My Experience with the Warner 165 engine by Charles (Chalkie) Stobbart.

This is a short summary of what I have learned by overhauling my Warner Super Scarab engine. The contents of this letter is not meant to supersede the Warner Engine Handbook circa 1946, but rather to complement it as my copy has never been updated.

1. When stripping the engine, to remove the inter-cylinder baffles, first remove all the exhaust valve pushrod tubes.
2. If your valve guides are worn and need replacement, DO NOT drive (or pull as per Warner Manual, tool FA-199) the guides out of the cylinder head, even if you do preheat the assembly. I cracked the land supporting the valve guide in the port, and found that it could not be welded due to sand grains in the casting! Instead have two drills (14mm for the inlet and 16.5mm for the exhaust guides) modified into a "step drill," this can be done by an engineering shop. The idea is to make it possible for the drill to guide itself concentrically down the centre of the guide as you remove material, drilling from the rocker side. Do NOT go all the way through stop about 3mm (1/8 in) from the end. The guide will then have a wall thickness of about 1mm (.040 in) and can easily be driven out of the head (into the cylinder) as it will fracture at the undercut below the flange on the rocker side of the head, this can even be done at room temperature without damage to the cylinder head.
3. When replacing the guides, the head must be heated (350 degrees F) and I used methanol (methyl alcohol) and dry ice (solid CO2) to cool the guides to about minus 40 degrees. They then almost fall into place.
4. Warner Handbook, Section X (2) (a) states: "Under no circumstances should the barrel and the cylinder head be separated." This job is actually quite easy to do if you have an oven and a hydraulic press. (Makes cutting the valve seats much easier) Take a round piece of hard wood and shape it to press on the outer edge of the cylinder head combustion chamber (in the squish band) and the area between the valve seats (I avoided pressing on the valve seats) Drill out the peen marks in the nuts attaching the cylinder head to the barrel but beware it might cost you a few drills (1/16 in) as the studs are extremely hard, then machine up a support ring for the cylinder flange. (I used hollow bar and made it about ¾ inch thick) Bolt this support ring to the cylinder flange when separating the head and barrel, to prevent deformation of the flange. Here comes the secret... You **MUST** use PB B'Laster. (Manufactured by B'Laster Inc. Cleveland Ohio 1-800-858-6605) If this sounds like an unsolicited advertisement, it is, because it IS GOOD STUFF. I tried other penetrating oils and had no joy at all. Next soak the nuts and flange area inside and out with B'Laster. I did this over a period of 3 days. The directions on the tin are, "allow PB to soak for a few minutes or longer in difficult situations." I chose "or longer." Now remove the cylinder head attachment nuts and heat the assembly to 450 to 500 degrees F for at least one hour, then place in a jig and press the two apart. If the PB has soaked through, you will be surprised at how easy the job actually is! To assemble I used the same procedure as describe above for inserting the valve guides and cooled the top 1½ to 2 inches of the barrel. Fit new, annealed, copper cylinder head gaskets to the head and the barrel can then be dropped into the head. The assembly is then placed back in the press (in a suitable jig) and a light pressure added to hold the assembly together, as you gingerly fit new nuts to the HOT studs and tighten them. Peen the nuts to the studs. QED.
5. The master rod and the link rod bushes are the next problem area. The link rod pins (knuckle pins) tend to wear so I had these ground .012 inch undersize then had them hard chromed and ground down to size. Needless to say they were heat treated after the chroming process and the grinding. I have a copy of the engineering drawing for this or one can contact Harman Dickerson for a copy. When boring the new bushes in the master rod to size, the Warner Handbook gives an assembly clearance of between

.0009 inch and .0017 inch loose with a replace beyond .003 inch loose. .0009 **IS TOO TIGHT,** DO NOT GO BELOW .00135 INCH LOOSE!! REMEMBER: the Warner Engine Handbook has not had the benefit of regular updates! I learned the hard way. I made my clearances (the second time around) .0014 to .0015 loose, some folks advise boring the bushes for #3 and #6 link rod to .0017 or .0018 but I find it difficult to go to the maximum assembly limit or above it. After all, the link pin is only 7/8 inch in diameter. When boring the link rod bushes, the master rod assembly must be bolted together and the 4 bolts tightened to the required stretch value. When assembling the link rods to the master rod, I heated the link rods to 350 degrees F and did the Alky/dry ice trick to the pins. Make sure that the edge of the link rod pin being pressed into the link rod has a radiused edge so that it does not act like a cutting tool as it enters the link rod and that the notch is lined up for the pinch bolt, you will not be able to turn it to line it up and do not want to have a multitude of attempts at getting it right.

6. The sludge trap. Old aircraft engines were designed to run on straight oil, which keeps sludge in suspension. Without the benefit of an oil filter (the mesh filter will only catch broken piston rings) this sludge is separated by centrifugal force in the crankshaft journal before the oil is pumped to the master rod bearing. If you have bought a used engine that has been idle for many years, this sludge will dry out. When starting the engine, this sludge could become dislodged and be pumped through the bearings, which is not good. Unfortunately to remove this sludge trap will require a complete engine tear down!
7. Running the engine in after a rebuild is a contentious issue. The modern thinking is to put it in the air and maintain a minimum of 75% power for the first few hours. With chrome cylinders fitted this 75% power should be maintained until a drop in oil temperature is noted. The Warner Handbook recommends a ground run-in of about 10 hours. Modern thinkers will say that you will glaze the cylinders with continuous ground running of the engine, whilst this might be true on a tightly cowled horizontally opposed engine this does not necessarily apply to an uncowled radial engine. I ran my engine on the ground for 8 hours on a hot Highveld day, following the manual's recommendation and then did the last two hours of full throttle work in the air, now after 30 hours I have no discernable oil burn ie: less than 1 pint in 15 hours. One engine shop in the USA (from experience) now runs their engines in as per the manual EVEN WITH chrome cylinders. The reasoning is simple, if the rings do not seat it is easier to change a cylinder than a spun bush in the master rod!
8. Ignition timing. The Warner Handbook recommends 28 degrees before TDC for 73 octane (minimum) fuel. As I use 100LL and fly on the Highveld with airport elevation in the vicinity of 5000 feet, I run 2 degrees more for the slower burning fuel and 2 degrees more advance for the altitude ie: 32 degrees advance. As the higher octane fuel burns slower, I run the exhaust valve tappets at .012 inch (.002 larger gap than recommended) to delay the opening of the exhaust valve (for more complete combustion) yet I still see 1500 degrees F on my EGT gauge and a CHT of 300 to 350 degrees F. On a hot day in the climb it might go to 375 degrees F but I have not seen 400 F yet. I also run my EGT at the peak during cruise.
9. Preliminary ignition timing of the magneto before fitting it to the engine. The Warner Handbook shows feint scribe marks on the magneto housing and the distributor drive gear, which might have been accurate when the magneto was assembled. I use these marks to ensure that I am setting the magneto up to fire to #1 cylinder, then with #1 cylinder set to 32 degrees BTDC compression stroke (31 degrees at sea level) I fit my timing light to the magneto and slowly turn it (on the bench) till it indicates that the points are opening. I then move the magneto drive gear to approximate the position of the drive tang and keeping the magneto in this position by holding the distributor drive gear still, fit the magneto to the motor. With the magneto and the engine at the correct position, the magneto timing should be correct first time. Secure the magneto and check the timing.

10. On the subject of magnetos, the numbers on the magneto distributor blocks are the firing order of the magneto and NOT the engine firing order. Ie #1 (mag) goes to #1 (engine) #2 to #3, #3 to #5 etc. Also, if you have magnetos with manual retard **and** the shower of sparks, it is recommended that you remove the shower of sparks. This has been known to burn out the magneto coil and with manual retard it is not necessary, just remember to go full advance for take off!
11. Oil control. I have been pleasantly surprised with the performance of the stock Warner piston rings particularly the oil scraper rings. I had read in another publication that due to the flooding of some of the rocker boxes in the Warner engine one could expect to burn oil that was sucked into the engine via the inlet valve to guide clearance. This publication recommended an automotive valve stem seal that needed to be reamed to size. (Perfect Circle PN 2012 of kit VS4) Not having access to the part or a reamer, I looked for an alternate part. The Warner inlet valve stem is .401 inch (as measured on my engine) and the Continental IO 520 has inlet valves with a stem diameter of .431 inch. That means that the Continental valve stem seals (PN 646985) would be .030 inch too big but they fit perfectly onto the stock Warner inlet valve guide boss and do seal (only just) on the Warner valve stems. So far the results have been good. I figure even a worn valve stem seal has to be better than no valve stem seal at all.
12. The exhaust collector ring. My exhaust system was rotten, corroded and badly repaired by some plumber. The only part salvaged was the part that attaches to #1 cylinder and includes the carb. heat pipe. Fortunately we have a helpful CAA that allows us to apply for modification approval, I guess the FAA must allow field mods. I had a circular tube (much like an inflated motorcycle tube) blown for me by a local guy who blows two-stroke expansion chambers using oil and a hydraulic pump assisted by oxy-acetylene. The pipe starts out as two circular flat sheets of steel that are seam welded together and then blown into a tube. Sections are then cut out and a new exhaust system manufactured! Difficult, but possible.
13. According to Jack Polk of Mason Texas, the Warner 165 is the Rolls Royce of small radial engines, and I cannot agree more. Failures are rare. Bronze in the oil indicates a problem with a worn or spun bush in the master rod. Engine teardown time again, ask me, I know! One other problem is caused by fitting the valve springs incorrectly (upside down!) this can lead to spring failure. If it is an exhaust valve spring the engine will run rough and will sound as though you have blown a sparkplug out the head. If it is an inlet valve spring, the effect is much more dramatic and I quote... "When the defective cylinder fires, it backfires through the open intake valve into the induction housing (igniting the fuel) causing the next few cylinders not to fire. The engine goes whirrp-bang-silence-whirrp-bang-silence-etc." Evidently the engine will continue running till you make it to an airport, the condition of your seat, depends on you.
14. I had one other "failure" after the first engine overhaul, before the first flight I did 5 minutes at full throttle, cooled the motor down, inspected it then set out for the flight and found I had a mag drop and a rough engine. Pulling the plugs sent me on a wild goose chase. What had happened was one of the exhaust valve tappet adjusting nuts had come loose and as a result the exhaust valve could not open. This resulted in burnt fuel being exhausted through the inlet valve! The guilty cylinder had a clean sparkplug and the cylinders 'downstream' had sooty plugs! Now I make sure the adjusting nuts are TIGHT.
15. Cylinder base studs 5/16 or 3/8 inch? Years ago (Warner A15/AD 54-4-2) suggested that if you had 5/16 studs on the cylinder base with a cylinder base gasket and had found any nuts loose, that all the studs were to be replaced. 5/16 studs could be fitted provided the cylinder base gasket was removed the case modified to accept an O-ring and then the torque value of the bolts was to be checked every 100 hours. (160 to 200 in lb, check low side 160 in lb ONLY.) Just checking the torque value of all the bolts was a daunting task. If 3/8 studs were fitted, the O-ring mod still had to be done but

checking the torque of the bolts was not required. (3/8 studs torqued to 200 t0 275 in lb) I was informed that the 5/16 studs were adequate, provided they had not been over-torqued nor subjected to excessive loads due to other nuts loosening. My engine had not complied with this notice and I found all the nuts still tight. Since then I have not done the O-ring mod, but have removed the base gasket. This was replaced by a film of gasket compound (Bostik Gasket Maker) and has held out well. Nuts remain tight with no signs of any oil leakage. Works great.

16. Three mods I have done to my engine were done to increase engine life and reliability. Firstly I removed the oil pump and had a boss welded to the oil pump body where the 1/8 NPT hole is for the oil pressure gauge fitting. This was drilled and tapped to 3/8 NPT and an AN 822-8 fitting fitted, then the oil screen body was removed, the screen removed and replaced with a section of 4130 pipe welded into place. An AN 823-8 fitting was fitted to the back of the screen body, with the non-return valve still in its original position. These two –8 fittings allow oil to be piped to a remote mounted filter. Clean oil equals long life. The second mod was to fit an air filter, something I do believe no engine should be without. The third mod was to remove the Eclipse generator and modify it into a V-belt drive for an alternator this gives reliable 28 volts and serves as a cushion drive for the gears.
17. High oil temperature in a Warner engine is an indication that oil is passing through the engine too fast, this could be caused by worn bushes or be caused by plugs (blank offs) not being fitted to bushes in the accessory case where accessory drive gears are not fitted.
18. The Warner oil scavenge pump is inefficient (I guess due to the height it has to lift the oil in a ¾ inch pipe) and this can result in flooding of the lower cylinders after long periods at idle (taxying a long way) this can be avoided by running the engine up at about 1100 RPB for a minute before shutdown.