

Cavalier Engine Swap

by Stu Simpson
Photos by Stu Simpson, Al Botting and Gary Abel



Over the course of the several months of flying my Cavalier in late 2014 I saw a substantial increase in oil consumption on the plane's Lycoming O-290D. There turned out to be a number of causes.

First there was a lack of oil-air separator, which, combined with a less than ideally routed crank case vent hose, allowed some of the engine oil to fall overboard. There was also a loose and leaky valve cover on the #1 cylinder. Carl Forman, Bob Kirkby and I repaired that during the formative stages of a three-day long snow storm that stranded us in Gillette, Wyoming on our trip to Washington, DC, in September of 2014.

Upon returning home I added an oil-air separator and I did note a slight decrease in oil consumption. Though still well within limits, it remained higher than it should have been. I consulted my favourite AME Ken Beanlands who indicated the problem my well lay in a worn valve guide. This, he explained, would allow oil to enter the combustion chamber and deplete the oil level more quickly.

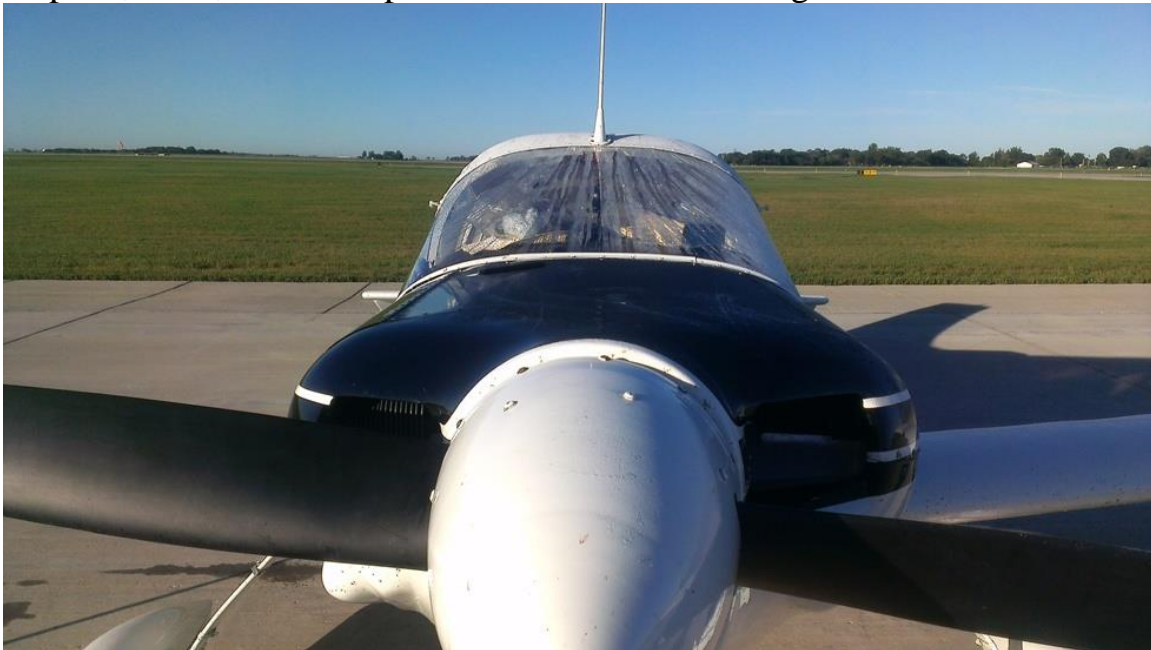
I took the Cav to Jon From's Cloud 9 Aviation in Red Deer, since Ken lacked the proper tools to confirm his diagnosis, and learned the prediction was spot on. The exhaust valve guide on the #3 cylinder was worn. Jon

stated that the engine was still plenty safe to fly, but would continue to use more oil than normal.



So, what to do now? O-290 cylinders are rare and expensive. Lycoming hasn't made them since the mid-60's and the supply sure isn't what it used to be. Well what about shopping around for a used jug, or even another 290 all together? I realized that would be a reasonably cost effective alternative, and I even found a good engine for a good price in Saskatchewan.

But I also realized that I was merely delaying the inevitable. My 290 would have to be replaced, either in whole in part, sooner rather than later. Not a surprise, at all; in fact I'd planned for this since I bought the Cav in 2012.



My goal is to keep the Cav until I die or lose my medical, which ever comes first. Thus, the most enduring solution was to replace the 290 with a Lycoming O-320, probably the most commonly found piston aircraft engine on the planet. They typically have a TBO of about 2000 hours. I'd need one of the older variety, one with the conical style engine mounts to match the existing engine mount on the Cav. That meant a 320-A or B series engine.



I shopped around and settled on an overhauled O-320-A2B from Vike Airmotive in Kamloops, BC. I bought an engine from Ken Vike for my Bushmaster a number of years ago with excellent results, so I had no trouble doing business with him again.

Switching to a 320 will be a double-edged sword. I wanted to stick with the 290D as it's an outstanding combination of power, reliability and fuel economy. It hauls the Cav at an honest 110 kts or better, climbs very well even when heavy, and burns about 5.5 gallons per hour. But, as I've indicated, parts are hard to find. I have no desire to be stranded somewhere as an engineer tells me the part I need for my engine simply no longer exists, or is outrageously expensive to acquire.

By comparison, Lycoming O-320s almost grow on trees. Parts for them are everywhere and relatively cheap. Every engineer who's worked on a Cessna 172 - and there are likely none who haven't - is familiar with the 320 and knows where to get parts for it. So if I am stranded, it won't be for long.

The 320 will burn more gas, of course, but it also means more power. The Cav is light and climbs well on 125 hp, so with the 320's 150 horses strapped on, it will climb awesomely. It means a change to the prop, too, of course. But I've already looked after that. I had Aero Propellers of Calgary twist the blades to meet O-320 specs.

A brief aside about the propeller. When examining the options surrounding what to do about a prop for the 320, my first choice was to simply have the 290's prop twisted to a new pitch that would match the engine. Gord, at Aero Propellers said it could only be twisted up to 58" of pitch from it's current 54". Diameter is 74". I had hoped that I could get it pitched to 60" because that's what I read was the standard pitch (as opposed to cruise or climb pitch) for the 320 of 150 hp. Thus, I thought 60" would be the standard pitch for all 150 hp installations. Not so.

Other charts I consulted showed that only 58" was the standard pitch for a number of 150 hp Lycoming installs on planes like Piper Cherokees, Beech Musketeers, some Citabrias and even some C-172s. Sorting out why these standards might differ is way beyond what I've got time for, so I'm just happy I could get my prop re-adjusted to fit the new engine rather than having to get a replacement.

One very good thing about the 320-A2B installation is how it's almost identical in all dimensions to the 290. With only a few changes necessary, it's mostly a matter of pulling one out and putting the other in. The 320's a bit heavier, by maybe 20 pounds, but I've already made up for that by using a light-weight starter and eliminating the vacuum pump and associated instruments to shave off nearly the entire weight difference. The CG will be nearly unaffected.

It was my goal to have the 320 in hand by mid-February 2015. I'd get the installation underway as soon as possible after that. As good a performer as the Cavalier was with 125 hp, I couldn't wait to see how it flew with 20 percent more power.

Cavalier Engine Swap - Part 2

Installation and Flight

In mid-February I drove to Kamloops, BC to pick up my engine from Vike Aeromotive. Once I found Vike's shop I spent a very enjoyable hour with him discussing engines and airplanes and looking around his shop at the

various engines under construction or repair. Then we loaded my newly overhauled and shiny purple, gold and black painted O-320 into my vehicle.

Two days later I set about the task of attaching it to the front of the Cavalier. Naturally, I wasn't alone in this endeavour. Gerry MacDonald had volunteered his services, and Bob Kirkby once again offered up space, heat and light in his hangar to enable the job to be done comfortably and efficiently. I couldn't have done this job without their help. Gerry is an experienced airplane owner who does as much work on his plane as he can, and that experience really shows through in all that he does around airplanes.

As we slid the hoisted engine into place on its new mounts Gerry noticed that two of the engine mounting bolts were noticeably worn with smooth gouges that had been worn into them over the 31 years since the Cav started flying. That was a full stop and it meant a nearly week-long delay while Aviall got the bolts in. Turns out I got four of the last six left in their entire system.

The following Saturday Gerry and I were back at it. We got the engine mounted and we began re-attaching things that were sticking out of the firewall. Fortunately, the dimensions between the 290 and the 320 are nearly identical. That helped most of the time, but I learned there are still some things that are quite different between the two.

There were only a few changes that arose during the install, and even those were quite minor and easily rectified. Things like the air box support bracket, routing of the oil cooler lines, and the exhaust bracing all required little adjustments.



Watching Gerry work was a real treat. He was rarely stumped by anything and he accomplished each task quickly, efficiently and with the highest quality. I sometimes felt embarrassed when I was struggling with a seemingly simple task while he was progressing steadily through everything he did.

This was most apparent with the baffling. The 320's size and shape are just different enough to make the baffles a bit of a challenge. I had a fair amount of difficulty with the baffle chores that I worked on. Obviously, the baffling has to be done correctly to effect proper cooling. What made those chores so difficult was the Cav's tight cowling and the slightly different shape behind the prop hub.

Finally, on the first Saturday in March, the 320 was ready to test run. Gerry wisely suggested that we run it first with the cowling off for a few minutes. This would make it much easier to check for leaks and squeaks before we cowed it up again for flight.

We rolled it out into a bright chilly morning and pointed it into the wind. I climbed in and latched the door. I went through my pre-start checklist and turned the key. Nothing caught on the first few blades, but by the third or fourth it did catch and started running.

A number of things competed for my attention; a low and satisfying whine, ironically similar to a turbine; the engine's noticeable smoothness, and the fact there was no oil pressure yet. Lycoming allows 30 seconds without oil pressure registering, but I saw the needle start moving at about 12 or 13 seconds. That was a huge relief.

I spent the next several minutes with my eyes glued to the instruments and my ears tuned for anything sounding amiss. Gerry braved the icy propwash to check for anything dripping or wobbling that shouldn't have been. I ran the engine up to 1900 rpm and everything seemed great. I gently pulled back the throttle and allowed the engine rpm to descend to about 350 or 400 rpm before I finally pulled the mixture. The low idle would need adjustment, but we'd cleared a major hurdle.

We fastened the cowling back on and went to lunch. This was partly because I was hungry, and partly because I wanted to take my time before I flew the plane. It turned out to be a welcome break and the weather improved during the time we were away from the field.

Upon returning, I climbed in and started up again. Two things had yet to be done; the static run up and the mag check, which I'd forgotten to do when we ran it naked. I wanted to minimize any low rpm taxi time, so as soon as I could I had the Cav headed for the button of Kirkby's runway 34. Once there I did my standard mag check and was quite relieved to see we had timed the electronic mag perfectly.

Now it was time for the static rpm check. This was the part I was most concerned over. I worried that the prop, a Sensenich 74 x 58, would be grossly under-pitched. A conversation with Ken Beanlands taught me a lot about why prop pitches differ for the same engine on different aircraft models. Generally speaking, the prop is pitched to match the performance of the airframe as much as the engine. Thus, planes that use the 150 hp Lycoming and the same 74" diameter as mine might have pitch ranges from 54 to 62 depending on aircraft performance. I needed to look for an airplane that had similar performance to what the Cav would have behind the 320.

My research turned up the Grumman Cheetah/Traveller, which also uses the 320-A2B. Its prop numbers are almost identical to mine, and its performance is pretty near what I thought the Cav would show. Maybe my prop worries would be for naught.

I set the brakes and eased the throttle to full. Just as I saw about 2450 rpm the tail came up sharply, surprising me. Worried about a prop strike on my brand new engine, I released the brakes and we started rolling. But the extra torque was ahead of me, compounded by the right crosswind. The acceleration was substantially higher than with the 290, too. Things were starting to get ahead of me and it scared me for a second.

I refused to let that happen. I stabbed the left rudder, tracked to the centre line and quickly got the Cav back under my control. In seconds the Cav and I were finally flying again. The climb rate was predictably excellent, exceeding 1000 feet per minute without even trying. All temperatures were in the green.

I spent the next hour staying close to Kirkby Field in the event I needed to land quickly, but no major issues arose. Carl Foreman was on the ground with Gerry and his airplane partner, Barry Wood. Gary Abel and Geoff Pritchard took video and photos. Carl reported on the radio that the engine sounded just great.

Despite my anxiousness upon first committing to flight, within half an hour I noticed a very comfortable relaxation setting in. I was still very aware of the Cav and what could go wrong, but nothing was going wrong. I was enjoying my beloved airplane once more. I landed after 60 minutes with a big grin and a lot of relief.

We checked the engine over carefully but could find nothing amiss. The only difficulties that arose in flight were high EGT readings, which I'm pretty sure is due to a mismatch between the gauge and the new probe; and the oil temperature sitting at about 205 degrees. Not dangerous at all, but we did learn that the engine oil is not making it to the cooler. Gerry and I suspect an airlock, and we have a solution we'll apply as soon as we can.

The prop is in fact under-pitched, but only by a little. It's easy to keep it well within safe limits. I'll likely acquire another, coarser one later on, but it doesn't need to be a priority right now.



I flew another 1.2 hours that day running the engine hard, at well above 2550 rpm. It's crucial to run the engine as far above 75% power as you can. This forces the rings to seat properly against the cylinder walls which is essential for engine longevity. I was gratified when checking the oil upon my second landing to see that hardly any was gone in the second hour of flight. I think I'm doing something right.

After 2 1/2 months on the ground I'm glad to be back in the air with the Cav. It feels right flying with this engine, and it's much smoother than it was with

the 290. I've gained 10 knots in cruise, maybe a bit more, but my fuel burn has increased, too. At the high RPMs it's burning just less than 8 gallons an hour. It should really be higher, but the Lightspeed Plasma electronic ignition makes a noticeable difference.

The really hard work is done now, thanks very largely to Gerry MacDonald's efforts and Bob Kirkby's generosity. I now get the fun of completing the break-in and then seeing just what the Cav will do with an extra 25 horsepower under the hood. I really am the lucky one.

Cavalier Engine Swap - Part 3

High Oil Temperatures

Over the course of flying my Cavalier through the few days in March that were available to me, I realized that the Cav had an oil temperature issue. This wasn't a huge surprise, but it was frustrating.

The first day I flew the new engine the outside air temperature (OAT) was about 5 degrees C and the oil temperature was steady at about 205 degrees F. This was a bit troubling because the O-290's oil never exceeded 200 F except on the warmest days, and even then not by much. Was the high oil temperature the result of a new and tight engine, or was there a more intrinsic heating problem with the Cav's cowling and oil cooler set up?

After landing on the first flight the oil cooler was cold, as were the lines leading to it. It was either an airlock in the system because we hadn't filled the lines or the cooler with oil prior to running the engine, or the cooler was simply blocked.

Ken Vike, my engine overhauler, said there should be enough ambient pressure from the engine to fill the cooler and force any air through. He also made a good point in saying that the cooler might contain a bunch of gunk from the old engine that I didn't want circulating in the new one. I tried unsuccessfully to find a place here in Calgary that flushes oil coolers. I ultimately decided that the Cav deserved a new oil cooler after more than 30 years, so I ordered one.

After installing the new cooler I flew the Cav on a day with an OAT of 10 degrees C but the oil temperature was now up to 220 degrees F. This wouldn't do.

Time to start the investigation in earnest and solve the mystery of why the oil temps were so high. First things first. I confirmed with a digital thermometer that the gauge was reading correctly. I also confirmed that the engine was pumping oil through the cooler. But a closer look at how cooling air was getting to the cooler revealed a possible villain.

The Cav has a cowling that slopes downward from the front of the wind screen to the prop. In the top of the cowling is a set of louvers that capture air and direct it into the top of the cooler. But there is a space of about 3/4 of an inch between the cowl and the cooler that allows air to run past the cooler itself. I decided to build a shroud that would attach to the cooler and capture and forcefully direct all the louvered air through the cooler. I also confirmed the cooler is well vented on its bottom side.

Incidentally, the entire cowling exit is a good size, too, so that cooling air over the cylinders also exits well. However, a closer look at the baffle on the front right cylinder showed me I could add a bit more there to ensure proper cylinder cooling and alleviate any hot spots. In fact, my cylinder head temps are only about 300 degrees, again confirmed with a digital thermometer.

I built the oil cooler shroud using scrap aluminum and baffle seal rubber. Here's a photo of it:



I test flew this arrangement on a day with an OAT of 5 degrees C and saw a reduced oil temperature down to about 195 degrees F. That showed promise and that my problem solving was probably headed in the right direction.

Thus encouraged, I decided to continue my efforts to force more cooling air through the oil cooler. The best way to do that would be to build an air scoop that would capture and pressure air directly into the louvers feeding the cooler.

I experimented with a template I fashioned from construction paper and settled on a set of dimensions that would fit. I made the scoop from aluminum and bolted it on using AN wood washers for backing on the bottom side of the cowl. I was quite pleased with the result and think it looks a bit like a hot rod part. Here is a photo of the scoop fitted in place without any mounting hardware:



I flew the Cav with the scoop installed on a warm spring day with an OAT of 15 degrees C. I was quite happy when the oil stayed steady at 190 degrees F. So far I'd shed about 30 degrees of excess oil temperature. The Sherlock Holmes approach was really starting to pay off.

No investigation of engine cooling would be properly complete without checking the Vernatherm, which is essentially a thermostat in the oil system. My research indicated that oil in the 320 circulates oil through the engine AND through the cooler at temperatures below about 180 to 190 degrees F. When the oil hits 180 to 190, the Vernatherm expands and seals off the port

that allows the oil to bypass the cooler. Thus expanded, the Vernatherm sends ALL the engine oil through the cooler. I pulled the Vernatherm plug from the oil filter housing and learned I didn't even have one.

This obviously isn't catastrophic at all, and some engines don't even have a Vernatherm. A quick call to Vike Aeromotive and I had one in hand the next day. I installed it and went flying on a day that varied from 5 degrees to 10 degrees C, but through it all the oil only got up to 180 degrees F for a few minutes. The rest of the time it stayed steady at 170.

This may be a mixed blessing because I'm not sure if the Vernatherm actually operated. My suspicion is that it opened near 180 degrees and because the oil temperature only dropped by about 10 degrees, it wasn't enough for the Vernatherm to return to its cold setting. Thus it stayed expanded and forced the oil exclusively through the cooler. Of course, the cooler now has so much more cooling air being scooped up and rammed through it to remove the excess heat. All tolled, I've shed an astounding 50 degrees of oil temperature.

By way of performance changes, here's what I'm seeing in my Cavalier. The IAS has increased by a minimum of 10 knots to 120 knots, which works out to just shy of 150 mph TAS. Climb is at about 1500 fpm. Fuel burn is about 7 gallons per hour running hard at 2550 rpm or more, due largely to the electronic ignition.

As spring creeps it's way into the Calgary area the days will get warmer. That's when I'll see if the cooling arrangement works as I hope it will. But at this point, I'm pretty sure that the oil cooling mystery has been solved. I also want to eventually add a couple more inches of pitch to the prop, but that will mean a different prop all together because my current one is pitched as high as it can be.

With the oil temperature mystery solved, and longer days ahead I can now focus more tightly on breaking in the engine and enjoying the reliability and longevity the new O-320 will provide for my Cavalier. There are a lot of airborne adventures out there waiting for us.