

**Bernoulli's Law: The controlling physical law of a manometer**

$$h_w = \frac{P_{air}}{P_w} \frac{V^2}{2g}$$

$h_w$  = height of water inches  
 $P_{air}$  = density air  
 $P_w$  = density water  
 $V$  = velocity air miles per hour  
 $g$  = gravity

V (mph)	Hw (differential height of water in inches)
60	1.77
80	3.16
100	4.95
120	7.14
140	9.73
160	12.7
180	16.16
200	20.0
250	31.6



By **VERNE VAWTER**

One instrument in my airplane that has been a source of constant irritation is the airspeed indicator. For some reason mine always reads too low and my friends' airplanes, at least during hangar flying sessions, say they are always faster than mine.

On the verge of an inferiority complex, I decided to do some investigating which revealed that the airspeed indicators are based on a well known physical law and that it is feasible for owners to check and calibrate their own aircraft's speedometer.

Before I relate the principles of airspeed theory, based on Bernoulli's Law, let's get right into how simple it is to make an instrument called a manometer, which is easily put together of a little of this and that found at most hardware stores.

#### **EQUIPMENT REQUIREMENTS:**

1. Approximately 10 feet of clear plastic tubing, preferably  $\frac{1}{8}$  inch to  $\frac{1}{4}$  inch inside diameter (it should cost between \$1 and \$1.25).
2. A board 30 inches in length suitable for mounting the plastic tubing in a "U" shape.
3. Some type of "T" fitting. This can be made by soldering small pieces of copper tubing together.
4. A yardstick.
5. A few ounces of water with a little bit of food coloring to aid visibility and a small quantity of detergent as a wetting agent.

#### **TESTING PROCEDURES:**

1. Examine the pitot tube carefully and if there is a small drain hole, cover it with tape.
2. Stretch the one end of the plastic tubing over the nose of the pitot tube (see Fig. 1).
3. Blow the manometer until the water level between the two sides of the tube has approximately 20 inches difference in heights. Pinch off the air supply tube and check for leaks. If the manometer and the static system are free of leaks the water level will remain constant.
4. With one person in the cockpit viewing airspeed indicator, bleed off the air by releasing the pinch referring to the chart (see Fig. 2) for proper water level differences. Start with a water level that is appropriate for the speed of your aircraft. For example, if your plane is capable of 180 mph, there should be 16.16" difference between the levels of the water in the "U" shaped tube. If your airspeed indicator is reading 183 at the 16.16 inch differential level, you know it's 3 mph fast. Repeat the procedure at 160 mph, 140 mph, 120 mph and so on. Most airspeed indicators are usually two to three mph off somewhat in their range. Naturally if there is a leak in your airspeed system this is indicated by an inability to hold the water level. It is sometimes difficult to bleed the correct amount of air to reach the exact inch difference that you want. Often several attempts are required. The yardstick is moved up and down so as to measure the different levels that the water will reach.

For those who may have noticed that the airspeed indicators are labeled "Do Not Blow In This Opening," you are protected if you do not make the manometer water height difference more than 36 inches, which is the equivalent pressure to less than 300 mph, or the maximum speed that most systems can safely take.

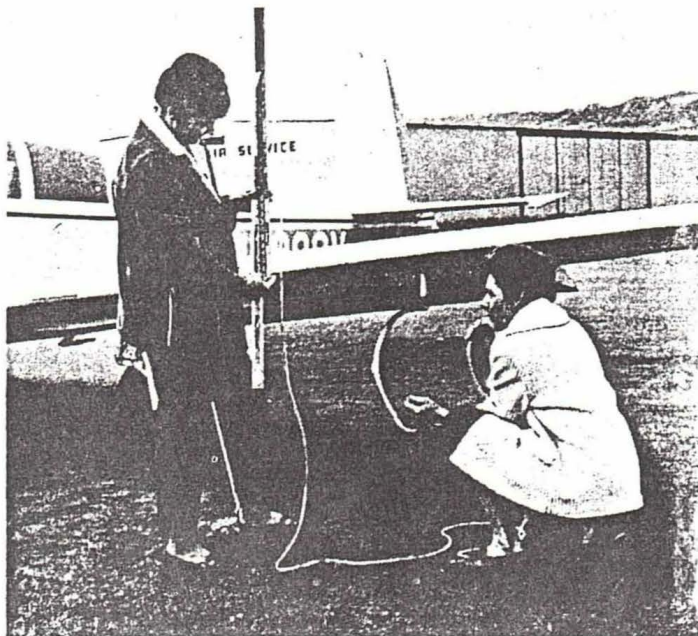
If on your initial test the manometer leaks off pressure at say one-half inch per minute and the test apparatus has no leak it is probably best to remove the airspeed indicator and check it separately to determine if it has an internal leak. From this point on, it is a matter of looking for rotten hoses or loose tube connections.

After calibrating the airspeed and determining that the pitot and static systems are free of leaks, you can make a backup inflight calibration check, best accomplished by flying at low altitudes in two directions between two points on a known distance, checking the time with a stop watch. Correction should be made for the altitude and temperature for proper calculations. Air check techniques are discussed elsewhere in this issue by Kenneth Vorlander in his article "Modern Math."

Once your airspeed has been checked by the manometer, you will have a better understanding and confidence in your indicator. In my own case I felt much better when I found that my airspeed reads slow on the top end which means that friends with similar planes and horsepower do not have the speed advantage I thought they had.

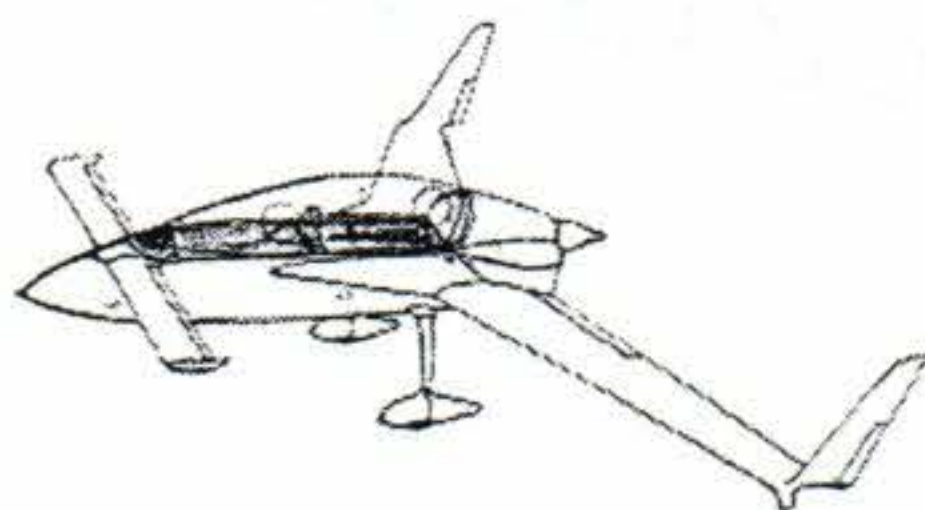
In fact, when I flew wing tip to tip with one friend's plane who indicated 2 mph faster than my plane, because my indicator was manometer calibrated as 2 mph slow, it was easy to determine that *his* airspeed was reading 4 mph too fast.

For those who are interested in the physics read on. For those who don't care why a manometer works, don't let that stop you from assembling one, as you may happily discover that your plane is faster than you thought it was.



*No, they're not smoking an Indian water pipe. Your favorite wife or girlfriend can make this simple test of your airspeed using a build-it-yourself monometer.*

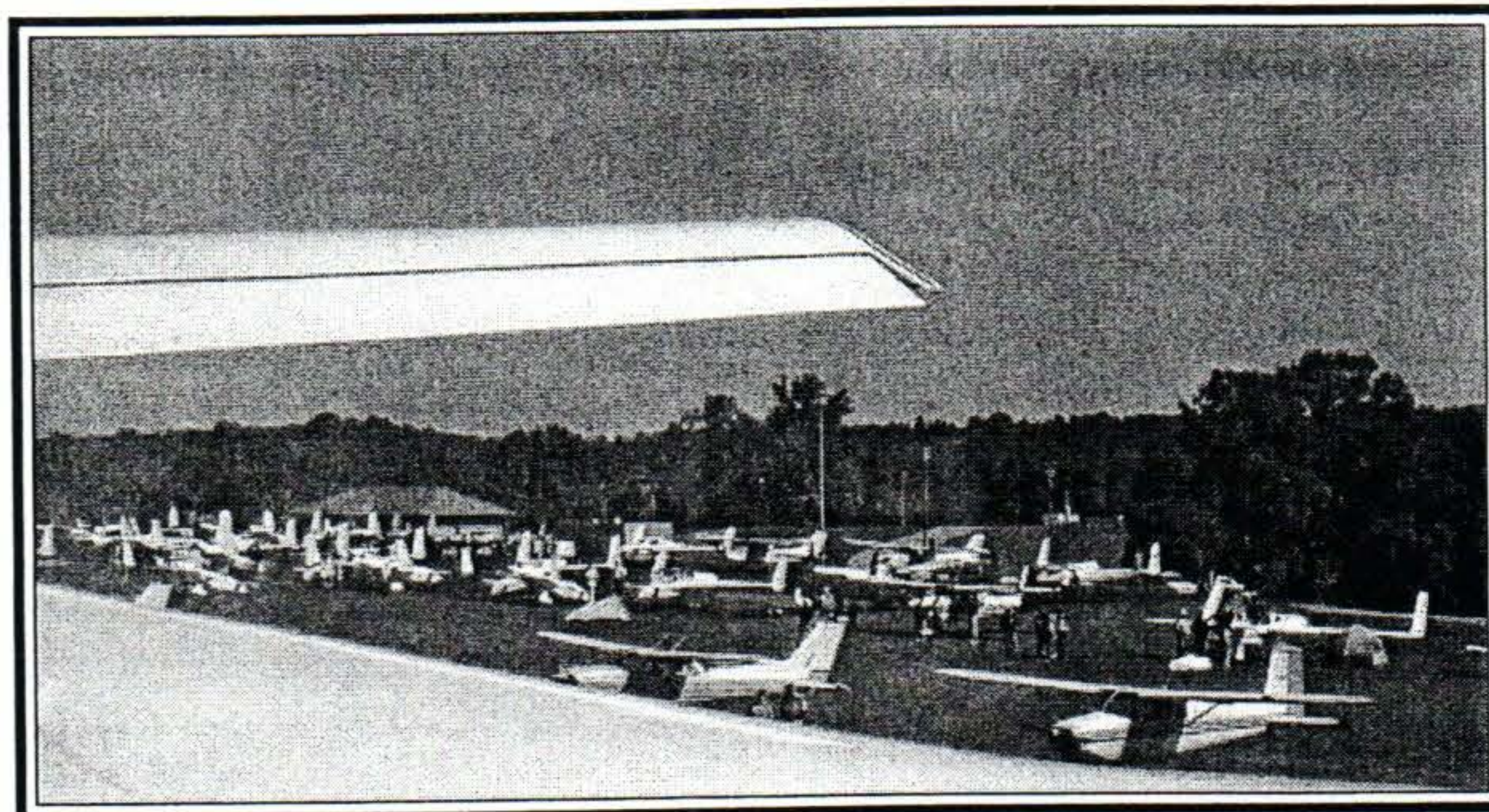




### Vari-Eze Project for Sale

A light and straight Vari-Eze with 700 hours. Gear was damaged in off airport landing. New gear is installed with airfoil on main gear leg. Rebuilt Cont. O-200 with Light Speed 9 to 1 pistons. Project includes Light Speed's light-weight Kevlar cowls and NACA duct. \$9,800.

Contact Charlie Airesman at 301-724-4586



Flare on runway 02 at  
Rough River,  
KY (photo by Terry Yake)

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801-224-4428		757-638-3463	

### NavAid Auto Pilot Jitters?

ED – A recent post on AeroElectric Connection shows that the NavAid unit's design fails to allow for voltage fluctuation.

If you are having aileron jitters on the ground with the alternator not producing, you may have a low voltage condition. Before tearing things apart, try running the engine or at least attach a battery charger to assure proper line voltage.

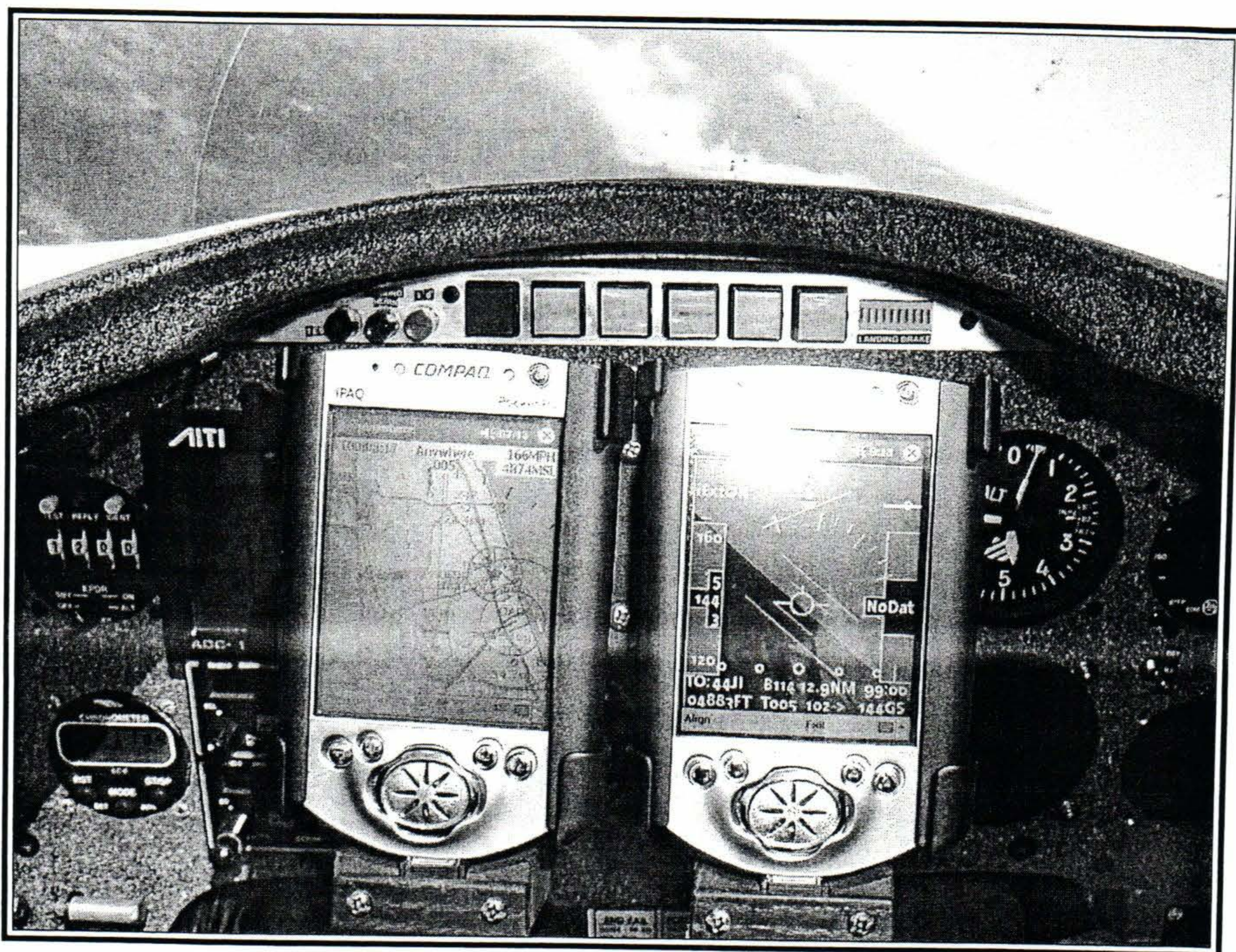
Terry Lamp, Long-EZ builder, reported, "When I was just checking to see if mine works, the servo was chattering and slowly going full left one chatter at a time until I hooked up my battery charger on 2 A and got voltage above 12. It appeared to work fine then."

### New South Carolina and Virginia CSA Representatives

ED: - A new South Carolina state representative has been appointed. Jim Evans, former VA state representative and Long-EZ builder-pilot volunteered to become the South Carolina representative. He can be reached at 803-754-6033 or [jevansez@att.net](mailto:jevansez@att.net)

A new Virginia state representative has replaced Jim. Steve Volovsek Long-EZ builder and spring fly-in host volunteered to become the Virginia representative. He can be reached at 757-638-3463 or [smurfbear@msn.com](mailto:smurfbear@msn.com)





## EFIS, from 500 Moving Parts to None

Dave Knox (FL) - I love the 21st century! I just finished installation of a poor man's glass electronic flight information system (EFIS). It works well. It's relatively easy to install. It's relatively inexpensive: about \$1600-\$2500. It should be far more reliable than my vacuumasaraus, since it has no moving parts. It weighs a total of 3.5 lbs (vacuum system weighed 16 lbs total). But it is not IFR certified.

**Artificial Horizon.** Reference web page <http://www.pcfightsystems.com/> Craig Sellers makes the 'gyro' unit and software in his home workshop. The guy is scary-smart, friendly and very interested in satisfying his customers.

The 2" x 4.5" x 6.5" module fit neatly under my Long-EZ's seat, below my left thigh. With solid state accelerom-

eters and gyros, it senses the accelerations and does some of the math, then sends the rest of the data to a personal digital assistant (PDA). The PDA is used for the rest of the math and displays a full color horizon with turn and bank.

But wait, there's more! Feed RS232 data from GPS or an air data computer into the gyro unit and you get a Primary Flight Display with airspeed tape on one side, altitude on the other, and a lot of additional GPS data around the edges. A GPS feed gives you GPS ground speed and GPS altitude, but an air data computer (ADC), such as Rocky Mountain Micro Encoder, or Mach III, gives you indicated airspeed and pressure altitude.

Its software can also be upgraded online as Craig comes up with improved algorithms and new features. He just released a software version

with a flight director mode and highway-in-the-sky that works well. Set the altitude on the PDA and select a waypoint on the GPS. A series of circles guide you to an intercept and up or down to the selected altitude. In the pipeline are new display features, an autopilot feed, even a HUD made by Microvision, Inc ([http://www.mvis.com/prod\\_nomad.htm](http://www.mvis.com/prod_nomad.htm).)

Another exciting development is Craig's own Edata module, which will have a built in ADC, integrated into his systems.

I was doubtful about its suitability until I 'chair flew' the gyro module while holding a PDA in the other hand. It was rock solid. I was sold and am pleased with it in the airplane as well. Also, it will run for hours on it's internal batteries if unable to feed from the aircraft and is fully portable via Velcro mounting.

Craig has a long list of upgrades to



come, including an interface module that will collect up all kinds of information and give it to numerous displays as required, such as a repeater display for the back seat. This is what will make the two axis autopilot feed happen as well. This upgrade will directly feed two servos, not needing an interface with an expensive autopilot black box. Craig is also planning a vertical navigation mode, able to leave your current altitude and capture a new one! That's normally a feature found only in five-digit autopilots!

If you want a little more glass in your cockpit look at his Engine Monitor, fed directly from sensors or piggybacking off an existing system with RS232 output, it uses an iPAQ to show a dual analog/digital engine display like the expensive Sierra Flight Systems. There's more, but you just have to see his web site.

I use Compaq's iPAQ PDA. I recommend it strongly and yes, it is going to survive the HP/Compaq merger. It is color and fully sunlight readable. It also serves many other functions before, during and after flight. I have checklists on it, a slew of books (free web downloads), star charts, and all that happy PDA organizer junk: address book, calendar, task list, etc. I bought it thinking it was a fun toy, but it has turned into essential travel gear.

One inexpensive source for these is HP/Compaq's Factory Outlet web site where I got a 'scratch and dent' for about \$350. Normal retail is near \$450, and I saw no scratches, nor dents. (Just a stubborn piece of tape which a little elbow grease removed.) I recommend a 3700 model, or 3800 (newer, more expensive.) Also, I recommend the PC Card sleeve with it. It cost more, but now you can put in a huge external CF Card with a PC Card adapter and the PC sleeve has a built in external battery, greatly lengthening runtime.

The gyro module will run for 8 hours on it own 9v battery and the iPAQ for at least 4 hours with the external battery. That's backup capability!

**Moving Map.** Reference web page <http://www.anywheremap.com/cv/> The Anywhere Map is a strong product and ControlVision is a company that values customer service as well. It's software turns an iPAQ into a high quality color GPS moving map. The existing product is great, and it is constantly evolving with online updates to the database and the application software, most recently adding GPS approaches. It comes with a year of free monthly updates and then costs about \$100 per year to stay up to speed with monthly downloads. I like it so much I am going to sell my Garmin 195 and never look back.

One of the features I like, which makes Anywhere Map unique for its price is its 'Cone of Safety.' If I'm inside a green ring displayed around each airfield, I can glide to the field. I've told it my glide ratio, it knows our GPS altitude, and the ring 'breathes' depending on glide range.

Another iPAQ / GPS map possibility is <http://www.gonavgps.com>. Craig is integrating their software into his big picture now. I didn't know about them until after my installation was complete, so all I can say is that the potential synergy from these two pieces of software is remarkable. Example: Craig just released a combined version of his EFIS software with NAVGPS's map. One push of a button and the display flips back and forth, reducing the need for a second iPAQ. I still like all the information in front of me with two iPAQs (as well as the backup one provides the other), but as a backup or a repeater for the back seat, this scenario would be very Gucci. I've tried NAVGPS's free trial download and like it. Some features more, some less. It will boil down to personal preference and maybe to the integration of the EFIS / Map software. I have not used <http://www.teletype.com/> but it looks strong on its web site.

This also highlights the flexibility of this glass setup. After a 10 minute download, I can change my cockpit to a new, better configuration, not just cosmetically, but fundamentally.

**Installation.** The RAM company (<http://www.ram-mount.com/>) now has an iPAQ mount. I mounted two side-by-side, on a three-inch extension, wired to their support gear via the panel. This solves one sometime-weak area of the iPAQ: at some sun angles the display does wash out a little. But with the RAM mount I can adjust the angle. After flying for about 15 hours in many different conditions I can say it is always readable, though a few times less readable than most.

Another advantage of this setup was keeping the remaining instrument holes behind the displays. I may have pulled my vacuum system out (and danced around the funeral pyre under a full moon) but I'd still like some old-fashioned steam gauges available for altitude and airspeed. They now live behind the EFIS where I can easily view them with a twist on the RAM base mount.

Installation of the EFIS was straight forward, with the only bugaboo being mounting the gyro module as true to the flying longitudinal axis as possible. It can adjust, electronically, for a generous mounting error, but as always: the truer the better. The Anywhere Map and NAVGPS can be independent or piggybacked off another GPS with NMEA out. I installed an independent unit in the backseat for my GIB and a dependent one in the front, though I plan to sell the Garmin 195 and free the iPAQ from its bonds. This change will also allow me to use the portable iPAQ / GPS in the car, since there is plenty of memory left for a street atlas.

Another weak area of the iPAQ is the tiny connector on the bottom. It tends to wiggle loose. I solved that by mounting a piece of MDF, cut to snugly position it in place (see photo). Since this creation however, new cradles are on the market, which should alleviate this necessity. Craig sells these too.

In summary, this stuff is what the 21st century is all about! It works; it's cost effective, lightweight and of course, it's very cool looking.





### Piece of Paradise

*Scott Church (HI)* - Anyone planning to travel to Hawaii and would like to stay on the Big Island should contact me (808) 322-9529. With two partners, I developed a 300 unit resort complex during the past 8 years and would be happy to extend condo rates for luxury accommodations to CSA members for the cost of maid service only - - (\$30 per night). Visitors could join myself, or the other Big Island Long-EZ owner, John Todda, in a flight within the island chains. I would love to share the beautiful flying, and gorgeous views.

Aloha!

## Fly Safely

### Think About It

*Byron McKean (AZ)* - **Stay out of weather you are unprepared for.** Please take an hour of instrument flying from a qualified instructor and ask the instructor to put you under the hood at a safe altitude with no instructions or help and just see how long you can really stay straight and level. Do this for an hour. You must really know by experience, safe experience, what "in the soup" is like.

John, we will truly miss you . . . . .

### Long-EZ Face Lift

Larry Laughlin recently completed repainting Long-EZ N18CC built by Cliff Cady in Florida. Larry will be participating in the CAFE program with the eight year old O-320 powered EZ and will hopefully pass on some findings.

### Cooling Problems?

*David A. C. Orr (CA)* - A local EZ owner complained to Klaus Savier about cooling when on a long climb out of the desert heat. Klaus suggested that the EZ owner do as Klaus had done. Remove the upper cowl stiffener as the cowl is pinched in place by the stiff lower cowl and wings. The upper cowl is floppy when off the airplane but stiff enough on the plane. I'll report any problems.

Klaus also suggested that if the cowl is within 3 inches of the leading edge of the prop it might be forcing air back into the cowl opening.

### Our Sympathy to Ron White

Arnie Ash reported that his good friend and Long-EZ builder, Ron White, has suffered a great loss. Ron's wife unexpectedly passed away in her sleep.

### Strobe Conditioning

*Jim Voss (TX)* - My Whelen strobe power supply died shortly after being put in use. It had been sitting in the box at home for some time while I was building. The Whelen folks were great! Since I had not used the strobe unit long and even though it was technically out of warranty, they repaired the unit at no cost.

Whelan said conditioning is required to extend the life of a power supply that has been sitting for a long period of time. When you first bring the unit on line, do it at a reduced voltage for about 15 minutes. This conditioning allows the capacitors to come up to charge more slowly and prevents capacitor over heating and failure. Strobes also work better if used regularly.

We should use our strobes for better visibility by other aircraft anyway. Longer system life is just another reason to fly with them on all the time.

### Long-EZ In Parts For Sale

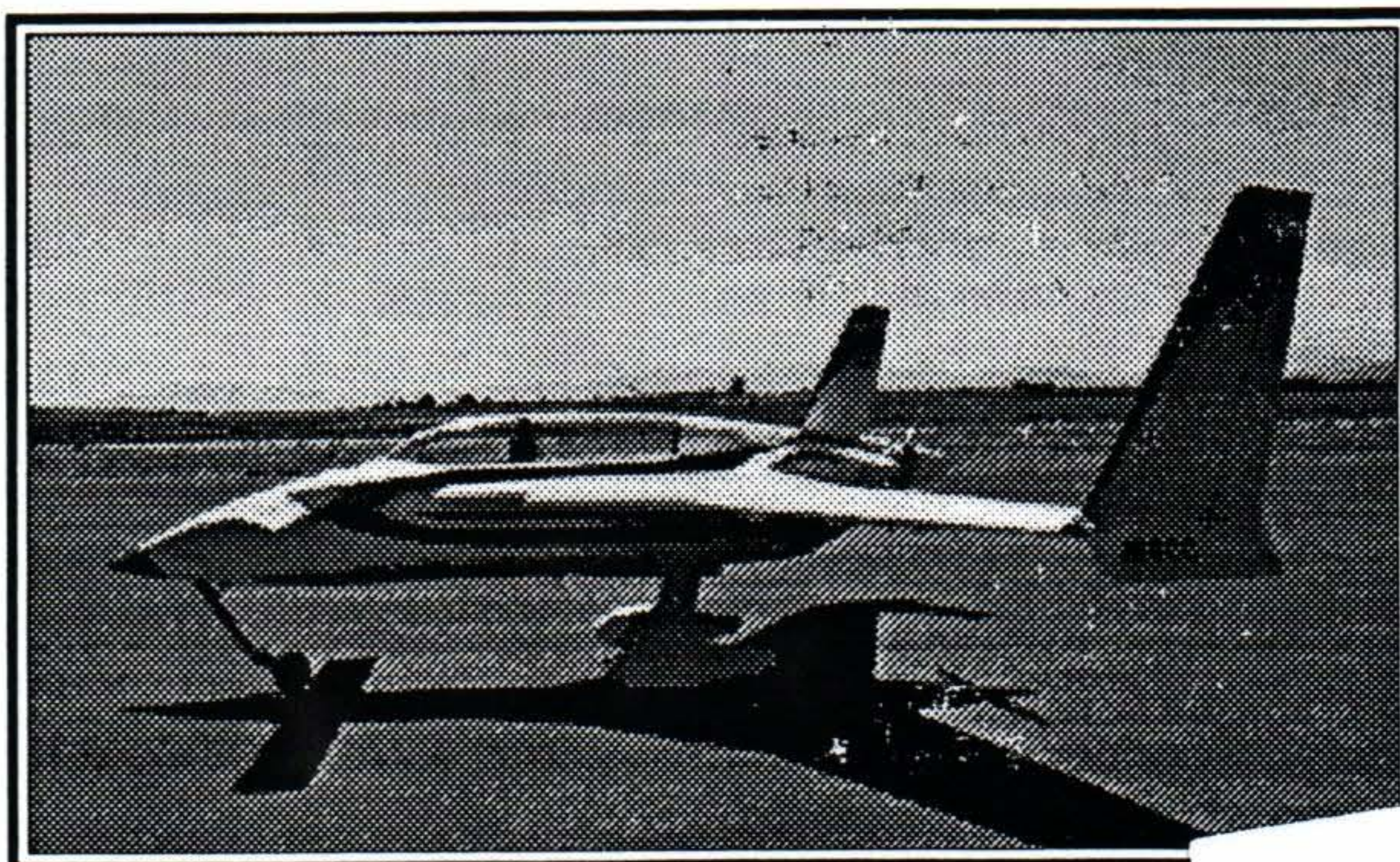
I want to build a Berkut - so must sell Long 137EZ - (only in parts).

Chuck Abbey  
P.O.Box 226  
San Marcos, TX 78667-0226  
512-396-0326

### Wheels for Sale

1 pair Cleveland wheels & brakes, 5.00 - 5, McCreary tires. - \$200.

Malcom Clarke  
121 Holly Drive  
Houston, PA 15342  
412-745-7923





MUCH better.

In my opinion, a three blade prop is smoother than a two blade on a pusher configuration. A two blade will produce a lot of vibration. On our type pusher aircraft, both blades are going through the wing turbulence at the same time; resultant thrust on the airframe is in pulses. A three blade has only one blade enduring wing turbulence at a time.

*ED: see CSA, August 1996, page 13 for related prop noise article.*

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### Wanted

I'm looking for an O-320 Long-EZ in excellent condition structurally, mechanically, and cosmetically. Updates preferred including Roncz canard and long rudders. Experienced responsible pilot willing to sign waiver of liability. Prefer purchase from original builder. Doug Prange 402-432-0774.

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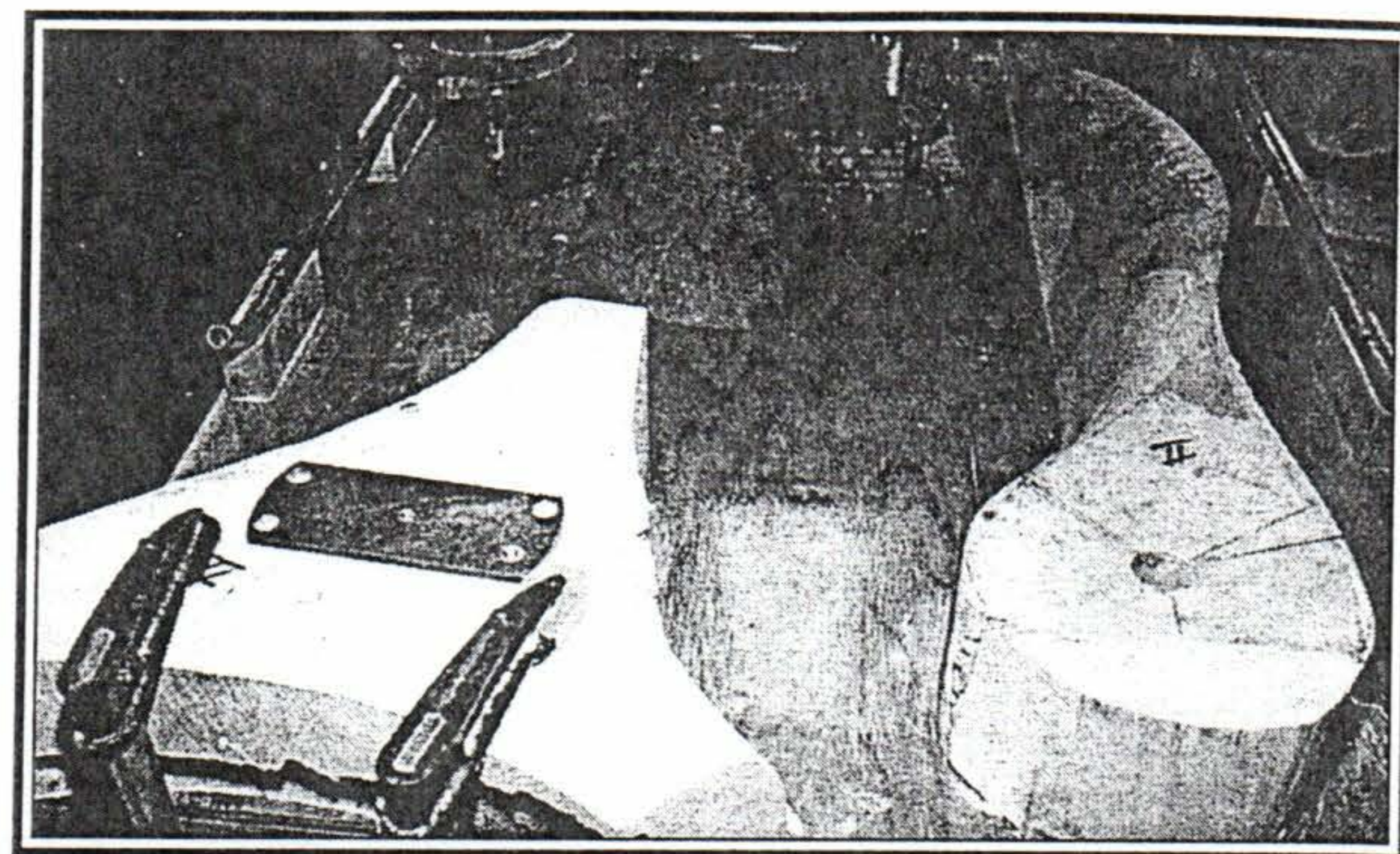
### Caution: Laptop in the Cockpit

*Tom Staggs (WA)* - Think hard before you tear out those instruments. The FAA has made it clear they will NEVER certify any primary flight instrument that use a Windows operating system. The primary reason is not the system's propensity to fail when you need it most, but has to do with the accuracy of the software code.

When we in the avionics industry write code, especially for cockpit displays, we do validation and verification. The purpose is to ensure every line of code performs its intended function, there is no potential miscalculation and there are no "extra" lines of code.

Lack of validation and verification allowed that rocket to blow up recently when an "extra" line of code was accidentally left in its software.

Certified displays incorporate "watch-dog timers" that continually track time to perform functions and update the display. Should a function get stuck in an endless loop, the timer sends the display back to a reset mode. No



Pattern of blade face and hub during trials

laptop-based system has ever incorporated this function and can't with current processing power.

Given some of the brightest engineers and most detailed cross-checks, errors still occur. About a year ago, an airliner accidentally stalled in flight. As it pitched and rolled, the flat-panel displays sensed what they thought was a failure (excessive roll rates beyond the design capability of the aircraft) so they went into their reset mode... just when the pilots needed their artificial horizon the most. No display is infallible.

Consider also the weakest point in most display systems are the backlights. Your computer can work just fine, but when the backlight fails, the laptop becomes 3 pounds you could have used for fuel. Backlights in laptops are not designed to handle constant vibration of a small piston airplane. Even backlights that are designed to do so fail somewhere between 5 and 15,000 hours. That means if 100 of you had laptop-powered instrument panels, I would expect at least one in-flight failure per year of your display. One company who manufactures 95% of the world's aviation backlights won't guarantee their backlights beyond 5,000 hours in aviation applications.

Large planes that do fly with EFIS  
issue 52 page 25

(Electronic Flight Instrument System) displays ALWAYS have a redundant, stand-alone backup for essential information; we just don't have that kind of room if you use a laptop.

The moral of this story: As Director of Cockpit displays for Allied-Signal Air Transport Avionics, I went to a lot of trouble and expense to install a vacuum-powered artificial horizon in my Long-EZ to replace a functioning electrical one. The vacuum pump has a low mean time between failures, but its failure will not likely be coincident with a total electrical failure.

Single-point failures (total electrical failure or software-induced display failures) are just too risky for a small plane like an EZ.

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### Alternate Canopy Supplier

*David Orr (CA)* - Steve Tillman (123A Butler Creek Rd, Sedro Wooley, WA 98284-9602, 360-724-3710) sent \$475 for a canopy from the Gordon Olson source I suggested in the last issue. He is getting the run around and hasn't seen the canopy yet. I advise others to check with Steve before ordering theirs. It might be a case of consolidating orders to build at one time or a fast scam.

Berend Ages 949-587-0614 has the same problem and reports Olson complains of financial problems.



## First Irish Long-EZ

*Dave Ryan (Ireland)* - My Long-EZ is at last flying! First flight was August 27 with Captain Bob Gardiner at the controls. Bob is a fellow CSA member and veteran Long-EZ builder living in Scotland.

It flies just as Burt said it would with numbers as per the book! Now that I am flying it myself, I realize what a wondrous machine it is. Keep at it guys. It is worth every hour you have spent on it. There are many people to thank over the 15 years of building including the many Central States contributors who kept me going during the dark days that sometimes occurred in the building process. I have incorporated many of the ideas that I read about in the newsletter.

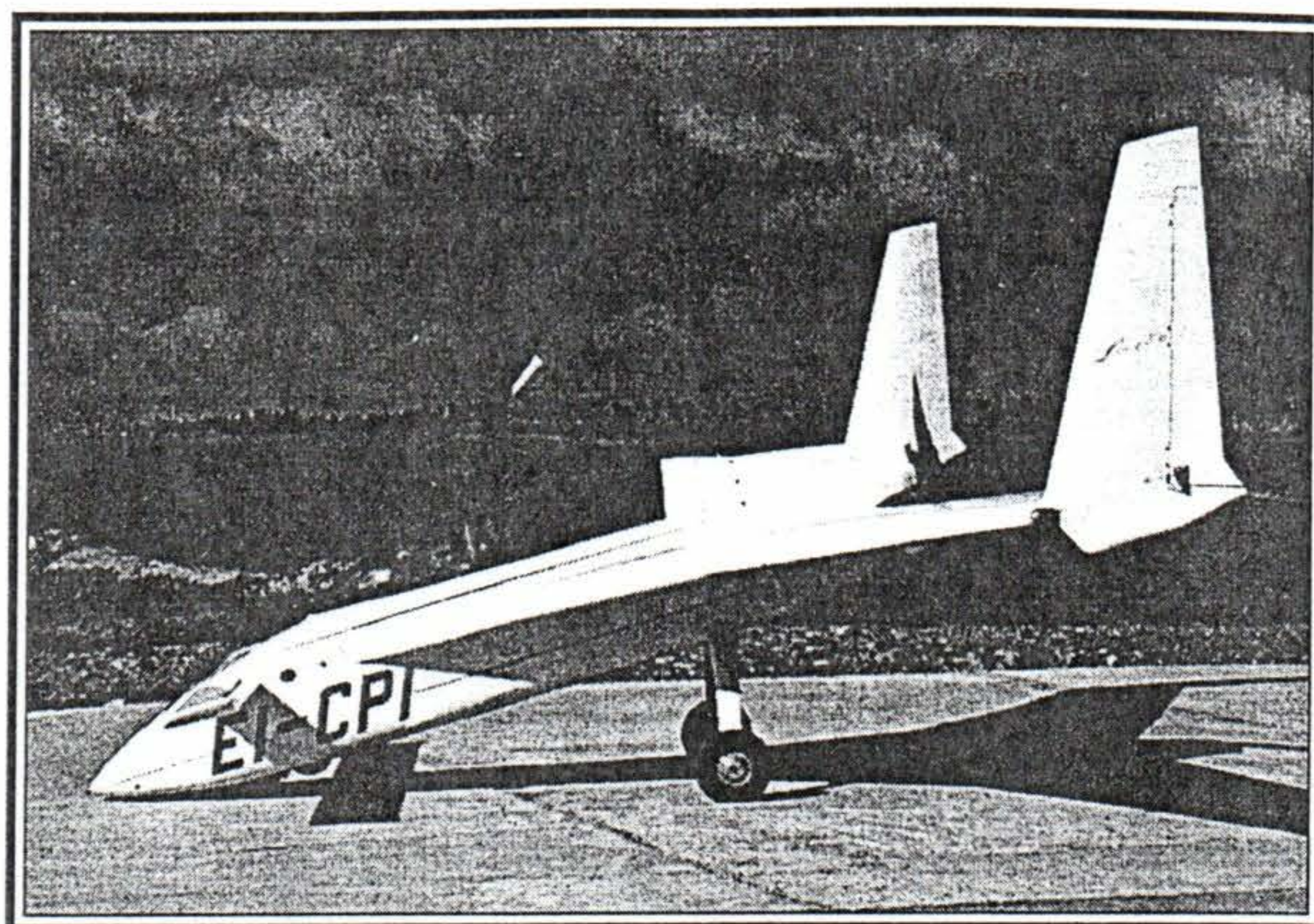
The Long-EZ's O-235 last flew attached to a replica SE-5 used in making the movie, *The Blue Max*, 27 years ago.

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### Glass Panels

*Paul Krasa (VA)* - In approximately three years, the AGATE consortium will have available two flat panel displays which will revolutionize the way we fly airplanes. The panels are a low cost Primary Flight Display (PFD) which will replace your standard six instruments and a low cost Multifunction Display (MFD) which will have a moving map, traffic data, engine parameters, datalink weather, radio functions, etc.

General Aviation is on the brink of a revelation driven by the digital bandwidth and all current paradigms are changing. VHF Datalink radios were on sale at OSH this year. These radios will facilitate new technologies into the cockpit at prices comparable or lower than the equipment being replaced. In the next few years acronyms such as ADS-B (Automatic Data Surveillance Broadcast), VDL-II/III (VHF Datalink Mode Two or Mode Three), CPDLC (Controller Pilot Datalink Controller), and DGPS (Differential Global Positioning System)



will be part of every pilot's vocabulary.

I feel, if you are years away from integrating avionics and your electrical system, wait to purchase your equipment until the last minute. If you don't, you will end up in the situation many builders faced when they bought a Loran and found GPS dominated the navigation scene by the time they completed their airplanes.

I applaud all who want to integrate a laptop into the aircraft. In the near future, the laptop in combination with the digital radio will bring a lot more useful information into the cockpit. If you want to know the weather at your destination airport, punch a few keys and up comes the latest METAR, TAFS, and NEXRAD. The future laptop will be the homebuilders MFD; eventually we will be able to plug small cards into our notebook computers which will be our radios. You can already buy a GPS on a PCMCIA card for your laptop.

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### High EGT May Indicate Ice <Canard.Com>

*Bruce McElhoe (CA)* - I have found carburetor ice will cause a very high EGT on one cylinder in my O-235, with MS carburetor. The high temp shows up long before the usual RPM drop

that indicates carb ice.

The O-235 has notoriously poor fuel distribution and induction paths to the cylinders are not equal. Ben Ellison has written in this forum how the fuel settles out on the wall of the induction piping in an O-235. I suspect a little ice near the venturi changes the fuel distribution among the cylinders.

On my engine, the first sign of icing is: EGT of #3 drops, and EGT of #2 skyrockets. I discovered this by recording temperatures every trip, especially before and after leaning, and plotting them. One day, I was intent on measuring wildly-variable temperatures (that didn't make any sense) and the engine quit from carburetor ice...duh, I figured it out! (No harm done, the engine started again okay.)

My engine will form induction ice even at full throttle. I've noticed that a full-throttle climb between broken clouds will often show these temperature excursions...right at the altitude of the base of the clouds.

Now, I watch my EGT's carefully. Also, I use Prist when the humidity is high. This is my experience...maybe your problem is the same, maybe it isn't. If your EGT #3 goes high in all weather conditions, clearly it's something else.