Austin Seven Engine

Part 5 – Assembly

This is the last in a series of five A7 engine re-build articles to appear in the HA7C newsletter *Crankhandle*.

Previously …..

- Part 1 - Nov 2018 - The crankcase
- Part 2 – Jan 2019 – The crankshaft, main bearings, conrods and flywheel
- Part 3 – March 2019 - Cylinder block, pistons, head and valve gear
- Part 4 – May 2019 - Manifolds, carburettors, fan spindle and clutch

Please remember that these notes are definitely not an attempt to say *'this is what should be done'*, they are simply an account of what I do.

Engine assembly …

Numerous books and articles have been written telling us how to assemble an Austin Seven engine and the ones I have found most helpful are Woodrow's A7 Manual, Notes from a series of lectures by Jack French - Pages 126 et seq of the 750 Club's A7 Companion, some elements of Chapter 2 in Bill Williams book *'A7 Specials'* and pages 37 to 42 of the Practical Classics *'Austin Seven Briefing'*. The following notes are not intended to be a complete start-to-finish treatise on A7 engine assembly but rather a collection of points that I believe are important.

Assuming the crankcase and the front main bearings have been prepared as described in Parts 1 and 2 - we can start by fitting the crankshaft. The crank' is threaded through the rear main bearing aperture after the front of the crankcase has been thoroughly warmed-up, for which I use a hot air gun. With the crankcase sitting vertically on its bell-housing and the tail of the crankshaft supported in roughly its final position on a hardwood block, the front angular contact bearings can be carefully tapped into position (over the front of the crankshaft and into the front main bearing housing) with the faces marked 'thrust' facing one-another and all surfaces lightly oiled. If everything is spotlessly clean, the crankcase hot to the touch and things reasonably well-aligned - the bearings can now be coaxed into position using a brass drift and a medium weight hammer without the need for any heavy blows. If you are too heavy-handed, you risk damaging the retaining lip in the crankcase or the balls marking the races which could give the engine an irritating rumble from day one.

The bearings should carefully be driven fully home against the retaining lip – then, if you have used the correct bearings (and spacers if required), the outer front race will protrude a little above its housing. The bearing retaining plate can then be fixed in-position, together with its locking tab washers.

The front crankshaft timing gear is then slipped into position (boss first) taking care to ensure that the small woodruff key stays in position. A new tab washer follows and I find it useful to first bend-up the tab extremity a little with a pair of pliers. This doesn't affect the fitting of the 'starting' nut but greatly facilitates locking the tab when the time comes.

With the front bearing retaining plate secure and the starting dog nut firmly tightened (but the tab not yet locked), we have a seriously exciting moment. Because, by trying to waggle the free rear end of the crankshaft by hand, we will immediately discover whether the A/C bearings at the front of the engine (whether brand new or adjusted as described in Part 2) have the correct pre-load. There should be no detectable 'waggle'.

It is useful at this stage to temporarily pop the cylinder block into position to check that the big-end journals of the crankshaft align centrally with the cylinder bores. This will confirm whether the combination of crankcase, front A/C mains and spacers (if any) is correct.

Assuming everything is in-order at the front, we can direct our attention to the rear main bearing. It is essential that the inner race is a good fit on the crankshaft and that the bearing housing is not damaged or distorted. If the housing is warmed-up it will help us drive (or press) the outer race fully-home, this assembly can then be fitted into the back of the crankcase - sandwiching the thinner of the two gaskets (smeared with a thin coat of Blue Hylomar or similar) making sure the housing and gasket holes align correctly with the tapped holes in the crankcase. At this point we must also check that the oil drain hole is correctly aligned with the return drilling in the crankcase and free of any stray sealant. The inner race can now be drifted into position firmly against the rear flange of the crankshaft taking care that the rollers enter the outer race happily without tipping or binding. The oil thrower (with appropriate indents as described in Part 2) is now positioned with the dish side facing away from the engine. The oil retention plate follows and my preference is for one that contains a modern lip-seal as discussed in Part 2. This sits on the thicker of the two gaskets (again with a thin smear of sealant) and the whole lot then secured in position with the four shallow head set screws and locking tab washers. Shallow head screws are important, because normal size heads would foul the flywheel when fitted.

That completes the installation of the crankshaft except for locking the front timing pinion tab washer which will follow later.

Trial assembly

Our cylinder blocks have been around for over eighty years and may well have had their top surfaces skimmed at some stage – so, I believe it is vitally important to check the clearance above the pistons before continuing with final assembly.

This trial assembly obviously requires that the pistons be attached to their con-rods but there is no need at this stage to fit either the little-end bolts or piston rings and I use an old set of big-end bolts and nuts.

For two bearing A7 engines - if either the top face of the Cylinder block has been machined, or significant lapping has been carried-out on the top surface of the crankcase - then a trial assembly will reveal whether there is sufficient clearance over the pistons. This may not be critical if you plan to use an early low-compression head but essential if you aspire to a high compression top-end, such as a '1937 A7 head' or one of the proprietary (often aluminium) varieties. It seems that A7 engines when new had a clearance above the piston crown at TDC to the top surface of the block of around five to ten thou'. This, together with a good old fashioned Copper/Fibre head gasket of about fifty thou (compressed) thickness - would allow a standard Austin two-bearing crankshaft to rev to around 6,000 rpm (for a short while anyway) without pistons two and three hitting the head due to crankshaft whip. Unfortunately, some modern Copper/Asbestos head gaskets are as thin as thirty thou' so, the clearance over the pistons needs to be assessed and corrected to between five and ten thou' if necessary. This is most easily achieved by adding an aluminium shim plate of appropriate thickness between the block and the crankcase. These shim plates are available in various thicknesses of typically 10 and 20 thou'. Incidentally, they may appear to be a regular pattern that can be fitted either way up - but one I used recently was a much closer match to the top of the crankcase one-way rather than when flipped over. Definitely worth checking.

Another option for increasing the clearance above your pistons, is to machine a small amount off the piston crowns. Whilst this might be perfectly feasible for earlier type pistons - it is inadvisable in my view for modern slipper pistons, because they have only a very shallow land over the top ring. Anyway, the whole idea of machining pistons and then making sure they are exactly identical in weight has never really appealed to me.

Happily, crankshaft whip is believed to be less of a problem with modern replacements, so the proud owners of these desirable items can perhaps get away with a lower clearance than suggested above.

One other influence here is whether or not a gasket is used between block and crankcase and if so, what type. Well, for years I used the traditional paper gasket typically having a compressed thickness of only a few thou', assembled with a thin smear of Blue Hylomar on each surface and that was generally fine. However, I now take great care to ensure the mating surfaces of the block and crankcase are both beautifully flat and carefully de-greased, then, using only a thin smear of Hylomar, has proved very successful, with no oil leaks and the block holding-down nuts staying tight. Of course, if you are introducing a shim plate, you will need to apply sealant to both sides. I did assemble one engine with a silicone gasket and whilst it certainly remained oil-tight - I noticed that the holding-down nuts regularly needed to be tightened. It seemed the silicone was gradually migrating under load despite having been assembled dry on de-greased surfaces as-per the instructions. The problem, was that the tightening affected the tappet clearances which consequently needed adjustment.

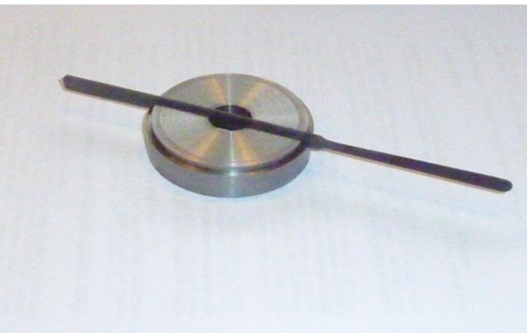
As mentioned in Part 3, the theory of fluid dynamics suggests that the movement of gasses into and out of the engine will be improved if the sharp edge of the block leading into the bore is slightly rounded. The key limitation is of course the position of the top of the upper compression ring at TDC and this can usefully be determined during our trial assembly. I then allow say an extra 20 thou' to be safe. The width of any chamfer or rounding should obviously be limited to correspond with the head gasket dimensions and all four chamfers should be identical. Please note that modern slipper pistons offer limited scope for this modification because, as mentioned earlier, they have a shallower land above the top ring than most 'full skirt' pistons.

Having made sure that our pistons won't collide with the head and created any required chamfers – we can now get-on and complete the engine.

Final assembly

Piston ring gaps

Opinions differ on appropriate ring gaps for A7 engines, varying from three to seven thou' but my preference is for something at the lower end of this range. I have found three or four thou' to be entirely satisfactory even in sporty road engines so long as the gap is consistent at the extremes of piston travel. However, if in doubt, you can always follow the manufacturers advice.



Piston ring filing jig

New piston rings are normally supplied to fit the bore size with virtually zero clearance, so, we usually need to file away a small amount of material to obtain the desired gap. I do this using the simple jig shown in the photo that has an accurately cut, centrally located vertical groove which is a snug fit to a thin flat 'Swiss' file. The ring is held on the jig by hand and squeezed to close the gap gently against the file. Proceed carefully with the filing, because rings are fragile and it's very easy to remove more material than intended.

Ring gaps are conveniently assessed by supporting the ring on an old piston to ensure it sits exactly square to the bore - then removing the piston and measuring the gap with feeler gauges. The gap is measured at both positions of interest and the measurements should be virtually identical.

There are two fundamentally different approaches to assembling A7 engines. The conventional method described in many books is to fit the piston & conrod assemblies in the block with the oil baffles in-place on the rods, then bring the block and crankcase together on the gasket if using one. However, I find this a right fiddle and very much favour ensuring that the conrod part of the big-ends can pass down the cylinder bores, which makes things much more straightforward.

Con-rods & pistons

Pistons can now be fitted to the con-rods remembering that it is essential the gudgeon pins are a firm sliding fit in the little-ends whilst not binding at all in the pistons. The grooves in the pins must be carefully aligned to admit the little-end screws and this can usually be achieved by hand, although Woodrow shows a suggested tool that can sometimes help. I always use new HT little-end screws with internal shake-proof washers together with a medium strength Loctite on degreased threads but care must be taken to prevent any Loctite from finding its way onto the gudgeon pin.

Spanner face ground flat

Little-end screws often have fairly shallow (often slightly domed) hexagon heads and must be very firmly tightened. This is greatly facilitated by using 'buttons' such as those described in Woodrow to hold the pistons in the vice and I use a high quality combination spanner with one face ground flat (see photo) to maximise engagement with the hexagon head of the screw. Interestingly, there is much better access to the little end screw with 'slipper' type pistons.

Bill Williams is one of the few sources of information that tells us that the little-end bolt heads should face towards the off-side of the engine although this might be Longbridge tradition rather than cunning design. Also, if you are using split-skirt pistons, the split should face towards the camshaft (near-side), but this is more obvious from first principles.

The piston rings can now be fitted to the pistons and most suppliers provide us with clear instructions. However, this is not always the case with some products from the far-east. For example, a recent set of slipper pistons with one oil control, one (dark finish) scraper and one (shiny) compression ring were supplied without any instructions. The rings were helpfully marked to show which surface faced 'top' but the two top rings shared identical dimensions and it was unclear which went where. It turns-out that the shiny one was the compression ring and should be fitted in the top groove.

Fitting rings is a straightforward process but care is needed to avoid scratching the piston lands and sliding the rings over thin brass shimstock can help. Interestingly, modern pistons with narrow rings (thus lower contact areas) are designed to give lower bore contact pressures than their conventional counterparts. This has the obvious advantage of reducing friction and happily, makes them a little easier to fit.

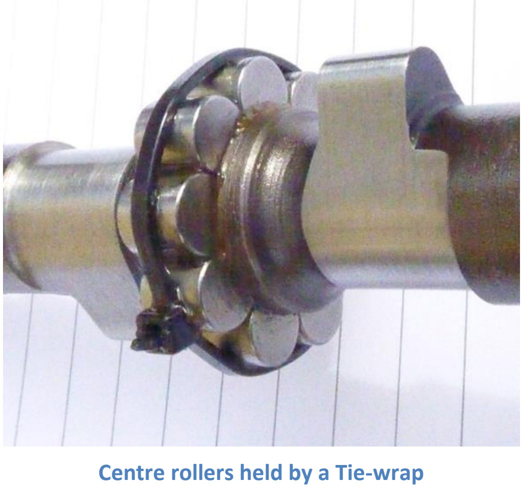
Camshaft

If your timing gears have enjoyed a happy former life in the crankcase you plan to use, we can skip the next step. Otherwise, it will be necessary to select a pair of suitable gears. If you are lucky, there will be an original Austin dimension stamped at the top front of the crankcase that indicates the departure from standard of the dimension between the camshaft and crankshaft bore centrelines. You will be even luckier if you can find a pair of timing gears that correspond, also, unhelpfully, some gears are unmarked. In this case it will be necessary to mix and match from a collection of spares from your own and your friends spares, avoiding badly worn specimens if possible and obtain satisfactory meshing by trial and error.

Good meshing is achieved when the camshaft gear can be rotated 360 deg' without any tight-spots and there is a reasonably consistent backlash (the clearance between teeth) of two or three thou. Incidentally, the gears on my spare engine have close to six thou' clearance and work perfectly well, but are admittedly a little noisy.

We must now set the longitudinal clearance of the front camshaft bearing. This is achieved on the bench by bolting the cam' pinion in place and measuring the clearance with a feeler gauge. We are aiming for a clearance very close to two thou'. This is important, because a larger clearance will almost certainly cause the engine to emit a rumble. It is easy to reduce this clearance by rotating the camshaft gear on its taper with a little fine grinding paste, then scrupulously cleaning everything and trying again. If however there is insufficient clearance, a very small amount can be removed from the back face of the gear in the lathe.

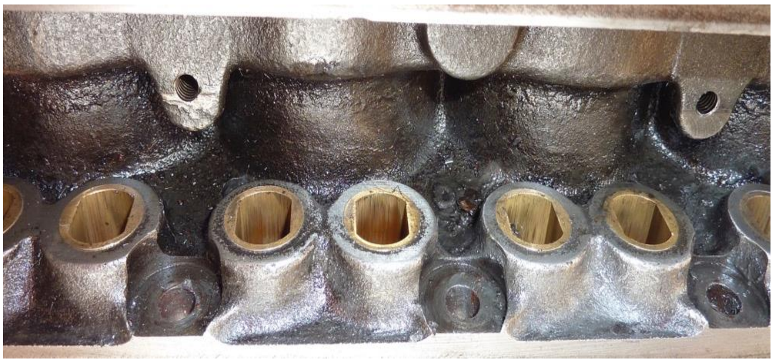
If the rear camshaft bearing has been removed for inspection and cleaning, it should now be refitted into the back of the crankcase on a thin gasket with a touch of sealant taking care that the lubrication hole lines-up correctly with the horizontal oil feed gallery.



Centre rollers held by a Tie-wrap

It is now time to install the camshaft and for years I used to simply stick the centre camshaft rollers in-place with Heavy Grease and that worked really well. However, I cannot find a supplier nowadays and typical general purpose grease is too feeble. So, I use a small Tie-wrap to hold the rollers in-place as can be seen in the photo.

Incidentally, the above photo clearly shows that this particular camshaft has had the base circles ground to give nearly 70 thou' of additional lift (actually a Pigsty Trials cam) and because the smaller base circles allow the tappet blocks to drop a bit lower, there is a risk that the adjusters might clash with the tops of the tappet guides. Therefore it is a good idea to mill some material from the tops of the guides as shown in the photo on the right if using a high-lift camshaft.



Machined tappet guides

Camshaft assembly ready for insertion

Once the assembly is ready as shown, it can carefully be inserted into the crankcase taking care not to dislodge the centre bearing rollers. The rear bearing spigot should be lubricated and the 5/16" BSF threaded hole in the front bearing carefully aligned with the corresponding hole in the crankcase. Then, the whole assembly is pushed firmly into position whilst rotating the shaft to help the centre rollers enter the outer race. As this happens, the tie-wrap holding the rollers will be pushed clear and can be snipped off.

Finally, the securing setscrew (as described in Part 1) is tightened onto a fibre washer (or even better a Dowty washer) to ensure the camshaft is firmly held in position and there are no oil leaks.

We must now check with a straight-edge that the two timing gears are in-line with one-another. Any necessary correction can be achieved either by adding shims or machining a small amount from the rear boss of the crankshaft pinion. When correct alignment has been achieved, the crankshaft 'starting' nut can be very firmly tightened and its tab washer locked.

Fitting block to crankcase

If the crankcase has been prepared as discussed in Part 1, we can now attach the block - but first, I use a thin 'Dremel' type cutting disc to make four cuts in each oil baffle and bend open the 'wings' just enough to let the big-end pass through. These opened baffles are then placed in the top of the crankcase with the small nibs sitting neatly in the crankcase recesses to ensure they are correctly positioned. The top of the crankcase and the bottom of the block are de-greased and a thin layer of sealant (again, I use 'Blue Hylomar') applied to the outer contact areas of both items. After a few minutes wait, the block is placed in-position and secured by firmly tightening the eight 5/16" nuts on new locking washers. I then attach my extra 'holding-down' brackets at the front and rear of the block as described in Part 3.

Before fitting the pistons in the block, the rings should be rotated in their grooves to position the gaps approximately 180 deg to the gaps in adjacent rings. This helps to maximise compression by presenting the most difficult route for any gasses escaping past the pistons.

'Real' engine builders use proprietary piston ring clamps but mine was cut from an old tin can many years ago (see photo)

Improvised piston ring clamp

and with everything liberally lubricated and a firm grip - it works a treat. It is obviously important not force the piston & ring assemblies into the bores because you might break a ring but if the rings are correctly gapped and firmly clamped, they will happily slide into position.

As each piston/rod assembly is inserted into the block, I attach its (well lubricated) big-end to the crankshaft using new bolts and new deep self-locking nuts (it's difficult to fit a socket on the shallow ones), having carefully noted the position of the rod orientation markings. The big-end nuts should next be torqued-up to 18 lb.ft, followed by a quick check that everything rotates smoothly. Finally, the 'wings' of the oil baffles can be closed whilst ensuring they remain clear of the rods.

I believe it is very important that the cams are properly lubricated before first starting a new engine so, I coat mine at this stage with EP 140 (back axle) oil.

Sump etc
I like to use a semi-deep aluminium sump because it gives useful additional capacity and also stiffens the engine. However, this requires a simple modification to the oil pump bottom plate. The one shown here has a lengthened pick-up pipe 'silver soldered' in position. Incidentally, very deep sumps are available but they make life rather difficult if you try to install or remove the engine with the sump attached.

The sump gauze and sump can now be fitted and this will enable the engine to sit more comfortably on the bench.

lengthened oil pump pick-up

Flywheel & clutch
Run-out has previously been checked and adjusted, so, assemble the flywheel with its woodruff key in position on tapers that are dry and clean. Check the flywheel nut has a good thread and tidy flats - but replace with new if in doubt – then, with a new locking tab in position apply a thin film of medium strength thread-lock and tighten the nut *very, very* firmly. Preventing the crankshaft from turning is probably most safely achieved by placing a good sized softwood block inside a strong area of the crankcase. I have read that a drift poking out of the flywheel rim and resting on the top edge of the crankcase can be used to lock the crankshaft. However, I have seen broken crankcases that look as if they have suffered from this method and several others sporting cracks hereabouts, all of which seems to suggest that this is probably not a great approach!

Clutch assembly and the insertion of the 'mousetrap' springs is very straightforward if you have three nice long ¼" BSF bolts with nuts and washers. A clutch plate alignment bar is also essential, I made mine in about ten minutes from a mild steel bar many years ago and the dimensions can be found on page A5-11 of Woodrow.

Valves & springs etc
Assembling A7 valve gear is well described in numerous books so I will not repeat it here. However, there are one or two points perhaps worth mentioning …..

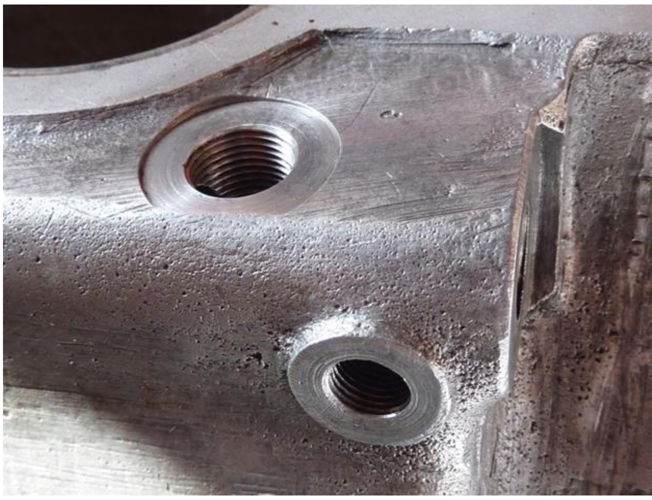
- I always use valves that are retained by cotters rather than pins
- Double valve springs (if used) should be accompanied by appropriate cotter retainers
- I 'flick' the bottoms of assembled valves with a screwdriver to make sure the cotters are fully seated before checking clearances
- I set tappet clearances at 4 thou' for both inlet and exhaust when using a standard A7 camshaft and this makes for a nice quiet engine. Interestingly, Woodrow reckons 6 thou' inlet and 7 thou' exhaust. For sporty high lift camshafts, I use 6 thou' inlet and 8 thou' exhaust although this makes the engine quite noisy at tick-over
- When adjusting tappet clearances I use the *'sum of nine'* method. For example, adjust one when eight is open, two when seven is open etc etc. Or you can simply adjust the inlet and exhaust tappets when the piston of that cylinder is at TDC on the compression stroke

Cylinder head

I carefully tighten cylinder head nuts (over flat washers) incrementally in the recommended sequence to 18 lb.ft and find this perfectly adequate. I have seen 22 lb.ft or more suggested and I believe this figure is too high and maybe the cause of cracks in the block around the centre stud (mentioned in Part 3 of these notes). Blocks with re-lined bores are particularly vulnerable.

External oil filter
I described a full-flow external cannister type oil filter in Part 1 and the photo on the left here shows how it is connected to the engine. My spare engine also has an external oil filter but its return connection was drilled and tapped (with some difficulty) into the top of the main gallery just behind the dynamo as shown in the photo on the right. The new approach is less tidy but definitely much easier.

Full flow oil filter - return connection



Return tapping on previous engine

Finally, it is important that dynamo bearings are in good condition and there should be no discernible end-float. We can now set the engine timing. I do this by removing the spark plug from No 1 cylinder and rotate the engine (using the starting handle or by pushing the car forward in top gear) with my thumb over the plug hole. It is then easy to detect the compression stroke and set the distributor so that the points are about to open with the rotor arm pointing in the direction of the No 1 HT plug lead. Thus set - the engine will invariably fire-up and run, then when warm, I rotate the distributor anti-clockwise (viewed from above) to advance the engine until it sounds very slightly rough, then back-off a little. Someone once said “start with it very slightly advanced then retard it bit at a time until your lap times increase”!

Well, that’s about it and I hope the reader has found these ramblings to be of some interest.

……….. Spanner