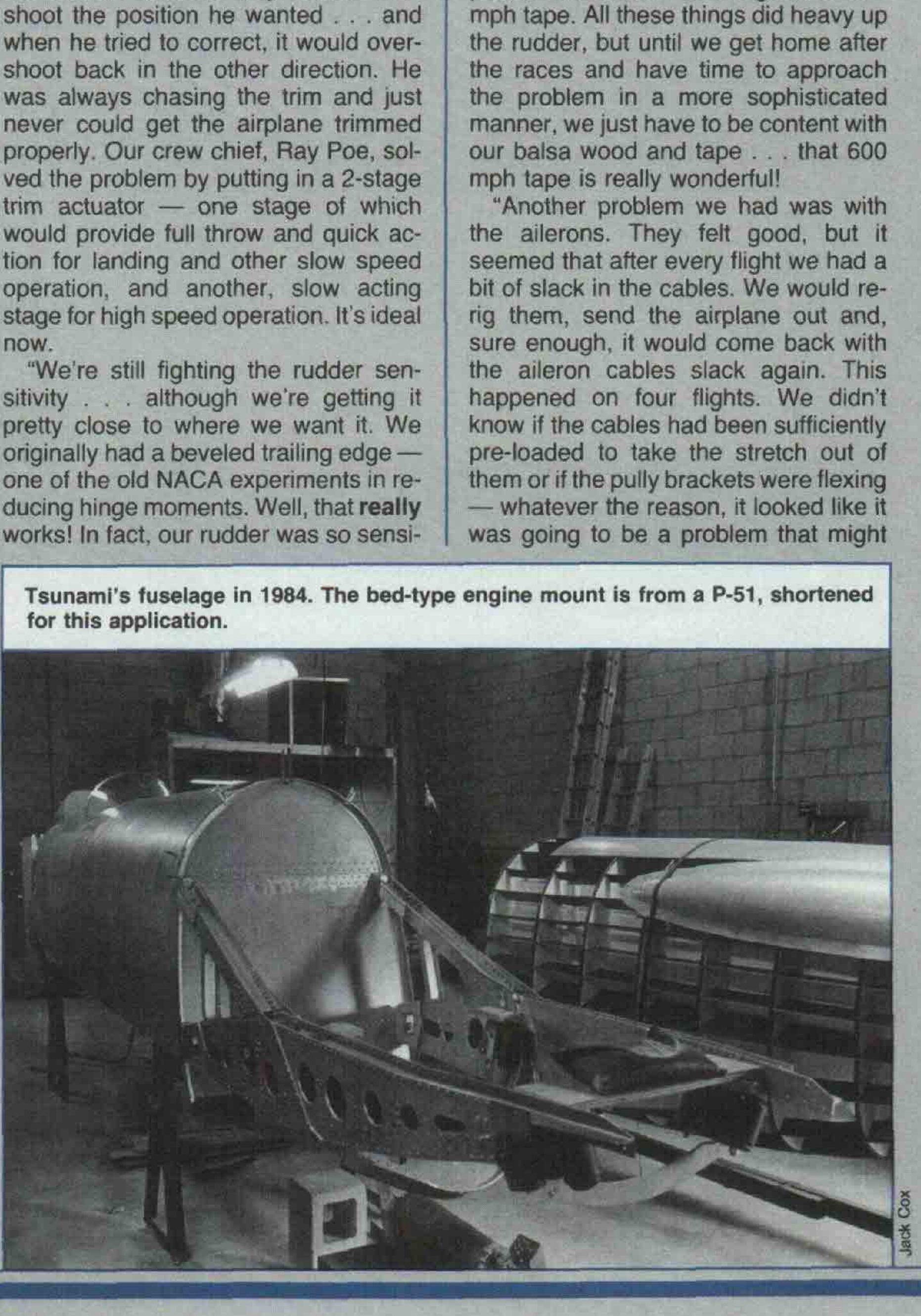
"Our first problem was that the tail incidence was incorrect — which is something you always find out in flight tests. There are empirical formulas you follow that involve the airplane's geometry, down wash, etc., to estimate where the tail incidence should be, but you don't **really** know until the first test flights are made. In our case, Steve had to hold quite a bit of forward stick on the first flight, so we ended up making about 4 changes in the (fixed) stabilizer setting until we got it where it would trim out the way we wanted it — out to zero for the most part. Incidentally, the distance between the wing and the stabilizer and the angle of incidence of the wing and the angle of incidence of the stabilizer are very, very close to that of a Grumman Bearcat. I wish I had realized this earlier and, in fact, I should have, having worked with Bearcats (Greenamyer) for a long time. Knowing the location of the engine thrust axis, etc., and the short coupling of the airplane, I should have noticed how similar it was to the Bearcat. When we finally got the incidence angle of Tsunami's tail worked out, it finally occurred to me.

"Another thing that cropped up was extreme sensitivity of the elevator and rudder. At first, you are more concerned with pitch stability — you can always control directional stability with your feet — so we began looking into the pitch trim system. What it turned out to be was that the electric trim tabs on there just operated a little too quickly. Every time Steve would make a trim input with the electric motors, they would overshoot the position he wanted . . . and when he tried to correct, it would overshoot back in the other direction. He was always chasing the trim and just never could get the airplane trimmed properly. Our crew chief, Ray Poe, solved the problem by putting in a 2-stage trim actuator — one stage of which would provide full throw and quick action for landing and other slow speed operation, and another, slow acting stage for high speed operation. It's ideal now.

"We're still fighting the rudder sensitivity . . . although we're getting it pretty close to where we want it. We originally had a beveled trailing edge — one of the old NACA experiments in reducing hinge moments. Well, that **really** works! In fact, our rudder was so sensitive that Steve couldn't keep the ball centered. We first removed the beveled trailing edge and put on a straight edge about 2 inches longer. That gave us a quantum jump forward in directional stability, but, now, right around zero rudder deflection there was a null, a dead spot, that was very annoying at medium speeds. We tried a number of things to eliminate the null. We put a trip wire on there, thinking that if we had a flow separation problem, that would handle it . . . well, it did not. So, we thought either the trip wire was not powerful enough to induce turbulent flow . . . or we don't have a separation problem. We were getting very close to Reno by this time, so we tried a multiple approach — we installed vortex generators ahead of the rudder, put some wedges on the trailing edge and some ramps ahead of our aerodynamic balance horn — the latter two done with pieces of balsa wood and good ol' 600 mph tape. All these things did heavy up the rudder, but until we get home after the races and have time to approach the problem in a more sophisticated manner, we just have to be content with our balsa wood and tape . . . that 600 mph tape is really wonderful!

"Another problem we had was with the ailerons. They felt good, but it seemed that after every flight we had a bit of slack in the cables. We would re-rig them, send the airplane out and, sure enough, it would come back with the aileron cables slack again. This happened on four flights. We didn't know if the cables had been sufficiently pre-loaded to take the stretch out of them or if the pully brackets were flexing — whatever the reason, it looked like it was going to be a problem that might

Tsunami's fuselage in 1984. The bed-type engine mount is from a P-51, shortened for this application.



Jack Cox

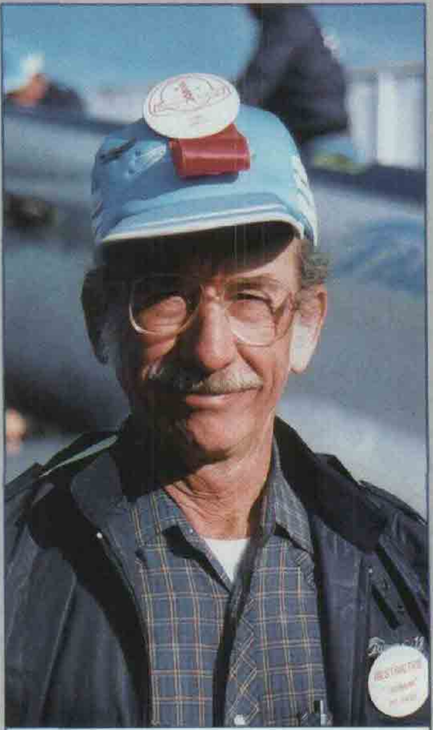
continue to plague us, so we decided to replace the cables with a push-pull tube system . . . and this occurred literally overnight. Initially, we had planned to use the push/pull system for the ailerons, but thought afterwards that if we decided to install flaps, the actuating systems would be vying for the same space in the wing. When the cable slack showed up, we looked at some of the other airplanes in the Planes of Fame Museum, like the P-40, Yak 11 and a T-33 and found they all had a sliding push/pull tube set-up that, if used on the Tsunami, would easily leave room for flaps. We finally decided to make the switch and after figuring out all the bell crank ratios, we had about five guys willing to work around the clock to install a push/pull system. The airplane went down one afternoon about 4:00 p.m. and by the evening of the next day, it was ready to fly again!

The push/pull actuating system seemed to solve the problem with the ailerons — there was no more flexing. It had been quite annoying for Steve because each time he flew the airplane with the aileron cables, it had a different feel. That's behind us now, however. Steve says the ailerons are heavy but extremely responsive. This was our intention — to have a large surface deflected a very small amount to get a very high roll rate. With the small wing on this airplane, the aerodynamic and inertial damping are minimal, so it does roll very well. For want of a better comparison, Steve describes Tsunami as an airplane with all the feel of a Grumman Wildcat, with a Bearcat rudder. The ailerons, themselves, are actually a few square inches larger than those on a stock P-51, but they're shaped a little differently."

Asked about the landing gear, Bruce said, "We used a Piper Aerostar main gear, turned around so the axles are inboard, and we use Learjet wheels and brakes. This provides us with a very large braking capacity, enough that we were able to set the airplane up like a Navy fighter — using the brakes for steering. The tailwheel is lockable but not steerable. The main gear wheel wells are very limited in space so we have to shave rubber off the tires to get them into the wells. We brought several sets of shaved tires with us to Reno, just in case, but, so far, the set we are running on the airplane seems to be holding up well. The tail gear, itself, is from a P-51H, but the tail wheel is a tail bumper from a Grumman S2F. This bumper has become the standard replacement for the original solid rubber tailwheels used on Hellcats and Bearcats. The original is no longer available, so the S2F bumper is the best alternative. We found, however, that using the full size bumper, we could get only about six landings before it would begin shedding a lot of rubber. It was experiencing a very high shear force at touch down and it would just delaminate the rubber on the tire. After the 12th test flight, we decided to shave off all except about a half inch of rubber and that seemed to be the solution. We've got about 25 landings on our shaved tailwheel and it is holding up well. We have a pneumatic tire we'll try when we get back home from Reno."

When I interviewed Bruce for the 1983 article, we discussed at some length the ultimate limiting factor for Tsunami — the propeller. When a propeller driven airplane is as near the sonic barrier as Tsunami and, in fact, most of the hotter Unlimited racers are today, just a very narrow performance band remains in which speed gains can be made . . . and the prop is about as often the brake that begins to slow the racer as it is the means for going faster. As soon as the tips begin achieving supersonic speeds . . . which varies greatly with differing atmospheric conditions . . . the airplane begins slowing down. I asked Bruce for an udpate on this situation as it related to the Tsunami, with particular emphasis on looking ahead to next summer's absolute world speed record attempt.

"This propeller uses four T-28A blades, which are the same design, have the same chord and came from the same blank as the P-51H blades. In fact, the T-28A, P-51H and F8F propeller blades are all from the same blank. The diameters vary depending on the power requirements and rpm range. Our diameter is 10 feet 2 inches compared to 11 feet 1 inch on the P-51H, but the blade chord and twist are the same. We feel that with reduced gear ratios and the reduced diameter of the propeller, we can run at a reasonable rpm and keep the Mach number down at the tips. I think this prop is probably good up to about, maybe, 530 to 540 mph on a very hot day. Most pilots cringe at this because they associate



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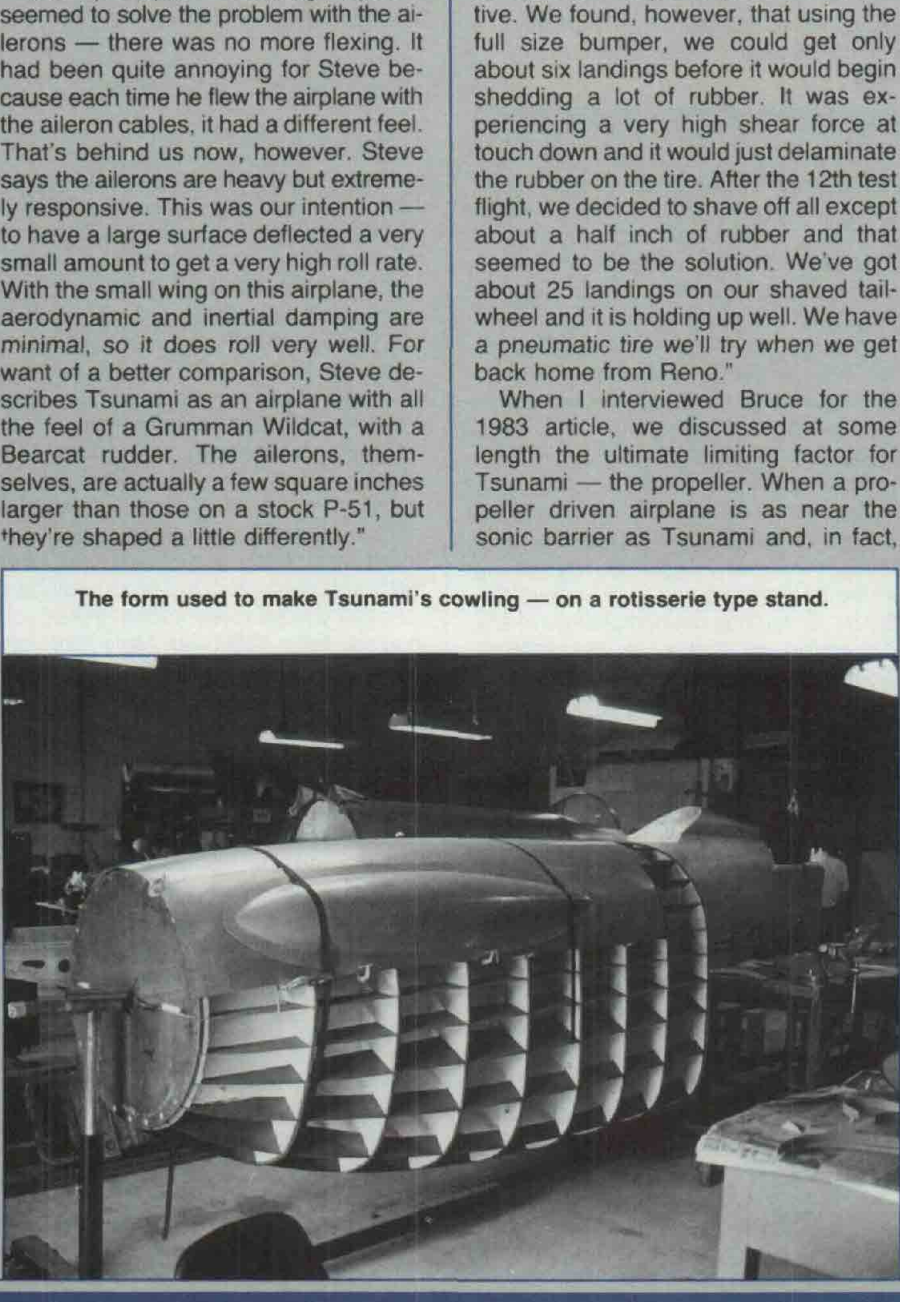
RAY POE

Ray, with the assistance of Tom Emery, was the principal builder of the Tsunami airframe.

The form used to make Tsunami's cowling — on a rotisserie type stand.



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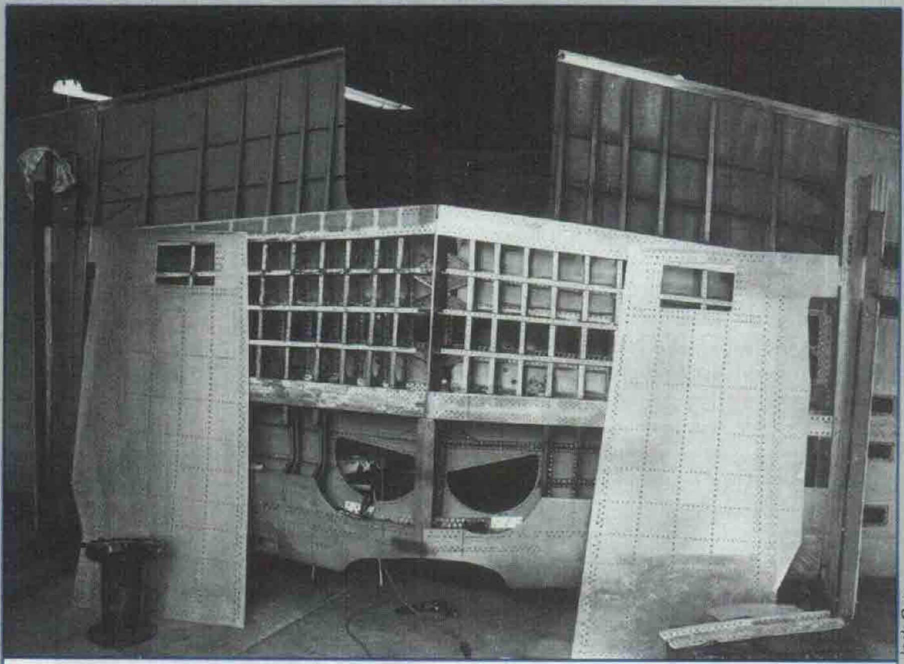
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A good idea of the work — and fine craftsmanship — that went into Tsunami's structure is evident in this shot of the wing center section . . . taken, incidentally, in June of this year, just 3 months before Reno!

high ambient temperature with lowered horsepower. But for a speed record, what we prefer is the hottest possible day because we want to keep both the airplane Mach number and the propeller Mach number low. We can do this because we can control the induction temperature. All the engine knows is induction temperature — it doesn't know how hot it is outside — and we can control that with old devices like water/methanol (ADI) and nitrous oxide injection. You could run a P-51H propeller with a .42 reduction ratio probably to about 3,500 rpm on a, say, 75 degree day and you'll be free of sonic effects. Anything beyond that, you'd probably notice a slowdown in the aircraft. But if the ambient temperature is on the order of 90 degrees, you could run a little harder — 3,600 rpm, perhaps 3,800, but at some point you're going to notice the airplane slowing down with an **increase** in power. The efficiency of your prop is dropping off as the tips are starting to go supersonic. That's the result of the forward speed of the aircraft and the rotational speed of the propeller — it's a vector, the sum of the two."

Other features of Tsunami we discussed included things like the sealing of the cockpit . . . and the flush NACA carburetor induction inlet on top of the cowling.

"We had intended from the beginning to seal the cockpit from the rest of the aircraft. As anyone who has ever been in a P-51 knows, the bottom of the cockpit is the top of the wing. There is no seal (between the two) at all — you're exposed. Any fumes you might get from fuel, the engine, oil or exhaust . . . or even the steam you get when you turn on the radiator spray bars, comes right into the cockpit, making it a very uncomfortable environment. Our intention from the beginning was to seal this cockpit and take air from an area we think would be very clean. We have a small inlet at the top of the vertical fin and we take a little hose and run it forward from there to an eyeball outlet inside the cockpit. The idea is to pressurize it maybe a tenth of a psi over pressure, utilizing the forward ram effect of the aircraft. This way, any leaking in the cockpit is going to be **outwards**. So far, Steve has not complained of any discomfort or fumes in the cockpit. There's a nice circulation of fresh air — it's warm, but it's moving and it's nothing like the heat in a Mustang. We want our pilot to be comfortable — and have nothing to worry about except flying the airplane.

"We've been fortunate in that in this action packed test period since the first flight on August 17, every modification we have made has been positive. Every one has improved performance . . . we've never done anything that has been a step backwards that we've subsequently had to take off. Even the purely experimental NACA flush carb inlet we have on top of the engine works at high angles of attack where we had some doubts about it. We did have to work on it, however. We knew we might not get as much ram effect as you would with a P-51, so none of our calculations assumed any ram. We wanted to keep the profile of the airplane down by eliminating every protuberance we could, so that's why we went with the NACA type flush inlet. Steve did notice that at high angles of attack . . . in a high G turn, 4 Gs or above . . . he got a drop-off in manifold pressure; 4 to 5 inches, which I think is a lot. There was, nevertheless, no decrease in speed and as soon as he rolled out of the turn, the lost manifold pressure immediately returned. To try to eliminate this, we taped some little balsa wood fences or strakes on both sides of the trough leading down into the inlet, using the 600 mph tape we used on the Lockheed L-1011 and other fast airplanes. Apparently it worked, because when Steve flew the airplane yesterday, he did not get the reduction in manifold pressure in the turns. **That's what's fun about this airplane — we're trying a lot of different theories to see if they really work or whether they are a lot of bull. So far, a lot of it is proving out."**

PETE LAW

Next up was the systems man, Pete Law. The first time I met Pete was in February of 1983 when he came bounding into the Tsunami shop with what looked like a Sears catalog under his arm. I later found it to be a computer readout for the racer's cooling system. I reminded him of that this year at Reno and with a chuckle he retorted, "Now I've got **two** books that size on it!" I cannot overemphasize how important those rows of, to me, undecipherable numbers are to the success of an Unlimited racer. You simply cannot run these old piston engines at well over twice rated power if you can't cool them . . . and you can't win races unless you can run them that hard. More than any other single person, Pete Law is responsible for the over 100 inches of manifold pressure operation common to the Mustangs that race at Reno. His water injection (ADI) systems, the work he and a couple of associates he has trained do on carburetors on his flow bench, and the numbers he runs for owners to use in having their coolant and oil radiators built are the standards for Unlimited air racing. Further, his involvement is just starting when he agrees to help another owner.

"When I sell a water injection system, it's warranted for life, effectively, and I come with the warranty."

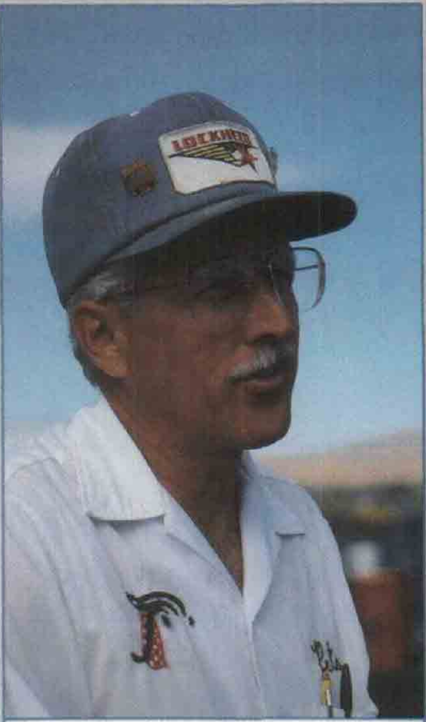
Pete made that statement tongue-in-cheek, but observing his dashing hither and yon in the pits at Reno, you wonder if it isn't completely true. The purpose of water injection on Unlimiteds is to keep induction air temperature below a level at which destructive detonation can occur . . . and, obviously, a big variable is ambient temperature. The cooler it is, the less water injection is needed and, conversely, the hotter it is (and the higher the power setting), the more water injection is needed. This situation is handled by varying the size of the jets in the injection system . . . and Pete scurries around the pits, sling-type thermometer in hand, and **personally** sets the jets on (this year) about 15 different racers! It's a terrible problem . . . and a terrible responsibility.

The problem is that most of the racers are based . . . and do most of their test flying . . . in low, hot places like Los Angeles, Bakersfield and San Francisco (well, at least it's low there), then fly up to Reno to race at nearly a mile above sea level — in an area notorious for drastic day-to-day temperature changes. It can be in the 90s during qualifying at Reno and snowing by the weekend when the Championship races are run . . . which drives owners and Pete Law up the wall trying to get the ADI jets properly set for conditions on race day.

The responsibility is a ton to shoulder because a miscue can result in a $30,000 plus engine being almost instantly reduced to scrap by detonation.

Pete's part in the design of the Tsunami included coming up with the numbers for the design of the oil and coolant radiators, building the water injection system and the carburetor. He had the following to say about each:

"The radiator was designed to my specifications by Rick Korff of Niagara Development Manufacturing in Niagara Falls, NY. He used to work for Harrison but when that firm decided to get out of the radiator business, he and some other guys bought out the Harrison rights and formed their own company. I told Rick what I wanted and what size envelope we had and asked him to send me a few options to choose from — along with their performance curves. He did and after a few iterations, he came back with a radiator that looked like it would work. It is a coolant radiator with an oil cooler built right into the side of it. The coolant portion is about the same physical size as a P-51 radiator — it's an inch deeper — and contains about the same volume of coolant, but it has about twice as many fins per inch. It has less in the way of tubes for the coolant to flow through but more heat transfer surface area. The oil cooling section also has more fins per inch — 12 to 14 per inch. Our radiator was designed strictly for high speed operation, whereas the Mustangs had to be able to handle long slow climbs when the airplanes were heavily laden with armament and fuel — on hot days. We have spray bars to spray water on our radiators if that were needed on an unusually hot day — but they are there principally to reduce drag. By spraying water on the radiators, we can close the door and reduce the amount of air coming on board, thereby reducing cooling drag. Our cooling system is still draggy, however — **all** cooling systems are draggy. About the closest you can come to eliminating cooling drag is to boil something. In the late 1930s the Germans set the absolute world's speed record with the Me. 109R with a non-recoverable cooling system. When the coolant came to a boil and began dumping overboard as a vapor, they had to land the airplane. They had just a few minutes to set their record. On Darryl Greenamyer's Bearcat, we boiled the ADI to cool the oil — and it just went overboard as a vapor. Still, there was some drag incurred from just carrying the stuff aloft. There's no free lunch in the area of cooling drag. You just try to minimize it.


Golda Cox

PETE LAW

"When I sell a water injection system, it's warranted for life, effectively, and I come with the warranty."

The only "problem" we've had with our coolant system is that while the oil temperature ran exactly where John Sandberg said he wanted it to run . . . and where the radiator was designed to hold it . . . we felt it would be desirable to be able to vary the temperature at will. This was accomplished by the installation of some moveable vanes in the inlet duct to direct more (or less) air onto the oil radiator. During the test phase, the airplane was flown in ambient temperatures as high as 105 degrees with no problems at all. In fact, Steve says he can run all the way up to METO power without having to use the ADI and spray bars (as most racers do). The radiators came out to be better than I thought they would be.

"The ADI (anti detonation injection) or water injection is actually a 50/50 mix of water and methanol. The alcohol helps the molecules of water break up and diffuse into a more even distribution to all cylinders. We don't need a lot of it — just enough to keep the induction temperature down to prevent detonation.

"We built a special carburetor for Tsunami. It is upside down from the usual aircraft practice — a downdraft carburetor like those we build for Unlimited hydroplanes instead of the Merlin's stock updraft carburetor. It's really the same as a Merlin carburetor except that you take some floats out and adjust it a little differently.

"That was the part I had to play in Tsunami — the internal systems. I had schematics made up on all the systems and John, Bruce, Steve and all the guys who were working would say how about if we did this instead of that because this pipe or hose won't fit here . . . or we need a few more breather lines over here . . . and I would revise my schematic. Finally, with this process of iteration, we got all the systems in the airplane. Tsunami was something new and different and was a very interesting challenge. My part was minor but it was fun — and I'm proud my part of it seems to work well."

JOHN SANDBERG

John Sandberg is Tsunami's owner . . . the man who paid the very considerable bills that ran up during its construction. He is also its engine builder . . . a very special engine whose parts came out of Rolls Royce (and RR licensee) plants, but not all at one time or at one location. It's a kind of hot rodder's dream — the best parts and pieces from all the scores of Merlin models made during and after World War II, put together to create what John considers to be the best racing engine that could be fitted into Tsunami's slender fuselage. Asked to verbally strip the engine down for inspection, he describes it as follows:

"We started with a V-1650-7 crankcase and supercharger. That was the engine used in the P-51 and is a good set-up for our operation because it's light and the 2-stage blower gives us the kind of power we need. Into that case we fitted a dash 114 crankshaft, which is a special heavy duty shaft built in the late stages of World War II for use in some stripped down, very fast Mosquitos used to chase German Buzz Bombs. The engines were fitted with nitrous oxide injection systems for short bursts of extra speed, so the crankshafts had to be very beefy. They're similar to the dash 9 crankshafts but, we feel, stronger. The dash 9 and 114 cranks were end oiled, but we changed ours to side oiling — with a secondary oil pump added to provide extra pressure. The head and (cylinder) bank assemblies are off the 624 and 724 series Merlins, which were post war transport engines used on airliners like the Canadair North Star, a modified DC-4 with four Merlin engines (imagine the sound of that!). We also use the heavy connecting rods made for these transport engines. The 624s were made to pull 80 inches for take-off (remember, the Mustang was limited to 61 inches for take-off) and to run for long periods of time at high BMEP — normal cruise was something like 1800 rpm and 40 inches. The banks and heads were really beefy and well cooled, so that's why we used them. We are also using the .42 to 1 reduction gear assembly off a 500 series engine, which was a post war commercial Rolls Royce used in airplanes like the Spanish Messerschmitts and the Italian Fiat G.59. We had to go to that gearing — a stock Mustang used .479 gears — to keep our prop from going supersonic at the forward speeds we hope to achieve. We don't use the stock aftercooler — we use water injection for induction cooling. The supercharger is turned upside down, as is the carb, to create a downdraft induction system.

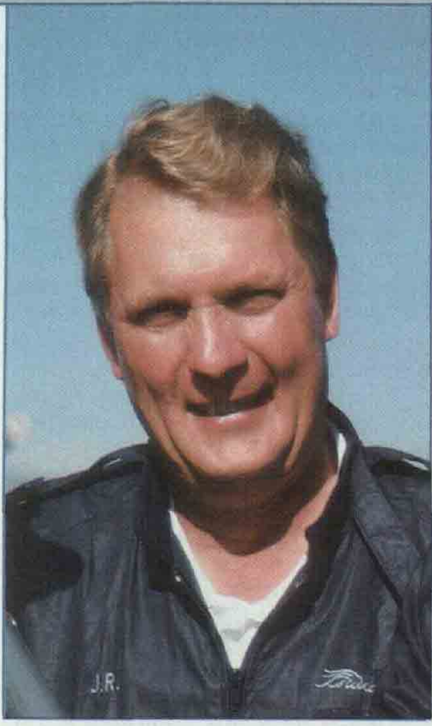
"The engine will make horsepower. It will stand a lot of overboost and a certain amount of over rev — but making it reliable under those conditions is the trick. We think it can live at racing power all day long — which is far above what we will have to use at Reno. When we try for the world speed record, however, we will have to run it hard. I want to put the record at 525 mph (currently 499) — that's my goal and we're going to have to pull a lot of power to do it.

"Here at Reno we had the ADI jetted so that we were getting an 85 degree induction temperature — and we didn't want to exceed that. We were over 430 mph at that setting, so we limited our qualifying run to 3200 rpm and 80 inches — which gave us the third fastest speed at 435 mph. Had we decided to

(Continued on Page 22)

JOHN SANDBERG

"I want the world's speed record to be held by a Private pilot."



Golda Cox

How did a project like the Tsunami ever get off the ground in the first place? Unlike the NASCAR and CART auto racing series, there is no money to be made in Unlimited air racing. There is only the one week per year at Reno during which the heavy iron is raced, and, as yet, there are no big time sponsors picking up the total expenses of any racing team. The prize money offered is a mere token when compared to the expenses of putting a competitive Unlimited on the race course at Reno. So, why do they do it? The only plausible answer is that men race airplanes for the pure love of the sport. That love may come in different forms for different participants — the race pilots, for example, obviously have a different perspective than the owners and the crews that support them on the ground. For some, it's a technical challenge, for others the thrills, excitement and notoriety are the motivating forces. For still others, air racing is the ultimate outlet for tremendous competitive drives. It is a highly complex, technically sophisticated endeavor . . . the tallest mountain they have not yet climbed. For most of the participants who show up each September at Reno, it's probably a combination of all of the above.

John Sandberg fits into a number of these grooves, but his love of airplanes and flying stands out most prominently. He is also competitive, but not so overtly as others. Whatever it is that drives him to succeed is almost totally self contained, hidden to most by a low key, easy going nature.

A native of Minneapolis, John grew up there and joined the Air Force soon after graduating from high school in 1950. He became an aircraft mechanic courtesy Uncle Sam and was an instructor of mechanics at Sheppard AFB in Wichita Falls, TX when he sustained a back injury that resulted in a medical discharge. Returning to Minneapolis, he worked for a time as an automobile mechanic, was married, and, in 1955, moved to San Francisco to go to work as a mechanic for United Airlines. Significantly, he was working on the big radial engines that were in use on transport aircraft at the time and worked his way up to powerplant trouble shooting on the Pratt & Whitney R-2800. After a few years, however, he moved his family back to Minneapolis and went to work for an auto dealership during the day while at night he attended the University of Minnesota studying engineering. In 1959, he went to work for a local firm that built mechanical control systems for the aerospace industry . . . and discovered he had a special knack for designing miniature and sub-miniature gear trains. In 1961, he and two friends started their own firm called Astrotech — which was a competitor of his previous employer. This was the period before solid state controls — a time when watch-like mechanical systems did the work microchips do today. In 1965 the Astrotech principals went their separate ways and John formed his own company called Metal Masters.

Metal Masters started out as a general machine company and ultimately moved into the closed loop control systems field. When the electronic control age came along, John was able to transfer his expertise in metals and

Rafe Tomsett

go up to 3400 and 95 inches, we probably would have been in the 460 plus range. We have a maximum that we will run and that is 3600 rpm — that's our prop's limit. At 3600 we should be able to handle anything that comes our way, however."

INTO THE CRUCIBLE

When Steve Hinton squeeked Tsunami's shaved down Learjet tires onto the runway at Reno in early September, he was making aviation history. Not since 1939 had a **serious** homebuilt Unlimited racer so much as made an appearance at a National Air Race . . . and a couple of days later when he qualified at 435 mph, another chapter was written. At least footnotes were added on three succeeding days of heat racing and the championship final, but, alas, no brass rings were snared. Tsunami started on each of these days, but was plagued each time by mechanical ills that came as a result of the lack of development time available to the crew in the scant three weeks they had between the first flight and opening day at Reno. John, Bruce, Steve and the entire crew knew they were taking a calculated risk just flying the airplane up across the desert to Reno . . . and all of them were fully aware that even if they could manage to qualify, it would be a major accomplishment. Reno had been their goal, however, and with all the work everyone had put in, the round-the-clock sessions, the weekends they had given up, they just **had** to give it their best shot.

Even before they left Chino, the generator had been giving them problems . . . and that particular bug was still active when they arrived. A test flight the evening before the start of racing, saw the thing acting up again, so much of the following day was spent installing a new one. The generator was critical because it powered the electric pumps for the water injection and the spray bar system. The engine could continue running on its mags if the generator failed, but it could not be operated at racing power without these cooling systems.

On Friday, Tsunami made its historic first start in air racing — but before the first lap was completed had the new generator fail. Hinton had no choice but to throttle back to a power setting where detonation was not a threat and just cruise around the course above the rest of the pack . . . led all the way, incidentally, by Rick Brickert in the Dreadnought. That evening, the crew **thought** they had found the source of their problems — a couple of crossed wires — and, breathing a collective sigh of relief, fixed them and settled down to do battle again the following afternoon.

Saturday's race was another disappointment. This time Steve had to pull up and out of the race and get the racer back on the ground as quickly as he could. Soon after going to high power at the start of the race, the oil pressure had dropped suddenly and although it leveled off sufficiently to safely continue running the engine, Steve wisely pulled out to possibly save the Merlin to race again another day. The problem turned out to be a sheared adaptor in the drive for the secondary oil pump . . . which could be replaced overnight.

In Sunday's Championship race . . . in which Tsunami was starting by virtue of its having been one of the six fastest qualifiers . . . the little silver and blue racer only made it down one side of the 9.222 mile Unlimited race course before, in air racing venacular, its Merlin "sneezed" and prematurely ended its chance to beat the ultimately victorious Dreadnought. Steve Hinton later said the engine had sort of coughed three times in quick succession, then backfired so violently that it all but blew the top piece of the cowling off the airplane. The engine kept running at reduced power and a successful landing was made . . . but it was all over for 1986 for the Sandberg team. After the races, the engine was removed and sent back to the JRS shop in Minneapolis for teardown. It was found that the generator had failed again, probably about the time the power was brought up to start the race, and without ADI, the engine quickly detonated. Two of the heavy duty rods were found bent and the supercharger was damaged.

Understandably, it was a disappointing debut for the crew and all the fans Tsunami had picked up at Reno. It's pit had been ringed with people all week, most of whom took it to their hearts as a sort of David among the goliaths of air racing and were hoping it would do well. All, however, realized that the airplane's potential was yet to be realized . . . and left with sport's oldest cliche on their lips: "Just wait 'til next year."

Before Reno '87, however, there will be an attempt at the speed record. John Sandberg says that early next summer Tsunami will be flown to either the Black Rock Desert in northern Nevada or the salt flats near Wendover, Utah for the assault . . . ironically on his own race pilot's world record. It will have to be a case of mixed emotions for Steve Hinton — watching an airplane he helped build and develop break the speed mark he has held since 1979.

The one thing we haven't told you is that when Tsunami was completed, John Sandberg insisted that FAA license it in the Amateur Built category, rather than Air Racing. This was done . . . and at Reno EAA President Paul Poberezny personally presented Builder's Patches and EAA caps to all the members of the Tsunami crew . . . and when the airplane raced, it had EAA decals on its sides. Almost all the owners, pilots and crew members at Reno are EAAers, but I'm sure they understand our singular pride in the fact that Tsunami is a **homebuilt**. When Bob Hoover turns 'em loose with his famous, "Gentlemen, you have a race", it's every man for himself and we'll all cheer the eventual winner . . . this year, EAA members Rick Brickert and the Frank Sanders team . . . but for the monumental seven year effort of the Tsunami team, we reserve a special salute.