The Starduster Magazine

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Published for the biplane builder, the biplane owner, and the aviation enthusiast

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The Starduster Magazine

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Presidents Message

Les Homan, President, Starduster Corp.

Well another Starduster open house has come and gone. I was looking forward to meeting all the participants as they arrived; I did not meet this goal. I hope at some time during the event I was able to communicate to all those Starduster people present. I was hoping to say goodbye but that did not work out either. We are discussing ways next year to either not open the plant except for one scheduled tour or for a very limited time for those wishing to pick up parts or materials. I believe it worked better this year than last but we still need to improve. I really enjoyed visiting with and meeting all the Starduster personnel. I know Ken enjoyed putting faces with the voices on other end of phone conversations.

Next year we will have our building added on to and will have many other exciting new products to show. We have been wrestling with many different entities trying to get our building bought and expanded. The building is ours and if everything works per latest plans construction will start in late July or August.

There have been many adventures so far this year and hopefully many more to come. I was hoping to go to Alaska but it did not work out. Oscar Bayer and Bob Pisani did fly their Starduster Too's to Alaska and back. Look for more on this in the next magazine. I did make it to the National Biplane Fly-in at Bartlesville with Oscar and Bob but remained in Kansas to take care of some personnel business and then flew home week of the 14th.

Remember, any long journey is just one step at a time. Lots of little steps gets us to our goals. Sometimes things come up and we do not get to our original goal, but nonetheless a great adventure can be had.

Keep the belly sunny side up and the seatbelts tight. May you all have good flying and building.

Les Homan

OSHKOSH/WAUTOMA 1999

Last opportunity this ~~month~~ ~~year~~ ~~decade~~ ~~century~~ millennium

Fly into Wautoma—No Traffic!

Wautoma Starduster Fly-in— Friday, Saturday, Sunday

- Showers, local transportation and ground transportation to Oshkosh provided by FBO.
- Kiwanis pancake breakfasts, Saturday & Sunday
- Famous Mullenmaster beef BBQ provided by FBO Saturday evening
- Fireworks Saturday night

Local Flying— Amatuer Aerobatics— Hangar Talk—

Awards Banquet— Sunday Night

News Flash !! Jack Mullenmaster, Wautoma Skyharbor's FBO operator, reports that application has been made to the FAA for an aerobatic box that will border the turf runway 8-26, hopefully to be in operation by 7/27..

Editorial

by Clay Gorton

The Henry Stampede and Stockmen's Reunion came every year to my home town of Soda Springs, Idaho. One year, when I was nine years old, I went out to the rodeo grounds, and there behind the arena was a Waco Biplane, giving rides for $5.00 apiece. I had never seen five dollars at one time in my entire life.

So I approached the pilot and asked if there was any work I could do to earn a ride in his airplane. The response— "Go away, boy, and quit bothering me." I didn't go away and I didn't quit bothering him, until finally he said, "If you'll go over to the concession stands and borrow me a rope to tie the airplane down, I'll give you a ride." So I ran over to the concession stands to ask to borrow a rope. I stopped at each stand, and received the universal response— "Go away, boy, and quit bothering me." So I ran back to the airplane and told the pilot I'd run into town and find him a rope. So he said, "Look, I just filled 'er up with gas and I need to run a little off. So jump in and I'll give you a ride."

So I climbed in the front cockpit. What a huge cockpit! I could almost see over the side. Off we took! I was having the time of my life. Then I decided to try to see out the side. When I looked off to my right, there was the world, standing on its side, spinning around! We were in a 90° bank and I wasn't even aware of it! What exhilaration! That was 67 years ago, and the memory is as vivid today as the day it happened.

The EAA Young Eagle program is giving that same opportunity to hundreds of thousands of kids. Most of them get their rides in airplanes with training wheels on them. I guess there's nothing the matter with that, but for a truly memorable experience, nothing will beat a wind-in-the-face, open cockpit, tube and rag, tail dragger. And we all know, there is not another biplane flying that is as beautiful and graceful as the Starduster.

Stardusters have not been the predominant airplanes in flying Young Eagles. However, they may have been the most predominant airplane in achieving the objective of the program—to instill a desire in young people to consider aviation as a career. National EAA has records of 333 Young Eagles flown in Stardusters to date, and 204 in Acrodusters. Although there may be more, we know of only two Acrodusters that have been involved in the program. We understand that Fred Myers has flown Young Eagles in his Acroduster, and an outstanding commendation goes to Glen Olsen who has flown over 200 Young Eagles in his N34LG. (Glen has more Young Eagle flights than are recorded in the National EAA directory.) He has flown more Young Eagles than any other pilot in the State of Utah.

Testimony of a Young Eagle

by Zack Moses, Salt Lake City, UT, age 15

I was having the same old summer like I always have. Then I was given the opportunity to fly in an open cockpit Starduster Too. I have flown in other planes before but this was the first time I had been in a biplane with an open cockpit. The experience is so much more exciting when the wind is blowing all around you. When I looked at the Wasatch Mountains they looked so much more beautiful from up in the sky than they ever looked from the ground. We flew along the shoreline of the Great Salt Lake where I could watch the birds flying far below us.It surprised me how much higher up we were than the birds. The colors of the ground below in the marshy areas were beautiful shades of brown, green and orange.

The other airplane which was photographing us was flying very close and I have never been flying that close to another airplane before. I enjoyed scanning the sky for the other plane when they changed positions. When I took control of the plane it was a great experience because you feel on top of the world when you are in control of an airplane high up in the air. You can just forget about everything and just go free. So all in all, I had a great time. Zack Moses, age 15.

Correspondence

Ken, March 23, 1999

I received my package in the mail yesterday. It was better than I anticipated. The plans are clear and easy to follow, and the gold duster book looks like a great manual. After looking over your plans and having seen the Skybolt's plans and accompanying material, your product is head and shoulders above the competition. Thanks again for all your help.

Michael G. La Forest, Livonia, MI

Ken, March 30, 1999

Great pictures on the v-y project. I would like to commend you guys on the wonderful site. I have not started a project yet, but I am in the process of getting one. I have not made up my mind yet on what I want. The pictures are great! Nothing like a little encouragement. Keep up the good work and keep us posted.

Michael, @pdrpip.com

Clay/Glen,

I was corresponding with a Starduster Too builder about fuel tanks and he relayed something that may be of interest. His main fuel tank developed a fairly bad fuel leak after 10 hours of flight. It seems he had the hold-down strap cinched down pretty tight and the weld seam right under it developed a 4" crack. Luckily it was on the ground and not in flight as he had to quickly drain around five gallons of fuel to get the level below the crack. It could have been real ugly. Guess it begs the question; how tight is too tight/how loose is too loose? Ever hear of this one before? I won't mention the individual's name but his Starduster is a real beauty! See you at Oroville. (cover the wings, paint and it's DONE!) (See page 15)

Bob Dwyer, Tucson, AZ, N28LJ

To Starduster Magazine, April 24, 1999

The Starduster Too advertised in the Starduster Magazine and on this Bulletin Board has been sold. Thanks to the people at Starduster for providing a great magazine and web site.

Titus Haynes, Shreveport, LA

Clay and Glen, May 1, 1999

I can't tell you both how much I enjoy each and every issue of "Starduster Magazine." Great picture reproductions and lots of interesting tales of travel. I always get something of value from every page!

Those of us in the midst of building (SA300 for me) need extra support and encouragement along the way, my shrink says its just completion and flying envy. I tell him, "That just because I'm paranoid, it doesn't mean they're not following me!" Please tell Les that the more motivated the magazine keeps us, the less we need the Shrink, thus the more materials we buy!

Thanks,
Don Hilliker, Fairfield, CA

Starduster Magazine, May 12, 1999

I'm looking forward to the Starduster Magazine. I always read it cover to cover and enjoy it. Oh yes, my new place has a 1000 sq. ft. shop to build in plus 2, yes 2, two-car garages attached. Kinda neat, huh? Gotta get back to work. Thanks for changing the address.

Bob Rogers, Villa Grove, IL

Dear Clay May 22, 1999

How are you doing ? Work on the Starduster is coming along slow. But it is coming along. I am thinking of displacing some of my tail weight by placing 2-inch spool spacers between the engine mount and the firewall. Some of the controls and connections will have to be changed or moved slightly. Some will be OK and of course I'll have to deal with the cowl. I may rebuild it totally or do

this later and use a four inch band to extend the old cowl so that I can fly this summer.

One of the reasons I am writing is to request two more copies of the April 1999 issue of Starduster Magazine. I showed it to Don Knauts and his wife, Kathy, and they loved the story and pictures. Kathy made a request and I told her that I would write you and see if I could buy more issues. Let me know.

Thanks
Nolan Getzinger, Idaho Falls, ID

Dear Mr Homan, May 24, 1999

I recently bought a Starduster Too in Camarillo CA and had some great flying with the bipe! I will ship the plane to Belgium by next week. It will be the only one in the country! A friend of mine, named Stefan Ponnet, who is busy doing some time building in CA, will pass one of these days to buy some stuff. As the Starduster will arrive at the end of June in Belgium, I am looking for the information about the rigging and stabilizer assembly. So, can you please provide the information or how I can get the information? Many thanks,
Sincerely Yours,

Michel Verschraepe

Hi, Les, May 24, 1999

Just came across your web site and wanted to say hello. Hope all is going well for you. 1998 was not a good year for my ole Skybolt! I didn't work on it once! However, 1999 is a new year and I hope to get it done now. Glen Olsen is helping me so there is more hope than in the past. I may try to come to the Oroville fly-in but don't know yet for sure. Say hi to Dave for me. See you later,
Lance Andrewsen, Salt Lake City, UT

Les, May 24, 1999

Thanks a lot for a great weekend in Oroville. Really enjoyed getting to see the Stardusters up close, and flying one (courtesy of Dave Baxter). My compliments to the people who put on the breakfast also. It was great. Thanks again.
Paul Schafer, Sutherlin , OR

To Les and the Local EAA folks, May 24, 1999

Great fly-in last weekend. Had a great time and saw lots of nice planes. Thanks for all the hard work putting it on. I will be back next year.
Great job.

Mike, Starduster 3242R, San Carlos, CA

Les, May 25, 1999

I am looking forward to June and the biplane convention in Bartlesville. My Starduster is progressing, but slower than I thought last year. In late June or July my intentions are to take my vacation in the hanger and try to finish the cover and paint.

Until last fall I had not flown a tail dragger. I began transitional training in a J3 Cub. I would like to know if it will be possible to get with you or some other flight instructor and fly a Starduster Too as I have never flown one. This will be a great help when it comes time for first flight and also give me a reference to judge how my airplane handles compared to another.

I will be in Bartlesville on Saturday only and I know how busy you will be and will understand if it is not possible to work a lesson in to a busy schedule. By the way I will have pictures of my plane with me in Bartlesville so you can see how it is coming.

Dennis, @yahoo.com

Dear Clay, May 27, 1999

Sure had a good time in Oroville again this year—always a great event. Thanks for all your efforts and hard work with Starduster. Look forward to seeing you soon!

Hap Schnaze, Scappoose, OR

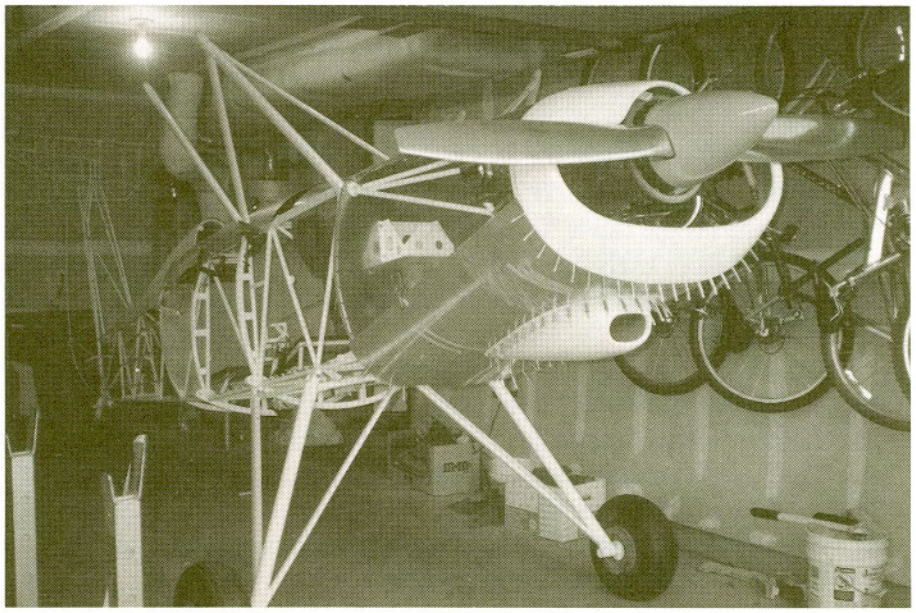
Dear Ken, 21 June, 1999

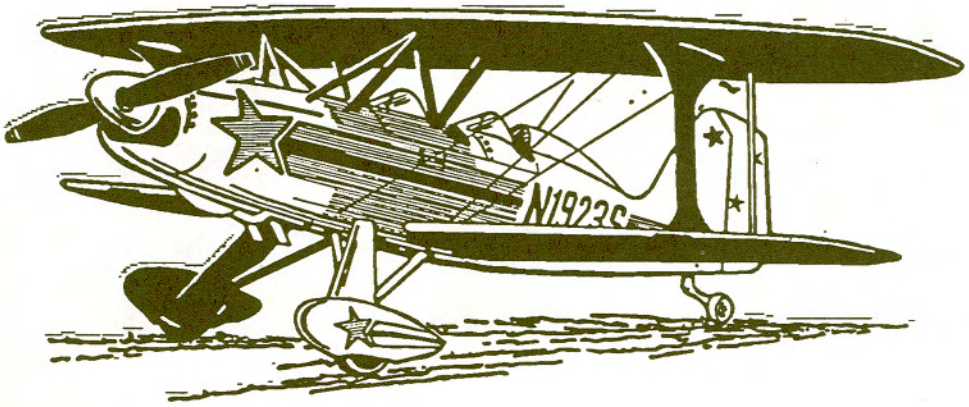
Here is the latest picture of my Starduster Too Project. I had my first ride in a Starduster when I was 15 years old, and decided that I had to build one of these . . . no matter what the obstacles. Well needless to say, obstacles is putting it mildly. Since I started the project I have gotten married, had three children, went to college for six years, have

lived in three states, and have changed professions twice. One thing I am proud of is that I have never given up. And as you can tell from the photo, I am finally starting to see the light at the end of the tunnel.

I have tried to keep this project very light and basic. I am very picky about keeping things as neat on the inside as well as out. Powder coating the framing really aids in keeping things clean. Power is a new Lycoming 0-320. Basic instrumentation, a Val radio and Garmin GPS round out the cockpits. The one bad thing about making this such a long-term project is that many changes have been made to the design over the years, and I found myself remaking components trying to keep these upgrades in my project. Building a Starduster once is hard enough without building it twice!!! From here on out . . . NO CHANGES!!! I recently purchased and installed a Comanche style air scoop from Aerodyne. It fits beautifully and is available if you give them a call at 619-448-6700.

Gary Shunk, Bend, OR





EARLY STARDUSTER HISTORY—N-84-CB

By Verne Reynolds, Mt. Vernon, OR

Clyde Bourgeois has a business card. Many people do, but Clyde's card modestly says: "Built everything. Flew everything I built." Funny part of it is, the card is pretty close to right. One of the Oshkosh judges for the past several years, Clyde knows what it takes to have an experimental aircraft in the winner's circle. As a pilot with several log books full of flight time, he also knows what it takes to strap yourself into the cockpit for that first test flight in an aircraft that no one else has flown before. Some people call it "intestinal fortitude." Clyde would more likely call it a careful decision based on the quality of workmanship and aerodynamic design.

The design. The way it looks. The beauty of shape. The flow of fuselage into empennage. The curve of the wings. The first time Clyde saw one that had the curve and the beauty, he knew he was in love. He was entranced, caught, hooked. He had to have one. "What was it?" "A Starduster!"

"How do I get one?" "You build it. From scratch. You buy the plans from Lou Stolp. You saw and weld, and rivet and stretch fabric, and hang an engine up front, and paint it like you've always wanted to paint your own airplane. And then you put a bunch of instruments in the panel, and you teach yourself how to fly it. And then you laugh and sing and cavort and watch people smile when they first see your airplane, and they ask you what it is, and you tell them it's a Starduster!" Clyde didn't know about the singing and the cavorting, but he knew he had to have one.

It all started for him in the late 60's. Not his 60's; the 1960's. Clyde was no stranger to aviation then, but was unprepared for the jolt to his system when he first saw a Starduster. There were only one or two around then. Lou Stolp had built the first Starduster Too, and the classic lines of that custom-made open-cockpit biplane completely captured Clyde's imagination. He ordered the plans, he ordered some wood and metal tubing and set to work in his Santa Barbara garage.

Clyde was good. He was a craftsman, but still the blueprints took interpretation and some trial and error in the building process. There were no parts pre-assembled as you can buy them now . . . everything was cut and fit, and it took Clyde nearly three years to assemble N84CB. He knew he wouldn't be content with just moderately good construction, so everything was tweaked and burnished until it met his specifications. He hung a new 0-360 up front, with a constant speed prop and enough instruments to fly IFR, and then it was finished—September, 1971. Probably the third Starduster to be completed; it was time to fly.

But the assembled airplane was in Santa Barbara, and the representatives of our Government who are appointed to be in charge of such things told Clyde he must take the airplane apart and move it to the Santa Ynez Valley airport, some 30 miles away, then reassemble it there for the first flight and where he must fly off the designated test hours. That didn't seem to make a whole lot of sense to Clyde, so early one morning he taxied his new Starduster out to the runway well before the tower was open for the day. Nobody seemed to object. In fact, there weren't any other people around, so Clyde saw no reason not to use a little bit of the runway for his initial take-off. The climb-out was smooth, the engine was smooth, the

controls were smooth, and Starduster N84CB was airborne. Outbound from Santa Barbara, Clyde remembered he was supposed to take the airplane to Santa Ynez, so he flew over the low coastal range of mountains and landed at the Solvang airport. That seemed uneventful, so he cruised back to Santa Barbara, landed there and taxied back to his hangar, still long before the tower opened. Nobody had objected. The Starduster worked perfectly. Clyde closed the hangar doors and leaned against them. He smiled like a cat full of milk.

And so it went for the next 40 hours of flight time. Early morning flights, with nobody objecting to his using just a little bit of Santa Barbara runway space. And every time he flew, his smile grew a little bigger, for he had tasted the best of the experimental aircraft movement, and it was good.

But he had to get his certificate of airworthiness. He had to get his documents in order. He had to make contact with the appointed representatives who signed those significant pieces of paper. And so, he did. One man who was there knew Clyde and lost some of his composure when Clyde told him he had logged 40 hours of flight time from the Santa Barbara airport. His acquaintance told Clyde he'd have to write up a report of violation with ominous overtones, and he did. But Clyde had learned a way to defuse the potential of such a grievance, and so Clyde merely wrote on the bottom of the report that, "All the above statements are true . . . Clyde Bourgeois."

The grievance disappeared. The arguments never started. Clyde's request for proper documents was approved. Starduster Too N84CB was alive and well and ready for cross country adventure.

After about a year of air time, Clyde decided to put a full canopy on the Duster to cut down on some of the air buffeting, for more comfort on his longer trips. He had installed a complete IFR panel when he built and flew it in some tough weather, until . . .

Clyde and his wife were flying home from a lengthy trip to Louisiana. It was nearly dark but Clyde had confidence in his electrical system, and he was in contact with radar guidance who was vectoring him around thunderstorms. Then, without his permission, his electrical power supply went on the blink. The storm thickened and he had no contact with the world outside his cockpit. He was sucked up in turbulence from 3,000 feet to over 10,000 feet and then spit out of the squall again. Violently tossed about by the storm, Clyde figured he was just about to own six feet of real estate, with his name on it. Then the violence stopped. The Starduster was unbroken, but it was dark; there was no way to make radio contact with anybody. After some serious confusion, Clyde spotted a golf course that was lighted for night play and decided he would land there. But there were people all over the place, so he kept flying and finally stumbled onto a small emergency airport that was lit up like a Christmas candle—Tyler County Airport, Tyler, Texas. No hangars, no airplanes, no gas pump, but good solid ground that looked awfully good to Clyde and his grateful wife.

Back home in California, the first thing Clyde did was to remove all the IFR instruments except for the turn-and-bank. He wasn't about to tempt himself into a situation like that again.

N84CB kept flying. Clyde put about 600 hours on the Duster before he sold it in 1978. Knowing he had been able to build the plane, with a new engine, for about $10,000 out of pocket, he figured his selling price of $15,000 was fair. It was. The Duster is still flying, to the best of Clyde's knowledge.

And Clyde is still flying, too. Since he built the Starduster, he has rebuilt a Cessna Airmaster, a Funk, a Davis. He's rebuilt his Beech Staggerwing twice (once after flipping it in an Iowa rainstorm on the way home from Oshkosh a few years ago.) He built a Sweringen on contract, as well as a 2-place Rotoway helicopter. Then he built N45EX, a stretched Glasair that he flies regularly. And now he has some bent pieces of a replica Red Baron triplane that he's planning to rebuild in a new addition to his garage in Santa Ynez, California.

Technical Guru and past president of EAA Chapter 491, accolades and awards keep coming to him. One of the latest is the plaque naming him as winner of the FAA Master Aircraft Mechanic "Charles Taylor" award. But no matter how the awards and trophies pile up, Clyde looks back at his Starduster as one of his greatest achievements. When he talks about it, his eyes light up, his infectious smile broadens . . . he looks just like a cat plumb full of milk.

Who The Hell Is Oscar Bayer?

(by himself)

(Note: Clay said he would not put the picture of my airplane on the cover unless I wrote this!)

My romance with airplanes began soon after I was born when my father, a pilot, took me for a ride in a Curtiss JN-4 "Jenny". My father owned 3 aircraft at different times—the Jenny, an E-1 Standard and a Velie-powered Monocoupe in which he eventually died while Flying out of Clover Field (Santa Monica, CA). From this brief exposure to aviation, a deep desire was born to spend my adult life flying.

I grew up in Southern California, graduated from high school and enlisted in the Army Air Corps, Aviation Cadet Program in September 1943. Over the next 31 years I had the privilege of flying many aircraft, from the North American AT-6 through the Convair F-106. When I retired my wife and I moved to Central California, (Arroyo Grande) and built our retirement home with plenty of shop room to build an airplane! Although I had flown over Mach 2 and above 70 thousand feet, I wanted to build a biplane to see the country low and slow and to take my Grandkids flying in an open cockpit the way my dad did me.

By the time 1979 rolled around, the house was finished and I started looking for the perfect project to build. I reduced the field to three—the Steen Skybolt, the Cristen Eagle, and the Stolp Starduster TOO. After talking to the Eagle folks I found it couldn't be built without the canopy, so I selected the Starduster over the Skybolt for several reasons: 1) the design and appearance was superior and, 2) the Starduster works were at Riverside, CA, close enough to allow a short trip to pick up parts and advice; the Skybolt plant was in Colorado at that time.

On August 13th I cut the steel for the first wing attach fitting and the project was under way. Up to this time I had not flown a Starduster, but in December, I flew with Wil Neubart in his TOO, N7X to Flabob airport to visit the new owner of Starduster, Bill Clouse. We got a chance to talk and compare a completed wing with what I was trying to build. Over the next couple of years things progressed pretty well, the wings finished except for cover and the fuselage construction well under way. In June 1981 N7X was sold to a buyer in Houston, TX, and I got to Ferry the bird down there for the new owner, George Ramin. Also, about this time I really thought I was getting close to finishing and couldn't wait any longer, so I reserved my "N" number with the FAA—good thought but bad timing!

By the way, I wasn't working an this project every day. Checking my construction log I found that the most I worked was in 1984 when I put in some effort only 174 days of that year. Still had to fly with my students, do some Corporate flying, take vacations, go fishing, etc. Six years, five months and five days after I first cut that 4130 sheet steel with a hacksaw, it was 18 January 1986 and first flight time. Over the next couple of months the flight testing went very well. I did some minor modifications such as moving the back windshield 2 1/2 inches backward and adjusting the trim to improve the handling in cruise.

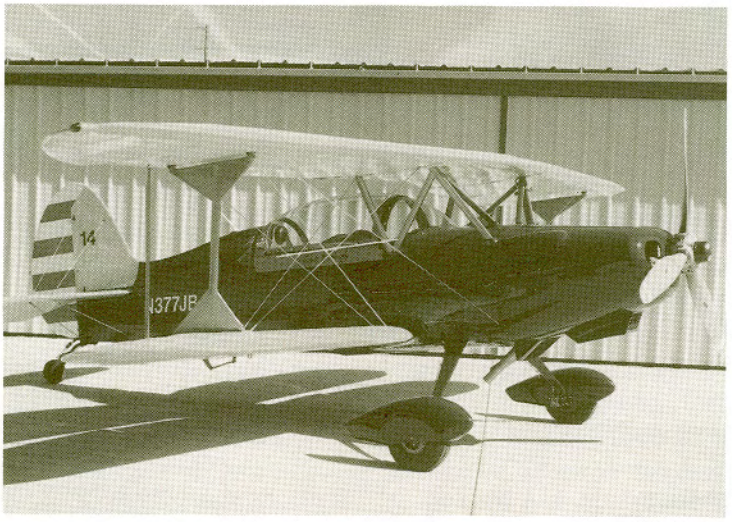
By April I had flown off the 25 hours and flew my first passenger, my wife! Since that first flight, (13 years now) I have flown the machine over 1100 hours, to Alaska, to Oshkosh 6 times, around the perimeter of the 48 states as close to the border as I could, flown the Lewis & Clark Trail and given a lot of rides including to a bunch of Young Eagles. I'm not done yet. I still want to fly over the Pony Express route, go to the annual Biplane Expo in Bartlesville, OK, back to Alaska again and of course—another trip or so to Oshkosh/Wautoma.

For those of you who read this and who are building your own Starduster, I have this advice: plan extra baggage space; there is plenty of room behind the back seat, or mount a baggage pod between the gear (Starduster has the plans). Nothing will do more to set you off to explore this country than being able to throw a sleeping bag and some clothes in the airplane and go off looking over the next ridge, landing at little out-of-the-way airports, sleeping under the wing once in a while and meeting some of the really great folks that are out there!

The Fabric Butterfly

By David Mercer, Klammath Falls, OR

Starduster Too N377JB, "Fabric Butterfly," made the Oroville, CA Open House, May 14-16, 1999, for the first time as a completely rejuvenated aircraft. With few problems, the flight from Klammath Falls, OR to Oroville and back was a complete joy and a dream come true. The two weeks prior to leaving for Oroville was filled with problems and overnight parts delivery. Even the weather would not cooperate for thorough test flights and would even turn bad the day leaving for Oroville with Wayne, Craig and Ray. But once out of the Klammath area, the weather was good, even for the entire weekend.



But, back up three years. N377JB was meant to be an airplane to fly around in while building another experimental aircraft. The other aircraft was going to take two to three more years to complete. Tired of being grounded and watching other aircraft leave on weekend outings, I thought this aircraft would fill that void.

I got N377JB thinking a little fixing here and there would be all it would take until the other aircraft was finished. Well, think again, the further I inspected it the more attention it needed. Before I knew it, I was standing in the middle of a completely disassembled aircraft.

It took 3 years to reassemble with a different engine, propeller, instrument/radio package and many other overly priced airplane parts.

Finally back together and signed off by the FAA, the fun started with taxi test. Having no PIC time in a Starduster, just a few rides, one's confidence can be shattered so quickly with a bad, high-speed taxi run and then it's time to start all over. Finally, the tower asked "When do you think you'll fly it?" I replied, "Lets go for it this time!" The tower replies back, "Good luck." I must say, I really wasn't that nervous until he said that.

Power on, tail up, lift off, it's really flying! OK, around the pattern, set up for a landing, mains touch down, power back slowly, hold the tail up, tail touches down, still in one piece! Wow! Let's go around again! Second touch down, a little bouncy but down safely. Let's stop while we still have it somewhat under control.

Friends who were watching came by with congratulations and I was feeling proud. Now it was time to call friends and family, it's like a new family member has arrived.

But the real joy for owning a Starduster for us has been going to Oroville, visiting and sharing with all the people. This has been the unexpected surprise for owning a Starduster, one that is shared by all who come to Oroville.

Now, what can I do with my other experimental now that I have spent so much restoring the Starduster?

Starduster Project With a Radial Engine

by John Clark, Oskaloosa, KS

It has been eleven years in the making of Starduster N245SD. I thought that you might like to see what it is going to look like.

Well, 245SD is not a standard SA300 by any means. The fuselage is 27" longer and 4" wider at the rear office. Also the tail surfaces have been increased in size.

It is powered by a Jacob 755, 275 hp, turning a fixed pitch metal prop. A full NACA cowl is being hand made at this time. Point of interest—there is no fiberglass used in this project, in that all formers and stringers are aluminum— 6061-T6, .020. I also intend to form a set of wheel fairings out of aluminum.

I just moved it to the airport at Topeka, KS, known as Phillip Ballard Airport. Anyone interested in seeing it can call me at home, 785.863-3117.

N2552, S/N 638, 1968

by Ken Farwell, Bellefonte, PA

N2552 was built at Riverside, CA by Ted Melshiemer in 1968, Ser. No. 638. Enclosed is a photo showing N2552. Thanks for the service for sending me the new catalog!

First Flight

By Richard F. Stiles, Morrisville, VT

Starduster Too N122VT has been completed and is flying. Finished in Stits polyfiber fabric with polytone in royal blue and Juneau white. Power is a Lycoming O-435-I 190 hp engine.

In January of 1970 I ordered the drawing and received plan #1046. While waiting delivery of my first order of tubing and other components from Stolp Starduster Corp., appropriate benches and a worktable were constructed. Sale of an antique car furnished the cash to buy a drill press, grinder, air compressor, and many specialized small tools.

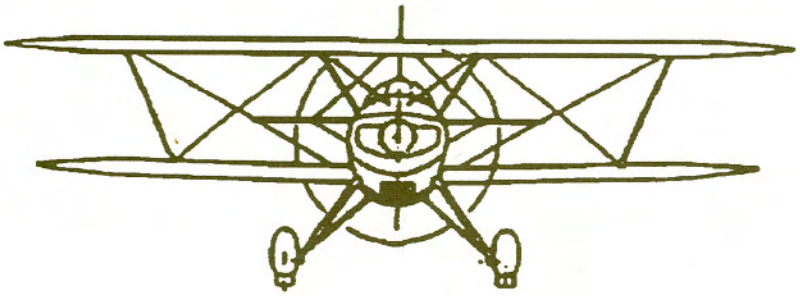
In 1972 the fuselage, empennage and wings were signed off for cover. The engine was installed and test run after the fuselage was covered and in silver.

In 1980 the competed fuselage, wings and tail assembly were put in storage until 1991 when final assembly was completed at a private airfield here in Morrisville. The plane could be kept under cover in the owner's hangar. Taxi test and runup found no major problems.

Because of the need for space in the hangar by the owner for his own aircraft, the Starduster was dismantled and moved to the local State airport where is was fully reassembled in 1996.

In November of 198 the Starduster was inspected and signed off for flight. An airworthiness certificate was issued along with the operations limitations.

On Wednesday, June 16, 1999 David Mudgett of Deland, Florida, and formerly of Morrisville, VT made the first flight of N122VT. David reports there where no problems and the plane flew well. David flies for a living, having flown many hours doing pipeline and power line surveillance and is currently towing advertising banners with a Grumman AG-CAT.



CFI Rating in a Starduster Too

by Gregg Reinoehl, Reelsville, Indiana

I successfully passed my Private Pilot check ride in 1974. I was 26 years old. My father had owned a Luscombe BC, but had to sell out after purchasing the family farm in 1959. My parents told me that I had flown with my Dad, but I don't remember it. Upon receiving my private ticket, Dad and I began the search for a Luscombe. In 1985 we took ownership of N1851K, a 1946 Luscombe 8E

After eight years and adding to my family, we were looking for a four-place airplane. In 1993, the Luscombe was gone and a 1949 Cessna 1970 was in the hangar.

About the time I received my ticket, a close friend gave me a ride in a UPF7 Waco. I was hooked on biplanes. That ride convinced me that a "real" airplane had to have five items— 1) a tail wheel, 2) stick control, 3) two wings, 4) an open cockpit, and 5) a radial engine. I decided then that some day I wanted to own one.

Last May I read an ad for a Starduster Too in Evansville, Indiana. I placed the phone call and spoke to a very nice lady, Mary Jane Reed. Evansville is about an hour away by C170, so Dad and I met Mary Jane to look at N76NP.

Mary Jane and her late husband, John, owned 76NP for over five years. John was an engine expert, so they had taken excellent care of this aircraft.

Within a week, we owned N76NP. Gene Glackman was kind enough to give me the instruction to satisfy the insurance. This plane has four of the five "real" airplane items that I wanted. N76NP is such a pleasure to fly —the more I fly it, the better it becomes!

My wife and I have two sons, 15 and 11 years old. I have been working toward a Certified Flight Instructor rating so I would be able to work with my sons when the time comes.

When I was taking the Commercial check ride in the Cessna 170, I spoke with an examiner about flying the Starduster Too for the CFI check ride. He was willing, if not even excited about it, if I could get the FAA to authorize him to administer the check ride.

When I was ready, I called the Indy Flight Standards District Office and talked to a very helpful man about the CFI check ride. They have an office policy not to ride in experimental aircraft and no one in the office was current in a tail-wheel aircraft. Therefore, they agreed to authorize the other examiner to administer the chick ride.

March 1st was warm enough to fly N76NP. We flew all the maneuvers in the Starduster Too. Completed all the takeoffs and landings the examiner requested. Then we finished the check ride with the Piper Arrow to satisfy the Federal Aviation regulations.

The examiner asked me to bring the Starduster Too back so he could get some stick time. It was a real delight to receive my CFI rating by using N76NP.

I have now started working with my oldest son in the Starduster Too. Hopefully, his skills will develop so he can solo on his 16th birthday in the N76NP.

Stardusters at Sun 'n Fun '99

Regional Editor Fred Myers attended the Sun 'n Fun fly-in at Lakeview, FL this year in his Acroduster Too. He found there the following pilots and planes—Bill Clouse, Jack Cogburn- SA300 N682, Bob Griffin- SA300 N507RG, John Hueser- SA300 N19EW, Gene Jackson- SA500, Jim Speer- SA750 N121RM, Al Tomlinson & Neil Reyngoudt- SA300 N77AN, and Elek Trok- SA300 N38ET.

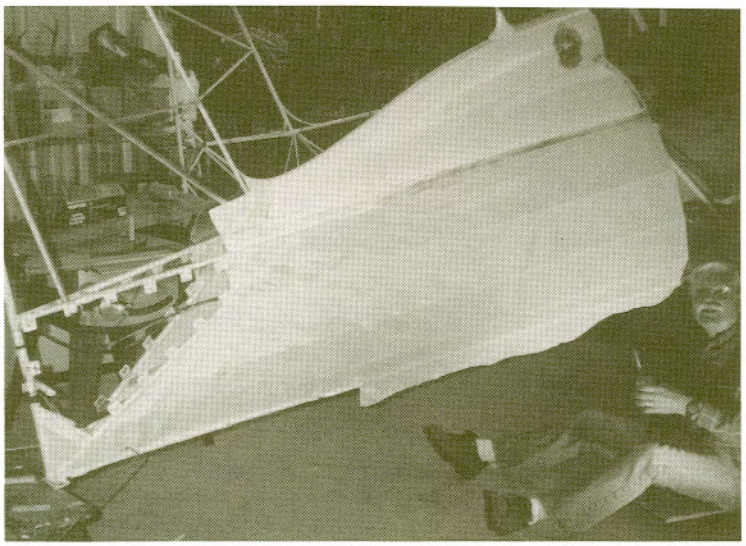
To emphasize that this is a major aviation event, Fred reports the following statistics for the 1998 Sun 'n Fun: "An attendance of 639,400 which contributed to an economic impact of $32,182,146.00; 1,822 show planes registered. Other records for 1998—337 forums were conducted; drawing an attendance of 16,644 participants; workshops with attendance of 67,689; 2,767 participated in educational tours; 2,355 international visitors representing 64 countries; 56,463 air traffic movements recorded by air traffic controllers including 2,958 helicopters and 3,927 ultralights; and 3,500+ volunteers contributing to the overall success of the event."

Photos of three of the outstanding Stardusters that attended Sun 'n Fun this year are shown on page 22.

Progress Report—N53T Repair

By Oscar Bayer

A mid-May update or progress report on the repair of Starduster TOO N53T, which suffered damage in an upset incident at the San Luis Obispo airport last December. The repair on the fuselage structure and vertical tail has been completed and the re-cover is in the final stages, up through applying finish tapes. The wing center section is complete through silver and is ready for final paint. Eight ribs had to be replaced in the nose section and the wing tank straightened and re-welded.



The spar for the left top wing was picked up at the Starduster Open house in Oroville and the ribs are being routed for shipment in the near future. Both top wing panels will have to be re-covered.

The engine has been repaired and is ready for installation as soon as the owner can pick up the fuselage assembly.

From the Chairman of the Young Eagles Program

by General Chuck Yeager

All of you Starduster pilots who have participated in the Young Eagles program realize that it costs money to fly airplanes. I want to personally congratulate all of you who have taken part in the Young Eagles program. You have given a great deal of pleasure to many, many young boys and girls.

When I took my first ride in an airplane, I got deathly sick and I didn't think there was much future in my flying career! But things have changed and I have thoroughly enjoyed more than 56 years in Air Force cockpits. Oh, I get to fly light airplanes and other airplanes other than military planes, and I enjoy them a lot. But, since I have primarily been a military pilot, just the satisfaction of doing a professional job in a military airplane gives me more pleasure than almost anything else.

I have had the fun of looking at the expressions on the faces of young boys and girls when they have their hands on the controls of airplanes like the CA7, Ford Tri-Motor, T-34, and other planes. I have flown more than 200 young boys and girls in these types of planes. The expression of excitement is so obvious in their eyes and on their faces when they make the airplane do what they want it to do.

I was a very lucky individual in that I didn't have to spend money to enjoy flying since Uncle Sam furnished the equipment! They taught me to fly as a combat fighter pilot, they taught me to be a test pilot, and a Commander. Today, young people don't have that opportunity unless they enter the military service. The numbers of those entering the service are decreasing every year. So, all the help that you professional pilots, both men and women, who have participated in the Young Eagles program are giving to many of the young men and women is appreciated. You generously share your knowledge and experience with these young people when you fly them in your airplanes.

Again, I want to thank you so much for the way you are supporting the Young Eagles program and I sure look forward to December 17, 2003, when we look back and say "Thanks for a job well done!"

Sincerely,

Retired Air force Brigadier General Charles E. "Chuck" Yeager has had a long and distinguised career as a pioneer in aviation and as one of America's heroes in World War II. As a fighter pilot in WWII he downed 13 enemy aircraft. He was the first pilot to break the sound barrier in the Bell X-1 on October 14, 1947, and was the first pilot to make an emergency ejection in a full pressure suit when his NF-104 rocket-augmented aerospace trainer went out of control at 104,000 feet (nearly 21 miles up.)

Gen. Yeager has been decorated twenty-five times for his military service and has received ten aviation awards, including a special Peacetime Congressional Medal of Honor by the Congress of the United States and the Presidential Medal of Freedom by President Ronald Reagan. He has flown more than 200 types of military aricraft and has more than 13,000 hours in fighter aircraft. He remains an active aviation enthusiast, acting as advisor for various films, programs and documentaries on aviation.


GLAMOROUS
GLENNIS

Jennifer Austin, age 11.
(Pilot Wayne Ensey)
"I think it was scary at first but then it was fun.
I think I want to become a pilot."

Tim Arsenault, age 15
(Pilot Ron Munson)
"It was awesome!
This way my first time flying and I had a great time.
My pilot, Ron, was very nice and showed a few things about pre-flight preparation.
I will remember this experience for the rest of my life and I hope to do it again."

Brian Hagler
(Pilot Hap Schnase)
"The take-off was probably the scariest part of the entire flight.
I loved the flight experience.
It just shows a person how insignificant they really are compared to the rest of the earth.
It humbles you."

Young Eagles Ryan, Nicole and Adam Frisby, Glen Olsen's grandchildren. These lucky kids are three of over 200 other kids that Glen has flown in his Acroduster, N34LG.

Young Eagle Brad Ely
Pilot, Oscar Bayer
N49OB

Veteran Young Eagle, Steven Rankin. Steve has flown in military, vintage, production and homebuilt aircraft. His goal is to become a pilot. Pilot, Fred R. Myers III N529FM

Bill Clouse, Al Tomlinson,
Neil Reyngoudt, N77AN

Elek Torok, Richard O'Brien
N38ET

Jack Coburn,
N682

Watch those tight cinches!

As reported by Dave Allen to Bob Dwyer, Reg. Ed.,Tuscon, AZ

Dear Bob,

My Starduster is an absolute delight to fly. You can imagine my disappointment when fueling the other day and fuel began running down the belly of my pride and joy. I was shocked! Well, after several of the airport guys ran for buckets we began a frantic search for the source, it was the main fuel tank. But where?

After I had drained about 5 gallons from the main strainer the deluge stopped. I pushed the airplane back to my hanger with the help of a few friends. The brainstorming began. It was decided that I would remove the sheet metal over the main tank and take a peak. No easy task since this piece of sheet metal is held in with about 250 #6 countersunk screws.

Yea, I know. Next time I'll build with maintenance in mind. Well, I got it off and much to my amazement there was a 3-inch crack at the weld seam directly under the hold-down strap. Yea, you guessed it I bet. The strap was too tight and when the tank expanded from the weight of the fuel it was too much. So, be sure to check yours and make sure it's not too tight.

Good luck with your project. Mine was twenty years in the making. Over 5000 hours. I absolutely loved about 4500 of those hours. I'll be most of the week fixing. I hope you get the picture. Best of luck to you, Bob.

Dave Allen

Laura Dwyer wrote:

My Starduster Too is nearly complete and I have removed the main tank on a couple of occasions with the center section of the upper wing attached to the cabanes. It involved removing the forward instrument panel. This allows raising the tank and moving it up and aft to clear the longerons and the roll struts. Tight, but it worked for me. Assumptions would be that your tank is standard, not unusually tall and that the distance from the top of the longerons to the bottom of the center section is also standard. I'd recommend one person on each side of the lower wing. I didn't have to work around the landing wires since only the center section was mounted. I'd also make SURE the tank remained GROUNDED throughout the removal (in a perfect world, you'd inert it first with nitrogen). Good luck.

Bob Dwyer

Tech Tips

The Necessary Evils of Landing Gear

By Barnaby Wainfan
extracted from *Kitplanes*, Oct. 1998

Landing gear design is one of the more difficult—and often neglected—tasks facing a designer. Most designers dislike landing gear. It's only there so the airplane can move on the ground and does nothing but add weight and drag in the air. Unfortuately, airplanes must take off, land and taxi. Landing gear is annoying but necessary.

The majority of aircraft structures are designed to take loads distributed over a wide area. Exceptions to this are major structural junctions such as the wing attach and the points where the landing gear attaches to the airplane. The loads at landing gear mount points are some of the largest, concentrated loads on the structure. Not only must the landing gear itself be designed to handle ground loads, but the structure it attaches to must be equally strong.

Landing gear, particularly the main landing gear, must absorb the landing impact and dissipate the kinetic energy of the airplane's sink rate. The

impact load on the gear is a function of the weight of the airplane, the sink rate at touchdown, and the stroke of the landing gear.

When the wheels first contact the ground, the airplane has a sink rate. When the gear reaches the end of its stroke, the sink rate is zero. The vertical acceleration required to arrest the sink rate is determined by the stroke of the gear. The greater the stroke, the more time and distance it takes to absorb the sink, and the lower the accelereatoin.

FAR Part 23 requires landing gear to withstand a sink rate of not less than 7 feet per second for any airplane. There is a formula for sink rate that increases with increasing wing loading, but no airplane is required to withstand more than a 10-foot-per-second sink. To put this in persepctive for pilots, 7 fps is 420 fpm, while 10 fps is 600 fpm. An airplnae flying a 3° ILS approach at 70 knots is descending at about 370 fpm.

For the purpose of calculating landing gear loads, it is permissible to assume that the wind is carrying two thirds of the weight of the airplane throughout the landig impact. Part 23 also requires the gear to withstand a minimum 2 G load, even if the gear stroke and sink rate combination yield a lower load.

The effective stroke of the landing gear includes the deflection of the tire as it squashes against the runway. A typical maximum tire deflection is 2-3 inches for light plane-size tires. Tire deflection is why some very lightly wing-loaded airplanes can get away with rigid landing gear structures. Note that for the 7-foot-per-second case, the landing gear load factor varies between 3,5 G and 4 G for tire deflections of 2.5-3 inches. This is a hard hit but not prohibitive.

Cessna designed the landing gear for its single-engine airplanes to take a 4.8 G landing load. Most landings are much gentler than this. Remember, even the 7-fpm case is more severe than flying into the ground on a 3° approach slope at 70 knots with no flare.

Most homebuilts have 2 G or less landing gear. The fact that gear failures are as rare as they are is testimony to the gentleness of most landings. Often, it is not the vertical impact load but the side loads in a crabbed landing that size the gear legs. This is particularly true for airplanes with vertically oriented shock strut main gear.

Part 23 requres that the main gear legs withstand an inward load of 50% of the gross weight of the airplane while simultaneously carrying 66% of the weight of the airplane vertically. It also requires the gear to be able to take an outward load of 33% of the airplane's weight while carrying the same verical load.

The vertical impact produces compression in the struts, but the side loads induce bending that can cause much higher local stresses in the gear legs near the attach points.

The points where the gear legs attach to the airplane experience high consentrated loads. The designer must ensure that the local structure is strong enough to withstand these loads. Load paths must be provided to transmit the gear loads into the structure as well. The gear often puts large bending loads on structural elements that take only compression or tension in flight. These members must be appropriately braced or they will fail.

One common example is the attachment of a spring gear to a steel tube structure. Both the vertical impact load and the drag load caused by wheel braking bend the lower longerons of the fuselage truss. Cracking of the lower longerons and welds near the gear are common problems.

Landing gear is not the most interesting part of the airplane, and it is tempting to treat it as a necessary after-thought when designing. The proper design of the gear is important, however, and can have a large effect on the safely and usefulness of an airplane.

Saga of N4226Y Continues, V-6, part II

Les Homan, President, Stolp Starduster Corp.

Part one was easy to start, part two leaves me with so many things I want to pass on that starting and staying in a sequence will be difficult. I guess the best place to start is by making sure it is recognized I learn most things in one of several ways. The most famous being the hard way, next in line is the old tried and true dumb way and least favorite method of pure dumb luck. The only good thing I have to say is that little bits and pieces sometimes get retained and applied to the next go around of learning, sometimes not.

I spent hours and hours working with prop adjustments trying to get it dialed in. Finally read the directions and found out you use the pitch setting device at the very end of the blades. I won't mention that I first just set it anywhere on the blade, or the fact that I carefully measured six inches in and tried this. After reading the instructions and applying newly learned information the prop finally came into line. ALMOST. The tachometer was showing 4,000 engine RPM and I was indicating 85 to 90 MPH. We adjusted the prop many times. Notice how I threw the "we" in here so you would think help was at hand. Actually it was, we were just having the same problems. 4226Y with the 200 HP Lycoming and fixed pitch prop was one of the fastest 200 HP Starduster Too's around. Here we were with an engine that was supposed to put out 180 to 200 horsepower at 4,000 RPM and the Lycoming would out do it at 1,900 RPM. The prop was set so the engine easily exceeded 4,000 RPM at 85 MPH. It was set to where full throttle operation resulted in 3,200 RPM at 85 MPH. After long and painful consideration it was decided to take a wooden prop I had used on the Super Starduster and build bushings so it would fit the V-6. The V-6 drive has 3/8" bolts and 5/8" drive lugs. The Super Starduster, Lycoming powered, has 1/2" bolts and 3/4" drive lugs.

A Friday night and all day Saturday was spent making bushings. Late Saturday afternoon, a few minutes before dark, the new prop was tried. Static RPM on the ground was about 3,400, equal to about 2,400 Prop RPM—about right. The first flight found 3,800 engine RPM at 85 MPH.As I taxied back, down trodden and forlorn I was asking myself, what is going on, what have we missed? The brain worked and the thought, maybe the new tachometer, was not correct. Well, a quick trip to the local auto supply store—had to plead and beg to get them to stay open just to sell me a big tach like the hot rod kids use on their cars. Made some quick, temporary wiring connections and cranked the engine up. When the nice expensive little tach, 0 to 4,000 RPM, said 1,000 it was accurate. At 2,000 it was off a few hundred RPM and when it said 4,000 we were turning about 2,500 to 2,700 engine RPM. Relief at last.

The next morning the Warp Drive prop was reinstalled and with the last setting was retested using the new tach. It took some adjustments but we got it to 3,950 at full power straight and level. Indicated air speed was in the 118-120 range. Best yet—not as good as before, but useable. Now with the engine turning up to the 3,800 to 4,000 RPM range a new problem developed. Looking back, this is a problem I experienced before but was thought to be related to mixture control. At first it was thought that this problem was mixture related. After some testing and changes in float levels it was agreed it was electrical related. Timing was checked, point setting was checked and rechecked, dwell was checked and rechecked, everything was checked. I still had the problem of firing back through exhaust, popping, farting and running rough. It started at about 3,800 RPM, no matter what was tried. Lots of man hours were spent on this problem. It was finally determined that if the ballast resistors were jumpered it ran great. We installed new coils, new ignition wires and tuned it up again. To be added here is that the battery voltage was 12 volts with no load and with the alternator in operation the voltage of the system was about 14.5 volts or so. It also might be said as I purchased the parts from a local auto parts store—a good old fashioned auto parts store—I was told the ballast resistor would drop the voltage to the coil to about 6 volts. This was measured and confirmed on several occasions. Without ballast resistors in place the voltage was about 10.5 to 11 volts.

Now for those quick on the feet you will have

just picked up the problem, understood some of my methods of learning and may be having a good laugh. I spent a year between High School and College studying internal combustion engines and what made them tick. I also tinkered with various cars and trucks as a young man. I should have known what the problem was.

The long of this short story goes like this. After about eight more hours of the new operation one of my new coils quit. A replacement coil and away we went. Another seven hours while I was in one place for a while I decided to check and see if I could get some spare parts—coils, points, condensers, etc. Found a high performance shop who handled Mallory and paid them a visit. Points, condenser, no problem. Asked about a coil that did not require a ballast resistor. Strange look from a person that obviously knew far more than I did. When someone calls me "son," and looks like he is talking to a 14 year old, I either run or listen. He tells me, you have to have a ballast resistor, it may be internal in the coil or a separate device but it has to be there. I tell him my tale, then ask him if he has a ballast resistor that would maybe put out more than 6 volts. Now the look changes to one of someone talking to someone who just fell off the turnip wagon. "Son," he says, "all ballast resistors will give you about 8 to 9 volts and if the voltage is less you have problems." As I looked up at him from the tops of my shoes, I ask if he has any of the ballast resistors. Turns out he has one in stock; it is a Mallory and is temperature compensated. Costs me less than the ones I had bought back home. As I walked out, I knew things were headed to a better place.

Over the next couple of days I mulled over what I had been told, ballast resistors put out 8 to 9 volts. Well, if you can learn things like this why not learn more. A different auto parts store, lots of friendly, unhurried counter personnel and I had lots of questions. I told them about my old chevy truck I was having troubles with. Thought the ballast resistor may have gone out, and what did they have. When asked what year, I told them it was mostly junk and I didn't know for sure. Guy tells me, "No problem, I will get you a Delco part, best there is and besides, all Chevies take the same ballast resistor." Now when he comes back I ask the big question, "What does this drop the voltage to." About nine volts was the answer.

Now this really caused me to do some serious thinking. How do you take a 12 volt battery, add an alternator, kick the voltage up to 14 or so and get 6 volts coming out of the ballast resistor. The next time I was able to work on 26Y, the first thing I did was pull the battery, take it into town, have it tested, 12 volts, load test, 9.5 volts. 10.5 and below is bad. New battery, add ballast resistors—new ones, started it up and it works like a dream, runs smoother at all RPMS and never missed a beat after this. To complete the battery story, the first battery was about 2 years old and had been used for less than an hour. Why spend dollars and buy a new one, it has 12 volts and takes a charge just fine. By the way, the new battery was $57.00, a lead acid aircraft battery. My trying to save $100 cost me a lot of lost time, 3 new coils, two new ballast resistors, and one new ignition set, about $195. This clearly demonstrates one of my learning methods.

As of this writing I have 78 hours on the V-6. One more area of learning is if you find a great idea and want to get the same results, don't try to take short cuts. Under this heading falls my intake manifold. Jess Meyers and I had discussed this item and instead of me getting a manifold from him or getting one like his and modifying it as he did, I got an after-market aluminum intake manifold. Still have to stand in the corner on this one. This set up is great if you are running a drag racer, street racer or anything with high RPM—lots more than 4,000. The problem with this set up is exhaust gas temperatures can vary by as much as 200 degrees. In my case #1 and #2 run about the same as #5 and #6, only about 50 degrees difference. Number 3 runs up to 200 degrees colder than #1 and #2, #4 a little better. With EGT's this far off the engine is not producing full power or efficiency. This results in excessive fuel burn and lost horsepower. We are working on this problem and results will be in the next issue and/or at Oshkosh.

Other findings include what happens if the oil level is exceeded slightly and what happens if it gets low. With a tail dragger the engine sits at an angle. This results in the original dip stick not being calibrated. When it is about 1/4" above the add oil mark you better add oil unless planning only to fly down hill. First indications of problem are the oil pressure dropping and oil temperature rising. This happens when the nose is pointed up

for a climb, not a steep one either. Now adding oil to a point above 1/4" *below* the full mark results in low oil pressure and oil temperatures that red line and it does not make a difference as to attitude or power setting. I believe oil is foaming. This situation amazed me because I had put the plane in a 30 degree climb attitude and remained there for some time during phase one testing. Watched the oil pressure and oil temperatures carefully, no change.

Another question often asked is, where is the carburetor heat. Jess had explained he had not needed carburetor heat in the 15 years of flying auto engines. Heat off the manifold created by crossover exhaust and cooling water keep the manifold warm, and the carburetor is close to the engine. I have not flown under all conditions yet, but some that stand out are 36 degrees, raining, sleeting, some snow and mush balls. Take off and flying was not a problem. Flying in temperatures from about 50 to 65 with light rain presented no problems and heavy downpores worked too. The prop even lived through the rain and gunk.

Other findings along the way included dynamically balancing the prop and engine. This made a major smoothness improvement in the engine. Prop did not require any balancing. At 3,500 to 3,800 RPM you have to look at the gauges to determine if the engine is actually running. Very smooth flying. There are a couple of vibration areas but they are not bad and I would not hesitate to fly in these areas. One is about 3,300 and the other is about 2,200 RPM. I flew most of the last 20 hours at 3,800 RPM, smooth as glass.

The carburetor proved to be another learning area. I first installed the carburetor to face the front of the engine. I was told by a hot rod type that the carbureror should face forward to the plane. Changes were made and float levels were adjusted. This proved a bit tricky because of the tail dragger layout. If you level the plane and set the float to bottom of view port and then set the tail on the ground, fuel flows nonstop out the venturi. I finally found a level but have found out that if it is too low and you are not on the step, fuel is evidently still going over and into the venturi. I raised the float slightly and improved gas consumption. Still need to do more fine tuning here. The leaning system has proved to be a simple but effective piece of equipment. The normal jets and power valve are removed and a block placed where power valve was located. The mixture control block is installed and is for all intents an adjustable jet. Goes from real small to real large. I do not use it to shut engine down but for leaning only. On my engine this unit allows to lean to a stop and enrich to engine flood and stop. The operating range is not large and I have found as float level has been lowered it becomes less sensitive. I generally do not adjust it after landing, just start and go. On climb out I may richen mixture slightly, very slightly. With larger movements it is possible to enrich to rough engine and then lean to popping and engine stop. *Small movements.*

I installed a radiator fan just in case. With help I finally figured out the only time it would do any good is on the ground and why not just shut down and restart. In the air only so much air can enter the radiator and leave the cowling. A radiator fan will not add more air flow. But it was tested in flight anyway. Did not work. Seems like Jess told me the same thing. I have a hard head.

Baffling and sealing the air flow across the engine and through the radiator is very critical. It is necessary to separate any air passed over the exhaust system from radiator inlet air. As I understand, up to 20% of the total aircraft drag can come from cooling drag. I have lots more work to do in this area and have developed several methods to explore. More on this next issue and or at Oshkosh.

Comments so far: I have not had time to finalize weight difference but it is between 50 and 56 pounds added weight over the Lycoming. Total engine power is not up to levels I expected but with intake manifold changes this should be cured. Air speed is not up to expected yet but I have several areas to explore. As of now I believe this is a viable alternative. I believe there is more research and testing to be completed. Hope to get input from all those either flying auto engines or thinking about it.

Electrical switches have played an interesting part on more flight experiences. During flight, not during a planed test, I found out what happened if you shut off the fuel pumps. At cruise the engine operates for about 400 foot, engine coughs, prop coasts to a stop. Allowing for some investigation time to determine problem, flip switches on, check for emergency landing site and restart engine takes 150 foot of altitude. I will not tell you the rest of

this story unless you ask me on a dark night in the hanger. I have accidently shut down ignition systems, fuel pumps both in the air and on the ground. Engine starting has not been a problem. Switches installed are the toggle type, RECOMMENDED, **rocker switches.**

One important item to interject at this point—I believe it was mentioned before. Someone once told me not to put an experimental engine in an experimental plane. On looking back it is now clear that if this same engine and drive had been installed originally I would not have 2,700 hours on 26Y. I was not prepared from a flying standpoint for things like unexpected engine stoppages, oil pressure and temperature changes. They would have had a very negative impact on my flying. I believe this is a process to be undertaken by someone who is mechanically inclined and has flying experience or someone to assist in the first 40 hours of flight testing with a high degree of flight experience in the same type aircraft. I believe it is better to stick to proven concepts where others have been than go where no man has been before. There has been a lot of experience built up over the years in auto conversions. This includes several engine manufacturers, different drive units and engine set-up concepts. I would maintain that a first time builder and/or a low time pilot would not be the best candidate for an auto conversion without a lot of mechanical and flying support.

Flying your Starduster cross country is an experience. You get to know the aircraft, build confidence in it and yourself. When you are 50 miles from the nearest airport, 10 miles from the nearest safe place to land and just sitting there listening to the rods knocking, gears grinding and the ignitions system cutting out does not make the end to a perfect day.

After nine hours in one day of never missing a beat, started easily, performed up to expectations, used the amount of oil and fuel expected and taxiing into a parking space as the sun sets, this marks the end of a great flying day. Tails are told of flying around thunderstorms, chasing trains, wondering whether to fly left or right of the coal mining shovel, wondering what that large building was. It had to be at least 50 miles away and it was huge. These are the tales of a good day.

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copy to Tom Lancaster

The Ten Biggest Lies About Piston Aircraft Engines

by Mike Busch, *AVweb editor-in-chief*

This article originally appeared in the March 1998 issue of Cessna Pilots Association Magazine.

When it comes to piston powerplants, there's an astonishing amount of misinformation making the rounds. Some of it may even come from sources you trust: leading aviation magazines, overhaul shops, even your CFI or A&P. Don't believe everything you read or hear.

Lie #1: Lycoming engines are better than Continental engines. (Or vice-versa.)

I bought my first airplane 30 years ago. It was a Cessna 182 powered by a Continental O-470-R engine. Since then I've owned a succession of airplanes, and each one—quite coincidentally—was powered by a big-bore Continental. My engines have always made TBO and been relatively trouble-free. So it's not surprising that I'm something of a fan when it comes to TCM engines. It's equally unsurprising that at least half the pilots and aircraft owners I meet are Lycoming bigots. They brashly state I'd never own a Continental-powered airplane! If you ask why, they'll tell you a series of anecdotal episodes about how their Lycoming-powered Turbo Saratoga made it to 1,000 hours past TBO, while their best friend wound up having to tear down the TCM factory reman in his Mooney 231 or Beech B36TC after just 475 hours.

Let's set the record straight. Lycoming and TCM engines are very similar designs using very similar technology and metallurgy. Both are horizontally-opposed air-cooled designs with bolt-together aluminum case halves and bolt-on cylinders with sandcast aluminum heads screwed onto nitrided steel barrels. Both use fixed-timed dual magneto ignition systems, and valve trains with overhead rocker arms, shrouded hollow pushrods, and hydraulic valve lifters. Both use similar compression ratios, similar RPM red-lines, and similar power-to-displacement ratios. And both have comparable records of reliability and longevity.

Certain problems tend to occur more frequently in one brand or the other. Continentals have a lot more crankcase cracks, head-to-barrel separations, and premature valve guide wear problems than Lycomings. On the other hand, Lycomings suffer stuck and broken valves and spalled cams and lifters much more often Continentals.

Some TCM and Lycoming models have better track records than other TCM and Lycoming models. For example, the TCM TSIO-360 series (used in Mooneys, Skymasters, and various other aircraft) tend to be more troublesome and maintenance-intensive than other Continentals. Likewise, the Lycoming O-320-H2AD engine has had a dismal history of cam and lifter problems when flown irregularly and operated in cold climates.

But while certain specific TCM and Lycoming models are problem-prone, it is simply wrong to make a general assertion that engines of either manufacturer are more reliable than those of the other. It's just not so.

Lie #2: Turbocharged engines are troublesome, inefficient and costly.

When I learned to fly on the East Coast thirty-something years ago, turbocharging was a dirty word. Everybody said turbos were expensive, inefficient, maintenance-intensive, and problem-prone; it shortens TBO and increases operating cost drastically, and makes no sense unless you live in the mountains. Or so everybody said.

Well, everybody was wrong. I've owned, operated and maintained a turbocharged twin Cessna for the past eleven years. It's proven to be the most reliable airplane I've ever owned: reliable, efficient, and almost completely trouble-free. Both engines made it to 500 hours past TBO without ever having a cylinder off, and when they were finally majored, they turned out to be in great shape.

Most of the anti-turbocharging arguments you hear are bunk. For example, take the claim that turbocharged engines are inefficient. Now, it's true that most turbocharged engines have a lower compression ratio than their normally-aspirated counterparts (typically 6.5-to-1 vs. 7.5-to-1), and that the turbo will burn a bit more fuel at any given power setting. But specific fuel consumption is only part of the story. The other part is that airframes are much more efficient up at the higher altitudes that turbocharging allows.

For instance, by climbing from 6,000" to 12,000" and throttling back from 75% to 65% power, my Turbo 310 can fly 5 knots faster than a normally-aspirated 310, and do it at lower fuel flow. If I'm willing to use oxygen and climb to FL200, I can beat the non-turboed 310 by 25 knots with no fuel flow penalty. The normally-aspirated airplane is more efficient than the turbo only if you force both airplanes to fly at the same low altitude, and that's not a meaningful comparison.

How about the claim that turbocharged engines are much more expensive to operate and maintain? It's true that turbos are more vulnerable to abuse in the hands of a ham-fisted pilot. If your airplane is used for training or rental use and flown by lots of pilots, you probably don't want a turbo. But barring such abuse, my worst-case analysis indicates that a 300 hp turbocharged engine should cost no more than $10/hour more to operate than its normally-aspirated sibling. When you consider that the sort of aircraft that use such engines—Bonanzas, Centurions, Saratogas, etc.— typically cost $100 to $150/hour to fly, you can see that the difference is chump change.

Lie #3: Modern multi-viscosity oil offers superior lubrication and longer engine life than old-fashioned single-weight oil

During the 70s and 80s, there was a dramatic shift from single-weight to multi-viscosity oils by operators of general aviation aircraft . . . due in large measure to very effective advertising campaigns by Shell and Mobil that touted their multi-vis products (Aeroshell 15W50 and Mobil AV 1) as the greatest aeronautical innovation since the nosewheel. During the same 20-year period, there was a dramatic increase in premature engine problems in the owner-flown G.A. fleet. It was not a coincidence.

In contrast to "working airplanes" that fly almost every day, most owner-flown airplanes spend most of their lives in the chocks. The biggest enemy of their engines is not inadequate lubrication. It's rust.

Multi-vis oil simply does not provide as effective protection against rust as single-weight oil.

The defining characteristic of multi-viscosity oil—the fact that it doesn't thicken up at cool temperatures—makes it a lousy corrosion inhibitor. During periods of disuse, multi-vis oil strips off cylinder walls and cam lobes much more readily than does thick single-weight oil, leaving those parts vulnerable to corrosion, followed by spalling and eventually destruction.

But what about the superior lubricating properties of multi-vis oil? Basically bunk! It turns out that multi-vis oil is not a better lubricant than single-grade oil. It's actually a bit worse. The reason is that multi-vis oil is made by starting with a thin, single-weight oil stock and adding man-made polymers called "Viscosity Index improvers" that increase viscosity as temperature increases. However, such VI improvers are not lubricants, and their addition actually displaces a certain amount of lubricating base stock (on the order of 10%). In other words, there's more "oil" in a quart of single-weight oil than in a quart of multi-vis.

Now this is no big deal, since the lubrication demands of most piston aircraft engines are rather modest (compared to automobileengines, for example). What is a big deal is the fact that single-weight oil does a better job of protecting engines against rust during period of disuse. That's why we've long recommend single-weight oil for any engine that doesn't fly at least once a week.

Fortunately, after two decades of multi-vis mania, it now appears that more and more G.A. operators are starting to recognize the shortcomings of multi-vis oil and are switching back to single-weight. An increasing number of top-rated overhaul shops are now recommending the use of single-weight oil.

#4: If you can't fly regularly, at least be sure to turn over the prop by hand every week or two to redistribute the oil.

Now there's a really dumb idea! I wonder who first came up with it? Engines that don't fly regularly are vulnerable to rust because the oil film that protects their steel parts from corrosion begins to strip off after a week or two. Gravity is the culprit—oil flows from top to bottom—and so the areas at greatest risk are the tops of cylinder bores,the tops of cam lobes, and so forth.

Now suppose you turn over the prop by hand. Does this "redistribute the oil?" Sure it does! It scrapes oil off the top of the cylinders and accelerates its flow downhill. The same is true of cam lobes and lifters.

Now I realize full well that at least one of the engine manufacturers recommends turning over the prop by hand periodically in its "flyable storage" recommendations. I still maintain, however, that the only way to replenish the protective oil film is to fling large quantities of oil around the innards of your engine with great vigor. And the only way to do that is to run the engine at high RPM . . . preferably by flying the airplane attached to it. Turning over the prop by hand just won't cut it.

Lie #5: The less oil an engine burns, the better.

Get a few aircraft owners get together over a few beers, and inevitably the conversation turns to oil consumption. "I'm only using a quart in 30 hours," one will say. "That's nothing," brags another owner, "I don't have to add any make-up oil between 50-hour oil changes!" The owners doing this bragging probably don't realize that they probably won't make it to TBO without a costly mid-term top overhaul! It turns out that ultra-low oil consumption is often a bad omen when it comes to cylinder longevity.

For a cylinder to make it to TBO, it must be protected from metal-to-metal scuffing by the piston rings. This protection comes from a film of oil that coats the cylinder barrel and causes the rings to "hydroplane" instead of scuffing the barrel.

Now, if the cylinder barrel is properly coated with oil, it's inevitable that some of this oil will be burned up in the combustion process. That's why a certain amount of oil consumption is perfectly normal.

Ultra-low oil consumption indicates one of two things: either the oil film is too thin, or the oil is not reaching the critical upper portions of the cylinder walls where the compression rings reverse direction at top-dead-center (the so-called "ring-step area"). Without adequate lubrication, there's a high risk of metal-to-metal contact between the compression rings and the cylinder wall.

Experience seems to indicate that oil consumption lower than about a quart in 20 hours maynot bode well for long cylinder life. Barrel wear in the ring-step area becomes likely, leading to rapidly

deteriorating compression and accelerating oil consumption at 500-1000 hours.

While low oil consumption has always been acknowledged as a sign of a tight, well-broken-in engine, there is strong evidence that a quart in 30 or 40 hours may well be too much of a good thing.

Lie #6: The cooler the engine's oil and cylinder head temperatures, the better.

It turns out that the "cooler is better" notion isn't quite right. While excessively high temperatures are bad for your engine, low temperatures are no great shakes, either. Take oil temperatures. Most of our airplanes have oil temperature gauges that have a green arc running from 75°F to 240°F, with a red-line at 240°F. Now, 240°F is way hotter than we'd like to see. Keep in mind that the oil temperature probe is usually located at the place in the oil system where the oil is coolest, often near the outlet of the oil cooler. So if the gauge reads 240°F, the oil is probably hitting close to 280°F at the hottest point in its circuit through the engine. That's hot enough to cause petroleum-based oil to oxidize and break down at an accelerated rate. We've either got to bring down the oil temps, or change the oil very frequently.

On the other hand, oil temperatures lower than 170°F or so on the gauge present a different problem . . . namely, that the oil is probably not reaching the boiling point of water at the hottest point in its travel. Why is this important? Every time we shut down the engine, a slug of water condenses inside the cooling engine and runs down into the oil sump. If we don't get rid of this water the next time we fly, there will be a progressive water build-up inside the engine. That water will mix with the sulfur and nitrogen byproducts of combustion to form sulfuric and nitric acid. And that will start eating away at the innards of our engine. The solution is to make sure the oil gets hot enough to boil off the entrapped water, so that the resulting steam passes harmlessly out the breather.

Oil temperatures of 180°F to 200°F on the gauge are hot enough to get rid of this water, yet cool enough not to accelerate the breakdown of the oil. So that's ideally where we'd like to see our oil temperature gauge in-flight. What about cylinder head temperatures? The CHT gauge on a TCM engine usually has a green arc from 200°F to 460°F, with a red-line at 460°F. Lycomings generally have a CHT red-line of 500°F. Once again, red-line CHT is way too hot for optimum engine longevity. At those temperatures, the aluminum cylinder heads are vulnerable to cracking, and the exhaust valve guides are vulnerable to accelerated wear.

On the other hand, CHTs below about 300°F create another problem: lead fouling. Our engines operate on avgas that contains large amounts of tetraethyl lead (TEL). Even so-called "100LL" contains enough TEL to keep the EPA awake at night. The purpose of TEL is to enhance the octane (detonation resistance) of the fuel. Unfortunately, it also can cause lead deposits in the engine, particularly on spark plug electrodes and in piston ring grooves.

To prevent such lead fouling, avgas contains a "lead scavenging agent" called ethylene dibromide, whose job it is to dissolve excess lead and let it pass harmlessly out the exhaust pipe. However, ethylene dibromide doesn't do its scavenging job unless combustion temperatures are fairly high. That's why lead fouling problems tend to emerge when CHTs are below about 300°F.

Ideally, we should try to keep CHTs in the 350°F to 400°F range as much as possible. That's cool enough to keep the cylinder heads and valve guides happy, but hot enough for effective lead scavenging. *To be continued.*

News From The Net (Avflash@a1.ipcc.com)

April 5, 1999

. . . Molecular Engineering Allows Lighter Fuel, Greater Range

100LW is identical to 100LL except that it weighs 17 percent less per gallon (5.05 pounds at 60 deg. F). The weight reduction is achieved by replacing heavy molecules in the fuel—which pass through the engine unburned—with smaller, lighter molecules that burn completely. Each large molecule is replaced with two smaller molecules that occupy the same volume but weigh just half as much. Since about 19.4 percent of 100LL consists of "heavy ends," an overall 16.63 percent weight reduction is achieved.

April 5, 1999

. . . Transition Plans Announced

The new 100LW is compatible with 100LL and may be stored, transported, and transferred in the same tanks and pipes. Pilots may mix 100LW and100LL in their tanks with no ill effects. The FAA says it may allow temporary increases in max gross takeoff weight of up to 15 percent until all 100LL fuel is purged from a plane's tanks. Limited quantities of 100LW should be available this summer, and the new fuel is expected to entirely replace 100LL by the year 2001.

April 5, 1999

. . . Gami Files for Patent on New Fuel Injector Technology

General Aviation Modifications Inc. (GAMI) of Ada, Okla., has applied for a patent on its new Molecular Absorption Micro Injector (MAMI) technology that promises to revolutionize mixture management in general aviation piston engines. "Our new GAMIMAM Injectors actually pair up fuel and oxygen molecules on a one-to-one basis, assuring optimum fuel-air ratio under all operating conditions without the need for manual leaning or EGT monitoring," says GAMI's chief technologist George Braly. "This is the first real advance in powerplant management since 1927."

April 12, 1999

. . . Crankshaft Problems Plague Teledyne Continental Motors

At least six new and factory-rebuilt Teledyne Continental Motors 520-and 550-series engines produced during a three-month period have suffered broken crankshafts. Last week, TCM phoned 127 owners of engines with cranks manufactured between March 11 and June 18, 1998, asking them to inspect their crankshafts at TCM expense.

April 12, 1999

. . . Few Clues So Far as to Cause or Scope

To date, there are few real clues to the cause of these failures, other than the manufacture dates of the cranks. The failures occurred in both new and reman engines, both sandcast and permold, with both 2- and 3-bladed props, both Hartzell and McCauley, in a variety of aircraft: Mooney Ovation, Piper Malibu, Cessna T210, Beech Baron, Cessna 206. Five of the six cranks broke almost identically— aft of the #2 cheek— at between 85 and 175 hours time-in-service.

April 12, 1999

. . . Lycoming Updates Piston Pin Plug Information

Meanwhile, Lycoming last week issued revised service instructions as a continuing response to accelerated piston pin plug wear problems in its engines. SI 1267C seeks removal of the new piloted-style LW-11775 aluminum piston pin plugs "at the next piston pin plug replacement," while SI 1492B expands on oil filter inspection and oil analysis.

April 12, 1999

. . . And Cautions Against Too Much "Snake Oil"

A little may be good, but more isn't better. Lycoming has revised SI 1409B and SB 446D on oil additive LW-16702, which is required by AD in the O-320-H2AD and recommended in other Lycoming engines. Revisions emphasize the importance of using the correct amount—6 oz. per

oil change—and only if the oil is not already pre-blended with TPP additive (e.g., Aeroshell 15W50 and W100 PLUS).

April 12, 1999

. . . Affordable Ga Avionics?

Avionics prices may drop if a new multitiered approach to certification embodied in AC23.1309-1C and advocated by AOPA is adopted. New avionics would not have to meet the highest reliability standards if the manufacturer can show a failure is not critical to safety of flight.

April 12, 1999

...And Opposes Part 135 Aging Aircraft Inspections

NATA is also concerned with a new FAA proposal requiring Part 135 operators to develop their own engineering-based inspections for aging aircraft. The proposed changes would require damage-tolerance-based inspections and procedures for older aircraft, but NATA contends that operators can only expect minimal assistance from manufacturers.

April 12, 1999

Planes, Not Trains, Say Missouri Pilots:

Local pilots are putting up a strong fight to save Richards-Gebaur Memorial Airport (GVW) near Kansas City, MO. City leaders have been working to close the airport and transform it into a truck/-train hub. Airport supporters working at the local and federal levels have forced a public vote this August.

April 26, 1999

. . . Latest on Tcm Crankshaft Inspections

Early last week, Teledyne Continental Motors issued Critical Service Bulletin CSB 99-3 mandating ultrasonic inspection of all TCM 470-, 520- and 550-series crankshafts manufactured during 1998. The biggest surprise is that the number of affected crankshafts has increased from 2,200 to more than 3,000. TCM will reimburse up to $700 for the disassembly and reassembly of normally aspirated engines—up to $900 for turbocharged engines—and will provide the ultrasonic inspection at no charge. At week's end, the FAA issued Priority LetterAirworthiness Directive 99-09-17 to give the force of law to CSB 99-3.May 3, 1999.

. . . Reporting GPS Goofs

If you're out tooling along and your GPS goes Tango Uniform, the FAA wants to know. FAA staffers say that notifying ATC or Flight Service about poor or missing signals will help them stay abreast of possible problems. AVweb is told that the controller/FSS specialist will take the information and forward it to Washington.

May 10, 1999

. . . EAA Pleased with Homebuilt Aircraft Logbook Clarification

The FAA has reiterated that individual airplane builders do not have to secure an A&P's signature before submitting airworthiness inspection forms for FAA approval. EAA requested the clarification after local and regional FAA offices required builders to have the sign-off before submitting an airworthiness application. An FAA memo stated that only the aircraft builder's signature is necessary.

June 12, 1999

. . . TCM Crankshaft Update

Teledyne Continental Motors tells AVweb that it has now inspected more than 2,200 of 3,000 affected engines for signs of crankshaft damage. The failure rate remains at about 13 percent. Anyone in need of an inspection who has has not yet contacted TCM can call toll-free, 1-888-200-7565, or complete the online contact form at <http://www.tcmlink.com/ form.html>.

CLASSIFIEDS

ADVERTISING CLOSING DATES: MARCH 1, JUNE 1, SEPTEMBER 1 AND DECEMBER 1.
CLASSIFIED ADVERTISING RATES $5.00 PER COLUMN INCH, MINIMUM CHARGE $5.00.
MAKE CHECKS PAYABLE TO STOLP STARDUSTER CORPORATION. THANK YOU.

FOR SALE

Starduster TOO. Completed 1989. 455 TT, 355 SMOH on 200 HP Lyc. IO360A1A, 355 since new on Hartzell CS aerobatic prop. King KT-76A Transponder/Mode C & KLX-135A Comm-/GPS/Intercom. Clevelands, Hooker harnesses, Scott tail wheel, ACK ELT. Always hangered. Full inverted fuel and oil. A&P built. Stitts fabric. Open cockpit. $28,000 (Firm). 318-949-3707 or email 71612.3110@compuserve.com. 992

1972 Starduster Too, Continental E185-3 (205-HP), 627 TT airframe, 332 TTSN engine.PS5C pressure carb. KX145 Comm, Mode C transponder, ELT, full canopy, aux. Fuel tank. $25,000. Call 520-219-5930. 984

Acroduster I (SA700) 72 hrs TTAE Lyc. O-360, fixed pitch prop, smoke, fully inverted, Ellison carb, Christen oil system, symmetrical wing, four aile-rons. White, blue trim, beautiful appearance, a delight to fly. Aricraft was completed at Flabob and test flown by Bill Clouse. Buyer must have 500 hours and 50 hours tail dragger time. (See photo, page 22) $24,500. Lee Holcomb, 916.933-7743. 984

Starduster Too. Completed 1989. 435 TT, 320 SMOH on 200 HP Lyc. IO-360A1A, 320 SN on Hartzell CS aerobatic prop. King KT-76A Transponder/Mode C & KLX-135A Comm/GPS/-Intercom. Clevelands, Hooker harnesses, Scott tail wheel, ACK ELT. Always hangered. Full inverted fuel and oil. A&P built. Stitts fabric. Open cockpit. $34,000. 602-580-8044 or email 71612.3110-@compuserve.com 984

FROM THE INTERNET

For Sale. Starduster Too. Completed 1989. 455 TT. 355 SMOH on certified 200 HP Lycoming IO360-A1A. 355 since NEW on Hartzell aerobatic constant speed propeller. King KT-76A Transponder/Mode C & King KLX-135 Comm/GPS/Intercom with moving map display. ACK ELT. Cleveland Brakes, Hooker Harnesses, Scott tail wheel. Both cockpits open. Full inverted fuel and oil. A & P built. Stitts fabric. Airplane is at DVT. March 1998 annual. $28,000 (FIRM). Call 318-949-3707 993

1998 StardusterII 30 tt A&E O-360 lyc, 50 gal fuel, new sen. prop fixed pitch, all acc. o/h when built, all AD's complied with, stits red and white, excellent workmanship, intercom,GPS/COM 190 handheld, clevelands, scott T/W, open cokpits, basic flight inst. both cockpits, eng. inst. rear only. BEAUTIFUL A/C $33,000.00 918-256-1999 or 918-605-3953 please leave message. 993

I have an SA-750 acroduster II project for sale. It is approximately 75% complete the fuselage is on gear needs plumbing,wiring, instruments and cover, wings 75% done, both fuel tanks,cleveland wheels and brakes,eng mount for O-540,flying wires and most materials to finish. I am asking $9500.00 I can be reached evenings 520-567-3608 or thru E-mail at vintaero@sedona.net 993