JOWETT JUPITER ENGINE ASSEMBLY

Engine Number E3 SCL 987

Recorded by Philip Dingle

HISTORY

- The Jowett Jupiter sports car was built by Jowett Cars Ltd. in Bradford, England between 1950 and 1953 alongside the Javelin saloon and the Bradford utility vehicle.
- Jupiters are to be found around the world but particularly in the former British colonies.
- The 4-cylinder 1.5 liter engine was relatively advanced and sophisticated for its day, featuring an aluminium crankcase, wet liners, Weslake-developed combustion chamber and porting, and two carburettors. It was not however a particularly robust engine.
- In period, the Jupiter was quite successful in competition.

ENGINE NO. E3 SCL 987

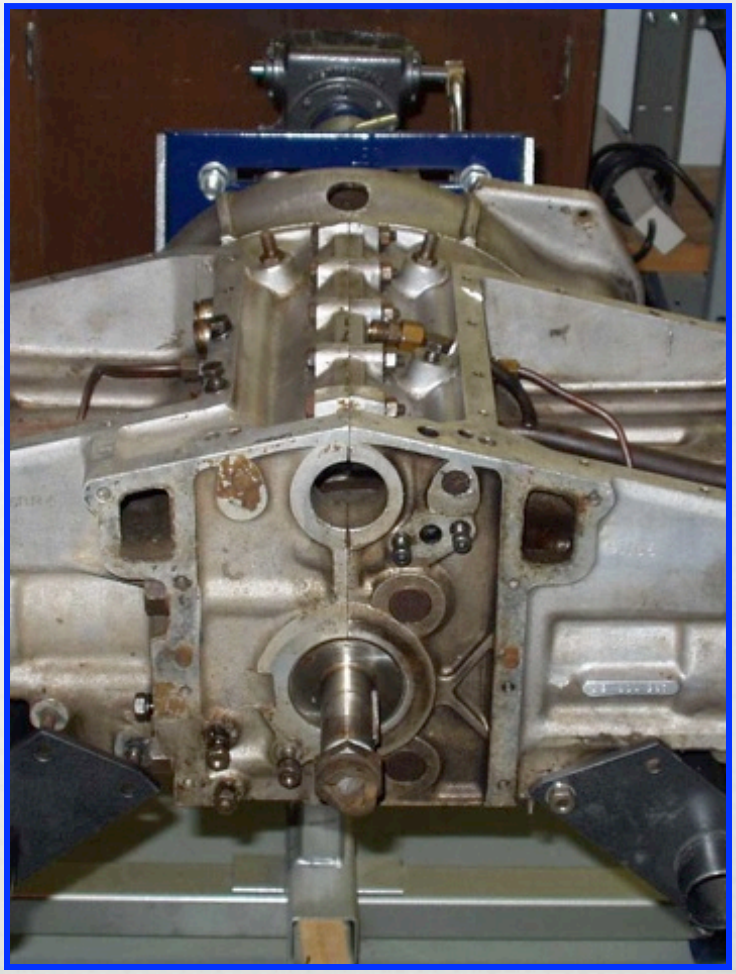
- This engine belongs to Car No. E3 SCL 987 owned by the late David Cleavinger of Livonia, Michigan USA.

- The crankcase-half numbers 91166/25884 do not match. This appears to be a replacement engine, probably provided by Jowett Engineering Ltd.

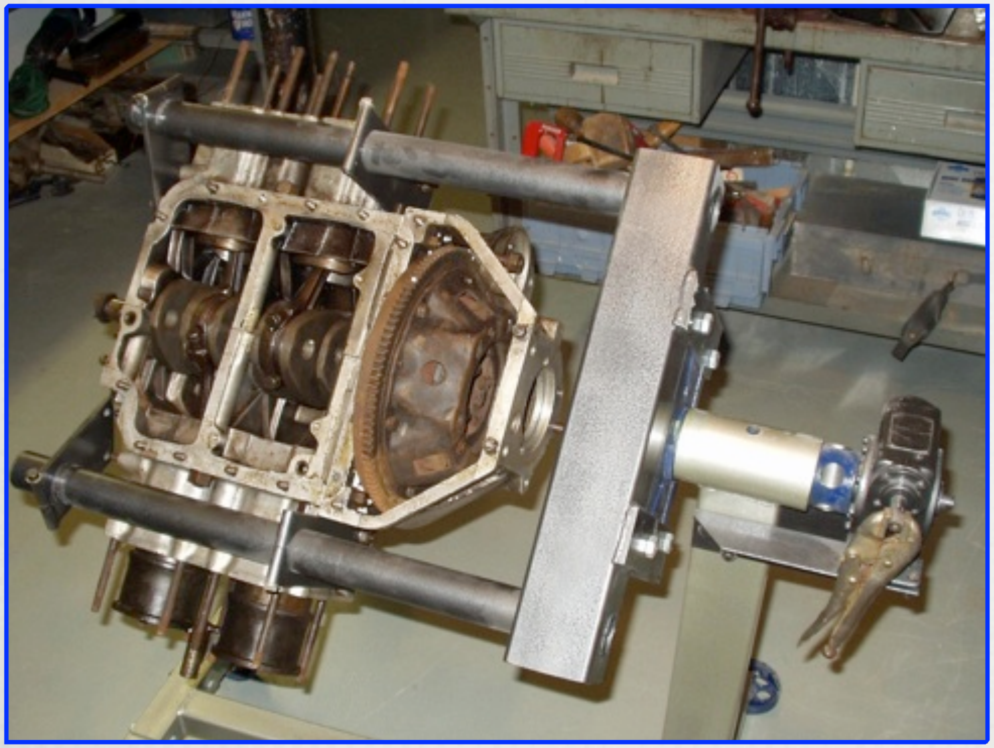
- In the photo here, another crankcase with the same number (possibly the original pair) can be seen under the car.

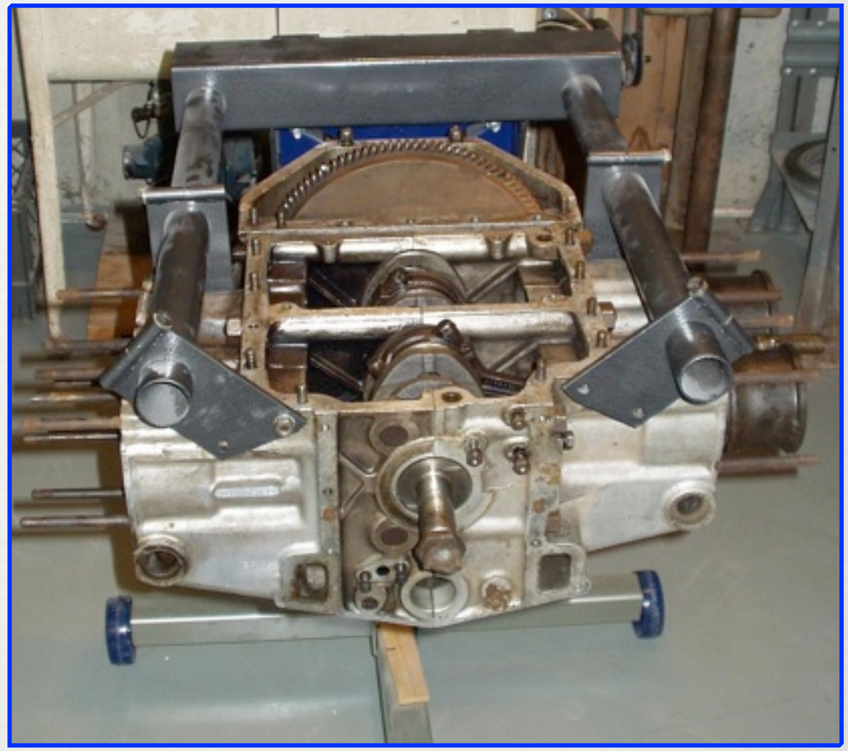
ENGINE DISASSEMBLY

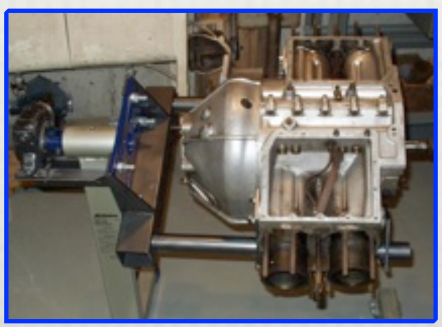
- For this project, a purpose-designed engine stand was constructed. This stand is described in a separate file.
- The engine was already partially disassembled (probably long ago), and my post-mortem indicated that a head gasket had failed allowing water and oil to co-mingle.

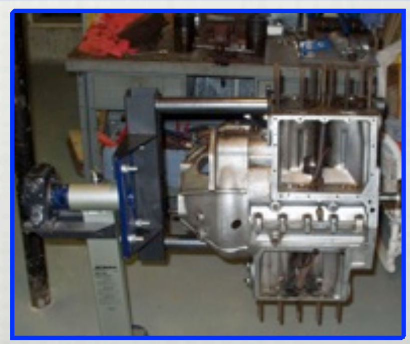


UNDERGOING DISASSEMBLY









COMPONENT CLEAN-UP AND INSPECTION

- For component degrease and clean-up, I used Brulin 815QR which is a water-based industrial cleaning agent and this did a good job on all components.
- Brulin degreases best when heated so I found a tub large enough to take a half crankcase, and then added a 1 kW heating element.
- To make items look like new, I used a carborundum-laced nylon brush wheel (picture) mounted on an electric motor which worked well.

ENGINE REBUILD CHECK SHEET

ITEM	JCL Part No	ISSUE	ACTION	SOURCE	REPLACEMENT	Part No.	COST	COMMENTS
							$	
Crankcase half L/H R/H	50522/3							
Crankcase bolts/trunnion nuts								
Balance pipe	50628							
Balance pipe O-rings								
Crankshaft	52010							
Main bearings	52573 / 50646							
Big end bearings	J54443							
Connecting rods	J54493							
Connecting rod bolts	54022							
Pistons	53227							
Piston ring pack								
Cylinder liner	54019							
Liner shims	52381							
Liner seals								
Liner support tubes	J54395							
Oil pump drive gear (crank	50648							
Drive key (crank)	50583							
Sprocket-crankshaft	50649							
Sprocket-camshaft	J54481							
Timing chain	50664							
Cam vernier dowel	J54483							
Lock plate	J54482							

Having cleaned all items, I created a rebuild log sheet at which time I inspected every part and made a decision on re-use, repair or replacement and with what. This log sheet template in full, in Excel format can be downloaded here:
http://pdingle214687.home.comcast.net/Technology/Jowett_Related/Engine_Rebuild_Log_Template.xls

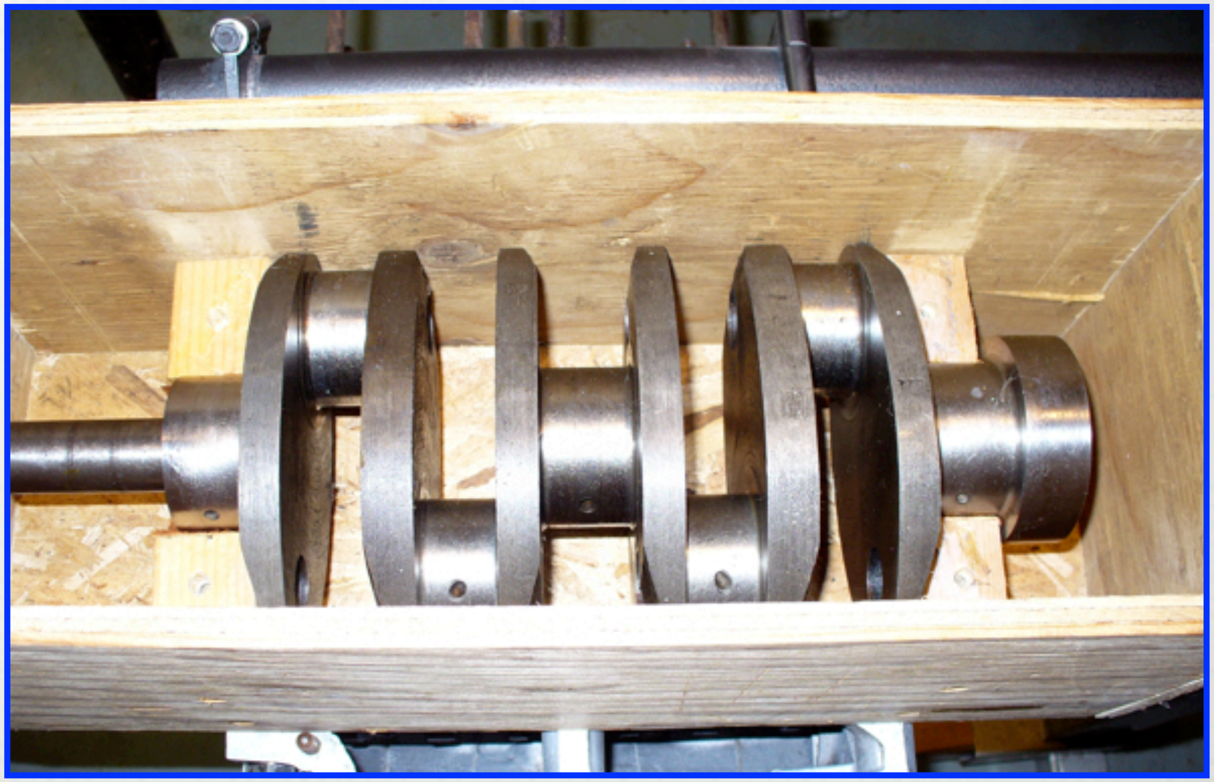
BILL OF MATERIALS - SEALS

LOCATION	JCL Pt. No.	MATERIAL	INTERNAL Ø (d1)	SECTION Ø (d2)	TRELLEBORG Pt. No. (Dowty)	PARKER Pt. No.	COMMENTS	Quantity (per Engine)
Crankcase Balance Pipe Seals	50629	High Temp NBR	15 mm	3.5 mm	200-206-565	3.5 x 15 GR-ND674-70	Static (Bore OD =0.828"; Tube OD = 0.625")	2
Water Transfer Seals	52708	High Temp NBR	1.162	0.21	200-321-4470	2-321-	Static	4
(Late) Liner Seals		High Temp NBR	78 mm	1.25 mm			Static-Triangular seat (from Apple Rubber)	4
Cylinder Head Oil Stud Seal	52192	High Temp NBR	0.375	See note			Square section .156" thick X .625" OD	2
Cam Sprocket Tensioner		High Temp NBR	4.484	0.139	200-246-4470		Static	1
Crankcase Tie-Bolt Seal		Nitrile	13.7 mm	Ø22.3 mm	DDW200500	14 E 021	This is a Dowty Washer (Bonded Seal)	4
3/8"BSP Oil Pipe Banjo Seal	J54549	Nitrile	17.28 mm	Ø23.8 mm	DDW400023	14 E 023	This is a Dowty Washer (Bonded Seal)	7 min
Cylinder Head Stud Seals		Nitrile	-	-		750-00-02-3/8	This is a ThreadSeal	20
Center Head Stud Seal		Nitrile	.375"	.139"	200-204	2-204	Replaces Square-section 52192 seal above	2
Oil Filter Gasket Plate		High Temp NBR	17 mm	2 mm			For main oil gallery	1
Oil Filter Gasket Plate		High Temp NBR	13 mm	2 mm			For feed galleries	2
Crankshaft Front Oil Seal	50694		1.625"				CR-16085 (CR = Chicago Rawhide)	1
Crankshaft Rear Oil Seal	50838		3.00"	4.00"			SKF 29925	1
Oil Filter Drain Screw Seal		Nitrile	.3125"	?			This is a Dowty Washer (Bonded Seal)	1
Oil Pressure Tapping Seal		Nitrile	.375"	?			This is a Dowty Washer (Bonded Seal)	1
Oil Filter Cannister Seal		Nitrile		.085" x .175"		2-151-	Static Square Section (or Quad Seal?)	1
Oil Filter Cannister Bolt Seal		Nitrile	0.375				Ø.6875 OD X .125 thick	1

This is a listing of the various o-rings and seals that I used (or considered using) in the rebuild.

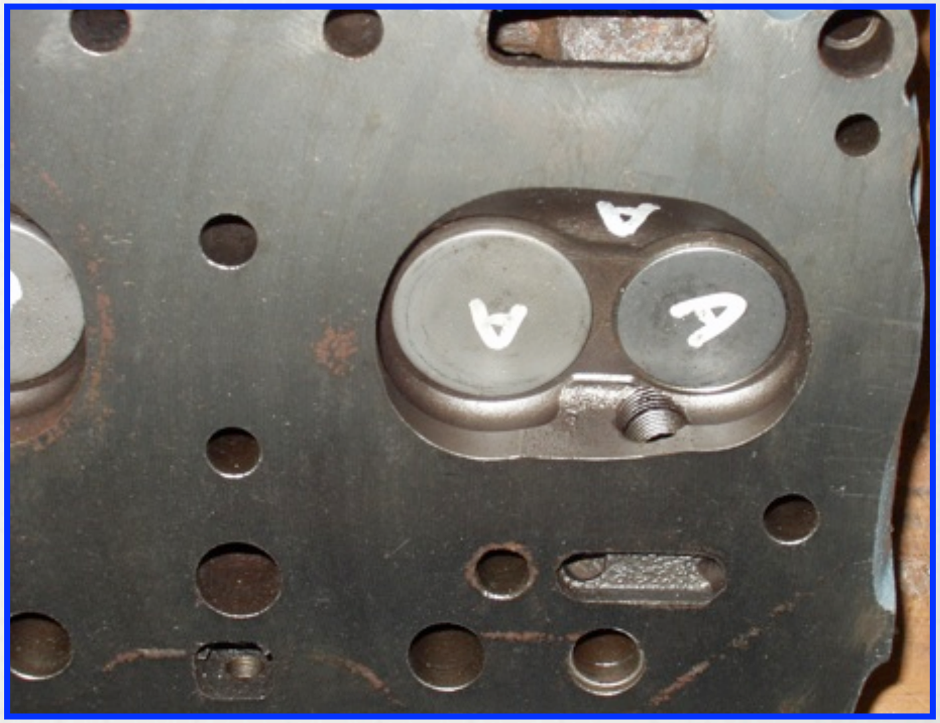
CRANKSHAFT CRATE

- To transport and store the crankshaft, I made up this wooden crate. The supports that it rests in are leather lined to protect the journals and have top caps to hold the crank in place.



CYLINDER HEAD

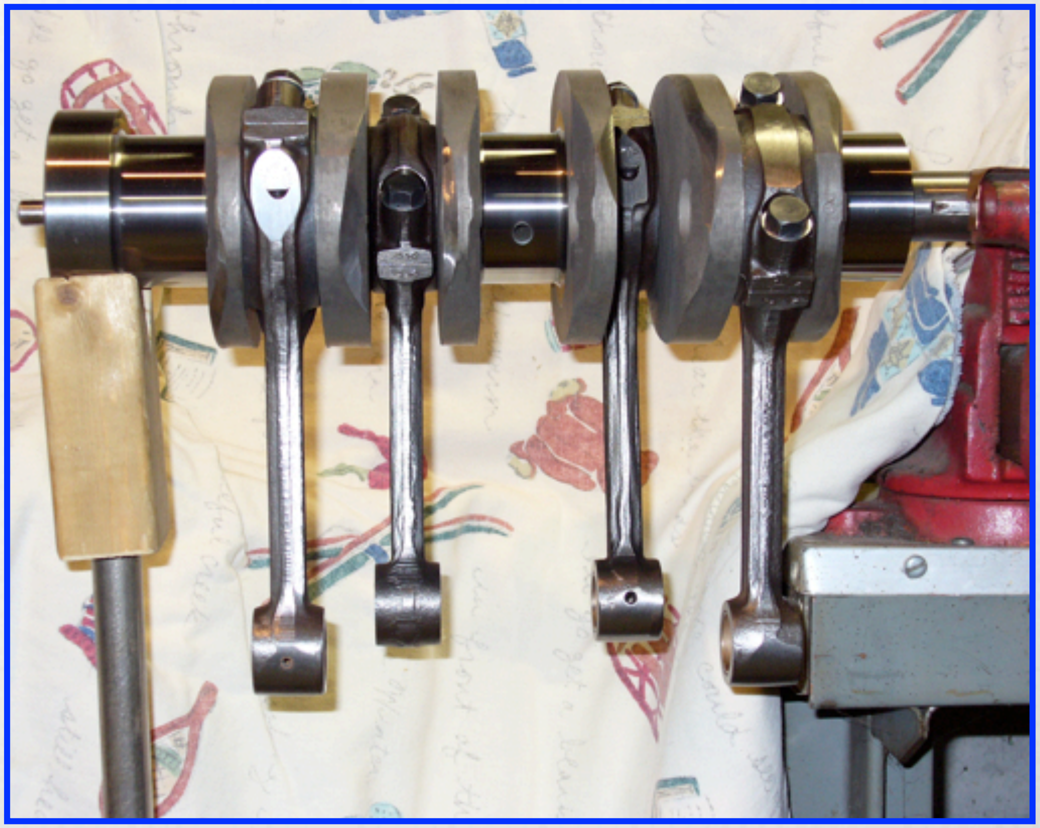
- The cylinder heads were reconditioned by a professional engine shop, and they did a good job.
- The heads received a bath to remove all the carbon and dirt, and then had the valves ground and re-seated. The head face received a light skim.
- The coolant vent passages were opened up as JCL recommended.



SWINGING THE RODS

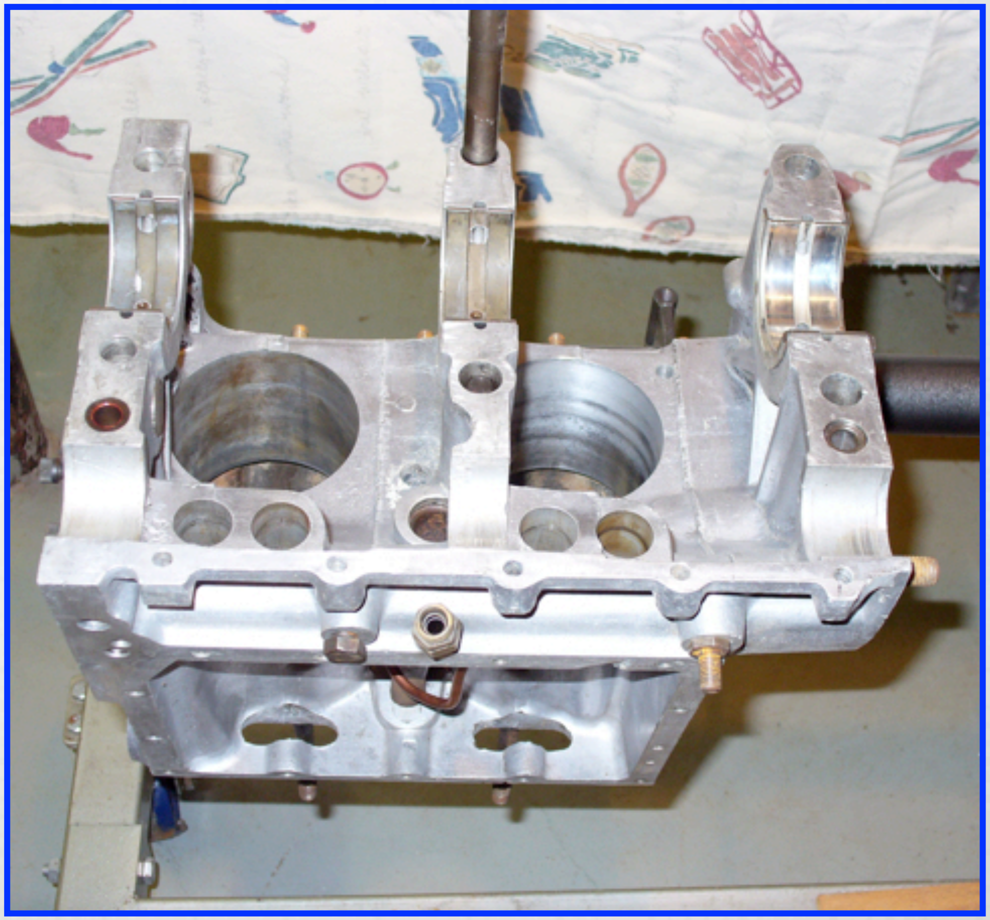
- The crankshaft was an oval-web nitrided shaft, and although showing only mild wear, it was ground to -0.010” undersize on all journals and balanced along with the flywheel and rods.

- “Swinging the rods” in which the rods with new bearing shells are assembled to the crank to check for fit and free motion prior to engine assembly is well worth doing.



CRANKCASE ASSEMBLY - 1

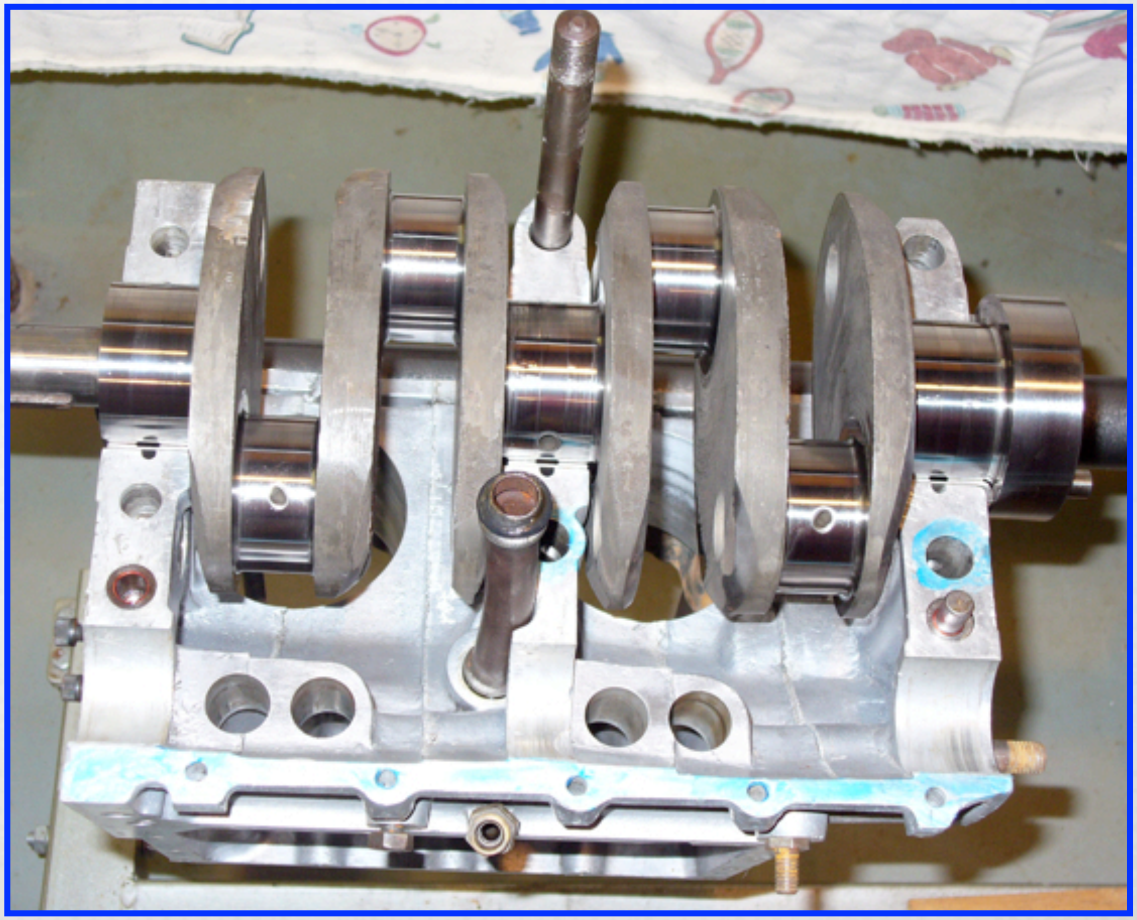
- The thoroughly cleaned crankcase, which is split on the vertical centerline, is ready for assembly.
- Here one half has been prepared with new Vandervell bearing shells (sourced from Bill Lock Spares Ltd.).
- Note that the long central tie-bolt is in place because it cannot be installed when the crankcase is together.

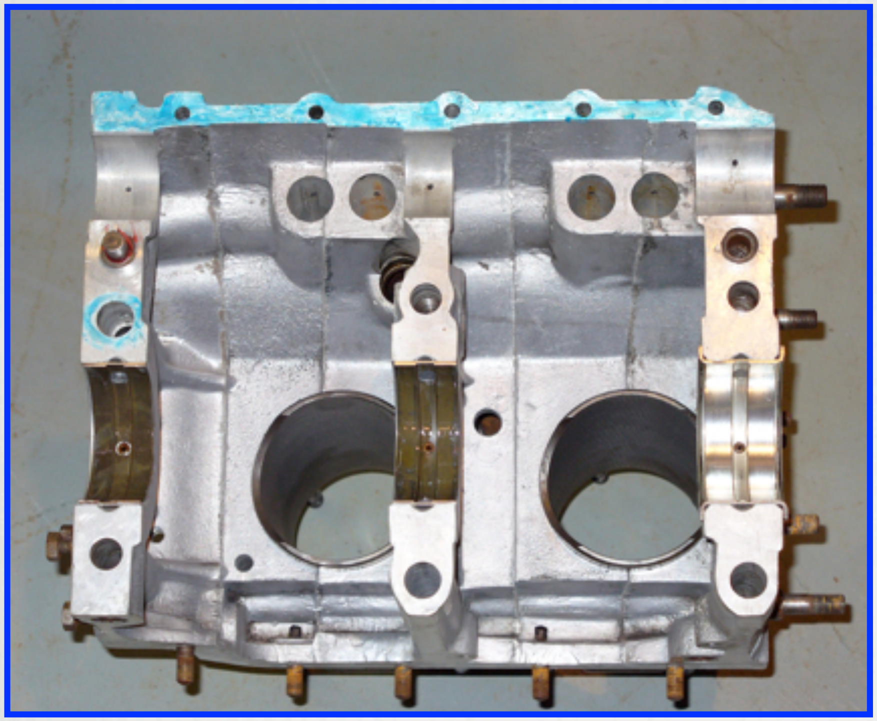


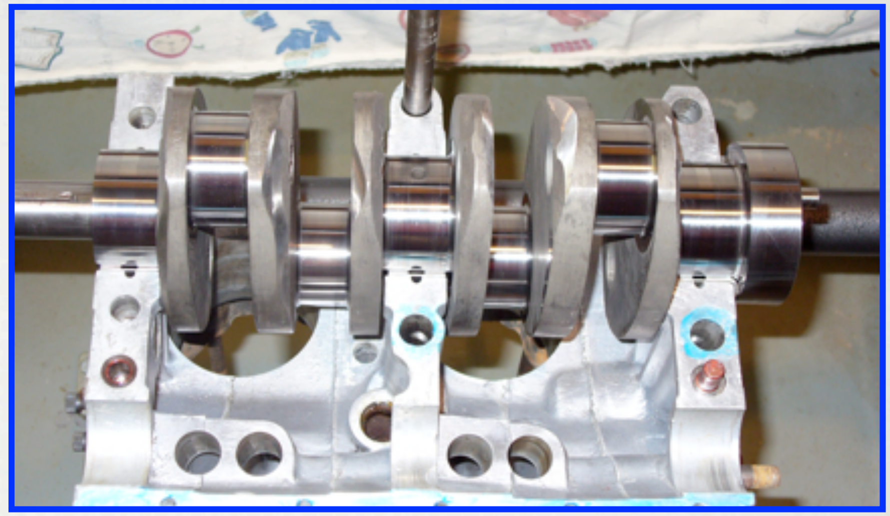
CRANKCASE ASSEMBLY - 2

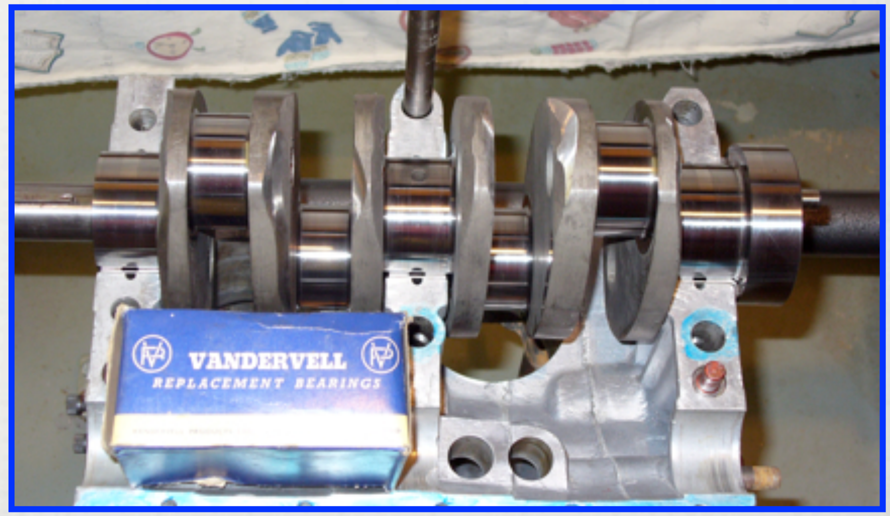
- Here the crankshaft is resting in the oiled bearing shells, and the induction balance pipe has been installed. Check that the crank web does not contact the balance pipe; a known issue.

- Hylomar sealant has been applied in areas where external leakage is possible.





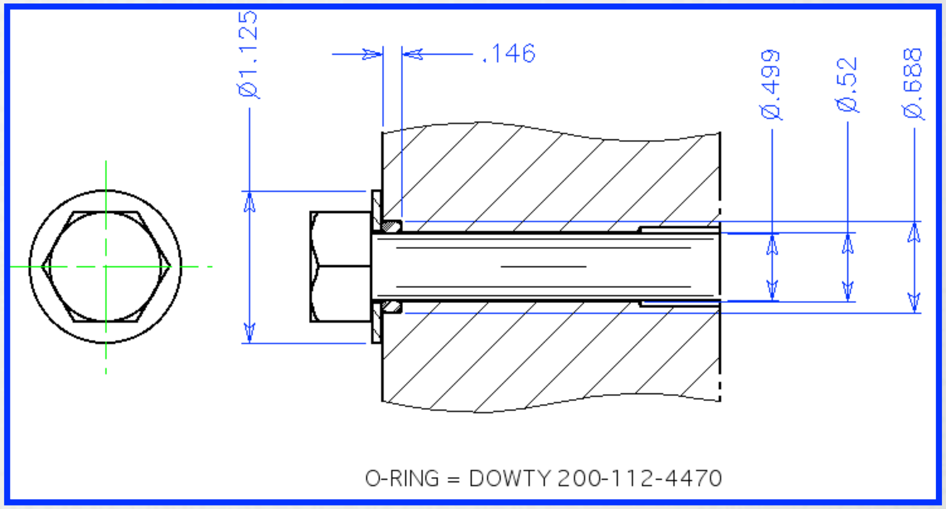




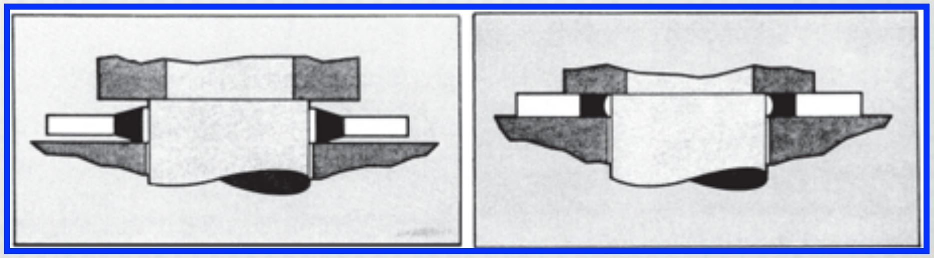
Crankshaft end float must be checked at this stage on both halves of the crankcase individually, and then again when they are mated.

THROUGH-BOLT SEALING

- Of the 6 through-bolts, the 3 upper ones pass through oil galleries feeding the main crank bearings. This means that only the surface finish of the crankcase spot face, the flat washer, and the bolt head are preventing an oil leak when the engine is running.



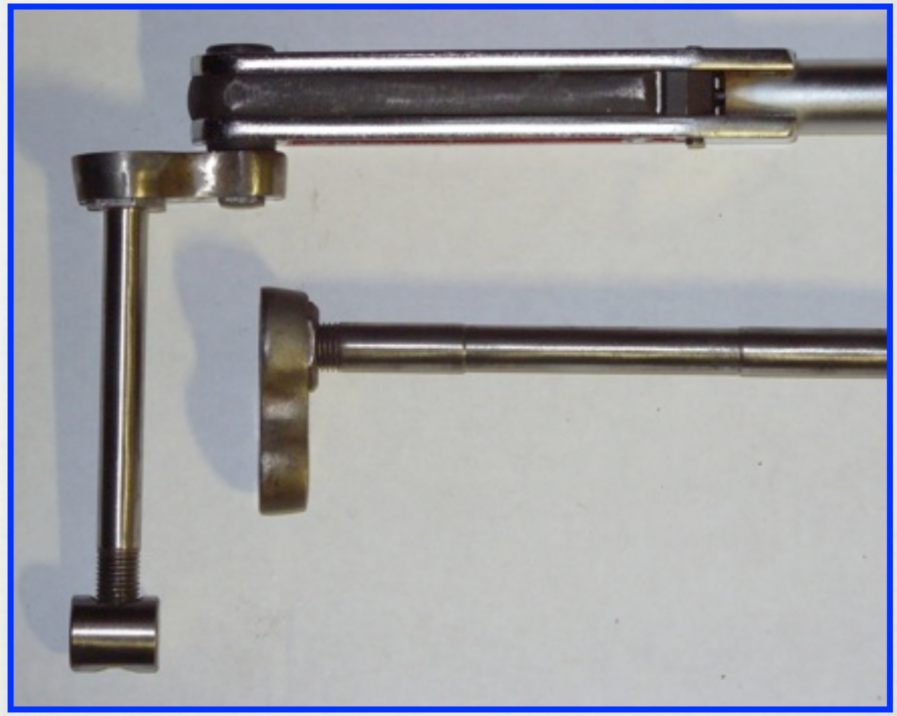
- I considered modifying the crankcase as shown here to incorporate an o-ring to seal this potential leak point.



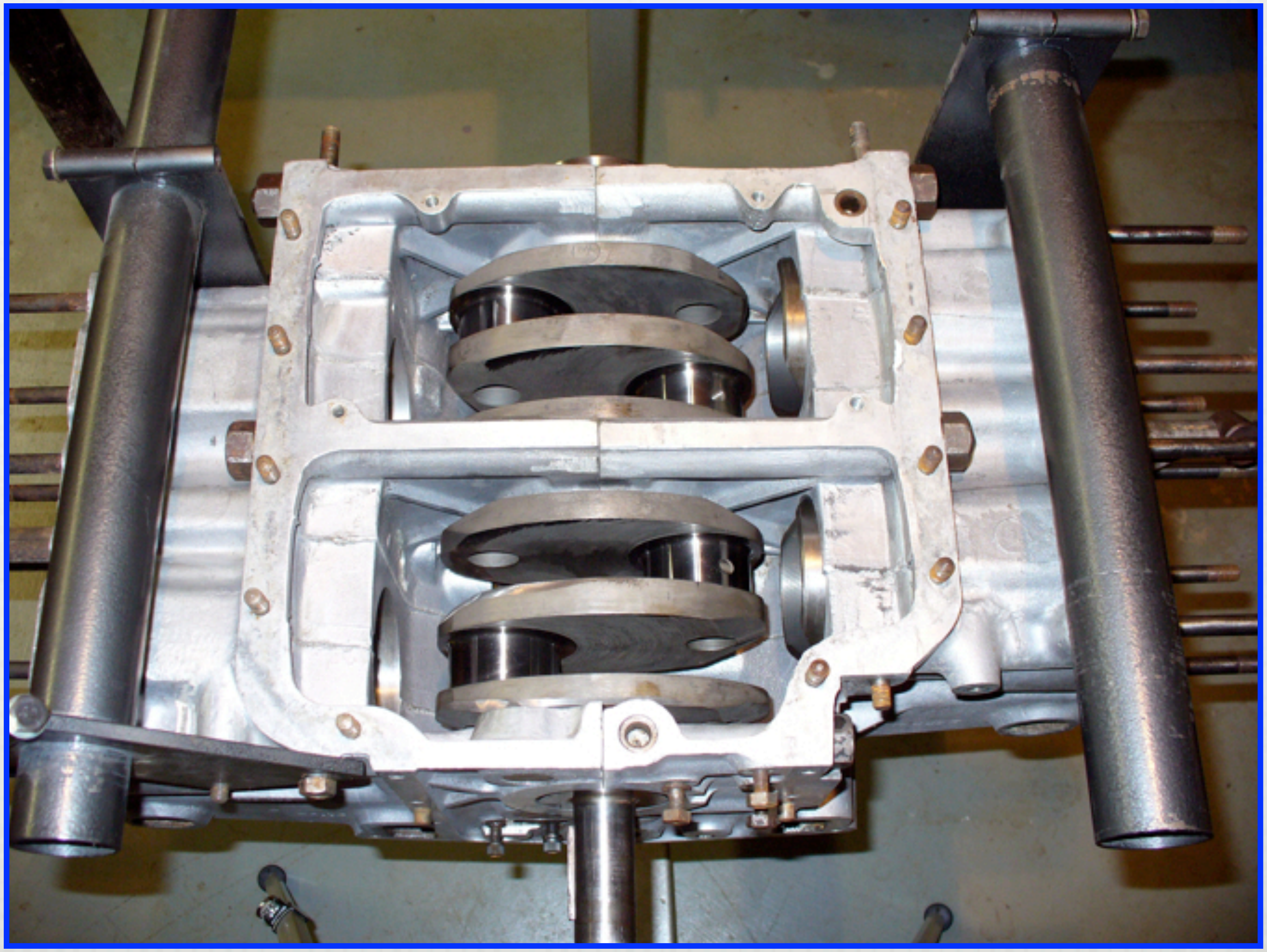
- In the end I went with a "Dowty" bonded washer like this which incorporates a seal.

CRANKCASE THROUGH-BOLTS

- It helps, but is not essential to have the correct Jowett tools for torquing up the through-bolts.
- Torque for both bolt sizes is 75 lb/ft.



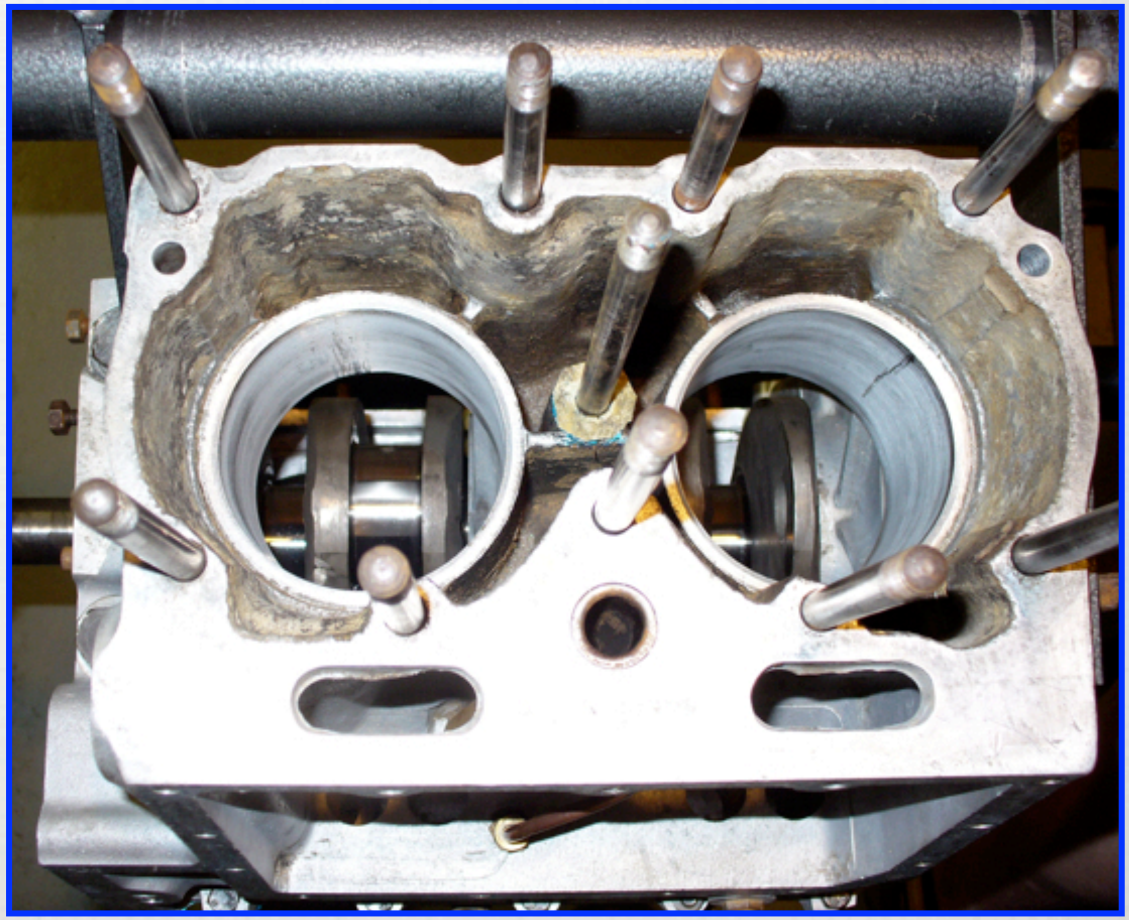
CRANKCASE HALVES ASSEMBLED



PRIOR TO LINER INSTALLATION

- As received, the cylinder liners were not a good slip fit in the crankcase, and so some fettling and polishing of the crankcase bores was necessary, as can be seen.

- This engine used the later arrangement of o-ring sealing at the mid-stop seat in conjunction with the uniquely dimensioned liners. The o-rings are no longer available, and so copper shims to adjust protrusion and Hylomar was used for sealing.



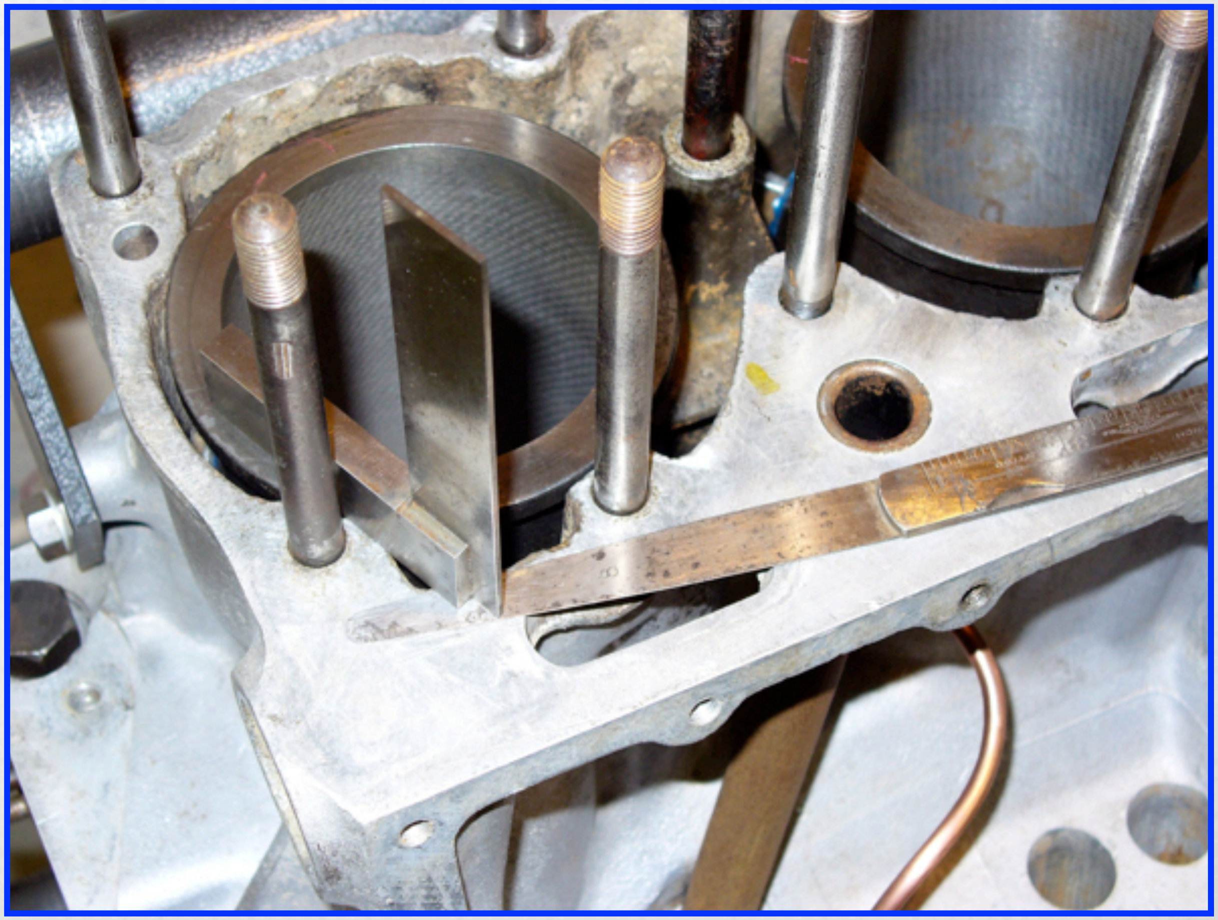
CYLINDER LINERS

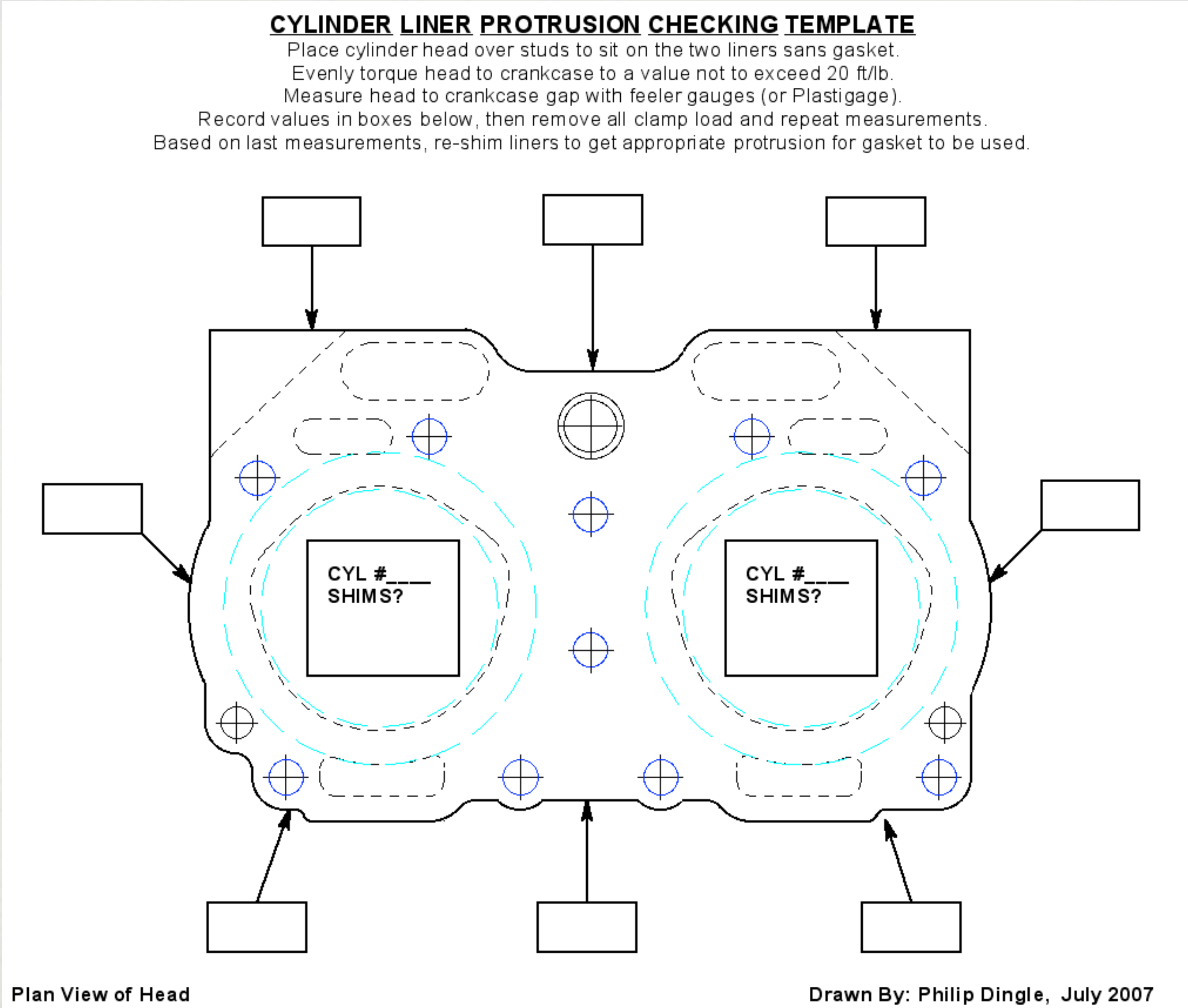
- To safely transport and store the cylinder liners, I made up a wooden tray to hold them (I don't recall why I made an 8-holer crate).

- Not too many auto machine shops in the US are equipped to handle wet liners. I had to make up a box into which a liner could be clamped so the boring machine could grip it.

LINER PROTRUSION CHECK

- Several methods were tried in an attempt to arrive at a satisfactory liner protrusion setting.
- Using feeler gauges as shown is the traditional method.
- Putting the cylinder head on sans gasket and applying a light torque is better, but that simply showed how pitifully lacking in rigidity the crank-case is (next slide).

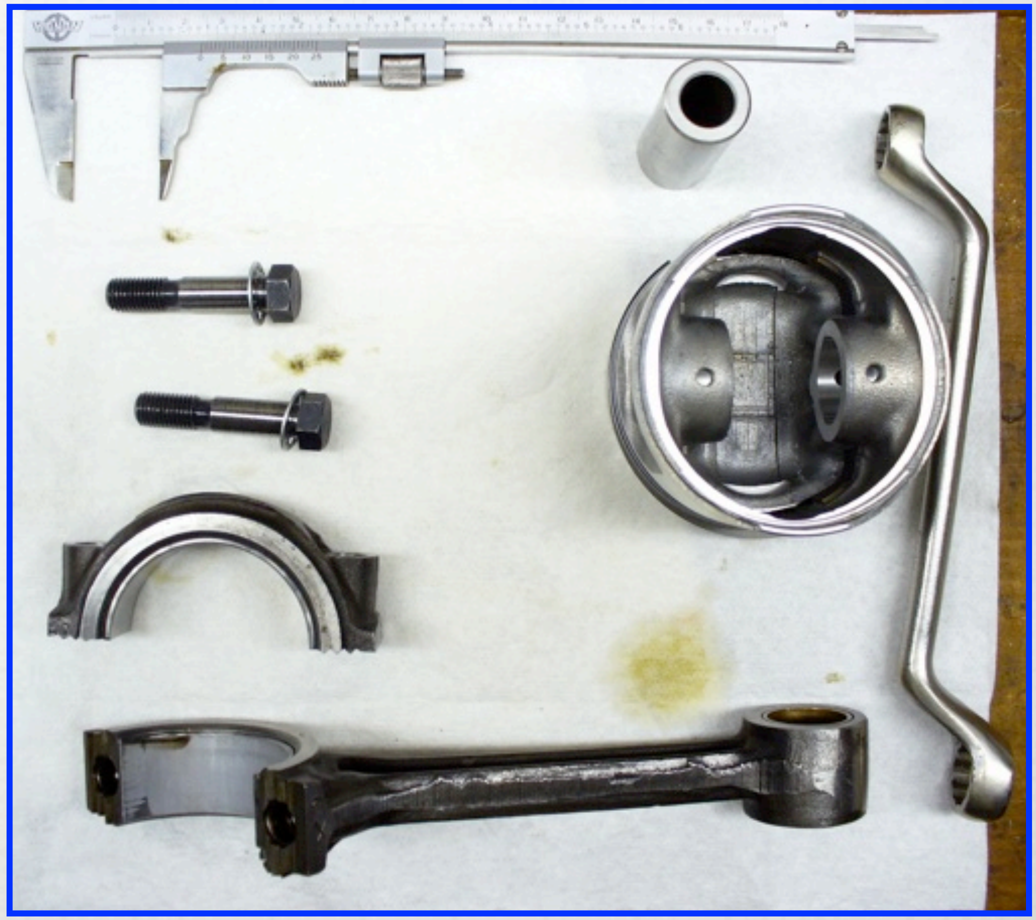




Download this template here: http://pdingle214687.home.comcast.net/Technology/Jowett_Related/Liner_Protrusion_Template.png

PISTON AND ROD ASSEMBLY

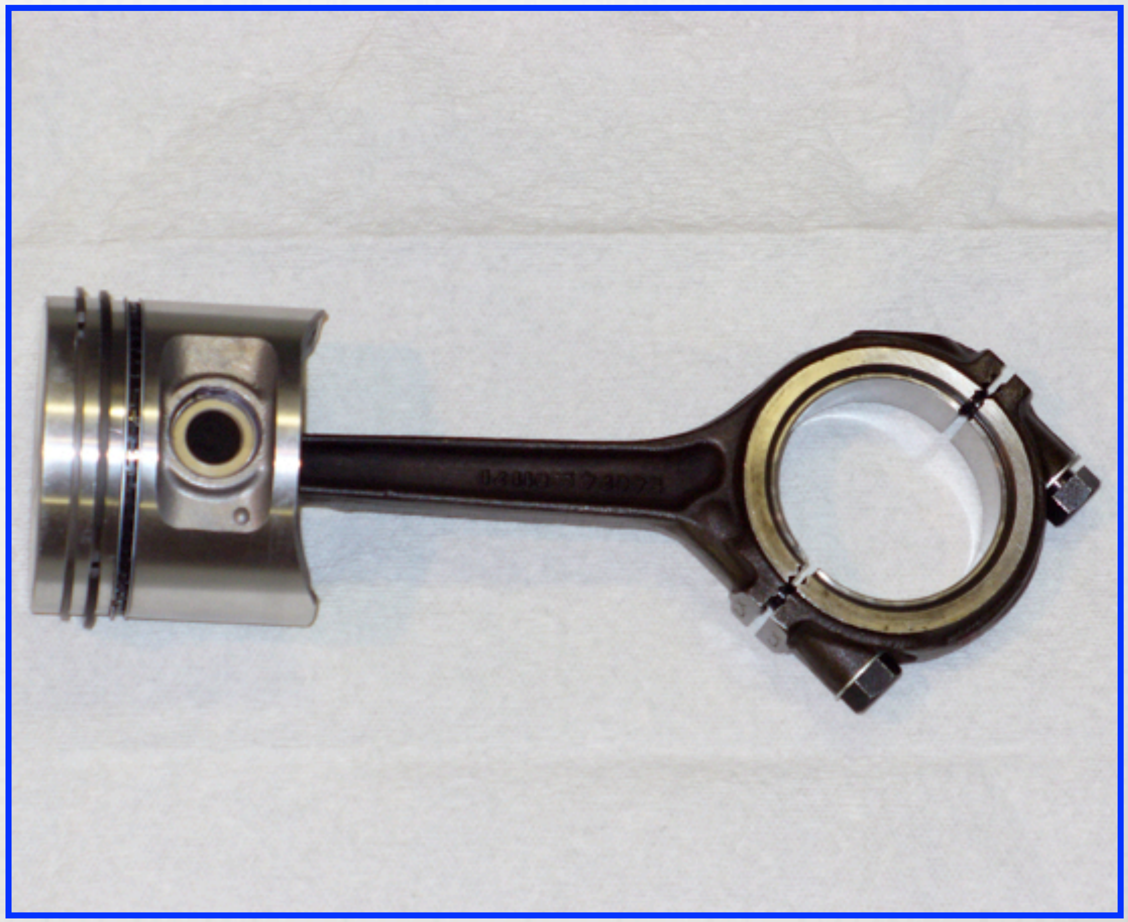
- Ford Fiesta pistons sourced from BAT in Florida were used. Both rods and pistons were matched for weight.
- The Ø74 mm pistons needed machining for wrist pin retaining circlips (not used in the Ford application).
- New bolts for the connecting rod caps were used. The shakeproof washers under the bolt heads were supplied by the engine machine shop but I am not convinced that they are necessary.



PISTON AND ROD ASSEMBLED

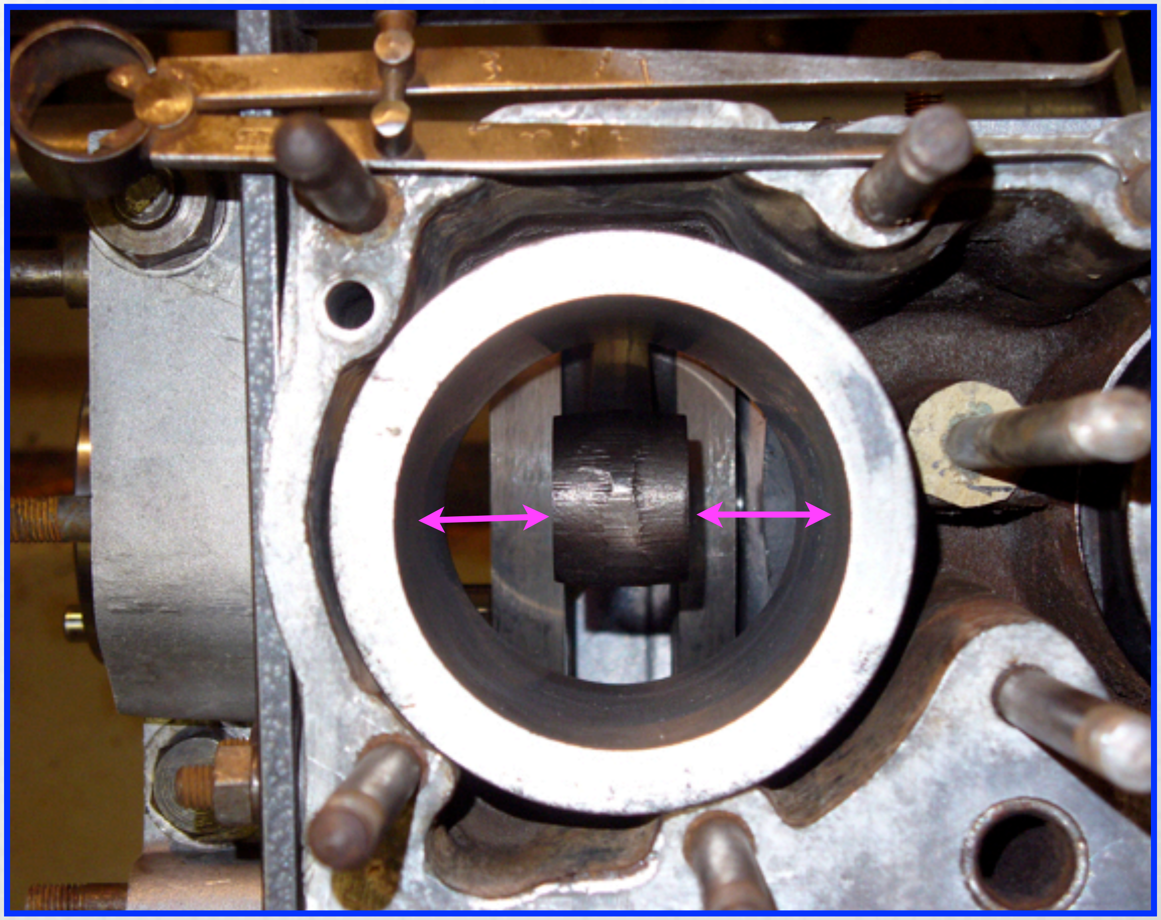
- The pistons were made by AE_Federal-Mogul, however I was not impressed with the quality of them; some of the wrist pins were loose in the piston bosses even at room temperature.

- The pistons needed some modification before installation. Specifically the width between the pin bosses is narrower than the rod width so they need filing to open them up, but which side and how much?



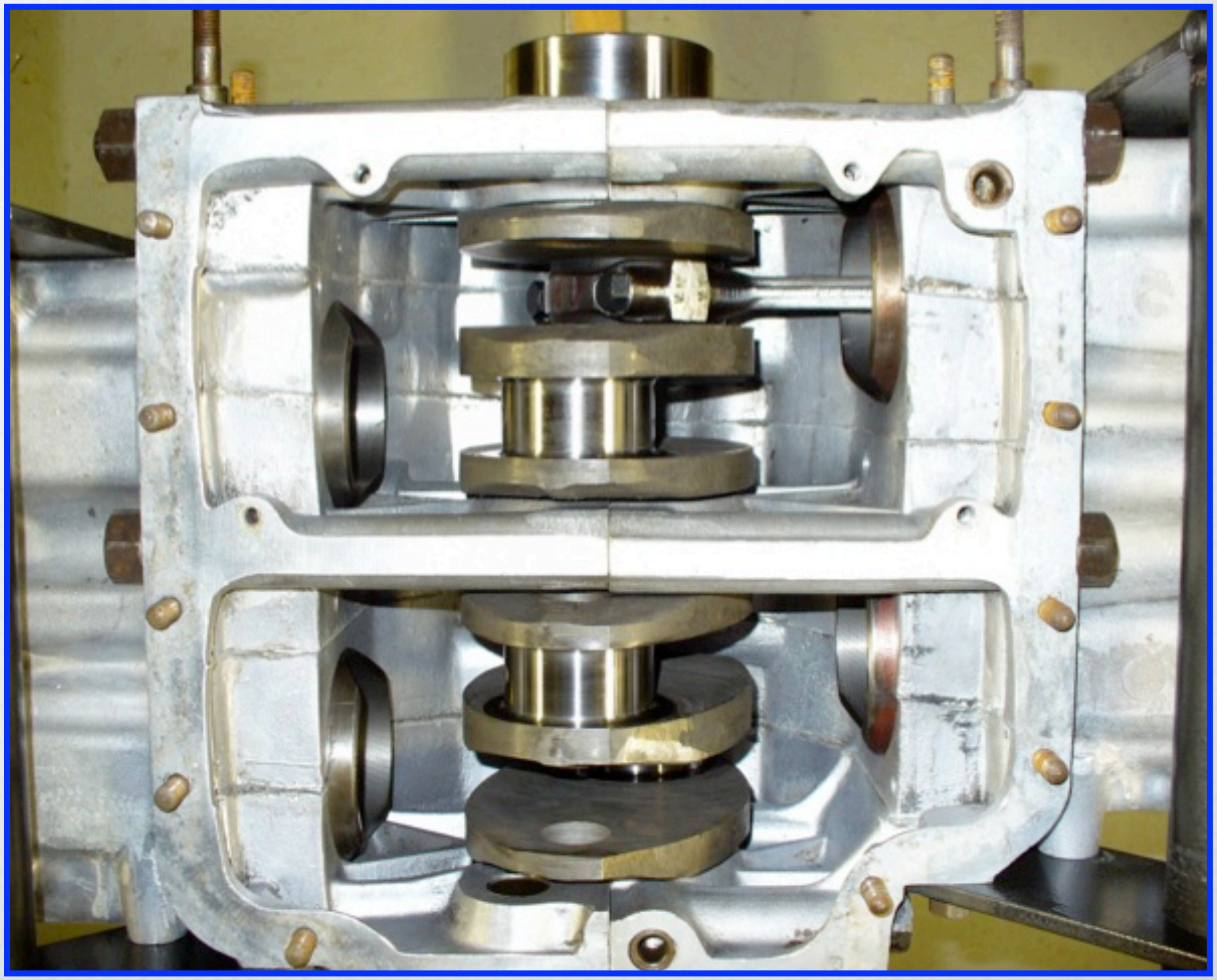
ROD ALIGNMENT CHECK

- To determine which boss needs modifying and by how much, it is necessary to measure where the rod ends up in each bore relative to the center line.
- With the little end at mid-stroke, I made side-to-side measurements with a caliper and then recorded the resulting dimensions.



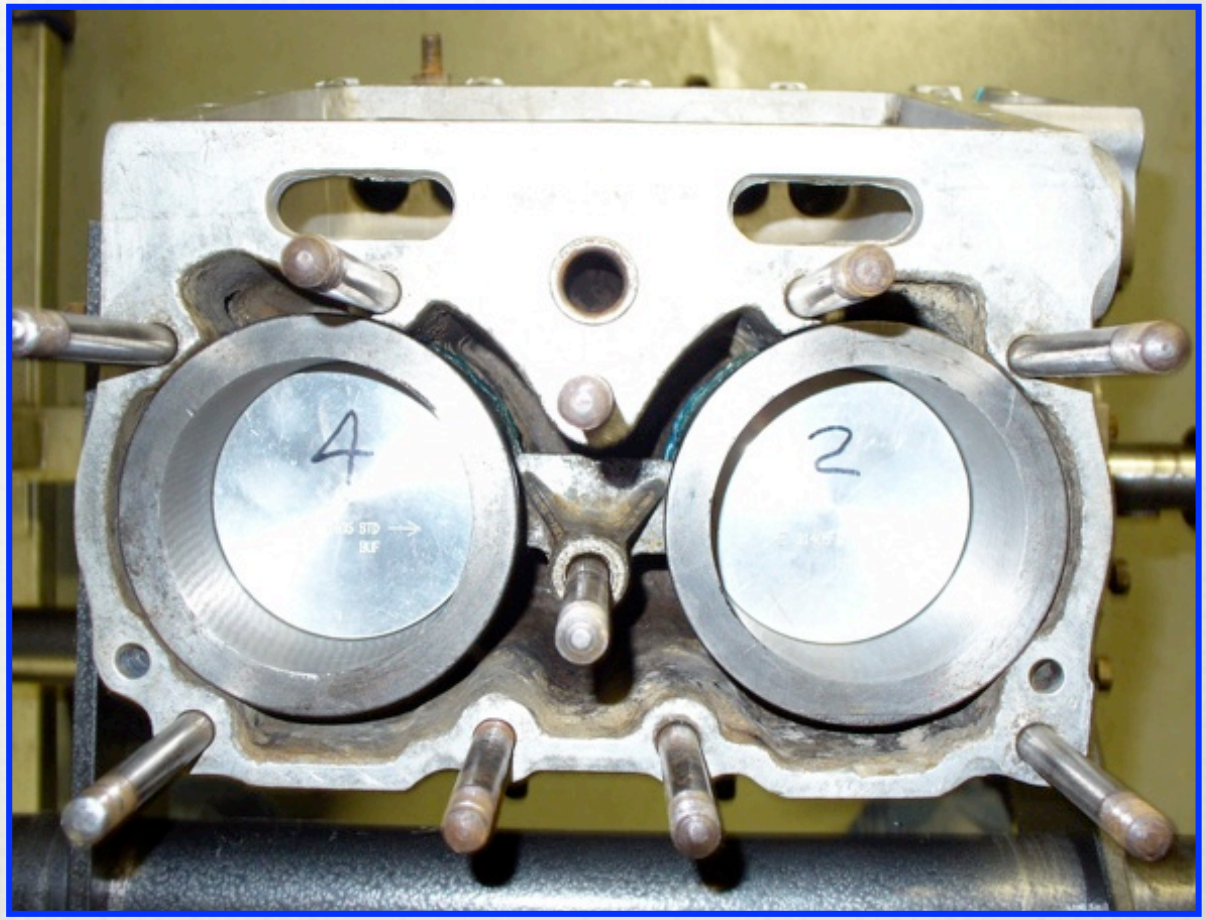
INSTALLING THE PISTONS AND RODS

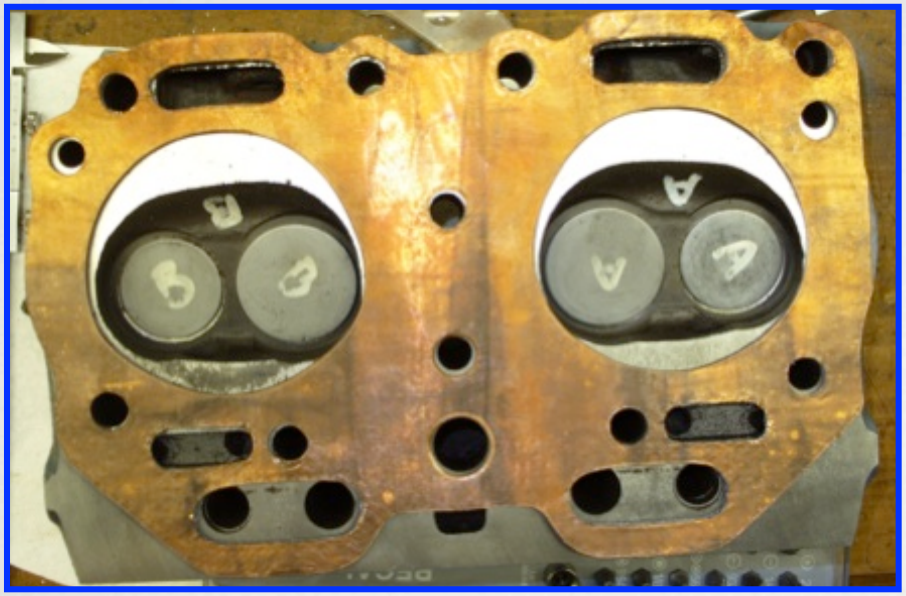
- Assuming the crankshaft rotates without undue friction, the pistons and rods can be installed.
- Make sure you match the rod to the crank pin that you ended up with from the swinging-the-rods exercise.
- Bolt torque is 35 lb/ft.

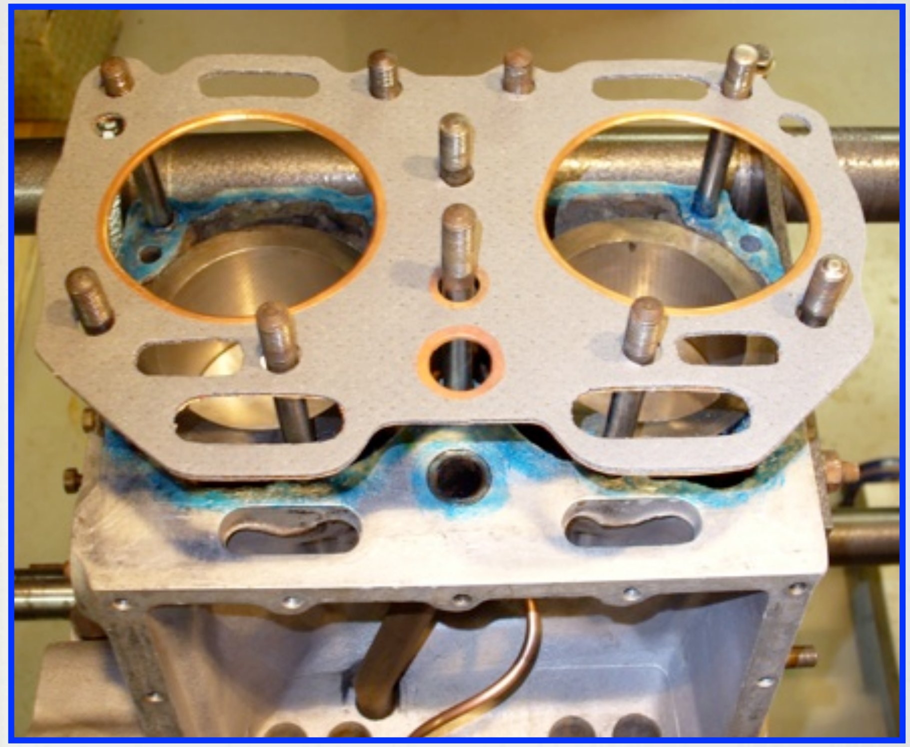


READY FOR HEAD GASKET

- With both liners and the intermediate liner locator shimmed to give the correct stand-out or protrusion from the crankcase, it is time to fit the head gasket.







Original Payen brand head gaskets are no longer available. These gaskets came from Bill Lock Spares Ltd.
They were not a perfect fit, and needed some adjustment to fit over the studs.

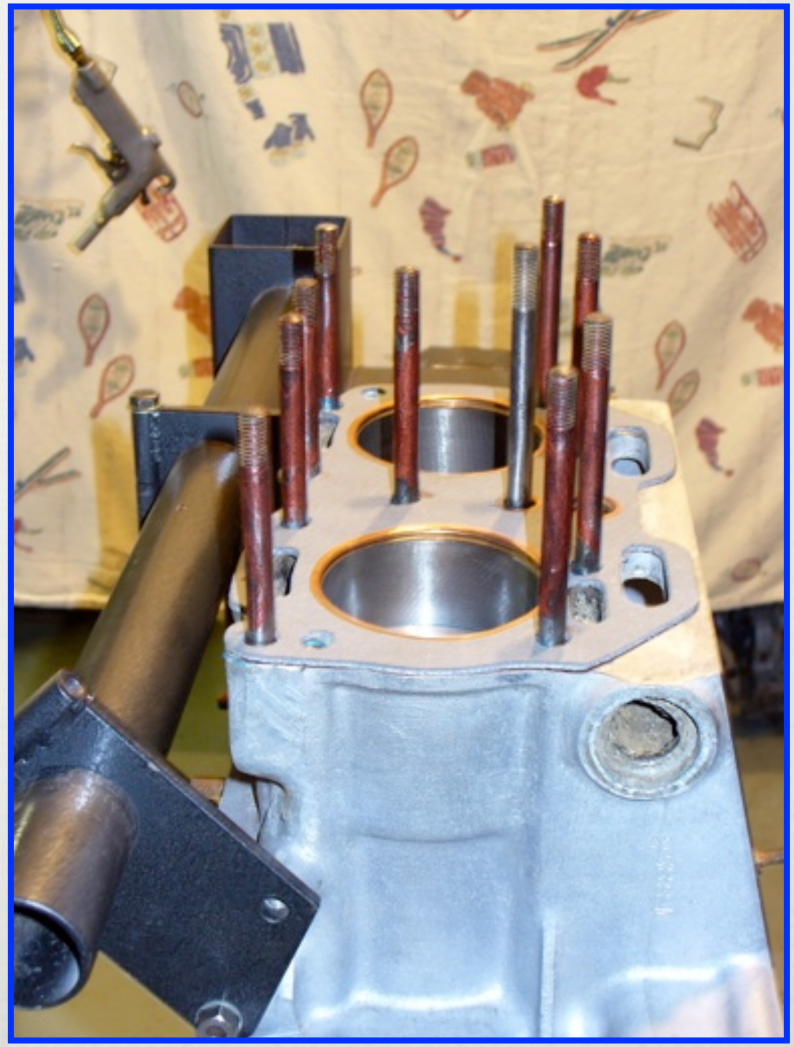
HEAD GASKET ALIGNMENT

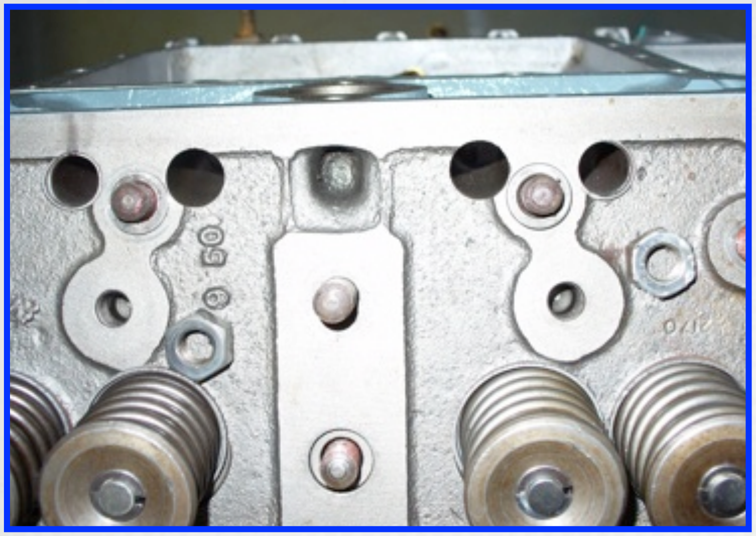
- The registration of the windows in the gasket are not aligned with the features of the crankcase as well as I would like to see.

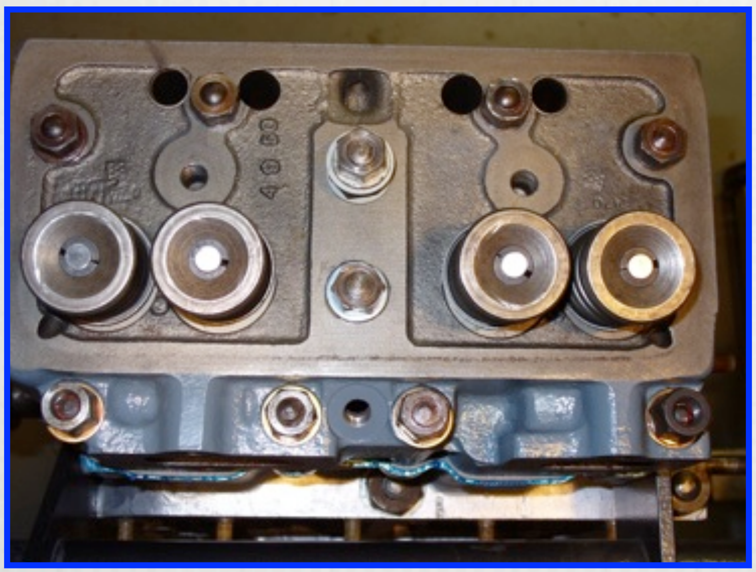
- The gasket underlaps the lower rim of the crankcase, which due to corrosion, is normally its weakest zone and most in need of sealing.

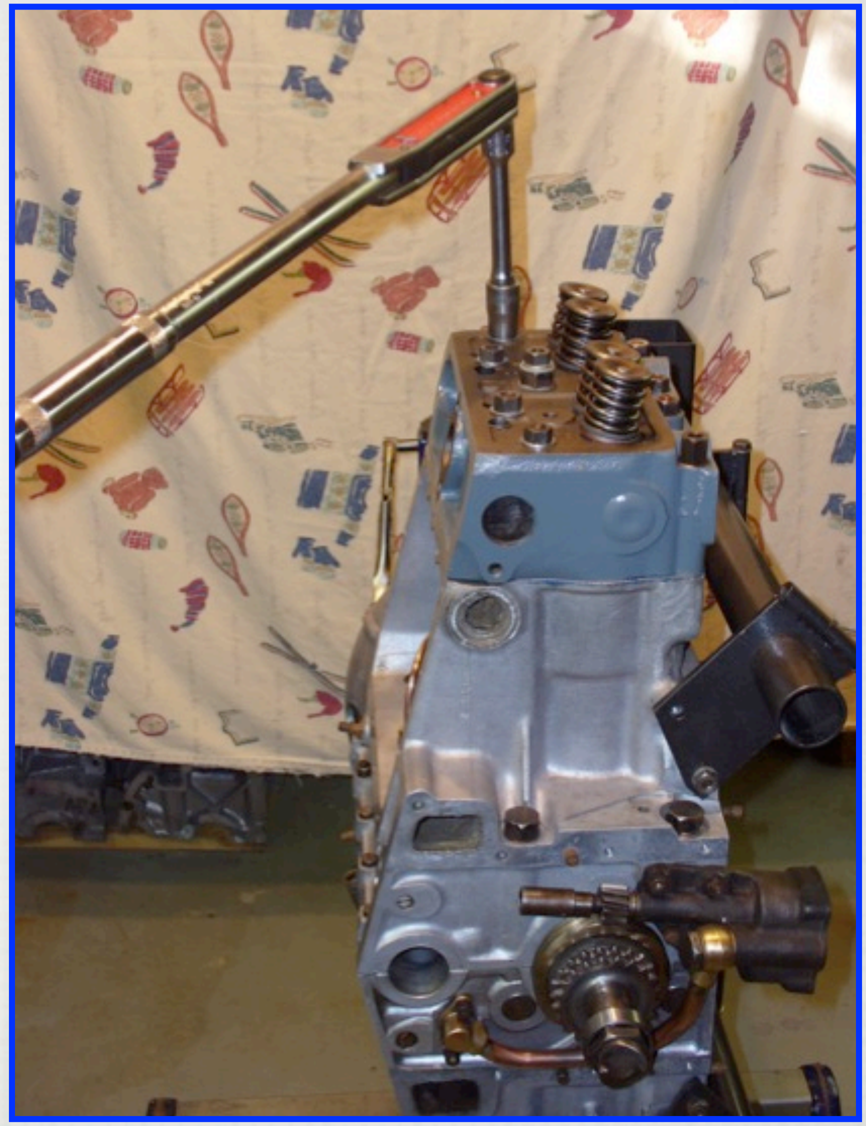
READY FOR HEAD INSTALLATION

- It is by no means uncommon for the cylinder head to be difficult to remove after use due to corrosion between head and stud.
- Since head gasket sealing is a weak point of this engine, and in-service removal a moderately common event, I applied copper anti-seize grease to the head studs in a feeble attempt to minimize this problem in the future.
- Hylomar was applied around the perimeter of the gasket on the crankcase side.









Head torquing by diagonal selection in incremental steps up to 37 lb/ft.

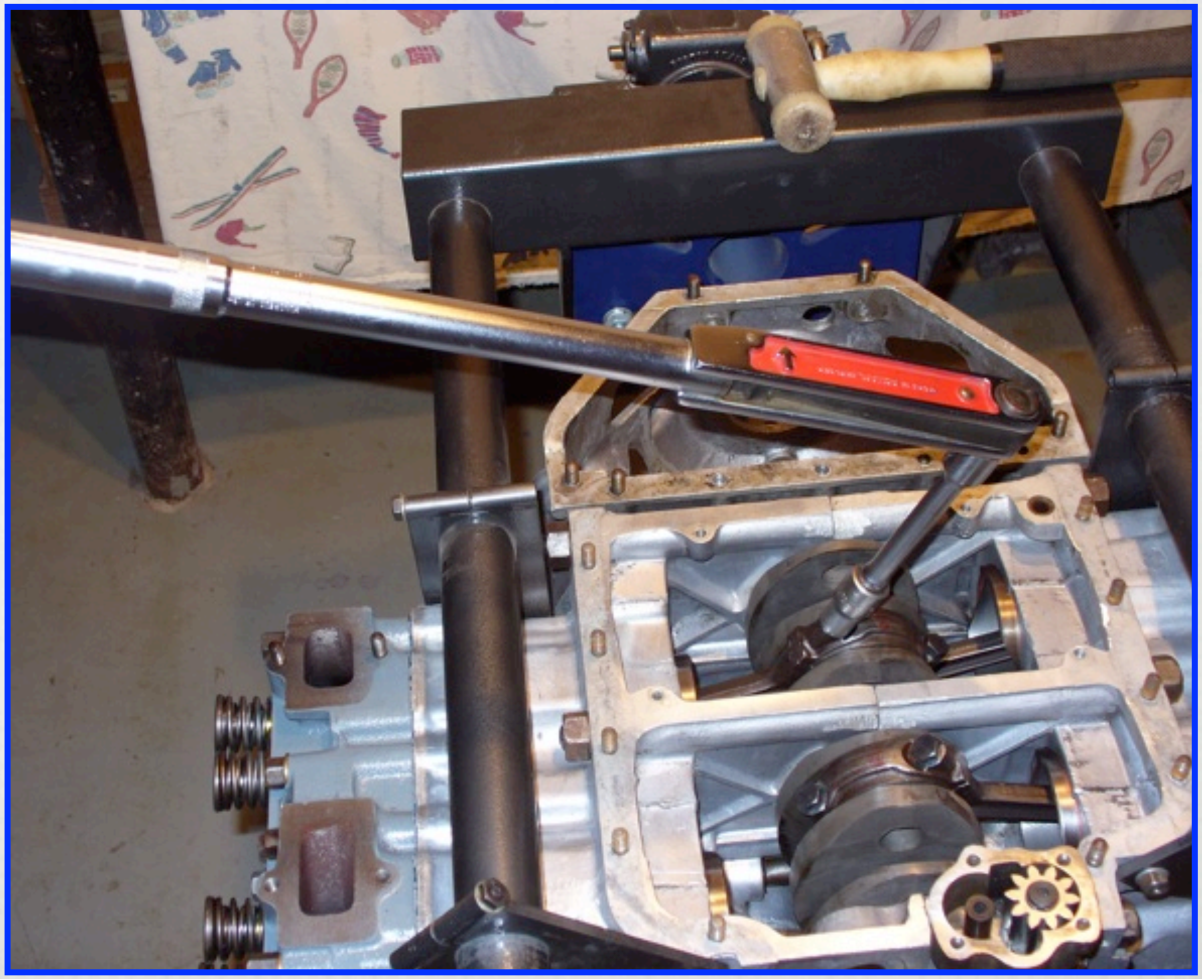
OIL PUMP DRIVE

- The oil pump and ignition distributor are driven off the crankshaft via a bronze worm wheel.
- Both driving and driven gears are prone to wear, particularly the bronze wheel which in this location has the effect of retarding the ignition timing over time.
- To minimize this wear, it is helpful to polish both gears, but particularly the steel oil pump drive gear.
- I used the nylon brush wheel for this purpose.

TORQUE OVERCHECK

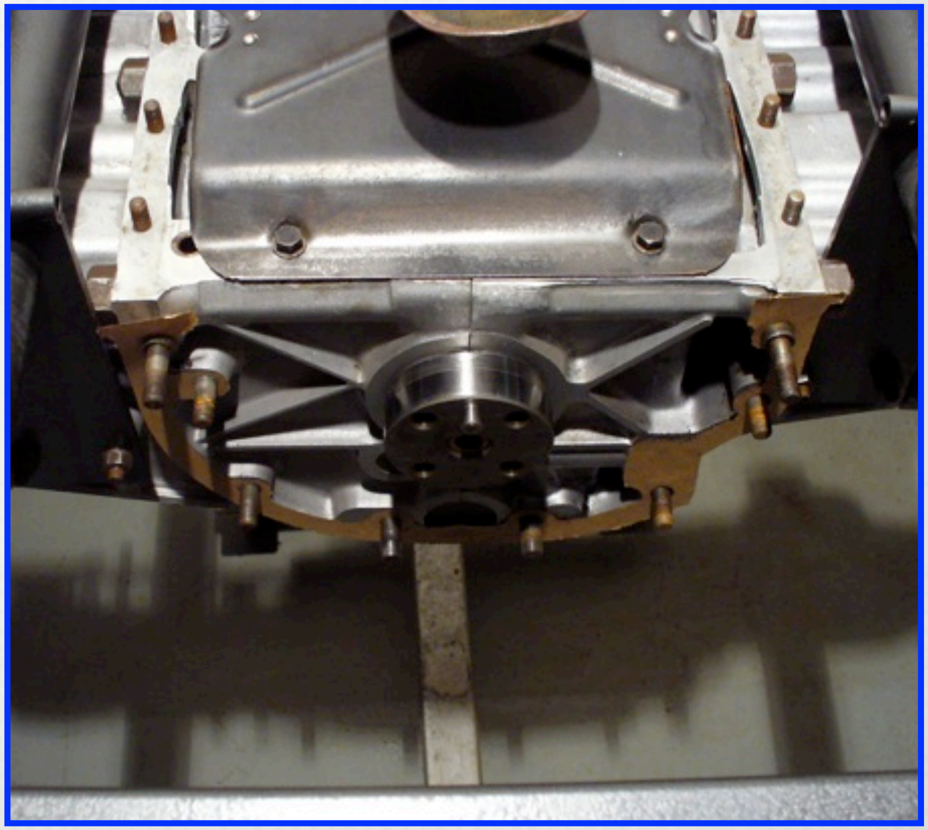
- Prior to installing the sump baffle or windage tray and oil pump pick-up, the rod bolt torques were rechecked.

- Ensure that the oil pump pressure regulator piston is not stuck in its bore; a moderately common fault.

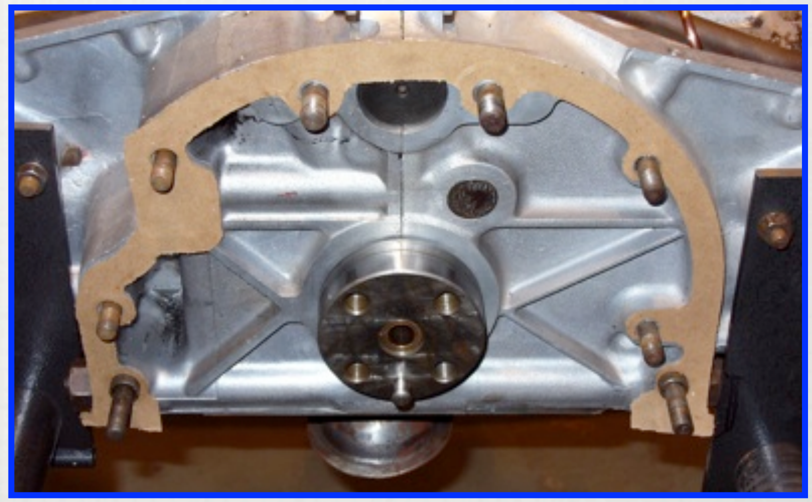


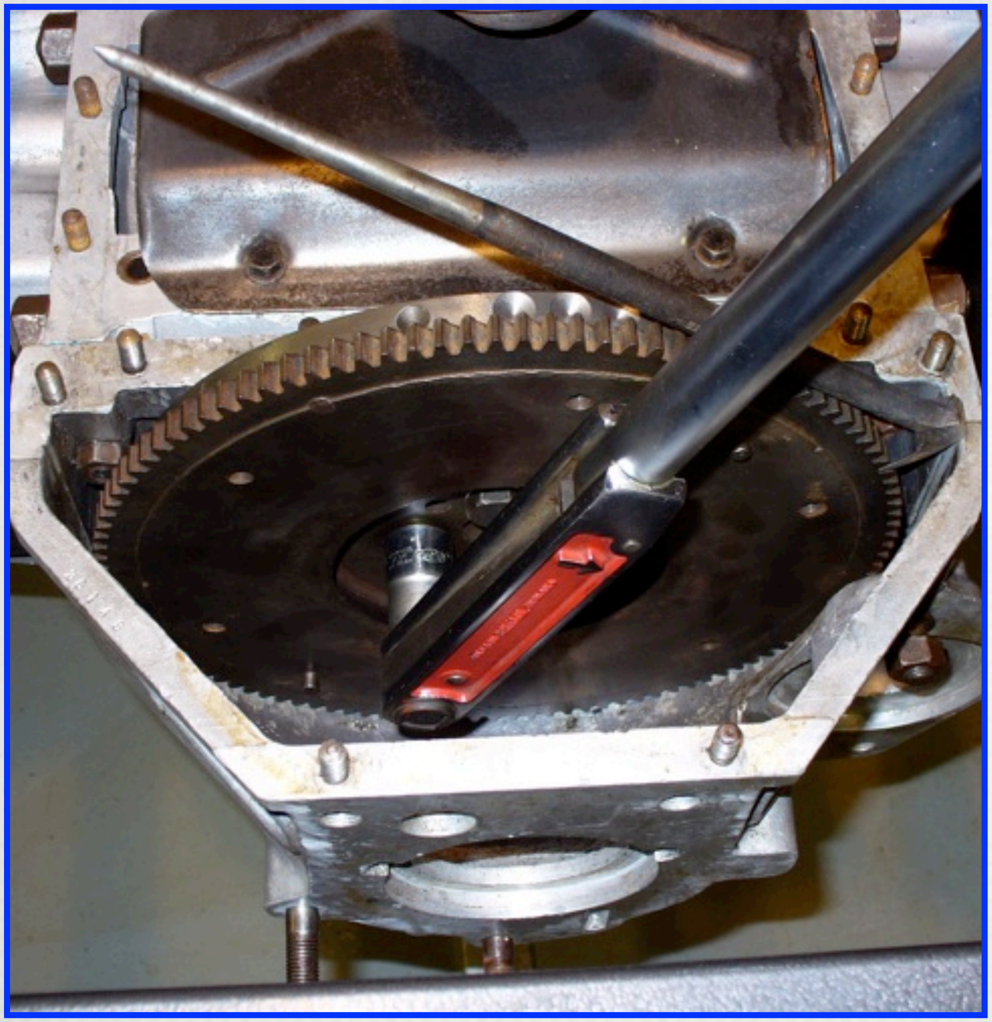
FLYWHEEL HOUSING

- A paper gasket was fashioned for the flywheel bell housing to crankcase joint, and Hylomar also applied.
- Installing the new crankshaft rear seal in the bell housing requires the use of a bench press and great care to push it in straight.



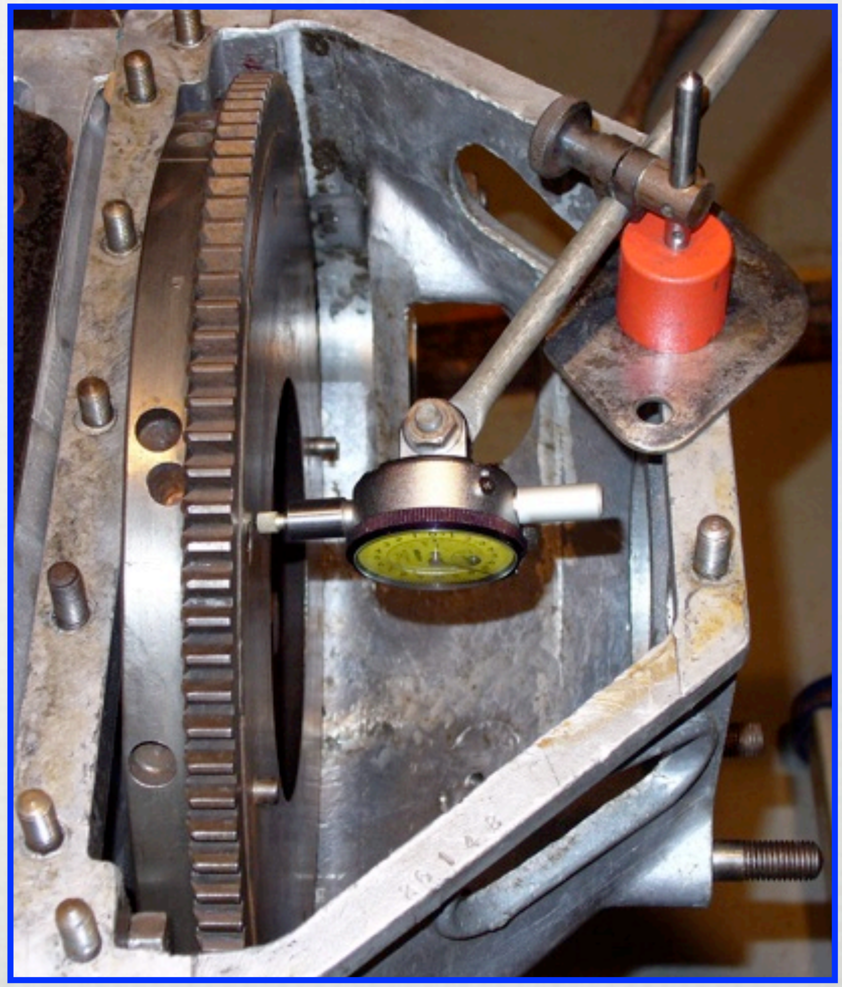

Oil seal
Joint radial
Retén radial
29925
SKF





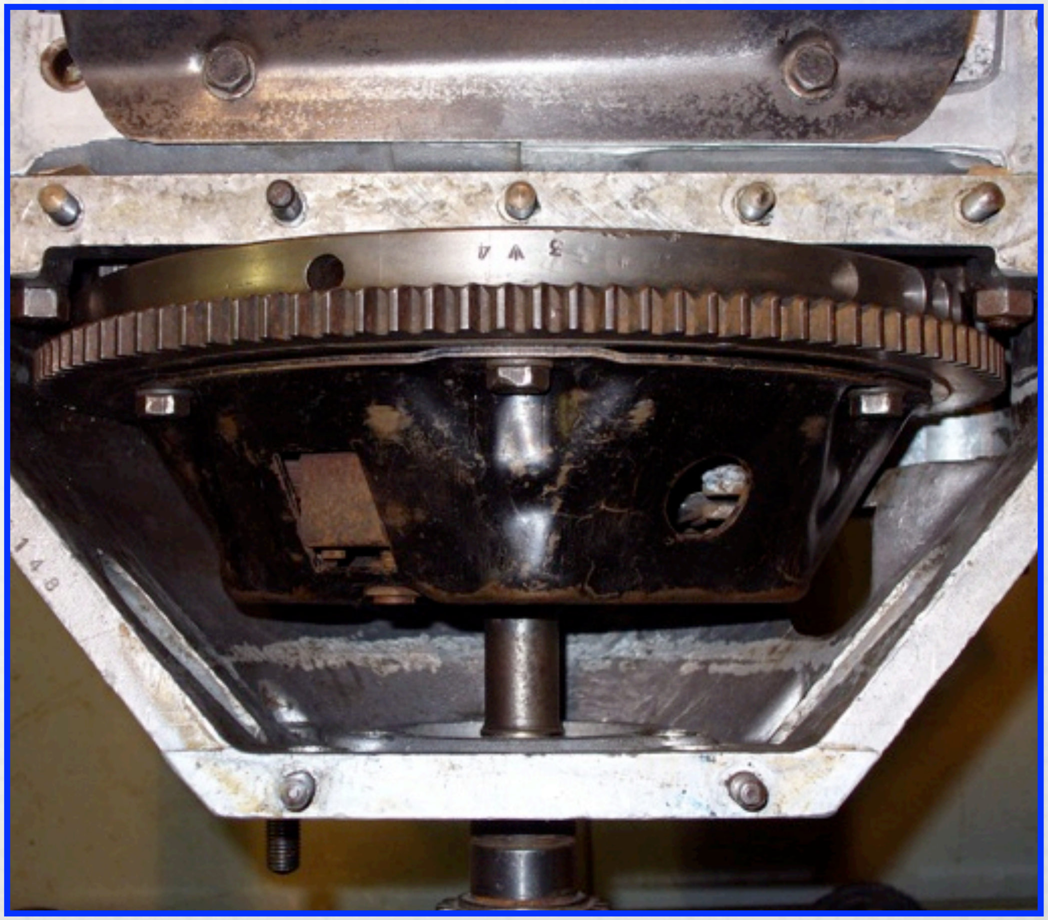
FLYWHEEL RUN-OUT MEASUREMENT

- ☐ The flywheel is retained with four bolts. Use the best ones you can find and use new shakeproof washers and/or thread locking agent. Torque to 60 lb/ft.
- ☐ I checked for flywheel runout in the manner shown here. It was good.
- ☐ This flywheel was slightly thinner than standard so appears to have been mildly lightened.



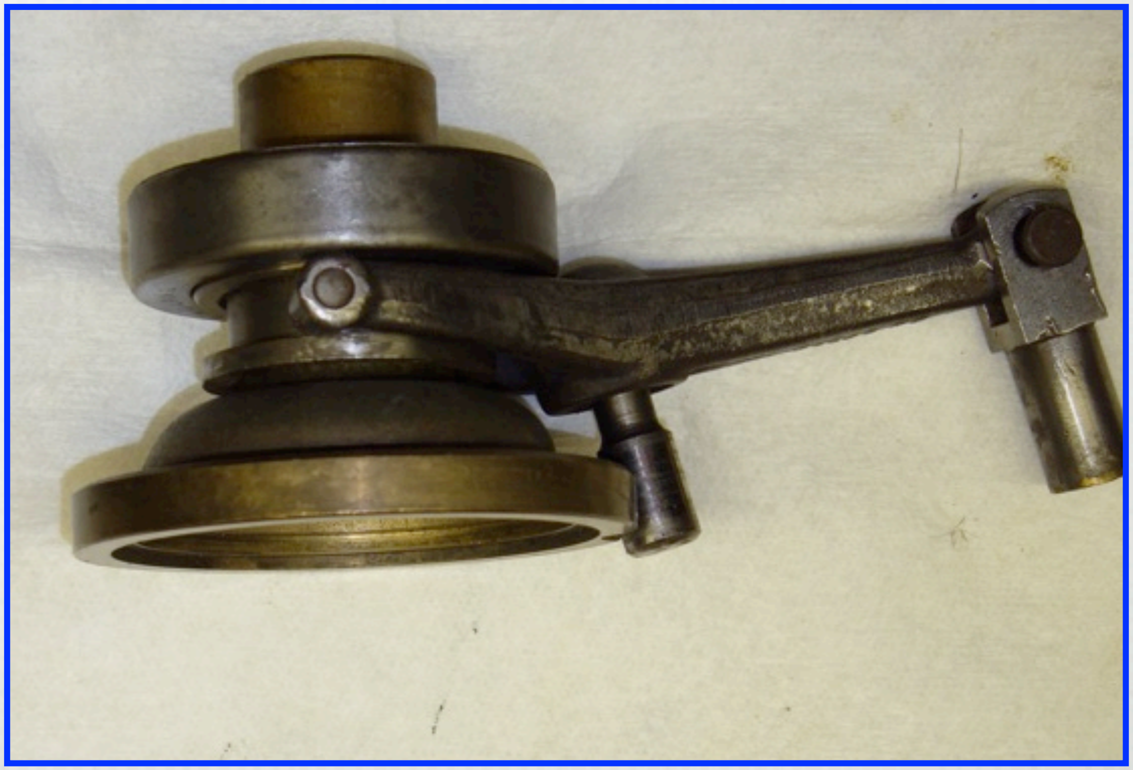
CLUTCH PLATE ASSEMBLY

- The original Borg & Beck 5 1/4” clutch was good as is, and the center plate was good for reuse also.
- An old clutch shaft was available as a means to locate the center plate.



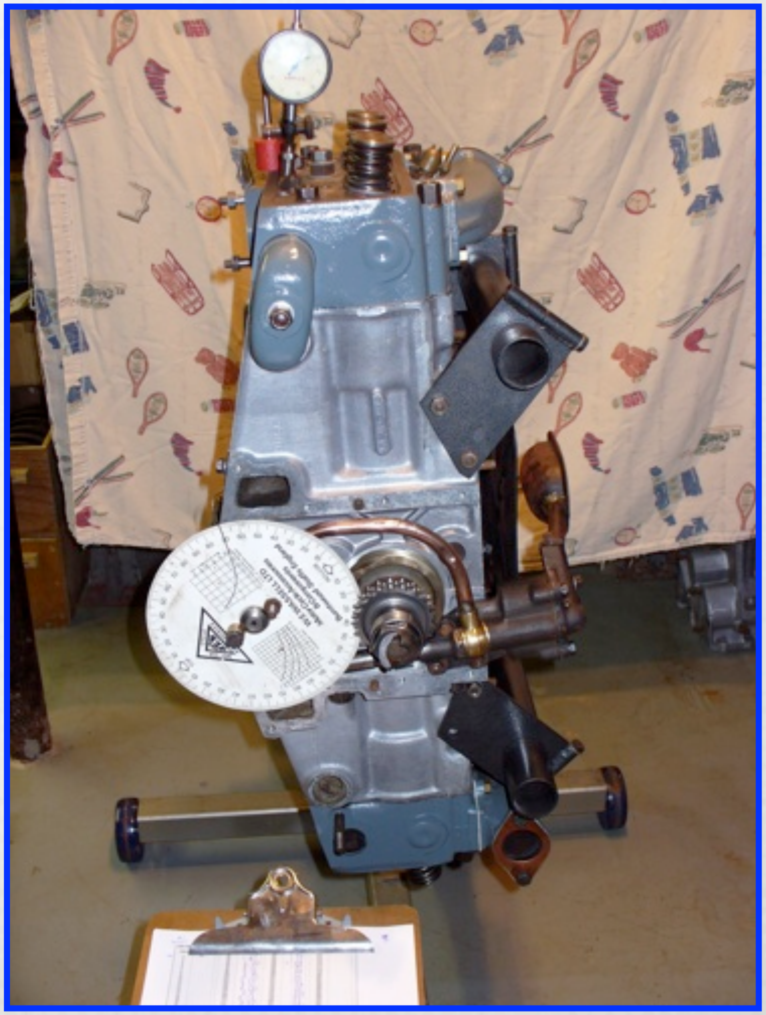
CLUTCH THROW-OUT GROUP

- The clutch throw-out bearing and related components were all reusable.

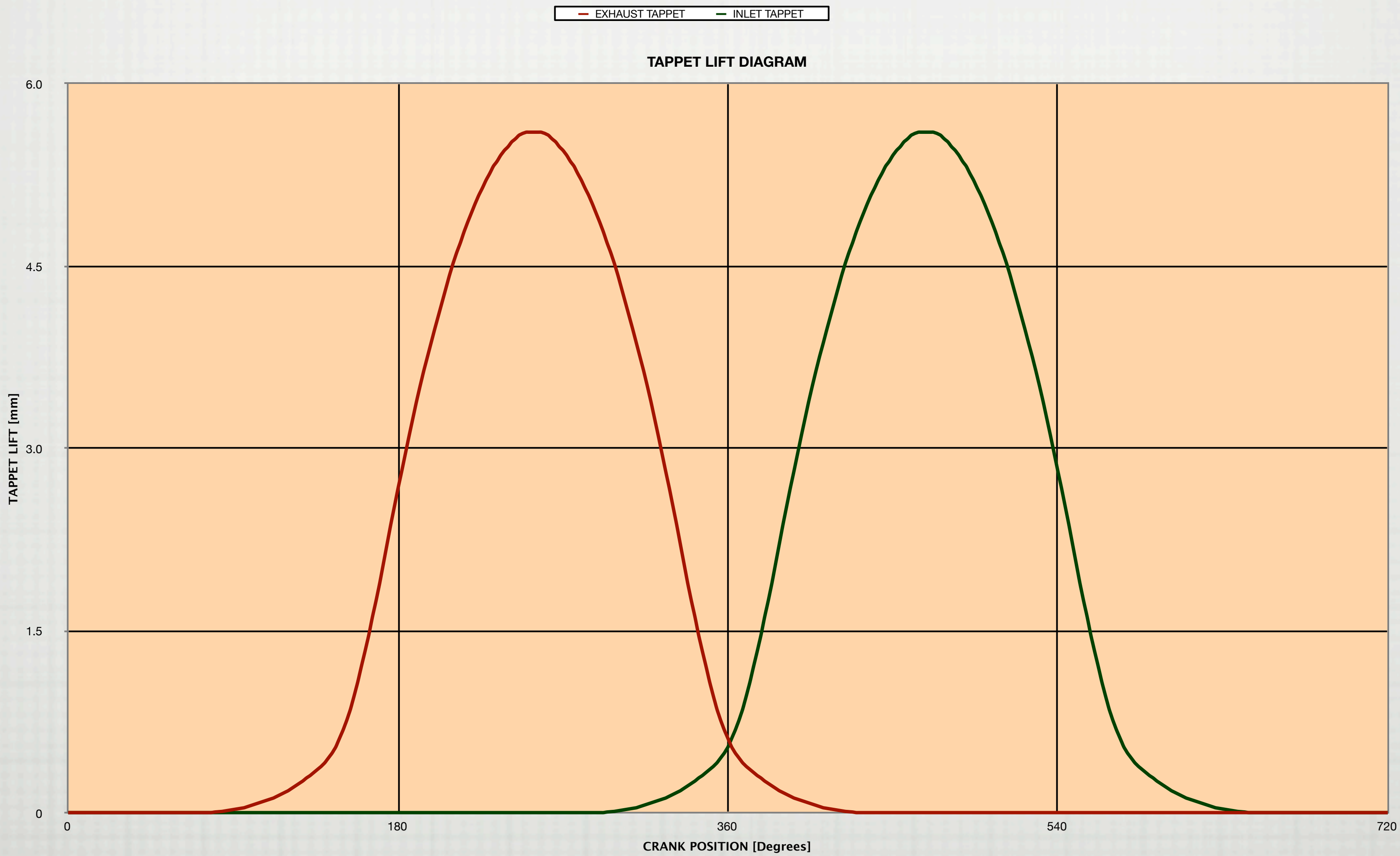


CAM PROFILE MEASUREMENT

- In this photo, the cam profile is being recorded. That is to say, the tappet lift (rise and fall) is being recorded at 1 degree increments.
- Note that the cam is not connected to the crank at this point, so it is free to rotate. A tappet and pushrod are riding on the cam, and a dial indicator tracks the resultant motion.
- This is a very tedious process, so only one exhaust and inlet cam lobe was measured.
- The lift data so collected resulted in the curve in the next slide, after some spreadsheet manipulation.

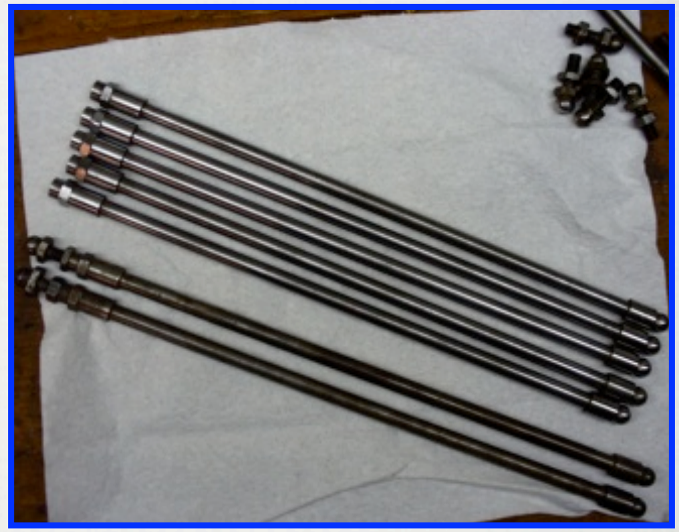


TAPPET LIFT DIAGRAMS



PUSHRODS

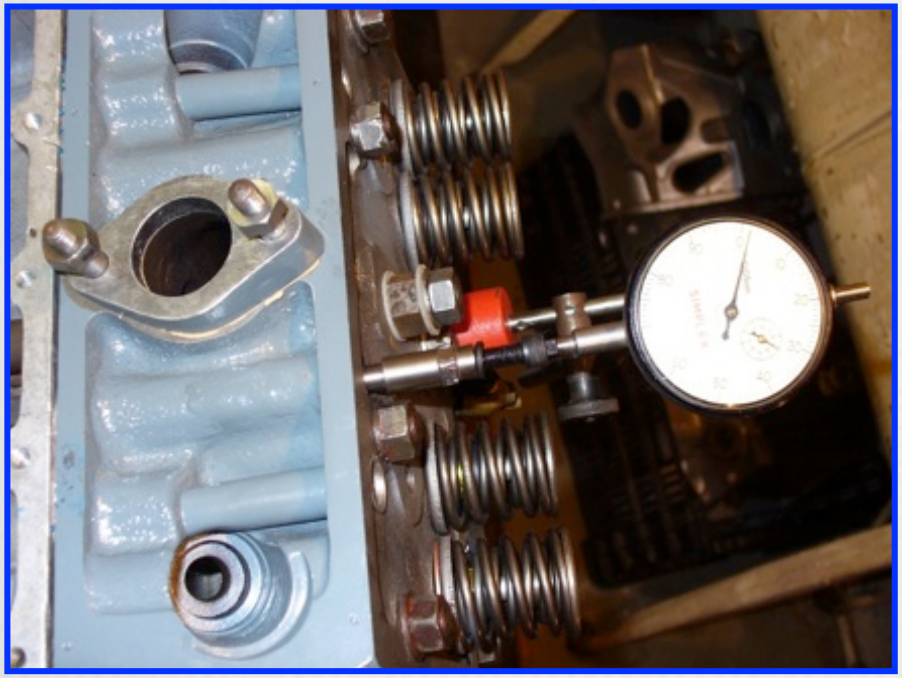
- The pushrods were cleaned up on the abrasive nylon brush wheel.
- Lacking anything better, they were individually spun in the electric drill to identify if they were bent.
- The solid tappets had already been cleaned up with the nylon brush wheel and the cam interface surface refinished by lapping.

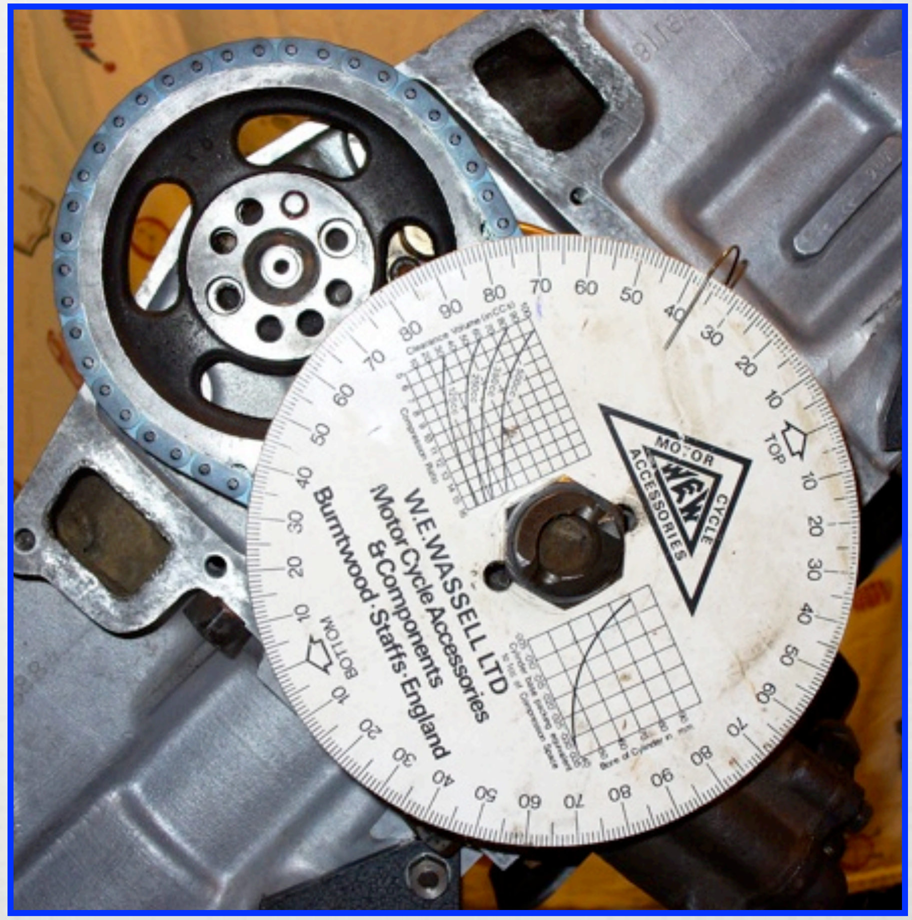


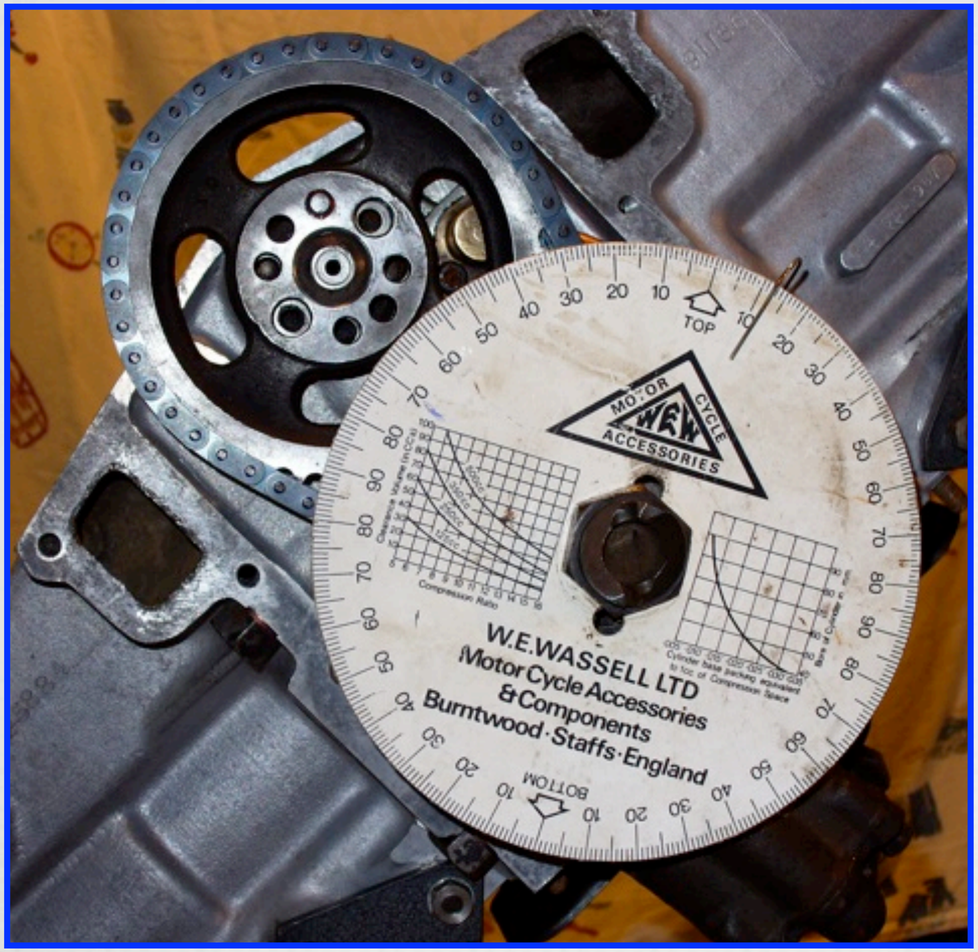
CAMSHAFT CHAIN WHEEL

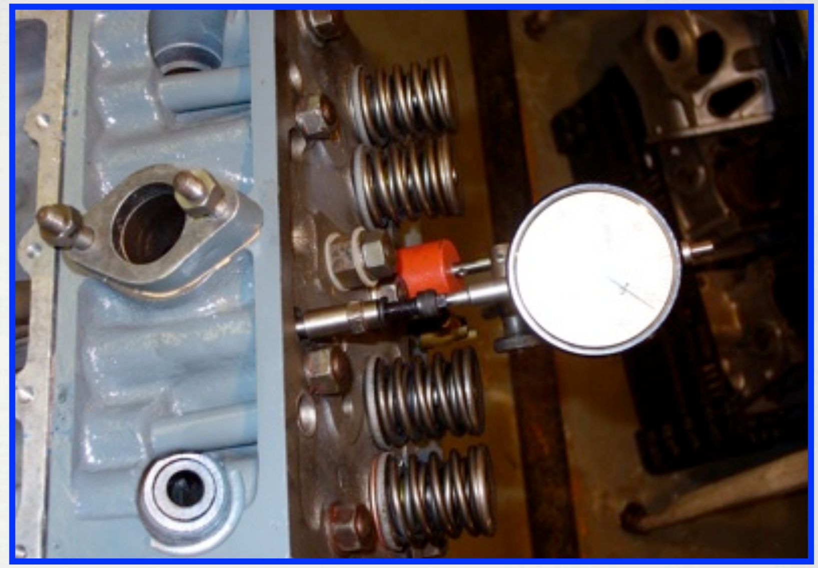
- This is the normal (later) chainwheel with the vernier holes for cam timing adjustment.
- Normally, there is no provision for taking up timing chain wear, but I added the neoprene o-ring seen here into the central trench between the two sheaves. This is a strategy used by others such as BMC.
- In the next two slides the cam timing is being set per the manual and the dowel has been inserted in the pair of holes that most closely coincide.

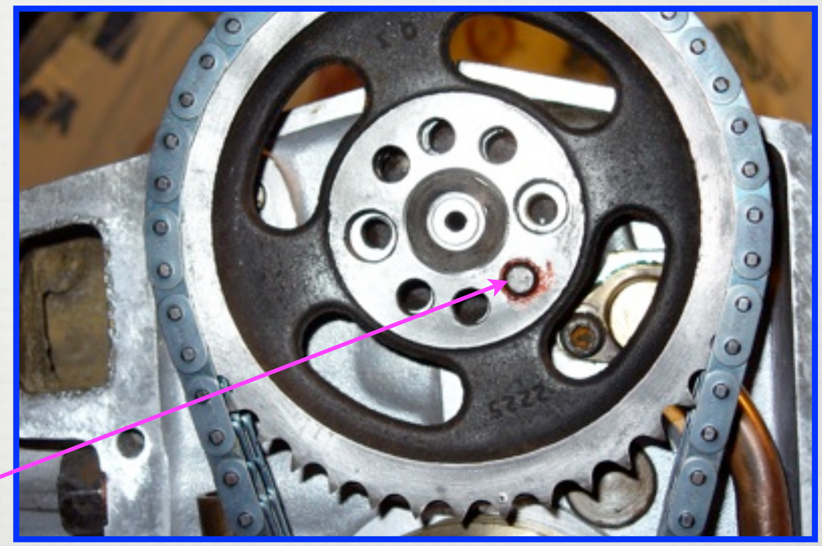
SETTING THE VALVE TIMING







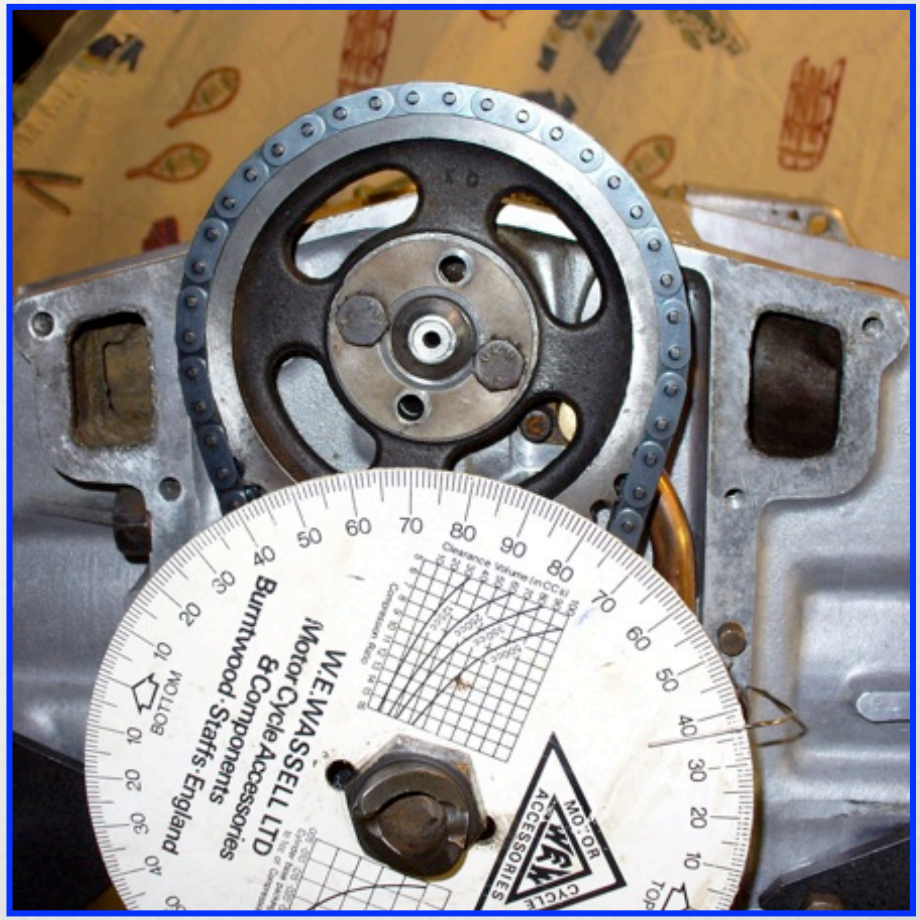


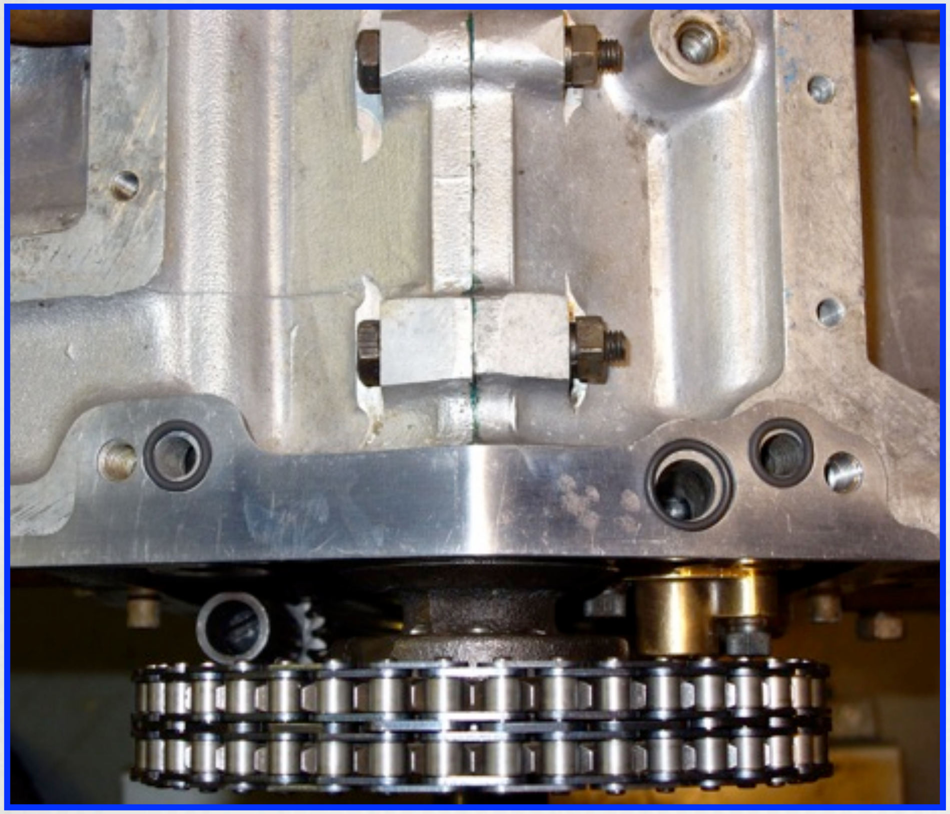


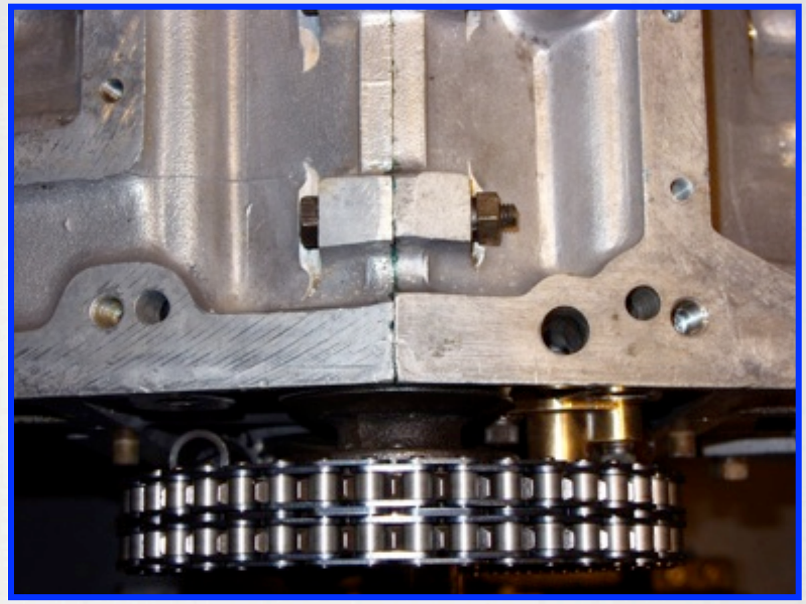
With crankshaft set at 12º BTDC and No. 1 inlet tappet at 0.33 mm lift, fit the vernier dowel in the holes that align most closely.

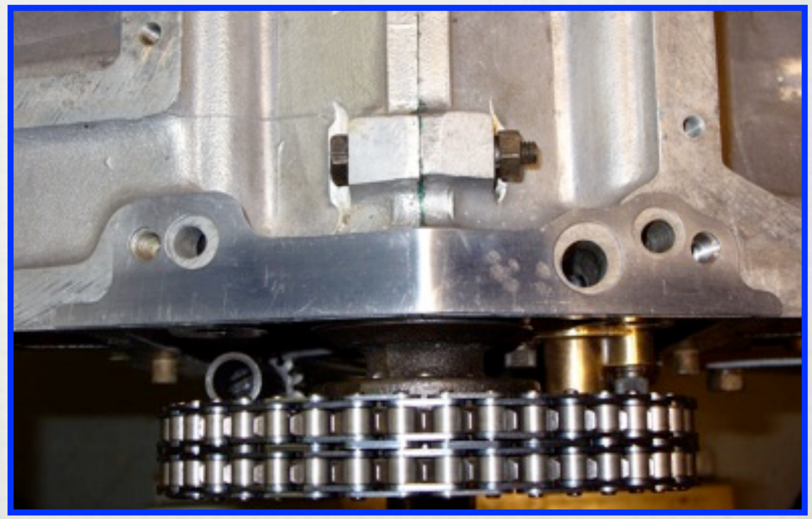
CAMSHAFT CHAIN WHEEL LOCK-PLATE

- Camshaft chainwheel lock plates are getting scarce now.
- I found one where I work that only needed minor modification to serve the purpose of retaining the timing dowel. I used shakeproof washers under the bolt heads as it did not have the knock-up tabs.









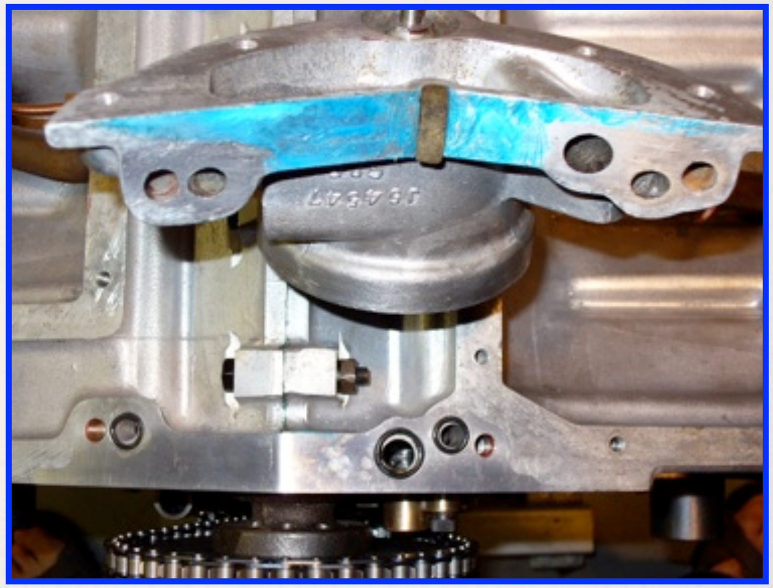
In this slide, the oil filter housing adapter plate is being installed. Top right is the crankcase interface. Bottom right with the adapter plate in place. Above with the o-rings installed.

OIL FILTER HOUSING

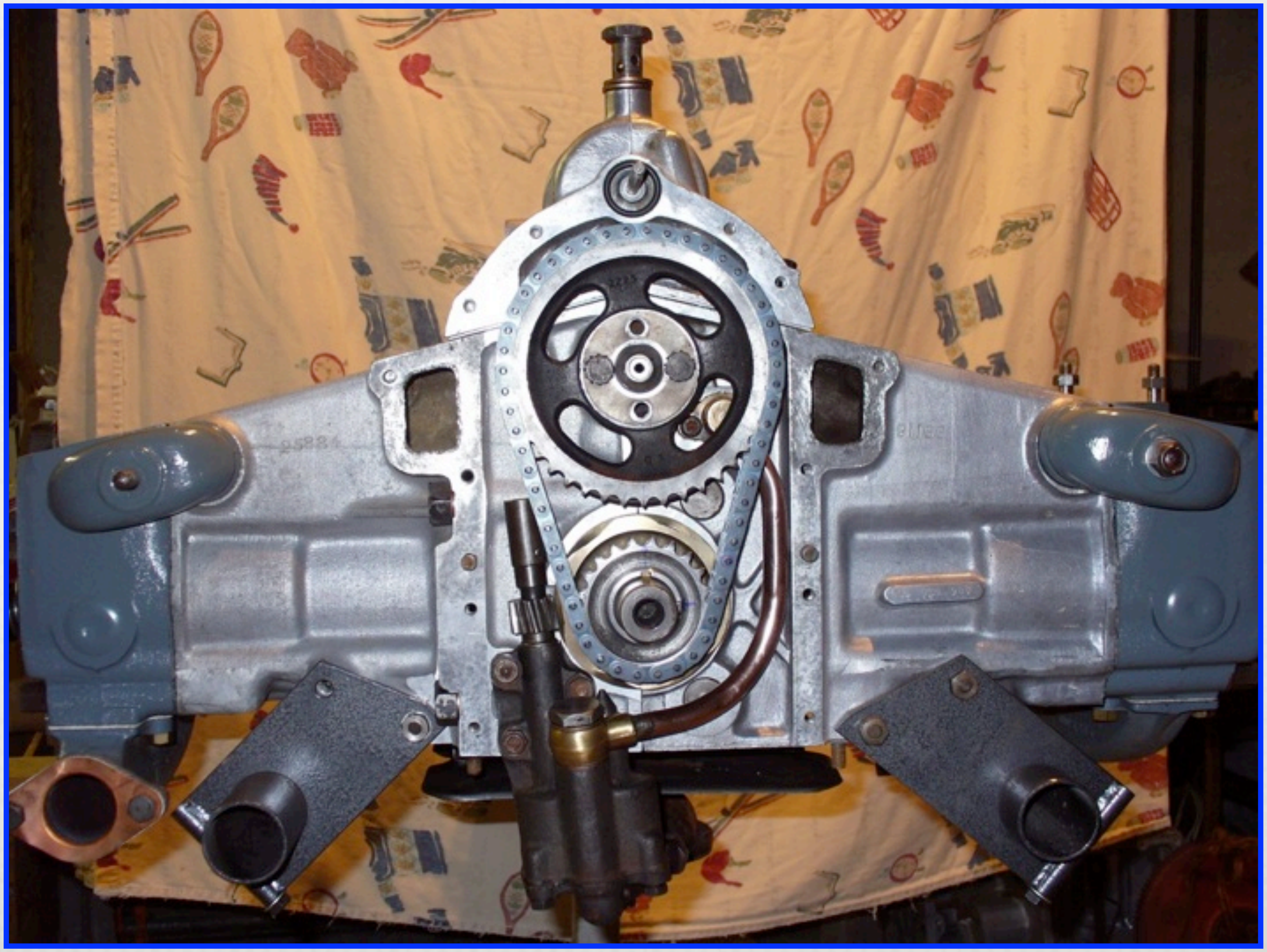
- The o-ringed adapter plate is only supposed to eliminate leaks from the pressurized oil galleries. A sealant is still required on both sides of the adapter plate except around the o-rings to prevent crankcase oil from seeping out.

- It is still necessary to fit the half-moon felt in the recess at the crest.

- One of the retaining bolt threads in the crankcase had been stripped at some time and required a thread insert, obtained from here: http://www.wti-fasteners.co.uk/



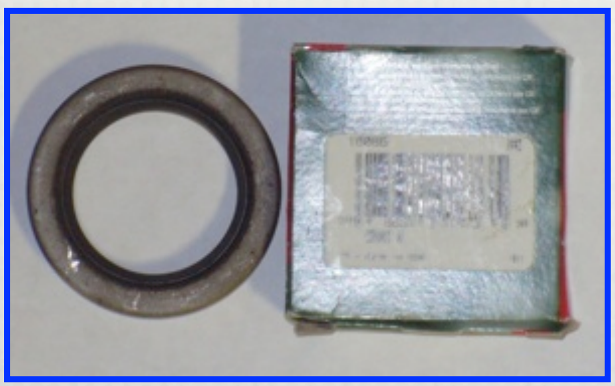
READY FOR FRONT TIMING COVER

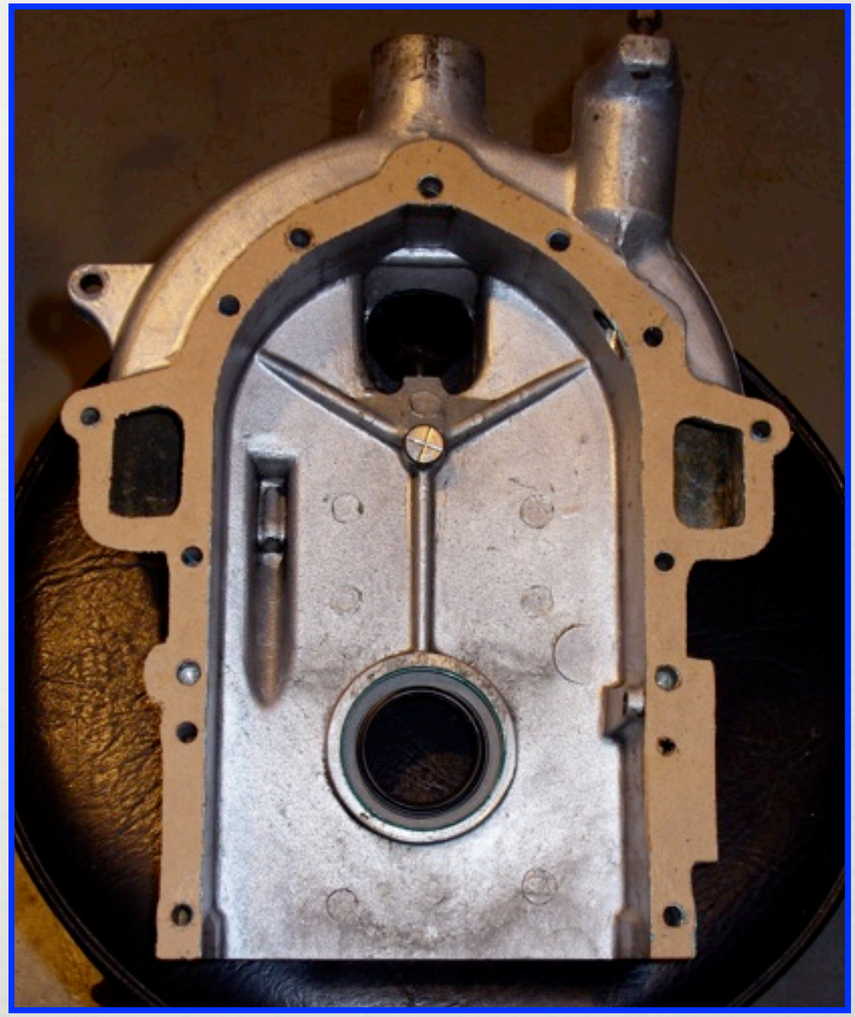


FRONT TIMING COVER

- A new paper gasket was made using a small hammer in the time-honored manner.

- Pressing in the new front crankshaft oil seal requires care to ensure it ends up square. Try to arrange for the lip to engage an unworn section of the pulley seal diameter.

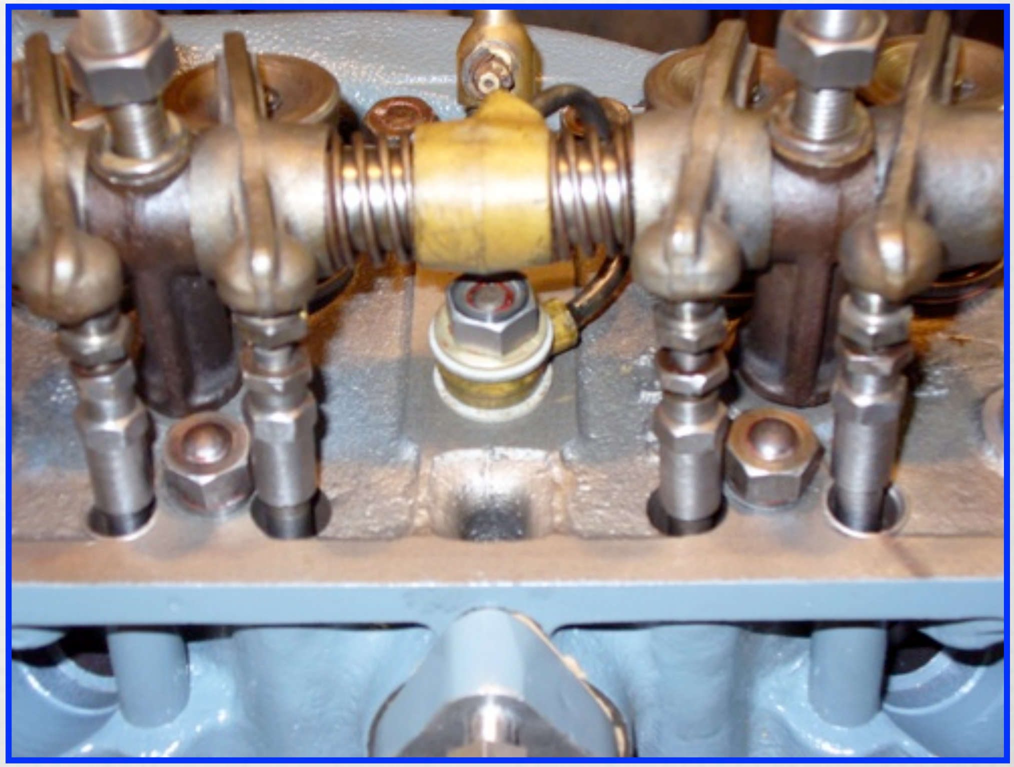




ROCKER SHAFT INSTALLATION

- Here the rocker shaft is being installed. Note that the center head stud that also feeds oil to the rocker shaft has new vulcanized fiber washers on either side of the banjo.

- Note also that there are reduced diameter hardened steel washers under the (not yet tightened) nuts that retain the rocker shaft pillars. Same for the cylinder head nuts adjacent the pushrods.



SETTING VALVE CLEARANCE

- Adjusting the valve clearances with the engine rotated in this manner was a pleasure and so easy.

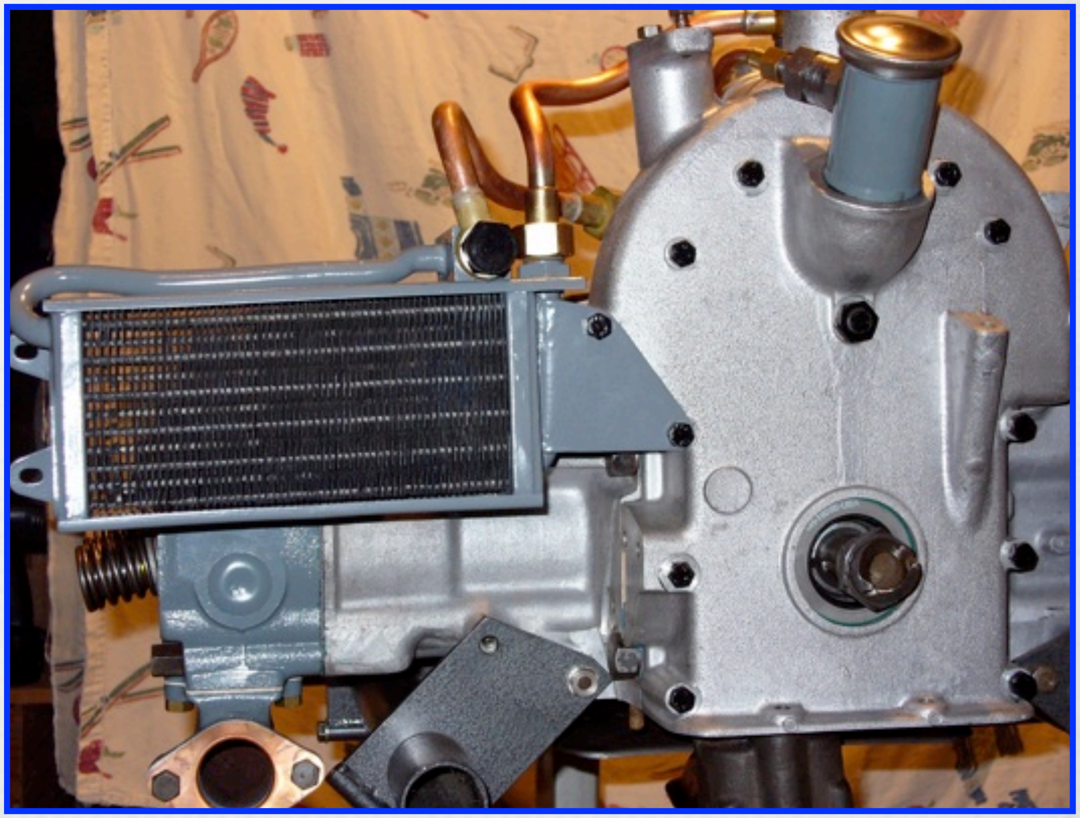
- It was only later that I recognized that I had a major problem (discussed later).

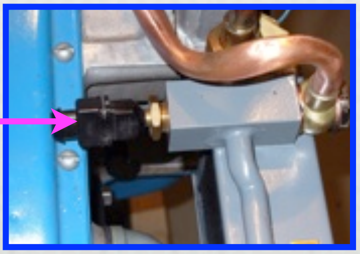
TIMING COVER AND OIL COOLER

- This engine is fitted with a Bowman oil cooler that relies on ram air for heat transfer.

- Oil flow is from the filter to the cooler, and then back to the main oil galleries in the crankcase.

- For those with a broken original capillary-type oil temperature gauge, I discovered that a Lucas electronic sender fits in the same port.



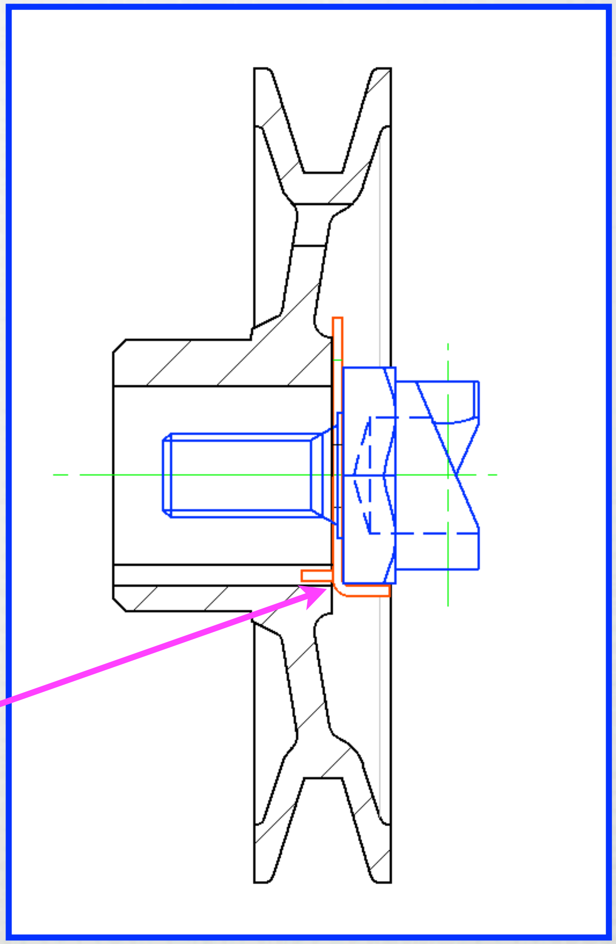


FRONT PULLEY OIL LEAKS

- It is not uncommon to see Jupiter engines with radial streaks of oil on the crank pulley emanating from behind the crank dog lock plate.

- This is due to inadequate clamp load applied by the crank dog bolt to the component stack assembled onto the crank nose, allowing oil to travel along the keyway to the pulley.

- A better solution is required here because as it is, the keyway is not completely covered by the bent-over tang of the lock plate allowing any oil that reaches the keyway to escape.

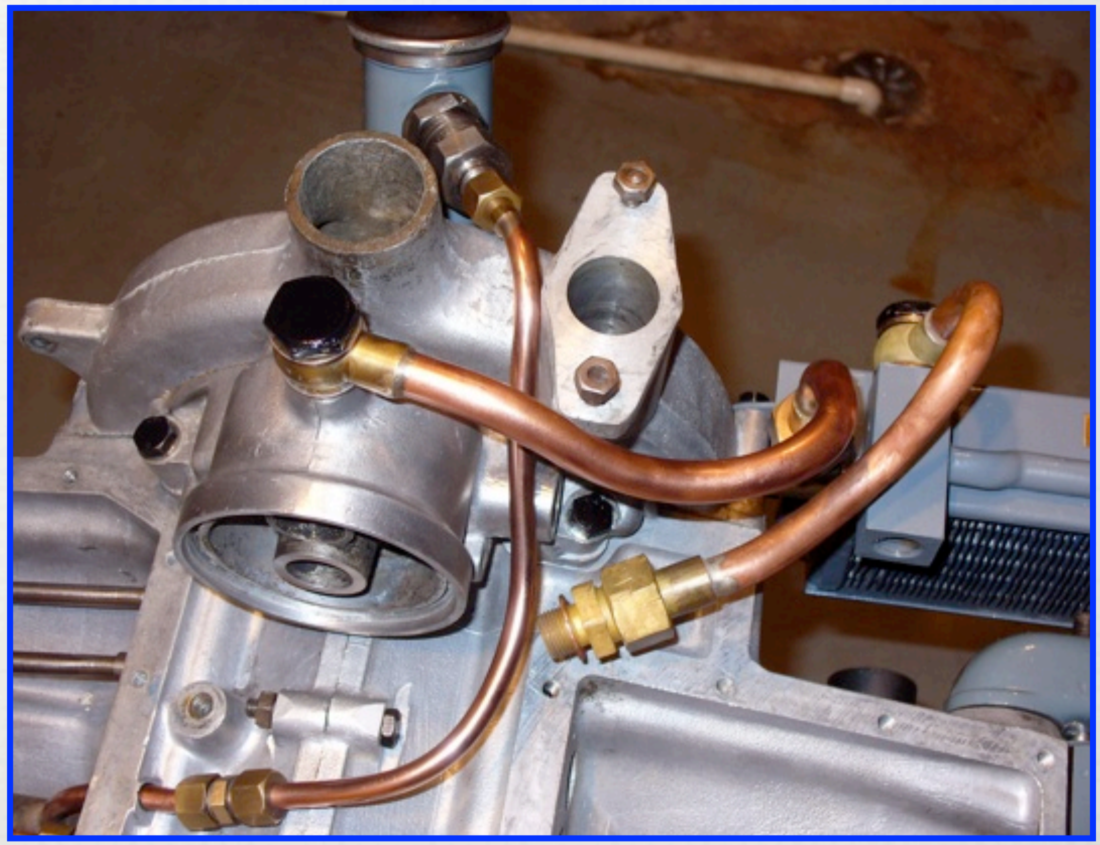


OIL COOLER PIPING FIT-UP

- Somehow, the return pipe from cooler to engine did not fit and required to be heated and bent.

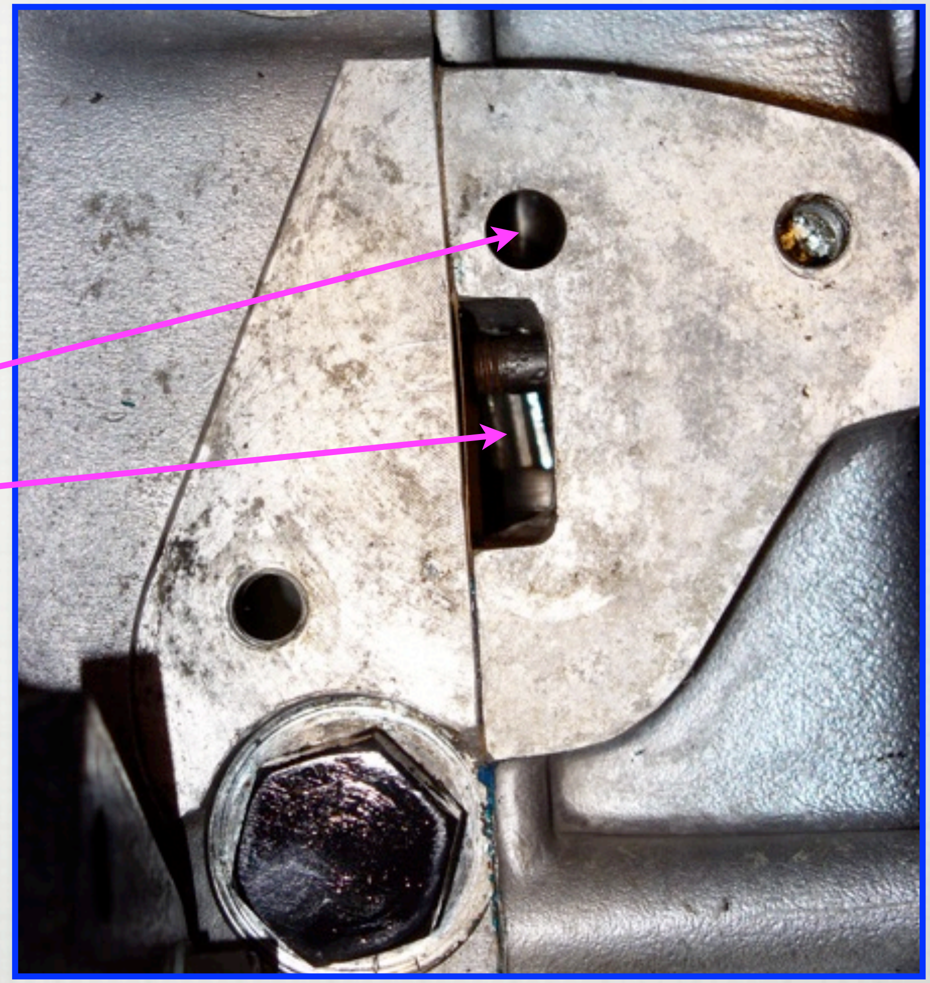
- Given the propensity for oil coolers to leak and the opportunity for dirt ingress during service, it might have been better strategy for the oil filter to appear in the circuit after the cooler...

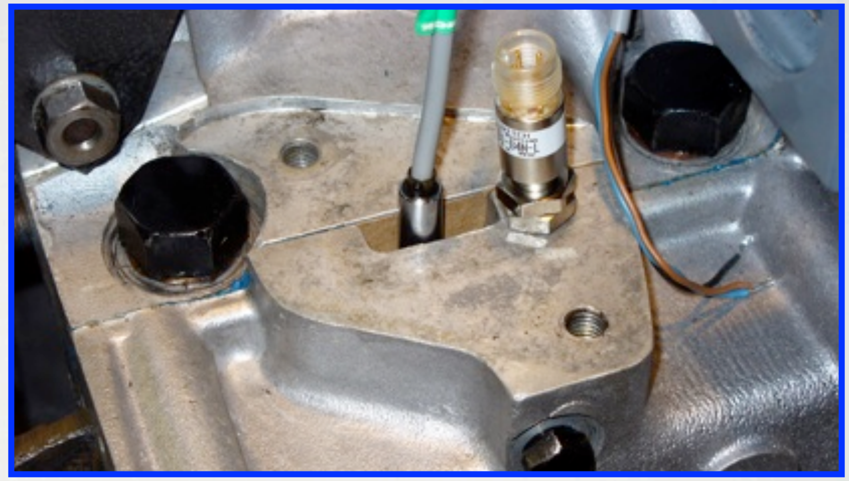
- Dowty washers with integrated bonded seal were used with all banjo bolts, not fiber washers.



PETROL PUMP PAD

- The petrol pump mounting pad is normally blanked off with a steel plate on the Jupiter because it has an SU electric pump.
- But this view shows that the half-speed drive shaft eccentric is visible and the 12 tooth oil pump drive gear.
- It gave me the idea that these could be used in conjunction with sensors to give engine speed and/or position with an electronic controller.
- Next slide gives an example.





These happen to be industrial sensors not automotive, but you get the idea.

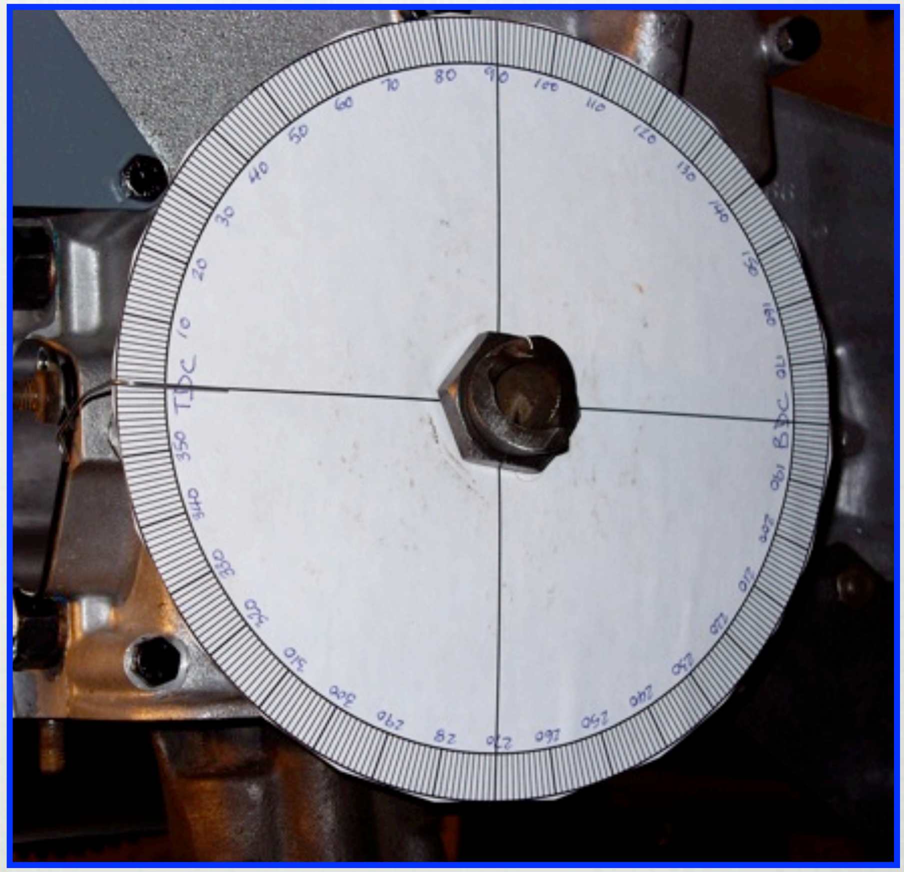
CRANKSHAFT DEGREE WHEEL

- For accurate measurements of valve lift relative to crankshaft rotation, I needed a larger degree wheel than the other one I was using.

- I made up my own wheel, using my CAD program, printed it out onto a 8” x 11” page and then stuck it onto some card stock.

- I cut it out and mounted it on the crank pulley, and used a bent paperclip as the pointer.

- You can download my degree wheel template at:-



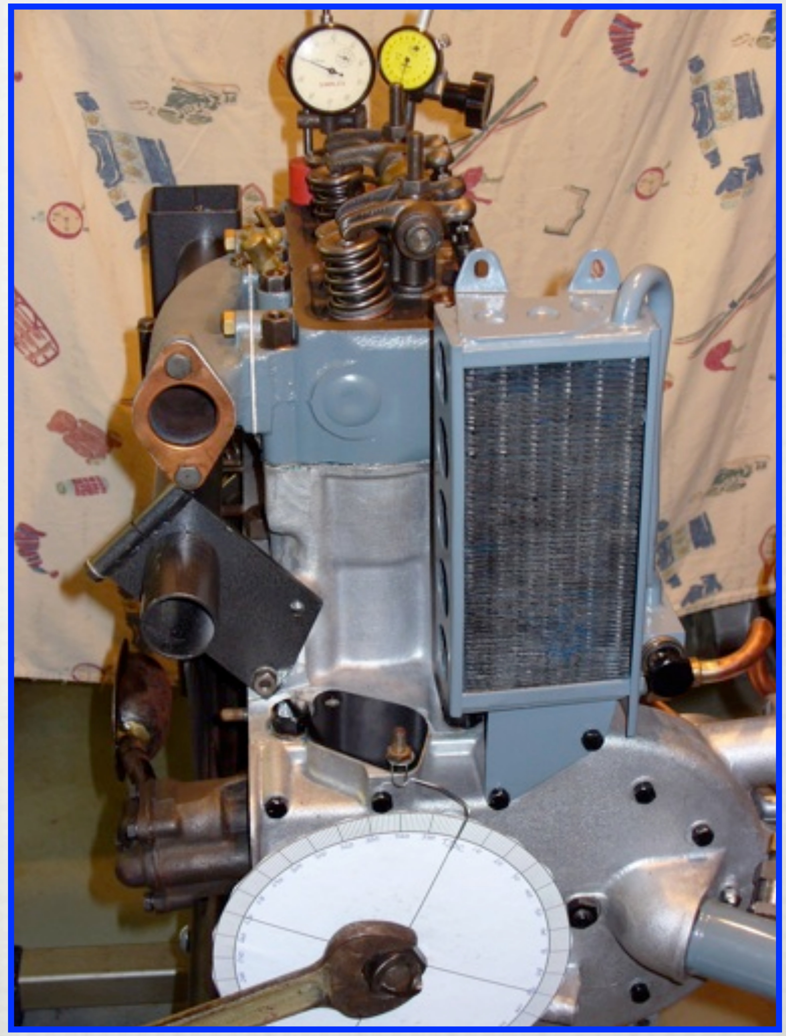
http://pdingle214687.home.comcast.net/Technology/Jowett_Related/Degree_Wheel_Template.png

VALVE LIFT MEASUREMENTS

- Having previously measured the free tappet lift to study the profile, I now wanted to check valve motion in the assembled engine to assess the effect of spring loads on valve train deflection.

- Using my large degree wheel, I was able to rotate the crankshaft in one degree increments (1/2º camshaft), and record <u>actual</u> valve motion.

- The results were not comforting.



ROCKER SHAFT DEFLECTION

- I discovered that the valve motion was not nearly as smooth as it should have been and that there were obvious deflections taking place.

- As expected, one of the deflections was at the rocker shaft, seen being measured here at full valve lift.

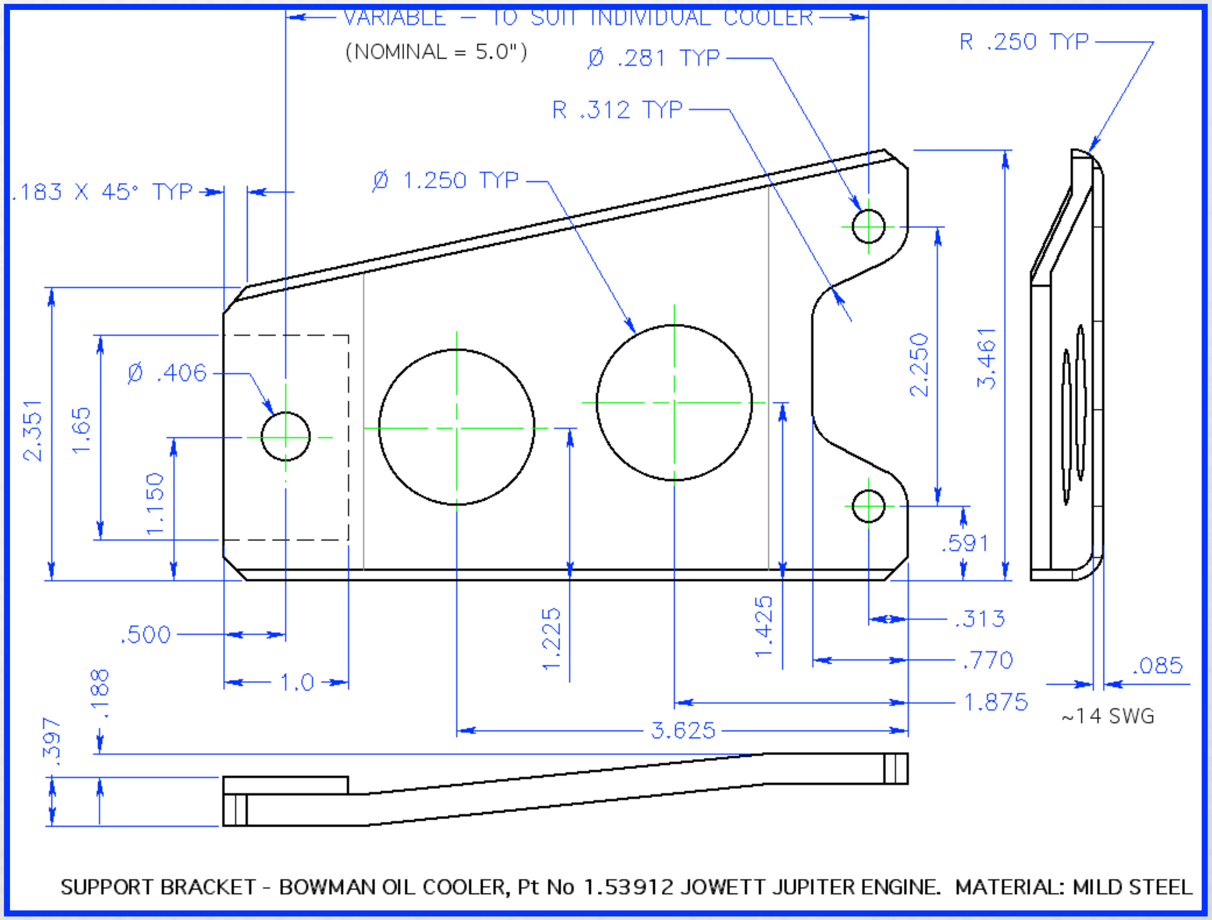
- Far worse was the effect of side-to-side clearance of the camshaft in its bore. Because the camshaft is balanced between the valve spring forces of the opposing cylinders, any slop will allow the camshaft to jump from side to side resulting in very undesirable valve motions. This exercise is reported in detail elsewhere.

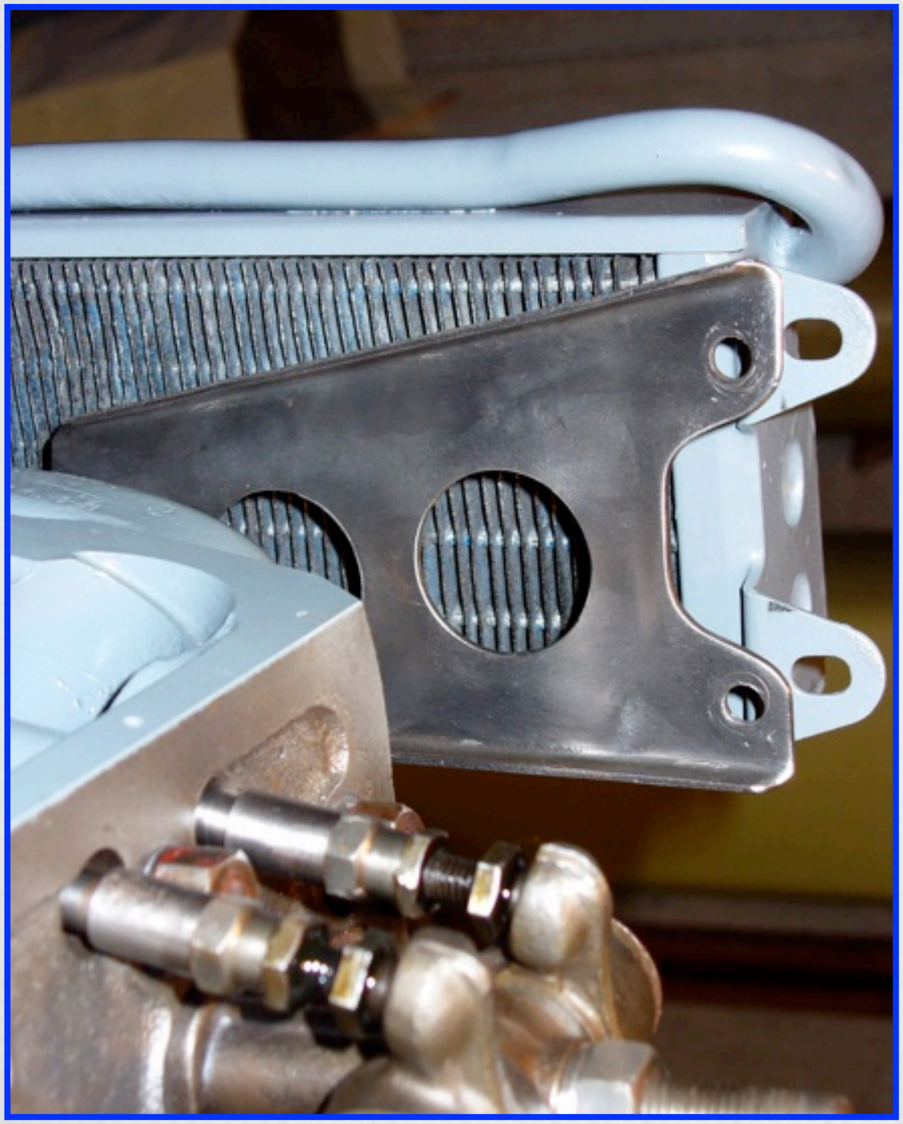
OIL COOLER SUPPORT BRACKET

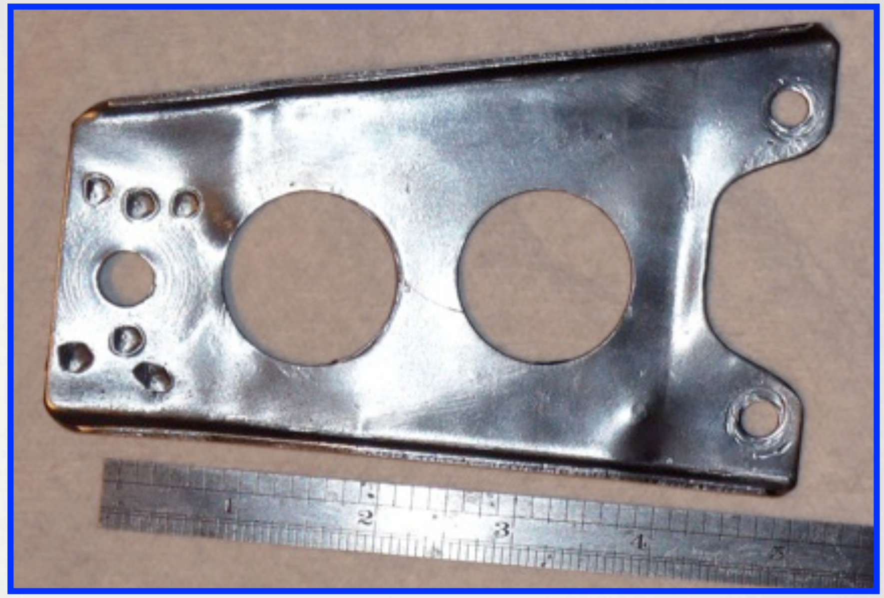
- When I came to fit the oil cooler support bracket, I discovered that it did not fit, being about 1/4” too short.

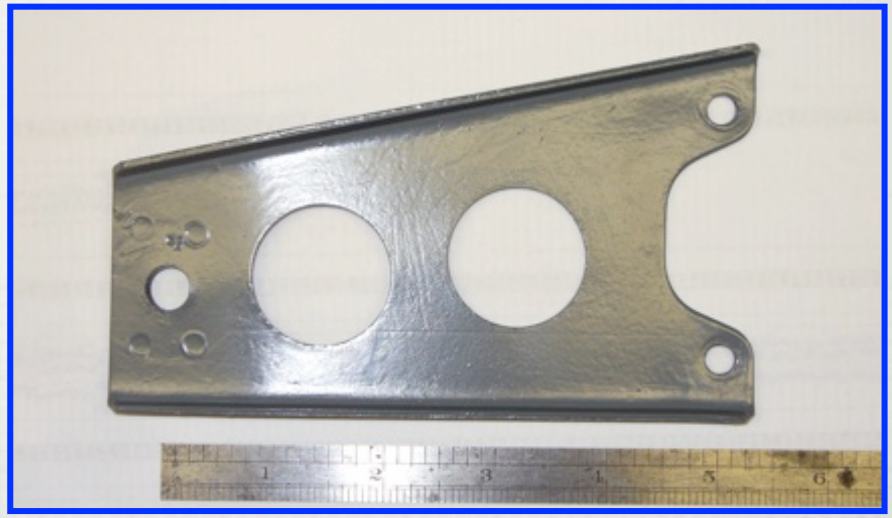
- I made a sketch of the bracket (shown) to try to understand what the cause might be.

- Fortunately, another longer bracket (next slide) was found that did fit.



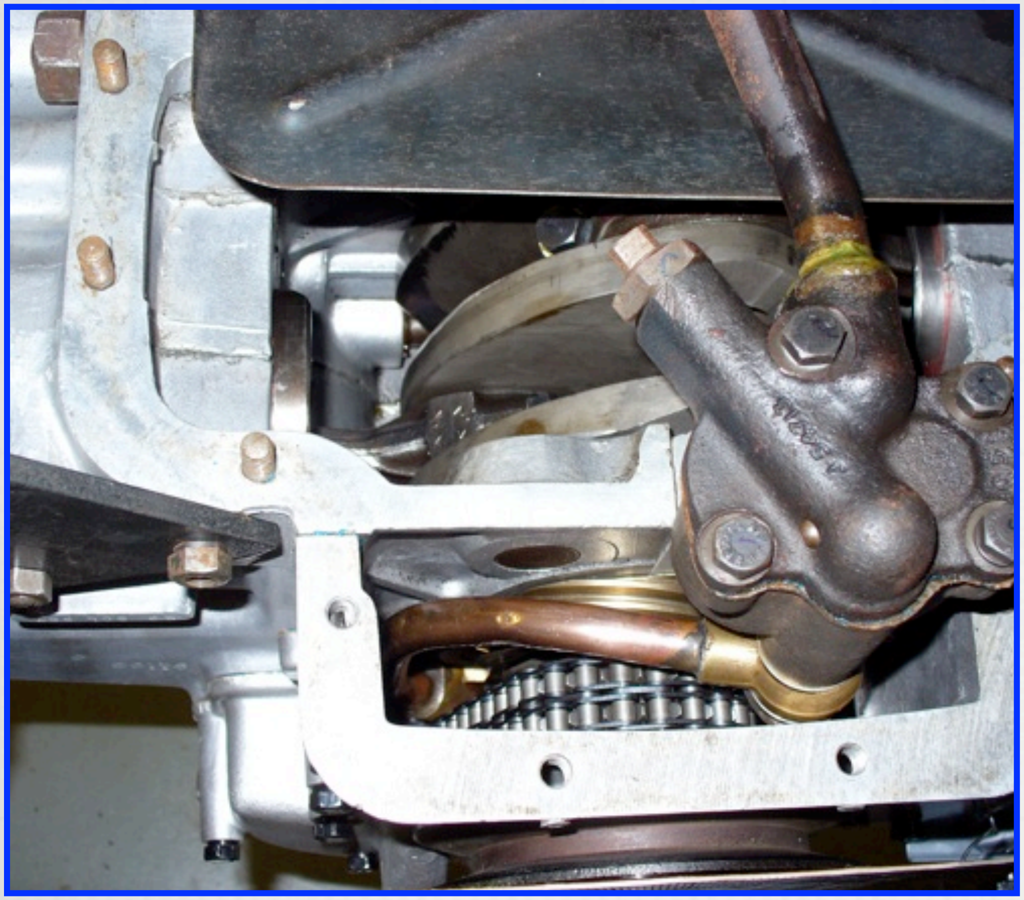






OIL COOLER SUPPORT BRACKET

- With the correct bracket to support the Bowman oil cooler, it makes a reasonably robust assembly from the up-and-down and side-to-side motion of the engine on its mounts. For the fore-and-aft accelerations that are peculiar to the flat-four layout (due to the out-of-balance couple), it is not so good.



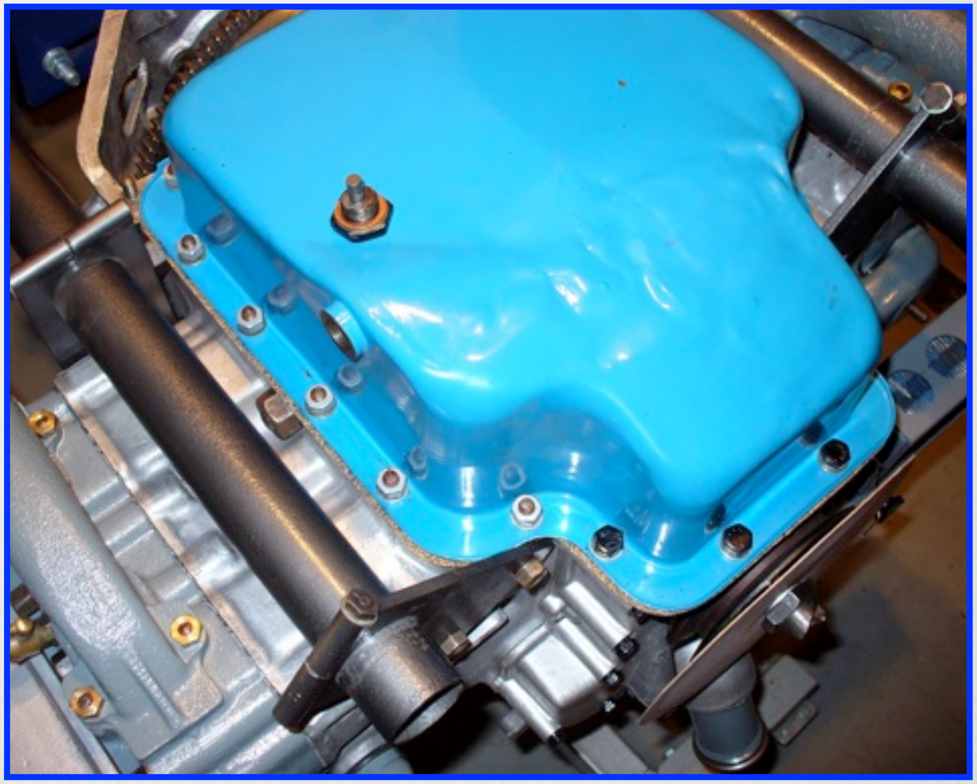
Before installing the oil pan, all bolts are checked for torque and then marked.

A new oil pan gasket was made from rubberized cork.

OIL PAN DRAIN PLUG MAGNET

- Adding a magnet to the sump drain plug is a prudent modification.

- Some of the oil pan/sump retaining studs are not blind and break through into the crankcase. Measures must be taken to prevent oil leaking past the threads.



OIL FILTER ELEMENT

- Good quality oil filter elements of the correct size for the Jowett engine are readily available from auto parts stores. This is the type 1300 from NAPA.

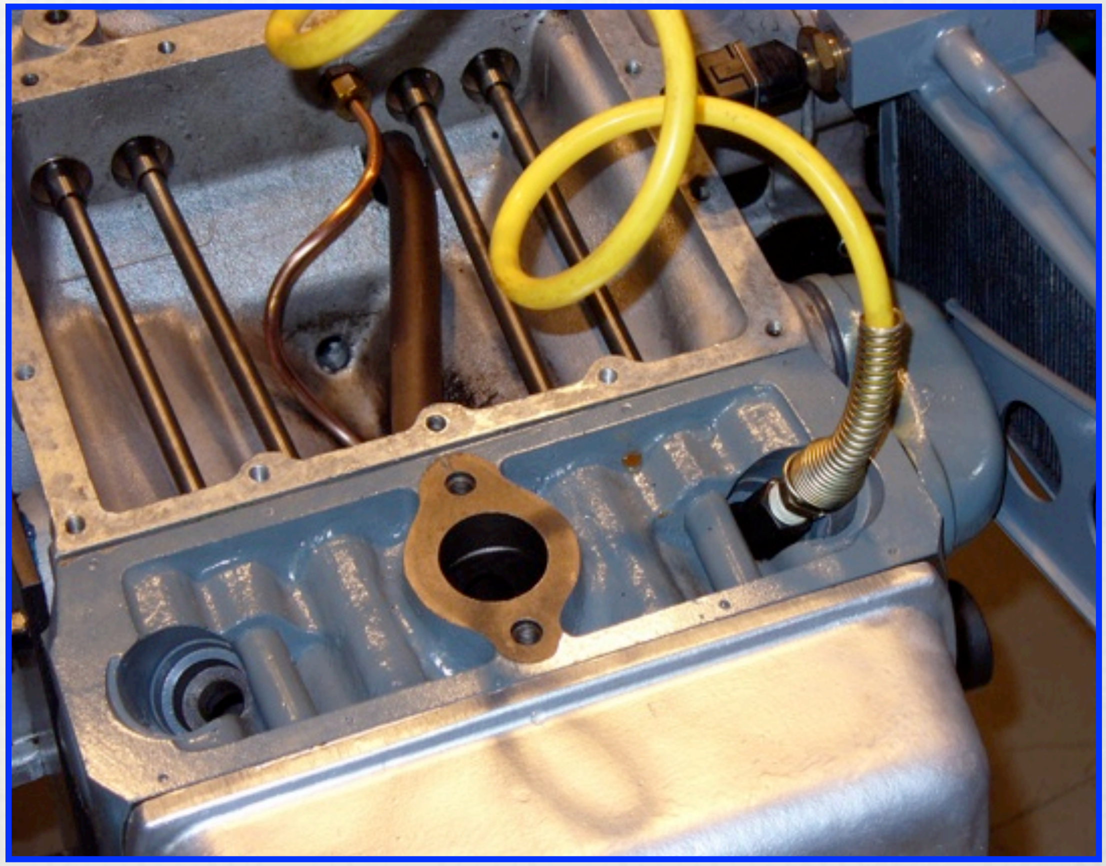
An adaptor for a spin-on filter was considered but eventually rejected. Modern engines have largely transitioned back to the replaceable element on ecological grounds.

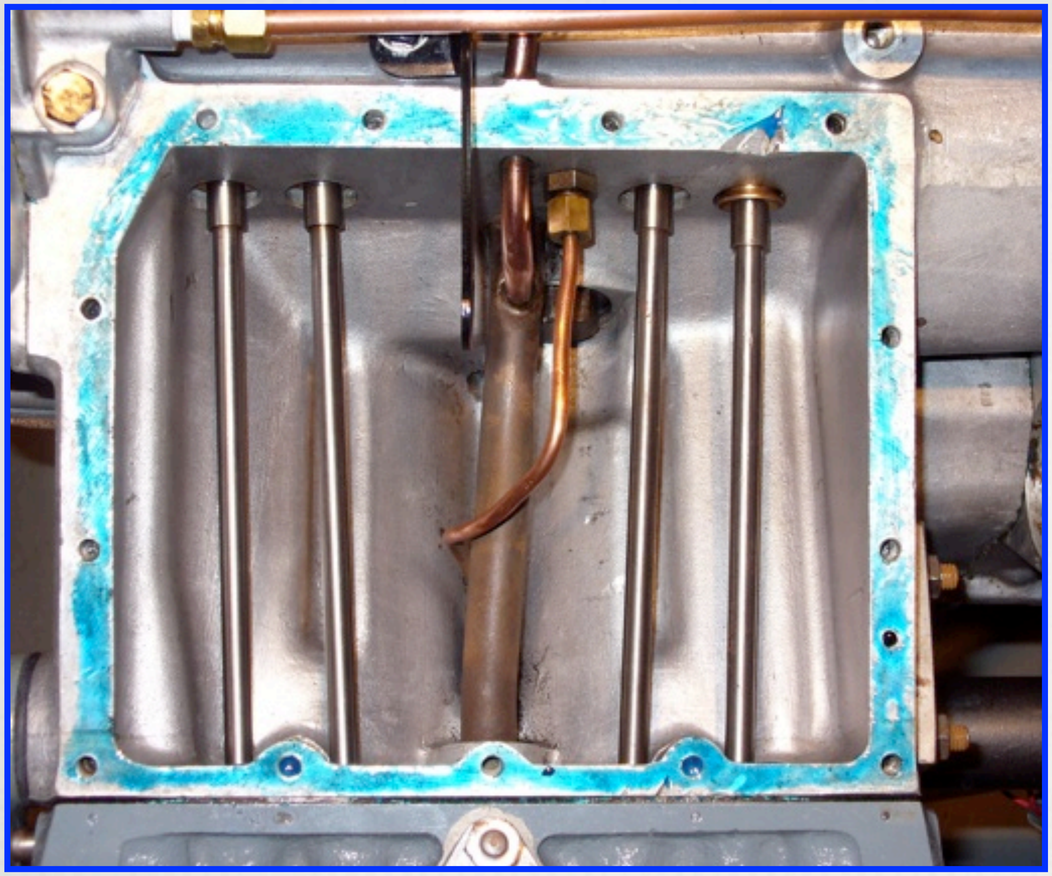
CYLINDER PRESSURE TEST

- I wanted to test the integrity of the cylinder by pressurizing it with compressed air. This checks that the valves, head gasket and piston rings are sealing.

- I used a simple adapter from NAPA Auto Parts.

- A running engine might see a cylinder pressure of 800 psi, while this test is at a mere 100 psi (7 bar).





New gaskets were made for the tappet covers, and new crankcase breather felts installed.

RECOMMENDED SPARK PLUG

- The original specification Champion L10 spark plugs have been superseded, so a modern replacement must be found.

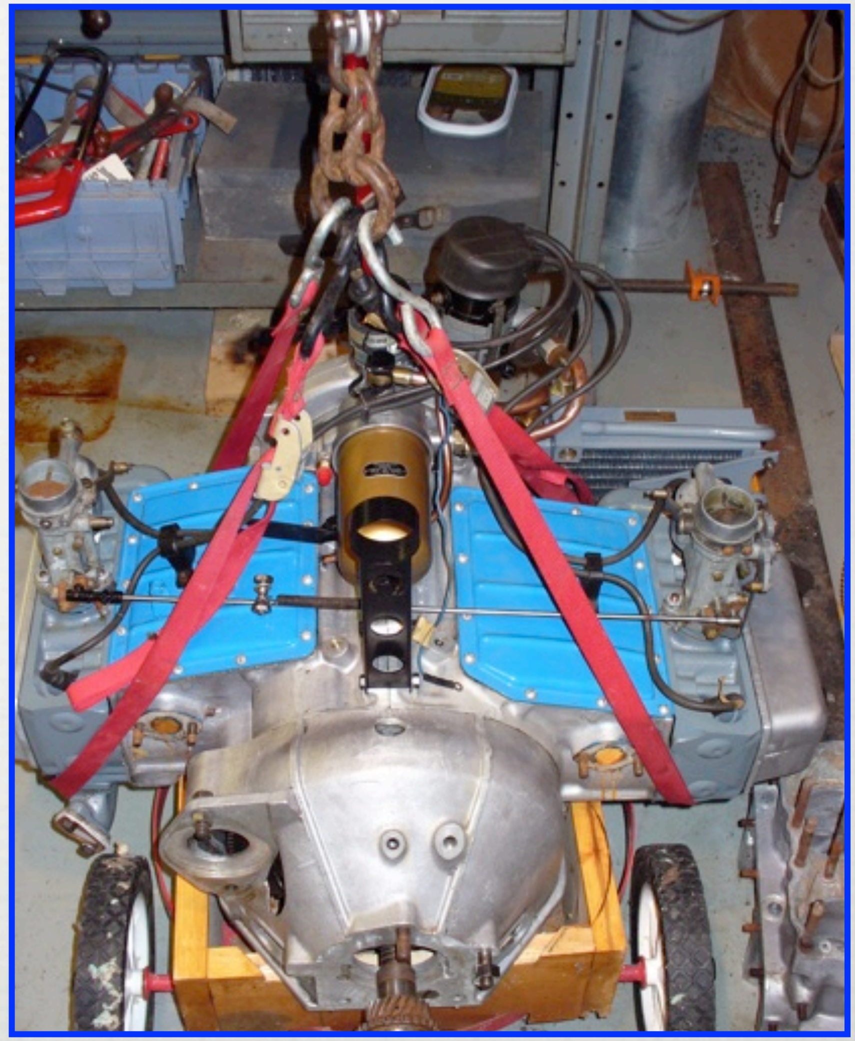
- Consultation with experts at www.sparkplug.com returned the recommendation that Champion **RL82C** is the closest modern replacement, suitable for normal driving, while the NGK **BPR6HIX** iridium tip plug is appropriate for performance motoring.

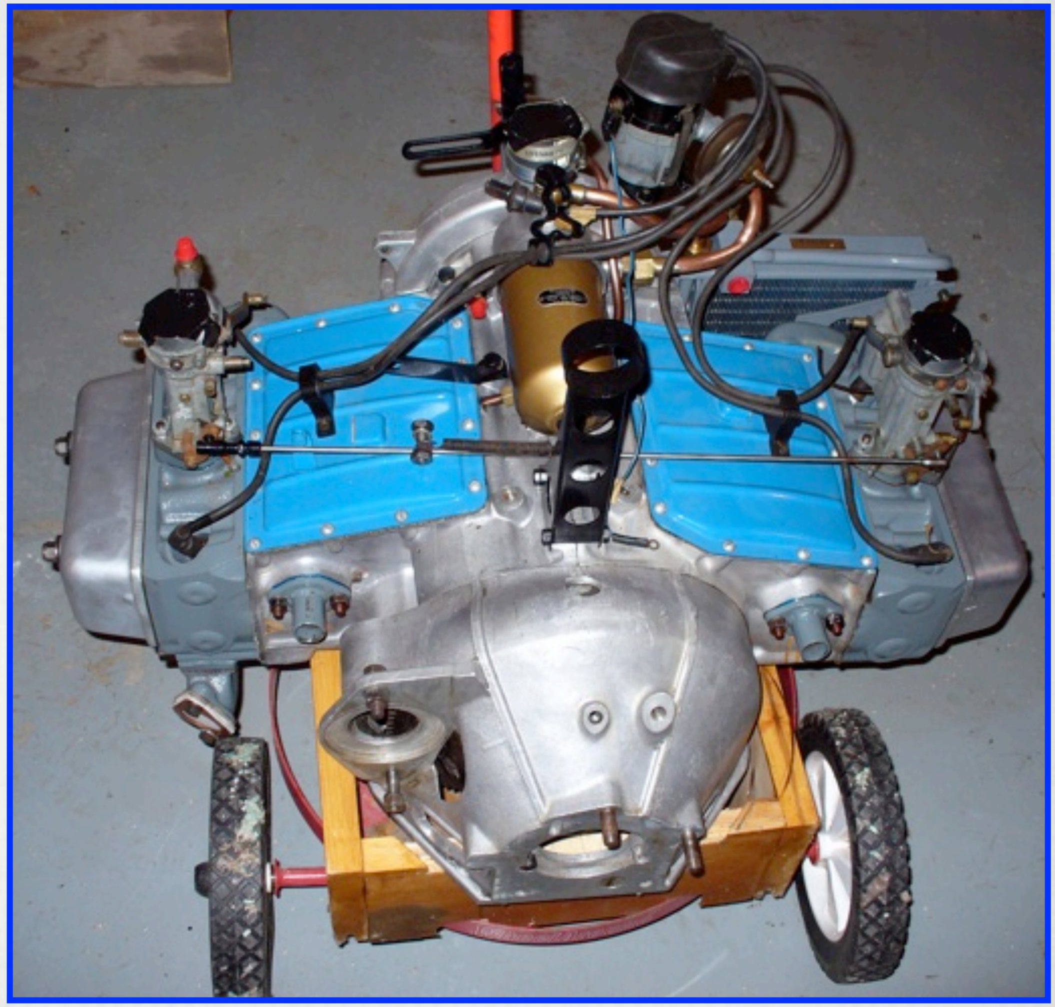
COOLING SYSTEM PRESSURE TEST

- Given the propensity for coolant leaks in odd places with the Jowett engine, it is prudent to perform a cooling system leak check on the assembled engine while it can still be readily worked on.
- I filled the system with water, made up an adapter to fit the pressure tester to the engine, and pressurized it to ~10 psi.
- It turns out, I did have a leak past the head gasket and up a head stud into the rocker box. It was resolved with a more careful application of lead wire under the offending head stud nut.

CAPTURING ENGINE WEIGHT

After hoisting the engine out of the stand, I lowered it onto a scale to record its weight. In not fully dressed (no starter, dynamo or water pump) state, it weighed 230 lb (103 kg).





I made up a wooden pallet to carry the engine, and made it to fit this handy three wheel cart.

READY FOR DELIVERY

Possibly the only two-engined Freelander?

ENGINE DELIVERED

- Here is the engine in the Cleavinger garage in front of his Jupiter. The gearbox to the right of the engine is unrelated to this car.

- From the factory, most painted items on the engine were stove-enameled black. The blue and grey painted items on this engine were provided by David and I think depended on what can of paint was open at the time!