Austin Seven Engine

This is the first in a series of articles describing my approach to building what I always hope will be a robust and reliable A7 engine. Put simply, this means an engine that after careful assembly and a period of sympathetic running-in - would be expected, with proper maintenance, to confidently undertake long-distance (several thousand mile) outings, achieve close to forty mpg, not use (or leak) much oil and not let me down. If a modern crankshaft is fitted, the engine should also be happy to rev to around 6,000 rpm on occasions without falling apart.

So, why am I writing this? Good question but I have built about fifteen A7 engines in my time and happily, most have proved robust and reliable, despite frequently being driven quite hard. The one notable exception was an engine I hurriedly put-together about forty years ago in which a gudgeon-pin clamp bolt either came loose or wasn't properly tightened. I don't think I knew about Loctite at the time and was probably using a collection of elderly ill-fitting open-ended spanners. The gudgeon pin wandered around in the little-end and wore an impressive vertical groove in the cylinder wall. The result was a ruined block and a smoke cloud that would have rivalled the Bunsfield industrial chemical plant fire in 2005.

One I prepared earlier!

Whilst I have been asked to put pen to paper on this subject - I am acutely aware that several members of the Hereford Club have vastly more A7 engine building experience than me. So, I will try to explain *why* I adopt my particular approach as we go along - but if you disagree in any way or do not understand my reasoning, then please make contact so that we can discuss the issue. We might then publish an agreed consensus in *Crankhandle* - that way, we can all improve our knowledge.

So, please bear-in-mind that my scribbles are in no-way intended to suggest *'this is how it should be done'* – I am simply providing an account of what I do, which so-far (touch wood) seems to be reasonably effective.

Incidentally, this series of articles is aimed specifically at two-bearing A7 coil ignition engines, typically found in Sevens from 1928 to 1936. Although of course, many aspects of engine building are common to both two or three bearing configurations and even the earlier magneto variety.

I have tried to cover all aspects of a complete re-build but clearly, readers can 'pick and mix' to suit their particular requirements or interests.

There is plenty of available information on dismantling engines that I won't repeat here (Woodrow is particularly good, also the 750 Club 'Companion' pages 107 et seq.) and will therefore assume we are starting with a completely stripped and cleaned set of engine components.

Part 1 – The crankcase

Introduction

Two bearing A7 coil ignition engines enjoyed three different crankcase configurations. The first two were for the high frame chassis and had solid engine mountings. The earliest having its starter motor facing forwards i.e. alongside the gearbox in the passenger compartment (sometimes confusingly referred-to as facing backwards) with the starter ring gear on the clutch cover plate. This was followed by the starter motor facing backwards and located in the engine compartment. Finally, a flexibly mounted crankcase with bigger feet was fitted to the low frame chassis cars that retained the backwards facing starter. The following notes apply to all three versions.

Studs

In order to build a reliable, oil-tight engine, it is first necessary to remove all studs – i.e. those locating the bellhousing, block and fuel pump. These can usually be removed by very firmly tightening together, two full steel nuts (not the ghastly modern countersunk ones) on the protruding thread and lean hard on the lower nut with a well-fitting ring or combination spanner repeatedly until it 'gives'. If this fails, then try applying heat (a hot air gun works well) to the surrounding aluminium. On the odd occasion this doesn't work either, it will necessary to use a stud extractor but this will almost certainly damage the stud, thus precluding its future use.

It is unlikely that studs will break when being removed from aluminium but not uncommon when being removed from cast iron. I will discuss the removal of broken studs in Part 3 – 'The cylinder block' and head.

Studs should then be cleaned (a rotary wire brush is ideal) and inspected because only those with perfect threads should be re-used. Damaged studs should be discarded and replaced.

All threaded stud and bolt holes in mating surfaces should be lightly countersunk to prevent the aluminium 'pulling-up' when tightened, thus preventing a good seal. Also, all crankcase threads should be gently cleaned with the appropriate BSW or BSF tap, taking care to remove only dirt/sealant and not any aluminium. Then, nosepiece, sump, fuel pump and front bearing housing mating surfaces should be carefully dressed with a file to remove any damage. Also the bell housing face but this is less critical.

Any damaged threads will need to be repaired. I am not aware of any data that compare the pull-out strength and costs of the following different methods but I like to think that my favoured approach might compare well.

The quickest way to repair a damaged thread is undoubtedly the coil insert process ('Helicoil', 'V-coil' or similar) – but this requires a specific kit for each thread type and diameter. Each kit includes an appropriate drill and tap, together with an insert tool, a number of coil inserts and a tang breaker. The process is quick and straightforward – the damaged thread is drilled-out, the new hole tapped and then the coil insert is wound-in maintaining slight downward pressure and a clockwise motion with the tool provided until it is just below the mating surface. Finally, the 'lead tag' of the coil is broken-off with the punch and the wire fragment removed. Interestingly, coil repairs are claimed to be stronger than the original configuration but it is useful to remember that they can sometimes be less oil-tight than their conventional counterparts.

An alternative approach for repairing threads that take a stud, is to buy (or make) a stepped stud with a larger thread at one end. The crankcase being drilled and tapped oversize to suit. A possible extension of this approach would simply be the deployment of a larger diameter stud. However, this might entail drilling a larger clearance hole in the mating component which obviously has the potential to weaken it.

Another approach and the one I usually adopt, is to drill-out and tap the damaged thread to a size larger than would be used for a stepped stud, then turn-up a bush that externally matches this newly threaded larger hole and is threaded internally as per the original. This bush can be made in aluminium but I prefer to use steel or brass to make it more robust (steel is cheaper but brass is easier to machine – so, '*you pays your money and you takes etc etc*'). The bush is secured in position using a high-strength industrial adhesive such as Loctite 648, then carefully filed exactly flush with the surrounding surface. This approach takes a little longer but it's cheap and has never given me any problems.

Carefully lapped flat top surface

Next, the top surface of the crankcase needs to be made perfectly flat if you want to keep your oil *inside* the engine. I do this by lapping; starting with coarse (then finishing with fine) grinding paste mixed with a little diesel or paraffin. Interestingly, the well-known Chris Gould writes on this very subject in the October 2018 A7OC magazine and he advocates a totally different approach.

Anyway, whilst lapping, the crankcase should be held firmly in contact with the plate and moved in a figure of eight motion. This is very important, because circular or fore/aft movements will tend to leave a high area in the middle. I use an offcut of granite kitchen work-top about two feet square for lapping but a sheet of plate glass would also suffice. Some people remove the tappet guides and lap the crankcase directly to the block but I have always found the underside of A7 blocks to be reasonably flat. In addition, it can sometimes be difficult to accurately replace the guides so-that the tappet blocks sit exactly square to the camshaft. Incidentally, nearly all the A7 crankcases I've worked-on, have had noticeably distorted top surfaces, no-surprise then that so many engines leak oil between block and crankcase. Some engine builders say that the top surface of the crankcase is sufficiently flat when a two thou' feeler gauge is rejected under a straight-edge. However, I simply continue lapping until there is an even matt finish over the entire block mating area.

Oil galleries

If modern multi-grade oil is known to have been used in the engine, you might skip this step. Otherwise, it is essential to thoroughly clean-out all the galleries before using modern and arguably superior oils. This means removing the hex' plugs at each end of the main oil gallery and the one covering the cross-drilling to the front camshaft bearing. The oil pressure relief valve - ball, spring and cover plug should be removed together with the two threaded plugs located at the bottom of the two vertical oil galleries at the back of the engine. To remove these, it is necessary to clear the screwdriver slots of the peened aluminium that prevents them from unscrewing in service. This can be achieved by driving a properly ground screwdriver along the slot in each direction to clear the peened material, then holding a well-fitting screwdriver firmly into the slot these plugs will usually unscrew without much trouble.

All the oil passages must be thoroughly cleaned and I use a number of model traction engine brass wire flue brushes for this purpose (every home should have these!) together with liberal doses of a petrol/diesel mix. It is amazing how much crud can usually be extracted.

Front main bearing lip

Sadly, many crankcases have damaged front main bearing lips. Often the result of the bearings being previously removed by ham-fisted 'mechanics' or occasionally perhaps by poor brakes leading to a frontal impact on the starting handle?

Happily, there is no great load on this front lip in normal service, therefore some slight damage is acceptable so long as the remainder of the lip is not cracked. Nevertheless, it is not difficult or expensive to replace a damaged lip – just a few hours of rather rewarding work – as follows …

Some years ago I made a very simple device (see photos) to machine-away a damaged aluminium lip. It is hand operated and typically takes about forty minutes of healthy exercise to provide a suitable surface upon which to screw a steel lip replacement ring.

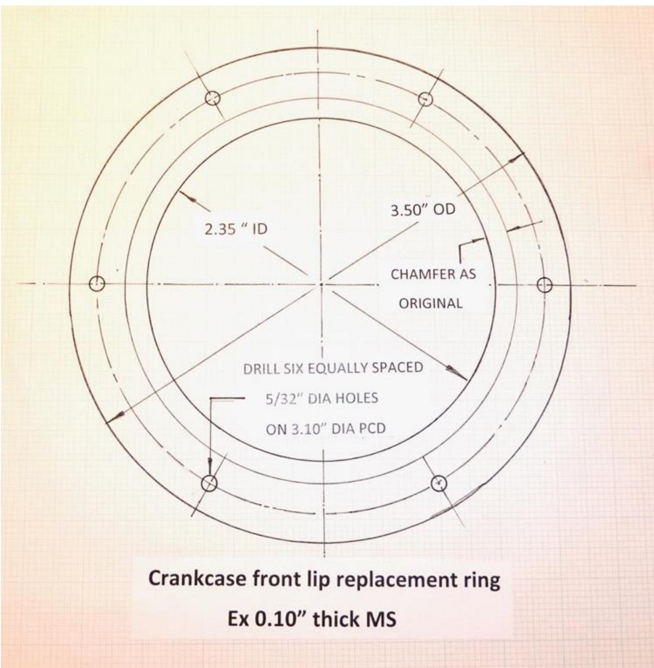
Flange removal tool

Flange being removed

Flange removed

Several of our well-known suppliers stock reasonably priced ready cut replacement steel rings but the ones I have seen appear much too thick (at about 5/32") which in my view are likely to give insufficient clearance to the front of the crankshaft.

I simply mark-out and cut a 3.5" diameter. disk from 0.10" thick mild steel to the dimensions shown in the diagram and initially drill six 2BA tapping holes equally spaced on a 3.10" PCD. The outer edge (which is not critical, unless you plan to show photos to your friends!) is roughly sawn then filed almost to size and the inner hole created by drilling a row of holes in increasing sizes – inside the marked line to remove the inner portion, which is then filed close to the finished circle dimension. I then trim the inner and outer edges in the lathe, exactly to size and create a slight chamfer on the inside that exactly replicates the geometry of the original



Crankcase front lip replacement ring
Ex 0.10" thick MS

Austin flange. If you get stuck-in, this will take less than an hour and is quite satisfying.

To secure this new plate, some people advocate drilling through from the front main bearing retaining plate holes and using ¼" diameter countersunk through bolts. However, once the original flange has been removed, there seems to be precious little radial width in the remaining aluminium boss and even less surrounding the ¼" Dia clearance holes in the new plate which might weaken it. I therefore use six 2BA by 5/8" long steel countersunk set-screws put-in with high strength Loctite. I have done this on several engines and never had any problems.

Replacement steel ring

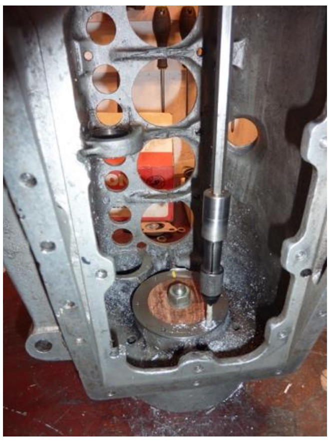
Jig to ensure ring is concentric

Ring in position on jig

The above photos show the turned hardwood jig that I use to hold the ring concentric with the bearing housing whilst drilling for the screws. I rotate the ring on the jig until none of the six holes correspond with the four front bearing retaining plate drillings, then drill one hole 2BA tapping (5/32" Dia is OK but a No 24 drill will give much higher engagement) to a depth of about 1" into the crankcase. It is also useful to mark the top of the ring, just-in-case the six holes do not lie on a precise regular hexagon.

This first hole in the plate is then opened-up to 2 BA clearance (3/16" Dia), the crankcase hole then tapped 2 BA and a temporary screw tightened gently in position to hold the ring in place whilst still supported by the jig. The same operation is then repeated for the opposite hole which then holds the ring exactly in-place before dispensing with the jig and dealing with the four remaining holes.

Drill / tap extension bar



Finally, the holes in the ring are countersunk to ensure the screw heads lie perfectly flush when tightened and the ring secured with high-strength Loctite (e.g. Type 648) on the threads. Job done!

Replacement ring in position

Replacement ring seen from front

Camshaft bearings

The front camshaft bearing is often found to be poorly located by an ill-fitting original Austin square headed bolt/peg and this can potentially cause two problems. The first is that the bearing is not held firmly in position by the peg, so the whole camshaft assembly can move to and fro longitudinally on the axis of the camshaft as the intermittent valve loads are applied and relaxed by the helically cut camshaft pinion. This movement can be the source of an unwelcome rumble from the engine. The second problem is that oil is likely to leak past the square headed bolt/peg.

There are numerous articles suggesting how to improve the location of the front camshaft bearing. Most are based on drilling a tapping size hole (7 mm dia is fine) into the bronze bearing exactly on the line of the former peg then tapping it 5/16" BSF. Finally, turn-up and insert a replacement screw with a shoulder to seal with a fibre washer against the top surface of the crankcase. The shoulder on the screw in the photo was silver 'soldered' in position but welding would be OK but not quite so neat – well, my welding wouldn't be! Clearly, it is important to check that the new screw reaches securely into the bearing but not so far as to foul the camshaft journal when tightened.

Replacement camshaft locating screw

The photo shows a locating screw I made from a hexagon set screw which has the advantage of being accessible for tightening if necessary, without removing the block - unlike Sir Herbert's original square headed offering.

The A7 front and rear camshaft bearings are sometimes thought to be the source of some undesirable internal oil loss. This is partly due to the fit of these bearings in the crankcase but perhaps exacerbated by the generous 5/16” diameter drillings that feed them - the front, horizontally from the main gallery and the rear vertically above the oil pump.

Front cam bearing ready for installation

In the interest of preserving as much pressure as possible for squirting oil towards the all-important big ends, it is quite easy to overcome the above. Firstly, two ‘O’ ring grooves can be machined on the periphery of the front camshaft bearing each 0.125” wide and 0.107” deep to take 32mm x 3mm nitrile rubber ‘O’ rings.

Secondly, the drillings to the front and rear camshaft bearings can be tapped 1/8” BSPP (0.383” outside diameter x 28 tpi) to an additional depth of around ¾” and clear of other gallery holes. Then, simple threaded brass restrictor bushes about 5/8” long & drilled 5/32” dia are fixed in position with high strength Loctite.

earing restrictor

The centre camshaft bearing lives in a wonderfully oily environment and is therefore unlikely to be badly worn. However, if there is any sign of a groove in the outer ring it should be replaced, along with a set of nine nice new rollers. These items are widely available and reasonably priced. Special tools are available for extracting & replacing the outer race but you can very easily make one yourself – see photos.

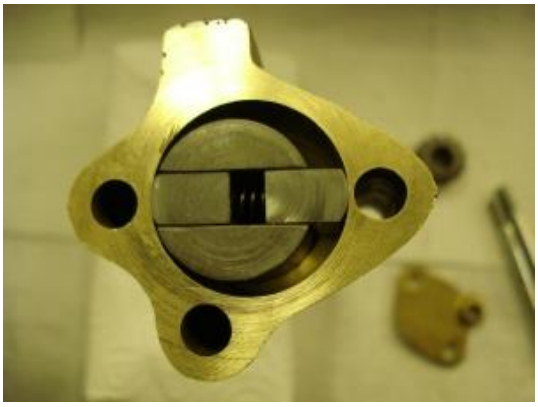
Extractor tool

Extractor in position

Almost out

This very simple tool comprises a length of 12 mm studding, a bush that locates in the front cam’ bearing housing and a dolly that is a sliding fit in the bearing ring to be removed and having a slightly smaller OD than the ring itself. The crankcase is not terribly strong in this region so it should be heated locally (a hot air gun is ideal) before commencing. Happily, the alloy crankcase expands more than the bearing so when the top nut on the extractor is tightened – the bearing outer ring is easily removed. A similar procedure is followed to pull the new replacement into position.

Oil pump
In my view, it is a good idea to increase the capacity of the A7 oil pump because it is a very straightforward modification.


Heavily over-bored pump

Increased output is achieved by boring the oil pump body 1/32" oversize on diameter and offsetting the centre of this new bore by 1/64" in the same direction as the original offset. It would be difficult to make the bore much larger than this due to the proximity of one of the pump retaining bolt holes (the right hand hole in the photo). This modification is described on page 254 of the 750 Club 'A7 Companion' (6th impression 1990) and allows the use of standard springs and vanes.

It seems that the standard pump housing bore is 1.000" diameter perhaps increasing by a few thou' when worn and I have two over-bored pumps in my collection that are 20 and 48 thou' above standard which compare interestingly with the recommended 31 thou' (1/32").

The example shown in the photo, is a pump I bored-out many years ago that has proved reliable for many thousands of miles and shows no signs of wear. This is not a difficult job in the lathe so long as you make a suitable jig to hold the pump body at the correct offset (although it seems that I may have slightly over-done this) and exactly in-line with the axis of the lathe. You also need a sharp boring tool to achieve a smooth bore and a sharp 90° corner at the top.

So, what about performance? Well, an often quoted benchmark for satisfactory oil pressure in a 'splash feed' A7 engine is around 1.5 psi per 10 mph in top gear with the engine fully warmed-up. In my experience, standard pumps often achieve this and both of my higher capacity pumps manage only a modest increase to around 2.0 psi per 10mph. Interestingly, there appears to be precious little difference between the two bored-out pumps in terms of pressure, despite their difference in bore diameter. Nevertheless, the A7 oil pump, being a positive displacement configuration, must shift a greater volume of oil at any given rpm when over-bored. So, even if the gallery pressure is not much higher than standard, the greater flow can only be a good thing - sloshing more oil towards the crankshaft and perhaps even helping to keep the big-ends a little cooler?

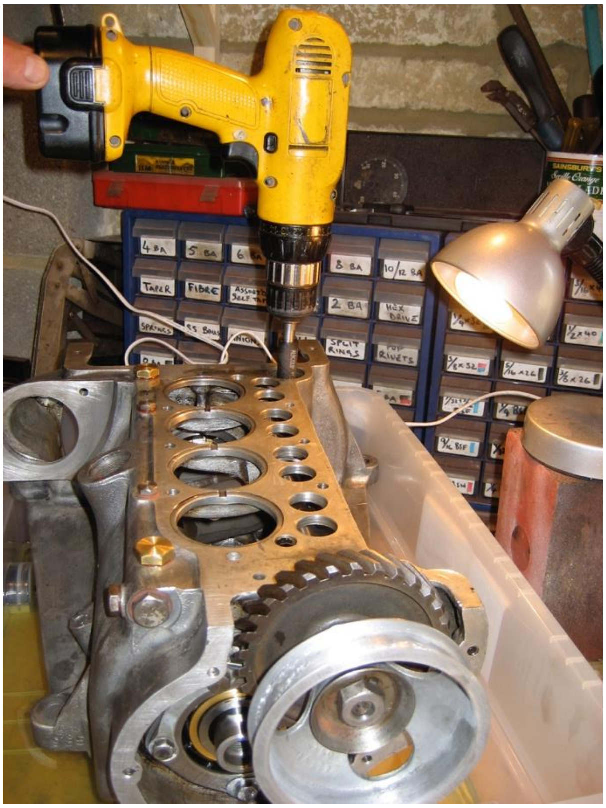
Several of our suppliers offer professionally over-bored (higher capacity) oil pumps for around £60 to £80 and they often come with new springs, vanes and a decent drive gear.

Oil jets
The oil jets should be inspected and replaced if damaged. I have come across jets that have obviously encountered flying pieces of broken crankshaft or suffered at the hands of careless mechanics and these need to be replaced. However, jets that appear slightly out of shape can often be gently coaxed back into a serviceable state.

If you decide to replace the jets, they are a press fit in the crankcase and can be removed by driving them upwards through the main gallery and out of the jet cover screw aperture. A bespoke drift that fits around the narrow part of the jet is a really good idea and one can easily be turned-up.

New jets are available if required from our suppliers and they are fitted by pressing into position from above after ensuring that everything is scrupulously clean. A very useful tip before fitting new jets (thank you Eddie) - is to put a slight countersink in the top (gallery end) that will help guide a wire down into the jet when attempting to clear a blockage. Without this, it can sometimes be awkward to coax a wire into the jet.

I also believe that it is worthwhile aligning the jets so that they point more directly towards the lubrication apertures in the crankshaft as it rotates. However, I appreciate that at least one well known A7 ‘expert’ thinks this is unnecessary, believing that the maelstrom of oil mist in the A7 crankcase with the engine running, is quite sufficient to ensure satisfactory lubrication of the big ends. He may well be right, especially if conrod re-metalling and machining leaves a generous end-float on the crankpins (Woodrow recommends 1/16” which sounds rather a lot to me) – but the fact is, that many firms only leave two or three thou’. I personally specify six to eight thou’.



Driving the oil pump

Flow from oil jet

It is often surprising how far standard jets need to be moved to achieve good alignment with the crankshaft troughs and Jack French (who was a strong advocate of such realignment) reckoned this could be as much as 20°. The method I use to check and adjust jet alignment is to sit the crankcase in a bath of diesel with the crankshaft, camshaft and oil pump in place and all gallery plugs inserted – then drive the top of the oil pump shaft using a rechargeable drill and a short length of rubber oil hose. It is then easy to see whether the oil jet reasonably encounters the crankshaft apertures. This process obviously needs to be repeated with the crankshaft rotated through 180° to check all four crank troughs and usually - an alignment compromise is necessary.   Bending jets to achieve a satisfactory alignment should be done very carefully. I use a steel tube with its sharp edges removed that fits loosely over the jet to gently ease it into the required position. Happily, I haven't broken or kinked one yet.

It should be noted that if your jets have been realigned in this way, you will almost certainly need to use a flexible wire such as bicycle brake cable inner to clear them.

Oil filter
The standard A7 oil filter is simply a wire mesh gauze mounted over the sump and this is probably quite adequate for intercepting large lumps of metal and blobs of sealant.

If absolute originality is important, then the rest of this section is probably of no interest. However, if you wish to almost completely eliminate the possibility of blocked oil jets, then you might like to consider fitting an external modern cannister type filter. After all, if you choose a commercially available kit, it can be fitted and subsequently removed without making any permanent alterations to your engine.

I personally favour the incorporation of a full flow filter on an A7 engine. To achieve this I have previously drilled and tapped for good size, new flow and return fittings into the main gallery but this is a fairly tricky and time consuming job. My latest engine is fitted with a kit supplied by Tony Betts (he of no VAT fame) at 7 County Austins (usual disclaimer) which is dead easy to fit but was supplied with what I thought were rather small diameter take-off and return fittings with an ID of only 5/32" (3.9mm). Nevertheless, he assures me that many such units are in regular use and have proved reliable. The take-off simply screws into the threaded hole originally provided for the oil pressure gauge on the top rear surface of the crankcase and the return is via an elbow fitting that replaces the ¼ " BSPP plug at the front of the main gallery. The filter housing incorporates a new take-off for the oil pressure gauge and has a mounting arrangement that fits neatly onto the tops of three head studs.

I have heard of people fitting such kits as 'partial bypass' filters but I cannot imagine that much oil would choose to go through the filter if it can happily and much more easily adopt a direct route straight to the jets. So, if full flow filtering is to be achieved, it is necessary to blank-off the main gallery between the oil gauge tapping and the rear-most oil jet. This is simply achieved by extending the existing ¼" BSPP thread (0.518" outside diameter and 19 tpi) at the back of the gallery to a total depth of around two inches and turning-up and fitting a suitable plug. Mine is 5/8" long and shown in the photo.

Main oil gallery - steel plug

When installing the kit, I chose to substitute larger (¼" ID) steel thin-wall fittings that increased the internal cross-sectional-area nearly threefold and used larger 3/8" ID flexible oil hose.

Rear main bearing Housing
I make two changes to the standard rear main bearing housing.

Firstly, I mill two half round cut-outs in the outer bearing retaining lip in order to make it easier to remove the outer bearing ring at a later date. Without these cut-outs this can be rather difficult. Of course, the cut-outs can just as easily be produced with a rat-tail file.

When it comes to removing the outer bearing ring, ideally a steel plate 'drift' can be made to fit across the ring and snugly into each cut-out or alternatively, a standard drift can be applied alternately to each cut-out - not quite so elegant - but it works.

Rear main- showing housing cut-outs

The second change I make, is to enlarge the 3/16" Dia drilling in the bearing housing and the supporting alloy crankcase to ensure oil at the back of the bearing can easily return to the sump. I take this to 5/16" diameter because this passageway was found to be clogged-up on numerous engines that I have dismantled.

Cleaning & assembly

Finally, the crankcase must be thoroughly cleaned of all traces of swarf, old oil and particularly grinding paste, paying particular attention to the oil passage-ways and all internal corners. I do this outside using a petrol/diesel mix together with high pressure compressed air and this seems to do the trick.

The two threaded plugs at the lower-end of the vertical oil ways at the back of the engine should now be thoroughly degreased and replaced. I use a thin film of high strength Loctite on the threads and firmly centre-pop the aluminium adjacent to each end of the screwdriver slot as per original Austin practice.

When replacing the cleaned and checked (or new) replacement studs, I use a lower strength Loctite (Type 243 for example) to secure block, fuel pump and bell housing studs.

Degrease, then insert and secure (if fitting an external oil filter) the new main oil gallery plug also the front camshaft cross-drilling restrictor with high strength Loctite (648 is good). Refit the remaining Gallery plugs and jet covers with new fibre washers using a very thin film of 'Blue Hylomar' or similar sealant.

The oil pressure relief valve can now be reassembled and the key point here is that the ball should sit cleanly on its seat. This can be helped by following model steam engineering practice of placing a hardwood drift on the ball and giving it a single clout with a medium weight hammer. Interestingly, a new ball and spring cost very little, so, if you are in any doubt about either, then it would be sensible to replace them.

Assemble and fit the oil pump, remembering that the small chamfers on the vanes go at the top, a new paper gasket is required between pump & crankcase and the skew drive gear must be held securely in position by the small woodruff key at the top of the drive shaft. Finally, tighten the securing nut over a new lock washer and fix the spindle cover disc on its washer with a little sealant in its recess on the top surface.

You now have a truly beautiful bottom-end (if you'll pardon the expression!) that is ready for building your pride-and-joy engine and it should be stored in a completely clean environment, a large polythene bag is ideal!

The next instalment (Part 2) will discuss the crankshaft, connecting rods and main bearings.

…….. Spanner

Austin Seven Engine

Part 2 - Crankshaft, connecting rods, main bearings and flywheel

This is the second in a series of A7 engine re-build articles. Part 1 appeared in the November 2018 HA7C newsletter *Crankhandle* and dealt with the preparation of the crankcase. Please bear-in-mind 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.

Crankshaft

If you drive your A7 like a nervous granny, or the engine is to be used simply as a spare, then I believe it is perfectly feasible to retain an original Austin crankshaft, so-long as it has been carefully crack tested and found to be sound. A common area to find cracks on two-bearing crankshafts is the rear web just behind number four big-end journal but they can also crack on the journals and elsewhere. However, if you are inclined to belt along and rev the engine enthusiastically in the gears and/or seek an especially high level of reliability from your bottom end, then a modern replacement crankshaft is probably a good idea. This is simply because 'two-bearing' crankshafts tend to flex when revved hard (i.e. go round like a skipping rope) and this can (and probably 'will') eventually lead to a broken crank' through 'fatigue' failure. Many original Austin cranks have been whizzing around for eighty or ninety years now, so it is mind boggling to think how many times they may have already flexed. You might be lucky enough to have a sound Austin crank that doesn't need regrinding together with four beautifully matching conrods and I can understand the temptation to re-utilise these items. However, if the big-end journals (sometimes referred-to as crank pins) need regrinding and consequently the conrods need re-metalling, then this significant cost might be better spent as a contribution towards a modern crank.

The only modern crankshafts of which I have personal experience, are the $1^5/_{16}$" splash-feed ones made by Phoenix Engineering and I have found them to be perfectly satisfactory in service. My only note of caution is that my first brand-new Phoenix crank' was supplied with one big-end journal 10 thou' undersize. Happily, the item was immediately replaced without any quibble and subsequent ones have been spot-on, but nowadays I always check. Interestingly, I recently checked the big end journals on my original Phoenix crank' after it had propelled a variety of A7s fairly enthusiastically for more than 20,000 miles and there was no measurable wear whatsoever.

So how do we measure big end journals? Well, when new or reground, the business part of a journal will start life as a precision cylinder, i.e. sides exactly parallel and constant diameter wherever measured. However, during its working life it will inevitably wear and because the heavy firing stroke load from the piston/conrod is applied to a particular side of the journal every other rotation - this will eventually cause some ovality. Similarly, any longitudinal flexing of the crankshaft can cause journals to wear in a conical manner. Therefore, to obtain a complete picture, we must measure the diameter of each big-end journal at six different positions. Firstly, a reading at each end (inboard of the fillet radius) and one in the middle, with the measurements taken at the same angle as the firing stroke load; then a second set of readings at right angles to the first three. The difference between the pairs of readings will reveal any ovality of the journal at each position and it is the maximum ovality that is of interest. Next, the difference between corresponding readings at either end of the journal will show the extent of any taper. Finally, a comparison of the end and middle readings will determine the extent of any 'barrelling'.

An ideal big-end diametric clearance for a splash feed two bearing A7 engine is probably one or two thou'. This is where a conrod lubricated with very thin oil, will fairly easily fall under its own weight with the big-end bolts fully tightened. This suggests to me that an ovality of up to three thou', and a similar amount of end to end taper or barrel shape can all be regarded as perfectly allowable tolerances without having to re-grind the crankshaft. Remember, whilst it may not be frighteningly expensive to have a crankshaft reground - the cost of the necessary conrod big-end white-metaling is considerable and several firms nowadays are quoting lead-times of three or four months.

Earlier, I mentioned ‘crack testing’ and I use the Johnson and Allen two part aerosol ‘magnetic ink’ method which is straightforward and seems to work well. It is used in the nuclear industry and by the military so, it should be OK for Austin Sevens! After thoroughly cleaning, polishing (with emery cloth) and degreasing the relevant areas, the Neopaint NPT16 ‘contrast aid’ white is applied and allowed to dry, which takes only a minute or two in a warm cosy workshop. Next, thoroughly agitate the black Neocol B black magnetic ink aerosol to ensure full dispersion of the magnetic particles in suspension and magnetise the item to be tested. I do this by holding a powerful magnet against the back of the area of interest with a sheet of paper in-between, to prevent spraying the magnet and don’t forget to keep powerful magnets well away from your pacemaker! Finally, the magnetic ink is sprayed onto the component surface and a careful visual inspection in good light will reveal the presence of any crack, as a discernible black line. This method is applicable for crack testing many other ferrous components including A7 conrods and will be referred to again in the next section. Obviously, if a crack is detected, then the crank’ should no-longer be considered suitable for use.

Conrods
If money is no object or you are building a racing engine, then I imagine it might be nice to have brand new conrods and several different manufacturers now offer suitable rods for our engines. However, I took expert advice some years ago that recommended sticking with Austin rods for road use (including enthusiastic use) so long as they have been carefully selected and equalised. My experience suggests this advice was sound because I have not yet broken a conrod and many of the failed ones I have seen were damaged for other reasons such as crankshaft failure or piston breakage. Interestingly, I have seen terribly damaged A7 engines where the conrods have bent but not broken which might suggest they might be stronger than they look.

So how do I select conrods? I firstly check the fit of a new gudgeon pin in the little-end, it *must* be a firm push fit with absolutely no slackness, then check that the little-end pinch bolt thread is sound. In my view, these checks are of the utmost importance because I have seen several engines where poorly fitting gudgeon pins have caused considerable fretting to the securing bolt. If this is left unattended, the engine is almost certainly doomed to failure. I always use new HT bolts on assembly with internal shake-proof washers and a touch of thread-lock - all tightened very firmly (this will be covered in a future article).

I also file smooth and polish any potential stress raising marks on the flanks paying particular attention to the top of the web just below the little-end where many rods can be found to have cracks. The rods are then crack tested in this area using the Johnson and Allen two part aerosol ‘magnetic ink’ method described earlier.

Readers with an excellent memory, will recall the January 2014 Newsletter article containing a photo showing how A7 con-rods can be simply checked for fore and aft bending or twist, by passing a length of 0.500" diameter ground Silver Steel through all four little ends with the rods firmly attached to the crankshaft. For new members and those with an imperfect memory, we have a similar photo here. The rod should be a firm sliding/twisting fit without any binding or loose play.

Some time ago, our Technical Advisor Eddie acquired a proper tool for checking the truth of con-rods and it is shown in the photo on the right being used to check the rods for an engine that I was building at the time. This delightful bench mounted machine is beautifully made of cast iron and reassuringly heavy - it would make a brilliant household ornament! The design is based on a precision expanding mandrel holding the big-end bore, whilst a rocking stirrup is brought into contact with the firmly clamped gudgeon pin protruding either side of the little-end, so that a pointer accurately registers the pin's position over a fine scale. The rod being examined is mounted as described and the pointer position noted. The rod is then reversed and if the pointer returns to the same place, then the bores of the big and little ends are truly parallel with one another.

Eddie assures me that slightly bent rods can be straightened satisfactorily. Very slight adjustments by cold twisting or bending are considered permissible. Usefully, the Dorset A7 Club website Technical Pages show how rods can be straightened using a vice as a press.

A later article will discuss engine assembly in detail but it is perhaps useful here to mention that I favour being able to pass the conrods down the bores. This usually necessitates filing away the 'bumps' either side of the conrod big-ends if the bores are smaller than +60. This filing can often usefully be incorporated in the process of equalising the weights of the four rods. At this stage, it is also useful to ensure the big-end rods and caps are permanently marked to ensure correct positioning on re-assembly.

Fitting conrods to crank' journals is straightforward in an existing engine where the journals are within limits and the white metal in the big-ends is sound. After thorough cleaning and careful inspection of the white-metal for cracks or other damage, the rods should be clamped in position on the crankshaft after lubricating the journals with light oil. I keep a set of old Nyloc nuts for this purpose and save a set of new ones for final assembly. Interestingly, it appears there are two different depths of 5/16" Nyloc nuts on the market and I prefer the slightly deeper ones because a socket fits more securely without binding on the cap. So, after torqueing the nuts to the required 18 lb ft and rotating the rod a few times to disperse the oil, check that the rod will happily fall from the horizontal under its own weight but without undue radial slackness. Slight (around $^{1}/_{16}$") fore & aft (rocking) play at the little-end is OK in my view. If the rod seems just a little too slack, it can be dismantled and the big-end mating surfaces rubbed on fine wet & dry paper supported on a truly flat surface, then cleaned and reassembled. Finally, give the big-end cap a reasonable thump via a stout brass drift and you might find this results in a better journal fit. If the big-end still seems slack the process can be repeated.

On the other hand, if the journal is a bit too tight, it will be necessary to indulge in the 'dark-art' of bearing scraping. I say this, because having discussed the subject over the years with a number of experienced practitioners, I have come to the conclusion that there are several different approaches. Anyway, the method I use (which happily seems to work) is as follows …

1. Prepare a 'jig shaft', ground to the required journal diameter plus the required bearing clearance. In our case say plus one to one and a half thou' on diameter. Note: if you use the crank journal directly instead of a jig, you will end-up with insufficient clearance in the finished big-end bearing
2. Coat the jig shaft *very* thinly with engineer's blue
3. Clean the conrod white-metal and bring it firmly into contact with the jig shaft and rotate it gently right around
4. When separated, the high spots on the conrod white-metal will be marked grey/blue
5. Use a sharp scraper to carefully remove these high spots, scraping alternately at plus and minus 45° to the centreline of the bearing journal
6. Repeat from Step No 2 until the blue marking covers more than 75% of the white-metal
7. Repeat the whole marking and scraping exercise for the big-end cap

If the above process has been carefully carried-out and the conrod is cleaned, lubricated and assembled on the crankshaft, it should now happily fall from the horizontal under its own weight.

Alternatively, if we are building an engine with a new conrod/crankshaft combination, then the conrods will have to be white metaled and machined to suit the crankshaft journals. Sadly, the days are gone when every town had its own white-metal business and the relatively small number of remaining providers seem rather expensive. More irritating, is that some outfits now quote lead times of up to four months, which can be very inconvenient. Incidentally, I'm sure readers will recall that the September 2017 issue of this Newsletter contained a useful list of white-metal specialists in the South of England (thank you Ray).

Now, I have known people who have had white-metaling done without specifying exactly what they want. This might be OK if the firm is very well acquainted with Austin Sevens but I always make sure to specify the following ….

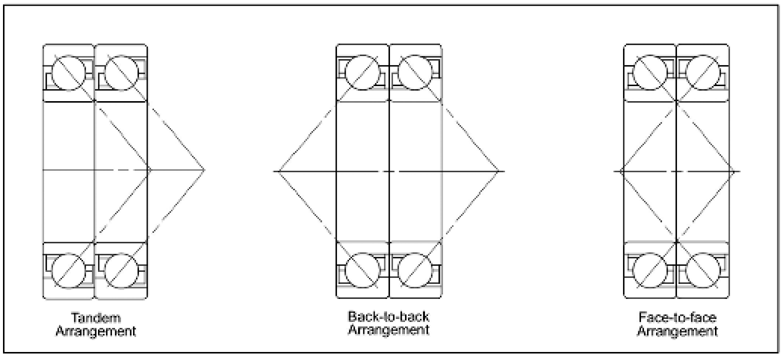
- One to one and a half thou' diametric clearance at mid journal
- An extra thou' or so 'bellmouth' at each end of the journal
- Eight to ten thou' longitudinal clearance along the crank journal (Woodrow suggests as much as 60 thou' which seems rather a lot to me)

My approach gives a slightly looser engine than some firms might provide if left to their own devices but is based on advice I received many years ago from a very well respected authority on A7s.

Main bearings

Front – There are two different depths of front main bearing housing in two-bearing coil engine crankcases. Until February 1934, the housing was $1^{39}/_{64}$" deep to accommodate a ball and roller race combination, each $^{13}/_{16}$" thick . Thereafter, the housing was reduced to $1^{35}/_{64}$ to take a pair of slightly narrower angular contact (AC) ball races. I cannot remember the last time I fitted a ball and roller race combination because nowadays, matched pairs of AC bearings are readily available to fit both depths of crankcase housing. The 'angular contact' arrangement is far superior, particularly in its axial load carrying ability which is useful in an A7 to resist clutch loads. New AC bearings are matched pairs and ours being an imperial size, are not cheap but if I have to buy new, then I prefer a known make (such as RHP) rather than the slightly less costly offerings made in China or India. The good news is that pairs of slightly worn AC bearings can be adjusted so long as the balls and tracks are in good condition.

It can sometimes be difficult to tell if an existing bearing is satisfactory for use in a rebuilt engine. Most bearings when thoroughly cleaned in petrol and dried (compressed air is ideal) will rattle alarmingly when rotated and can sound decidedly dodgy. However, it must be remembered that even new ball bearings are designed with some clearance, because a perfect fit would in theory cause line contact between the balls and the track and the thing would struggle to rotate (part of the ball surface would have to slide). A small clearance allows point contact, which enables delightfully uninhibited rotation. So, if the tracks of a perfectly clean bearing appear unmarked (no visual damage or corrosion) they can be sparingly lubricated with very thin oil such as '3-in-one' and rotated slowly whilst applying a variety of axial and radial loads by hand. If any roughness can be felt it means the balls and/or track are damaged and the bearing should be discarded. A7 front main bearings are pretty robust, so, I suspect that any damage is possibly the result of some muscle-bound 'mechanic' fitting or removing them with a large hammer & drift without first warming the crankcase.



Incidentally, matched pairs of AC bearings can be arranged in three different configurations as shown in the diagram. However, we are concerned only with the 'back to back' arrangement which offers good axial and excellent radial load resistance. Just out of interest, 'face to face' is less stiff and would let your crankshaft flex even more than usual and 'tandem' would be only be appropriate if you needed to resist extraordinary high axial loads - quadruple clutch springs anyone? Anyway, for our 'back-to-back' arrangement, the outer race faces that sit together should be marked 'thrust' and you will see that they have a deeper shoulder (in a radial sense) supporting the balls at this interface. Similarly, but in reverse, the inner races each have deeper shoulders at the front and back of the combined pair. In theory, we might expect the inner and outer races to be ground so that their faces are exactly in-line when the balls are at design clearance. However, 'back to back' matched pairs of AC bearings are manufactured so that the mating surfaces of the outer race each protrude by about a thou' compared to the inner. So, when the inner and outer races are clamped in position, the bearings attain the correct pre-load between balls and tracks. This pre-load is carefully designed so that the assembly will comfortably accommodate the prevailing combination of radial and axial operating loads, whilst running smoothly and quietly over a good service life.

OK that's fine for a brand new AC pair but how do we adjust ours if they are a little slack but otherwise in good condition? It is useful here to turn-up a couple of simple buttons that are an easy sliding fit in the bearings with a shoulder to hold the inner races and a pad so that the whole assembly can be clamped in the vice. Mine are in aluminium (easy to turn) but almost any material would do and they are shown in the following photo. Note: the boss on one 'button' protrudes sufficiently to hold the pair in-line.

The bearing assembly is held back to back in the vice by the buttons to ensure the two inner races are pressed firmly together - the clearance between the outer races is then measured with a feeler gauge.

Front AC mains and support buttons

Assembly held for checking pre-load

Adjustment is made, either by inserting a (ring) shim of appropriate thickness between the outer races or grinding the mating faces of both inner races. In either case, adjustment should be carried-out only until the slack is just removed but no more. This is easily tested if using a shim, by clamping the bearings in the vice again (with the shim in position) using the two support 'buttons' and checking that the outers can just about be rotated relative to one another by hand. If grinding the inner races, they can be checked the same way or with a straight-edge and feeler gauge to ensure each outer race protrudes by about a thou'.

Incidentally, A/C bearings can easily be dismantled for cleaning, inspection or grinding, by driving-out the inner race and it is prudent to employ a cloth to catch the balls as they fall-out of the cage. Careful examination will tell you the correct direction to drive the inner race i.e. so that the balls are moved away from the deeper radial shoulders.

If you happen to have a narrow A/C pair in good condition that you wish to use in an earlier deeper crankcase housing, you will need to insert a pair of 1/32" shims to the outer races – one each side of the bearing cluster. This will give the correct 1/64" projection at the front of the housing to make sure the front clamping plate bears on the outer race to prevent the whole lot from moving fore and aft. It also ensures the crankshaft big-end journals correctly line-up with the centres of the cylinder bores.

Rear – The rear main bearing is a simple roller affair that handles radial loads well but offers no resistance to crankshaft axial loads and it seems to attract some bad press with frequent accusations of rumble. New ones seem to have just one or two thou clearance but in my experience, even quite tired ones often don't have a great deal more. It is widely believed that a beautiful new specimen will quickly wear and then go-on for years so long as the engine oil is frequently changed and the car is in regular use. It seems that rear mains can suffer through condensation and subsequent corrosion of the roller tracks if the car spends long periods standing idle and this might be the source of

Rear main in its housing

some unwanted noise.

In a nutshell, if the rear main seems rather loose but the tracks are not grooved, then you might be able to mix and match a better combination of parts from your spares box, otherwise a new bearing beckons.

A couple of useful modifications to the rear main bearing housing were mentioned in Part 1 of these notes. Enlarging the oil return hole (both housing and crankcase) to decrease the likelihood of it becoming blocked and two cut-outs to facilitate future outer race removal.

Flywheel

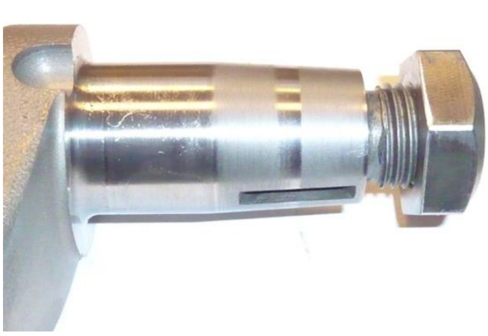
As mentioned in Part 1, there are two possible locations for the starter motor on two bearing A7 coil engines and this means two different flywheels. The early configuration with the starter in the cabin alongside the gearbox incorporated the starter ring-gear on the clutch cover plate whilst later models had the ring gear shrunk onto the front of the flywheel.

Fortunately, Austin Seven flywheels are decidedly robust and seem plentiful, but how do we select a good one? Well, my view is that the taper is of primary importance, because it is absolutely essential that we achieve a good fit on the crankshaft. Flywheels and crankshafts in Austin Sevens occasionally display an uneasy relationship by tending to come loose. Austin may have become aware of this, because whilst the taper in early flywheels took the form of a continuous truncated cone, the later ones had an annular relief half way down the taper which seems to make it easier to achieve a perfect match with the crankshaft taper.

This match is achieved by holding the crank' firmly in the vice (soft metal facings in place please) and coating the taper with a thin film of fine grinding paste, then without the woodruff key – rotate the flywheel a few times whilst applying some pressure to push it onto the crank' taper. If you are lucky, when the taper surfaces are thoroughly cleaned you will see a dull ground area covering the whole contact area. If not, I simply repeat the process until a contact area of at least 80% is achieved.

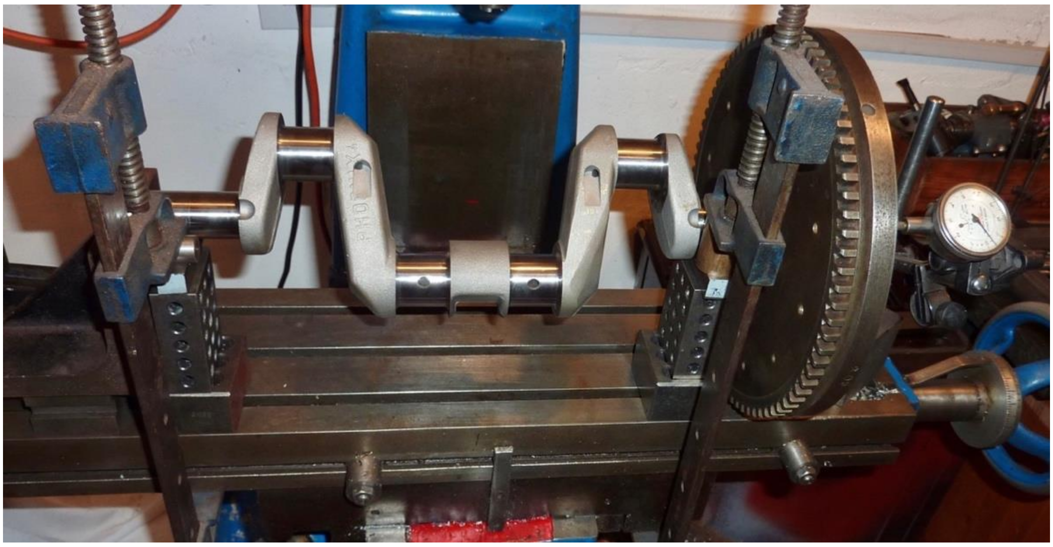
Whilst we are messing about with grinding paste, it is a good idea at this stage to test the run-out of the flywheel near its rim. Some engine builders accept a run-out of up to fifteen thou' and others don't even bother to check it at all but I like to get it to around five thou' or better, because it all contributes to a smooth running engine and also gives the clutch an easier ride. Checking flywheel run-out is very straightforward once the crank has been installed in the engine but making any

Flywheel taper



Matching crankshaft taper

adjustments with grinding paste so close to the rear main bearing fills me with horror. There are endless alternative approaches but I simply clamp two shallow vee blocks (supported at an appropriate height) on the bed of the vertical milling machine, to support the main bearing journals. A further 'stop' is clamped in position to bear on the front of the crankshaft. The mill table provides an ideal firm flat surface and happily accepts a magnetic mount for the dial gauge. The set-up I use can be seen in the photo ….



Checking flywheel runout

The flywheel is firmly tightened onto the crank' with the woodruff key in position and the assembly is rotated slowly by hand whilst keeping it pushed firmly against the 'stop' clamped at the front end of the crank'. Obviously the face of the flywheel needs to be perfectly clean where the dial gauge runs, nevertheless it is not uncommon to get erratic readings with very slight rotations of the assembly. So, I tend to take an average of several readings close to four (north, south, east & west) positions of the rim.

Incidentally, it is important that the Woodruff key is both a firm (gentle tap) fit in the crankshaft slot and also there is no slack in the flywheel groove. However, it is even more important that when assembled, there is a slight but definite clearance between the top surface of the key and the groove in the flywheel. This can be checked by careful measurement or tested with a small shim. Unwanted interference here has been known to be the cause of loose flywheels.

If any adjustment is required, the flywheel is marked where the run-out is greatest and removed from the crank. Then it's back to the grinding paste but this time, the flywheel rim is rotated back and forth (without the woodruff key) whilst pushing firmly to correct the 'high' area. You need not be too concerned about over-correction, because it takes several minutes to correct a tiny amount of run-out with fine grinding paste. This process of cleaning, tightening and removal with the flywheel puller can be rather time consuming and require multiple iterations. Nevertheless, when friends and family enquire about your flywheel run-out, it is very satisfying to be able to say 'it's negligible'!

Loose A7 flywheels can also be caused by a lack of clearance between the flywheel boss and the centre of the rear main bearing, when fully tightened. This clearance needs to be small enough to nip the oil thrower indents to prevent it rattling around loose but large enough to prevent it being squashed flat. If the indents are completely flattened, the flywheel taper might not fully and firmly engage with the taper on the crankshaft. With the flywheel fully tightened in position, we need an *absolute minimum* clearance of 0.906" this being the depth of the rear main bearing centre race of 0.872" plus the thickness of the fully squashed oil thrower indents of 30 thou' plus a small allowance of say 4 thou. The thickness of new unsquashed indents is typically around 70 thou so the *maximum* clearance we should allow is 0.932”, which assumes around 10 thou of squashed oil thrower indents. In the unlikely event the clearance is greater than this, then the thrower indents will need to be enhanced. On the other hand, (and much more likely) if the clearance is too small, then an appropriate amount must be machined from the front of the flywheel boss. I have read a number of articles that glibly suggest mounting A7 flywheels in a lathe and carrying-out such operations but not many of us own a lathe big enough to do this. Never mind, material can easily be end-milled or fly-cut from the front of the boss in a domestic size milling machine with the flywheel clamped flat on the table. This should be followed by lightly dressing the front edge of the boss with a smooth file to remove any roughness.

An oil-tight Austin Seven engine is a thing of great beauty, so I like to pay attention to the oil retention arrangements at the back of the engine. Rather than Sir Herbert’s reverse oil scroll groove which in many engines is rather worn, I favour one of the quite reasonably priced modern oil seal plates machined to take a modern lip seal. However, these are only effective if the seal engages correctly on the flywheel boss and the boss itself has a suitably smooth finish. Incidentally, these lip seals are available in either ‘touring’ or ‘high speed’ versions and if you are inclined to rev your engine freely – then the later item seems a logical choice. However, these sporty seals are made of ‘Viton’ and are about three times the price.

The seal position can usually be adjusted a little if necessary by moving it forward or backward in its housing and this is usually sufficient to ensure the seal sits close to the middle of the periphery of the flywheel boss. Next we should examine the finish on the boss itself and if unable to achieve a smooth shine with fine wet & dry, I fit a thin wall sleeve such as an SKF Speedi-Sleeve. Most coil engine flywheel bosses are nominally 1.872” diameter and the appropriate SKF Speedi-Sleeve Stock No is 99188 which has an overall depth of 0.415” and fits diameters of 1.872” to 1.879”. These sleeves are easy to fit using the tool supplied but the boss must not have any rough high spots because they would ‘show-through’ the very thin wall of the sleeve. The following photos show a flywheel boss that needed a sleeve, the sleeve kit, the sleeve knocked in position with the metal ‘cup’ tool and finally the sleeve in position on the flywheel boss.

The instructions suggest that the sleeve needs no adhesive but I use a touch of 'gentle' Loctite just to make sure it doesn't move. However, if the boss is badly damaged, then I file away any high spots and assemble the sleeve over a thin film of two-part epoxy filler. These sleeves have a flange at the inner end on which the assembly tool engages and this can easily be removed after assembly if required; although, I usually leave it in position because it's not in the way. The key point is that the sleeve should be positioned so that the lip of the seal sits close to its centre.

Earlier, we took a great deal of time and trouble to ensure the flywheel was correctly seated on its taper whilst properly supporting the oil thrower. However, several engine builders have raised the question of whether a thrower is required at all if we are fitting a modern lip seal. The argument being that a modern spring loaded seal should comfortably resist A7 crankcase pressures and might last longer through better lubrication if fully exposed. However, it seems to me that the thrower (which should of course be assembled with the dish side facing away from the engine) tends to fling oil into the seal, so the seal rubbing surface is probably adequately lubricated. Therefore, so far, I have not had the courage to leave-out the thrower but if anyone reading this has already tried – then our Editor would be very pleased to hear from you.

Another flywheel feature worthy of consideration is the condition of the starter ring gear. It has always surprised me how successfully A7 starter motor pinions can engage with quite chewed-up ring gears but if the teeth are really badly damaged, then a new gear is probably required. I have always entrusted ring gear replacement to specialists and the costs have always seemed reasonable. Usefully, new ring gears can often improve the balance of an engine.

It is not uncommon for A7 engines to run perfectly smoothly without ever having been balanced and I imagine this is more likely to be the case if the engine is treated gently. However, if you are inclined to belt your engine, then I believe you are more likely to have a smooth rewarding experience if the rods are carefully equalised and the crankshaft/flywheel/clutch cover plate assembly has been dynamically balanced. On several occasions, I have found these items to be alarmingly out-of-balance even when using a Phoenix crank', so nowadays, I always have have my engines dynamically balanced. The following photos show how much metal can require removal to achieve a well-balanced bottom end ….

Some owners of sporty A7 engines have their flywheels lightened and whilst this might be an advantage in a racing scenario, I have never dabbled - probably due to cost if I'm honest. In my experience, a modestly tuned and well set-up A7 engine will pick-up pretty quickly and reasonably rapid gear changes are quite achievable. I have therefore convinced myself that until someone gives me a whopping great lathe – an unmolested, reassuringly heavy original flywheel will be just fine - and maybe even contribute to a smooth running engine.

The next instalment (Part 3) will discuss how I prepare the Cylinder block, pistons, head and valve gear.

……… Spanner

Austin Seven Engine
Part 3 – Cylinder block, pistons and head

This is the third in a series of 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

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.

Cylinder block
Happily, there still seem to be quite a few Austin Seven cylinder blocks around but sadly they are not all in useable or recoverable condition. Many problems with blocks can be overcome so how do we select one that is suitable for use in an engine rebuild? Well, the first thing I check is that there are no cracks running radially from the centre head stud towards bores two and/or three. This fault is not uncommon and is probably caused by severe overtightening of the head nuts - more of which in a later part of these notes on engine assembly. The centre head stud has less supporting cast iron than the others and is even more vulnerable if the nearby bores have been fitted with liners. Unfortunately, if cracks are present here, I believe the block should be consigned to the bin.

Bores
First, we need to consider the condition of the cylinder bore surfaces and I firstly check to see if there is any evident damage such as vertical marks or gouges from a loose gudgeon pin or patches of very thin wall. I have seen examples of both and such blocks need to be bored and liners inserted before use. The process of fitting liners definitely requires expert attention to get a satisfactorily result and even then, many builders of sporty A7 engines avoid lined blocks.

The most obvious indicator of excessive bore wear is the existence of a ridge above the top piston ring on the off-side of the block. A slight ridge can often be honed away but a noticeable ridge might suggest significant wear that requires a re-bore.

If the cylinder bore surfaces appear in good shape we next need to check the bore dimensions and if you are the proud owner of a proper bore gauge this is very straightforward. The rest of us probably need to adopt a more basic approach based on measuring the clearance between a piston and the cylinder wall. So, how do we make the necessary measurements? Well, there are four key diameters to measure on each cylinder, the longitudinal and transverse diameters close to the top and bottom of each bore. This can be achieved by using a reasonably well fitting piston together with a set of narrow feeler gauges. Clearly, it is important to use a consistent part of the piston for this process in order to obtain comparable results because pistons often have a variety of different diameters. The aim is to establish any ovality near the top of the bore and compare it with that at the bottom. It is normal to find very little ovality low down in the bores because of generally lower sideways piston loads and better lubrication. The ovality that matters is found towards the top of the bore and some sources recommend a re-bore if the ovality here exceeds twelve thou' but personally, I would be looking to re-bore the block if this ovality was greater than say six or eight thou'.

The other feature of interest is the top to bottom transverse taper because even at 8 thou', this causes the ring gaps to change by around 12 thou' twice for each revolution of the crankshaft and I believe this is undesirable.

If you decide a re-bore is required, it is important to provide the pistons you intend to use and state the required piston to bore clearance. Also, the bores should be brought to their finished dimensions by honing which gives an excellent surface to hold oil – essential whilst running-in.

Pistons

There are three distinct types of piston that we commonly use in our engines –

- Cylindrical split skirt – Ideal for touring engines with two compression and two oil control rings, happy to operate with low radial clearance (say three thou' on diameter) giving good control of oil consumption. Sometimes thought to be insufficiently strong for highly tuned engines, although I have had very satisfactory results in moderately tuned road engines
- Cylindrical solid skirt – Until recent years the go-to piston for sports engines, again with four rings as above but needs a little more diametric clearance – typically four or five thou'. May use more oil but very strong
- Cut-away sports slipper – These modern pistons have two often narrow compression rings and a single oil control ring all above the pin. Supplied in a variety of metric dimensions and considerably lighter than the above types therefore happier at high rev's. The ones I have seen have relatively narrow lands and this restricts the amount of chamfer that can be applied at the top edge of the bore. I have no personal experience of this type but I am told they can cause higher oil consumption

Piston ring clearances will be discussed in Part 5 – Engine assembly.

Head and manifold studs

The studs in A7 blocks are often difficult to remove. This is no surprise, because the buried ends have been in contact with engine coolant (sometimes for many years) thus causing some inevitable corrosion. It is highly unusual to be able to remove studs by using two nuts locked together, unless they have recently been replaced. So, we have to consider other options - and these range from a rather basic approach using a good size 'monkey' wrench or Stilson to the various forms of proper stud extractors.

Stilsons can be effective, especially if used as a pair at 180° to one another but they will often damage the studs - which of course doesn't matter if you plan to replace them. Undoubtedly, the best method of removing studs, is by using a proper stud extractor tool and several different socket-drive types are available. The cheaper ones are based on an eccentrically mounted hardened & knurled steel ring that grips the stud and they can accommodate a range of stud diameters. However, undoubtedly the best ones are the 'roller cage' type but they are rather expensive and you need a separate one for each diameter.

Using a 'roller cage' type stud extractor

In all cases, it is helpful to lean repeatedly on the socket wrench or drive bar until you eventually feel it 'give'. The application of heat to the stud can sometimes help release more stubborn examples.

Sadly, despite all our best efforts, it is not uncommon for manifold and sometimes head studs - to break rather than allow themselves be unscrewed - and the break will invariably occur just below the block surface. Now, many books tell us that in this event - you simply centre-pop the broken stud remnant near its centre, drill a suitable hole and use a left-hand screw extractor to remove it. I strongly suspect that these writers are simply repeating something they have read but never actually tried to do it themselves. I'm afraid that I have had only very limited success with this approach.

My method of removing broken studs is simple and so-far, has always been successful. For head studs I use an old cylinder head as the primary jig, in conjunction with a steel guide ferrule sitting in the appropriate stud hole. The remains of the stud should be filed flat with the mating surface if it protrudes, then the head secured in position with at least three or four other studs & nuts before inserting and pressing-down the ferrule and drilling-out the core of the offending stud.

Many years ago I turned-up several ferrules to suit 5/16" BSF head studs. The one shown on the left is 1/8" internal diameter and the outside diameter is sized to fit the 5/16" dia stud hole in the head. It is important that the ferrule is a close sliding fit in the stud hole and the drill a good fit in the bore, also the ferrule must reach down to the top surface of the block. A second ferrule is then substituted to take a 5/16" BSF tapping drill - 7/64" dia will do.

Two head stud drilling ferrules

Very often, after drilling, the remains of the old thread will fall-out or easily be coaxed out. Finally, a carefully aligned 'second' tap will quickly restore the thread to a usable condition.

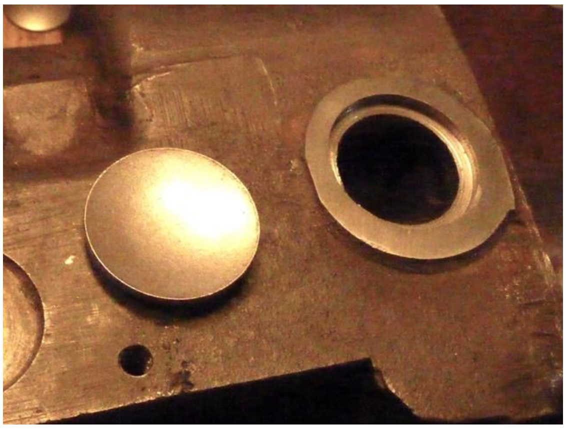
Broken manifold stud threads can easily be repaired by an entirely equivalent method, with appropriately sized jig ferrules and an old Austin manifold.

I believe it is essential that all threads in the block are in good condition, so if you are unhappy with the results of the above process, or the threads are loose, then stepped studs are probably the answer and they are widely available from our usual suppliers. Several other approaches are discussed in Part 1 of these notes. In any event I would always advocate replacing with new - any studs that do not have excellent threads.

Core plugs

If you are lucky enough to have an early cylinder block with screw-in core plugs – you can skip this section. Unfortunately, the more common 'knock-in' core plugs can appear perfectly OK but in-fact be wafer thin due to internal corrosion. So, unless I'm sure the core plugs have been replaced in recent years and therefore known to be sound, I believe it is prudent to replace them with new when rebuilding an engine. It is also much easier to clear the internal water passages of the block with the plugs removed.

Core plug removal is normally straightforward - you simply drive a small sharp cold chisel through the centre and lever out the remains.



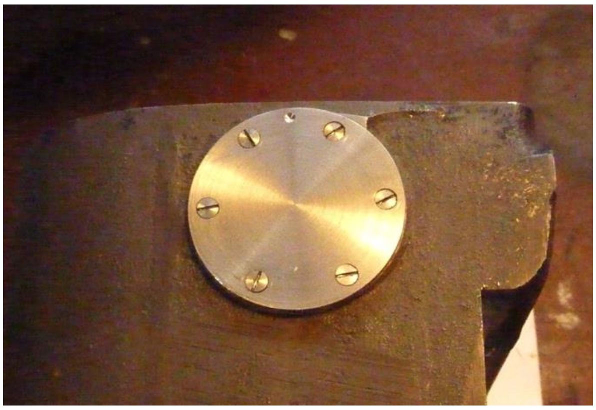
New core plug and clean seating

Many years ago I had a core plug fail not long after I had replaced it, and the problem seemed to be a badly corroded housing. So, nowadays, I always ensure the seating is thoroughly sound before assembly. The seat shown here in the photo was machined a little deeper (there is plenty of metal to accommodate this) using a boring head with the block clamped upside-down on the bed of a Myford 7 Series lathe with suitable spacers. This provided a perfect seat.

Some new core plugs have a corrosion resistant plated surface but if this is absent, then it is prudent to apply some protection to the inner surface. A two-part epoxy paint would be ideal. The proper installation process for domed core plugs is well known - using a steel drift, slightly smaller in diameter than the plug and the plug placed (concave side down) on a thin bead of 2-part epoxy putty. Then quickly follow-up with a whopping blow from a heavy hammer (sometimes several) but definitely not a series of gentle blows.

For core plugs in the block, I adopt a belt and braces approach to completely eliminate the likelihood of any further problems by adding steel cover-plates (see photos). The plates are about 1/16" thick -

Plug fitted & 6BA holes tapped



Core plug cover plate complete

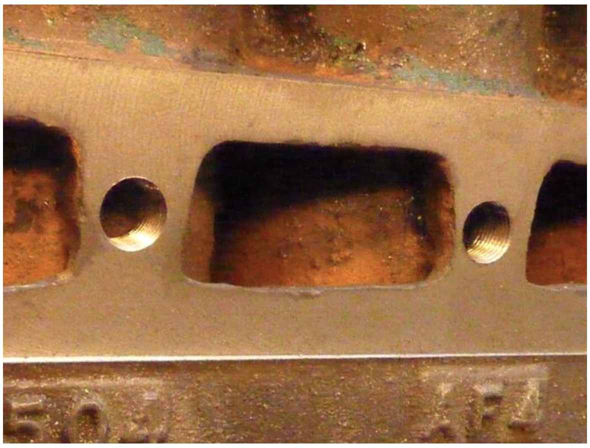
sealed in position on a gasket smeared with Hylomar and finally secured by six 6BA x 3/8" long countersunk steel setscrews. Yes, I know what you are thinking and I agree - this is probably completely unnecessary but I am determined never to have another a core plug problem! Interestingly, I recently heard of another risk averse engine builder who used to install a second core plug on top of the first - something I've never seen in the text books but certainly a lot quicker than my method.

Coolant passageways

The water passages in A7 blocks are often restricted by hard rust deposits which need to be cleared if we are to avoid an engine that boils when climbing long steep hills on sunny days. Most of this obstructing material can be removed by poking around with a hardened blade through the side water inlet opening but the worst affected region is likely to be the 'hot side' adjacent to the exhaust

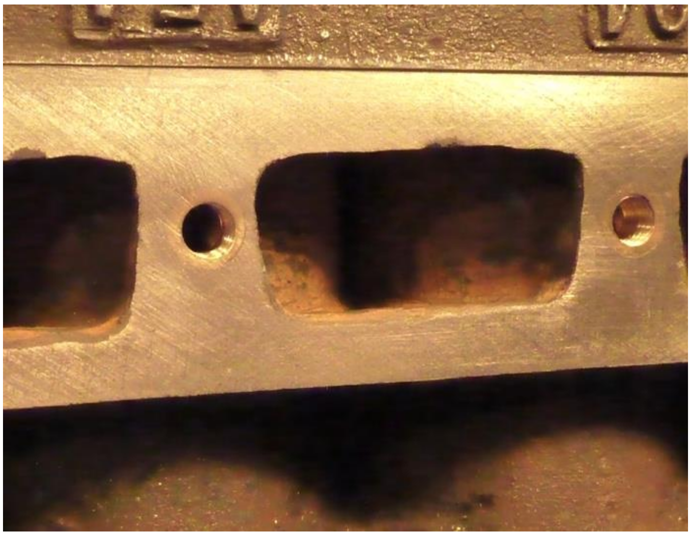
manifold. Luckily, there is an excellent article on the A7OC website dealing with this very subject, that
recommends appropriate drill sizes and depths to clear this part of the block (and head). It is also important that when the manifold studs are installed, they do not protrude into these newly cleared areas.

Side water inlet
The cast iron 'bridges' supporting the side water inlet mounting studs are often badly corroded. If the 'bridges' are largely intact but the 5/16" BSF stud hole threads are in poor condition, it is often possible to drill and tap say 7/16" x 26 TPI and turn-up a pair of bushes (I use bronze) threaded externally to suit and internally 5'16" BSF as shown in the following photos.



Holes drilled and re-tapped oversize

Fitting new bronze bush



New bushes finished flush

The bushes are fixed in position with high strength Loctite and after curing – cut and filed flush with the flange surface as shown in the photo on the left.

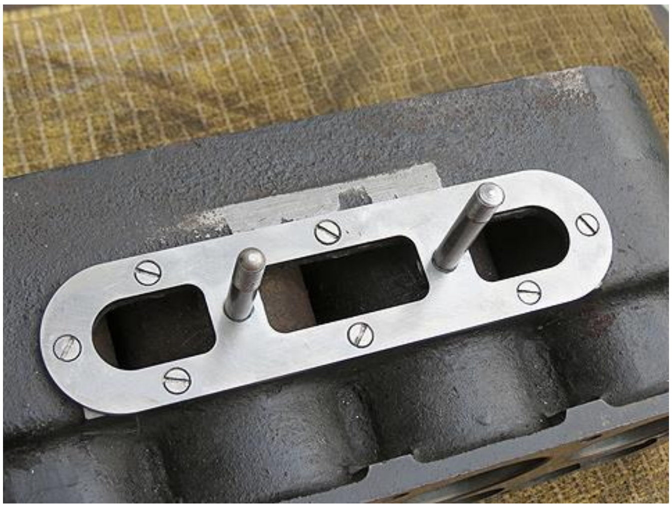
I have used this method several times and it has proved entirely satisfactory.

However, if the 'bridges' are badly damaged or non-existent and you are desperate to retain your favourite block – then all is not lost, because laser cut stainless steel repair plates are now available.

There is an excellent article by Colin Danks on the Bristol A7 Club Website …. http://www.ba7c.org/ (with photos by Terry Griffin) that describes in detail the fitting of a repair plate.

In essence, the plate is fixed in position with stainless steel countersunk set-screws on a gasket with sealant. The plate is not really thick enough to thread for the 5/16" studs, so nuts (preferably also stainless) need to be silver 'soldered' on the back. Any remaining 'bridge remnants obviously need to be sawn off to clear these nuts.

My thanks to the BA7C for their kind permission to include the photo on the right of a completed flange repair installation.



Manifold studs

Austin's standard ¼"diameter manifold studs have always struck me as being slightly flimsy - so, I make mine 9/32" diameter, threaded BSF and make nice beefy 7/16" AF brass nuts to suit. Much better engineering in my view and I like to think that Sir Herbert wouldn't be too disapproving!

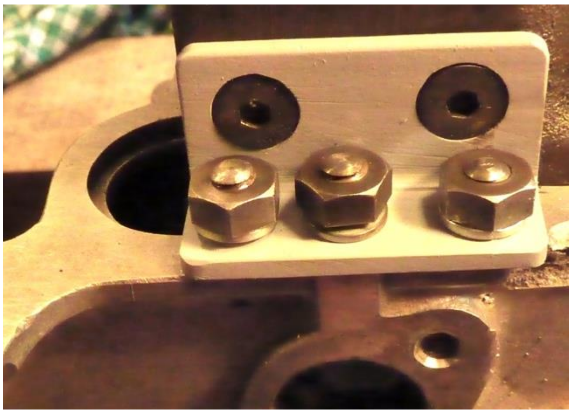
The photo here shows a set of completed manifold studs and nuts on an engine that was destined to be fitted with a sports free-flow exhaust together with a separate alloy induction manifold. Hence the different stud lengths, bespoke spacers and a blanked-off centre stud.

Block to crankcase fixings

The cylinder block is attached to the crankcase by eight 5/16" BSF studs and for normal use with single valve springs and a standard camshaft this is probably adequate so long as the threads in the crankcase are in good condition. However, if like me you like your engine to develop a little more power, you might employ a camshaft that gives a little extra valve lift and to fully exploit its potential, you will frequently want to employ high engine revs which calls for double valve springs. All this suggests to me that those eight studs might appreciate a little help especially in the areas at either end of the camshaft. I have seen a variety of solutions over the years that include bolts running from inside the crankcase to different patterns of external brackets some of which struck me as decidedly clumsy.

My approach is to attach simple mild steel brackets at the front and back of the engine above the line of the camshaft attached to both the block and crankcase. Although there is not a great deal of space to accommodate such brackets (especially at the front of the engine) or depth of aluminium to secure them, it is possible with care to make and fit suitable items. The examples shown in the following photos are attached to the block by a pair of 5/16" BSF countersunk hex drive setscrews secured with threadlock and to the crankcase by ¼" BSF studs and nuts. The stud spacing of the rear bracket looks somewhat irregular but they were positioned to maximise the available depth of crankcase material.

Front - straddles the cam bearing screw

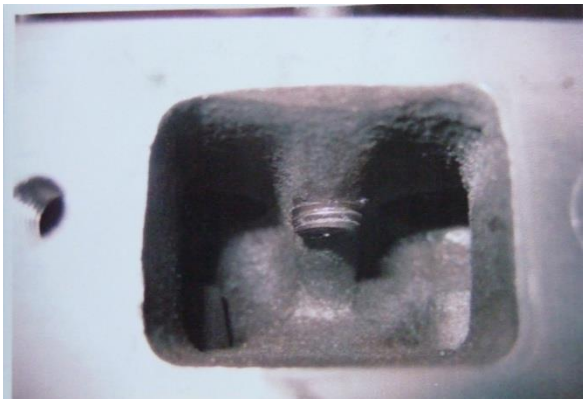


Rear - deliberate uneven stud spacing

A very approximate calculation suggests that each bracket provides a 'holding-down' capacity at least equivalent to an additional 5/16" block/crankcase stud. In any event, it seems to work because I have no oil leakage from the block/crankcase joint despite frequently using high engine rev's.

Ports

A great deal of information regarding optimal side-valve port geometry for high revving racing engines, can be found in the 750 Club Companion and Special Builders Guide. Much of this is very interesting reading but for a lively road-going engine, I conclude that generally smooth passages devoid of any sharp steps is all we need. Depending on the choice of manifold, this probably means removing some metal from the outer ends of the ports and making sure the gasket does not intrude. The bottom end of the head stud immediately over the Siamese inlet ports can also usefully be smoothed-off as shown in the following photos.



Before

After

I believe there is no advantage in polishing the ports, a smooth matt finish being more desirable, although this is not the case with the cylinder head and piston crown where a polished finish will offer some advantage.

Valves

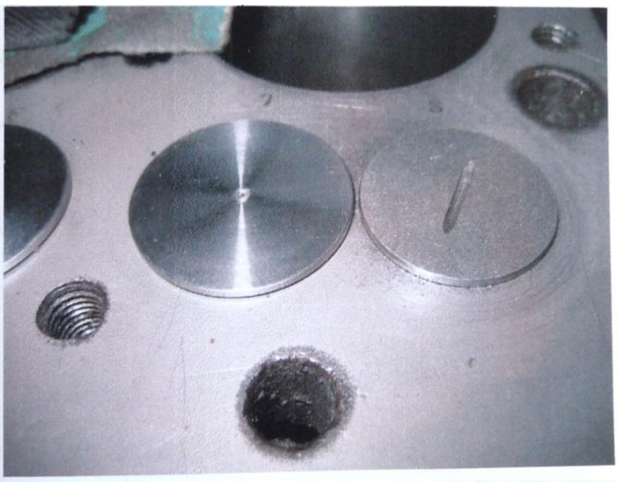
If the valves can be wobbled in their guides to any extent, I always replace the guides with new. The old ones can easily be driven downwards for removal with a suitable stepped drift and new ones inserted the same way, preferably with a copper washer protecting the top surface of the guide. Better practice of course would be to use a simply made threaded 'puller'. With the new guides in place, it is useful to check that a clean valve slides freely but without any play. If the valve is tight, careful use of an expanding reamer will soon ensure a good sliding fit. Incidentally, the guides should be positioned so that the top surface projects 3/32" into the valve port.

The valve seat should be re-cut after installing new guides, removing as little material as possible noting that standard seats are 45° and a seat width of around 0.10"is typical.

Valves

It seems Sir Herbert believed that standard size valves were fine for A7 engines - and for modest power requirements, I'm sure he was right. On the other hand, if you seek a little more oomph and are willing to run the engine at higher revs, then fitting larger inlet valves is pretty straightforward. A 1.00"dia cutter with a 0.275" dia mandrel to fit the valve guide is run at slow speed to cut a depth of around 5/8" and the bottom of the cut blended into the port with a rotating grind stone. A new valve seat is then cut in the top face. This can with advantage be cut at 30° and only a narrow seat of say 1/16" width is needed, because the incoming mixture tends to keep the valve and seat a good deal cooler than the exhaust.

Boring for larger inlet valves



Large inlet valve in position

Inlet (top) and exhaust valves

Large inlet valves are available from our suppliers and the heads are typically 1.142" (29mm)dia. I make sure there is a clearance between enlarged inlet and standard exhaust valves on assembly of around 10 thou and this can be achieved by carefully turning down the inlet valve head in the lathe.

Incidentally, whilst using the lathe, the top edges of enlarged inlets can usefully be slightly rounded to improve gas flow into the combustion chamber. This can be seen on the top valve in the photo also the much wider seat on the lower standard size exhaust valve.

I definitely favour valves secured with cotters rather than pins because many years ago, I had a pin shear. I also use double valve springs with cotter cups to suit, which allows the engine to achieve high rev's whilst eliminating the chance of any valve bounce.

Chamfer to top edge of bore

If you consider the many changes of direction of the gas path from the inlet port, up past the valve, across into the combustion area then back out, it will be no surprise that some rounding of the top right-angle edge of the bore will help matters. The theory of fluid dynamics suggests that even a very small rounding will make quite a difference. The key limitation is of course the position of the top compression ring at TDC and this is determined by a trial engine assembly then allowing say an extra 20 thou' to be safe. Also, the width of any chamfer is obviously limited by the head gasket dimensions.

Cylinder head

The low compression Austin cylinder head is not usually associated with performance and often believed to respond poorly to skimming in an attempt to extract more power by increasing the compression ratio. Nevertheless, I have observed one or two early lightweight Sevens performing remarkably well with skimmed low compression heads. Received wisdom tells us that the higher compression (originally 5.8:1) '1937' head enjoys a far superior combustion chamber shape and in my experience it does seem to offer more power, although I have never tried a skimmed low compression head.

Original Austin cylinder heads have now been around for rather a long time and it is sometimes difficult to tell whether they have been skimmed and if so, by how much. There is an excellent article on this subject to be found on the Bristol A7 Club Website but it can be useful to know that original heads were believed to measure within 10 thou of 1.50 inches in height when they left the factory. Bill Williams also cautions us not to take the compression ratio (CR) above 7 to 1 and don't forget that increasing the bore will also increase the CR. I will return to this subject in the final part of these notes on engine assembly, because the compression ratio is also affected by the thickness of the head gasket.

A variety of alloy heads are available for our engines but I only have first hand experience of the Speedex and Supalloy offerings. Both seem to provide a power output similar to the 1937 Austin head but have the advantage of being considerably lighter. However, if you aspire to compete in VSCC events, you might find you are restricted to the Watmough Hewitt head with 18mm plugs. I have heard fears that alloy heads distort and regularly need re-facing but this is most definitely not my experience. Just for the record, I have been using a Supalloy head (estimated CR of around 6:1) for over ten years without any problems.

The next instalment (Part 4) will discuss manifolds, carburettors, fan spindle and clutch

……… Spanner

Austin Seven Engine

Part 4 – Carburettors, manifolds, clutch and fan spindle

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

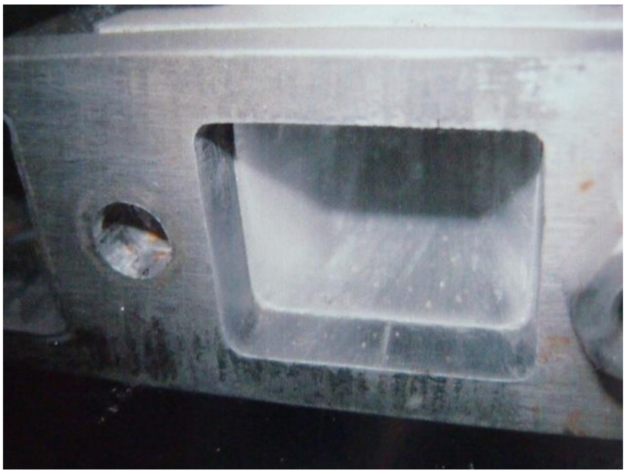
Previously

- Part 1 - Nov 2018 - Crankcase
- Part 2 – Jan 2019 – Crankshaft, main bearings, conrods and flywheel
- Part 3 – Mar 2019 - Cylinder block, pistons & head

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

Carburettors and manifolds

I have personal experience of a variety of different carburettor & manifold combinations on both standard and mildly tuned road-going Austin Seven engines and my findings are summarised in the following notes. However, I do not include details of the selection, adjustment and maintenance of specific carburettors, because there is already a wealth of information available and indeed whole books written on the subject.



Smooth passage through manifolds

In my experience it pays to ensure that manifold passageways are generally smooth with no sharp steps or corners. It can sometimes be useful to remember our basic fluid mechanics theory here, that tells us sudden enlargements are a greater source of friction loss than sudden contractions of similar proportions. An interesting fact and perhaps somewhat counter-intuitive.

It is often necessary to remove material to achieve reasonably smooth passageways and this can be achieved with small grind stones in a hand-held drill or 'Dremel' style flexible drive. It is also important to remember that gaskets might need trimming to ensure they don't interfere with the smooth flow of gas.

I believe the inlet tract is more important than the exhaust and I am not convinced that a polished finish is necessary in a touring engine. The photo shows a reasonably smooth gas flow path in a current A7 engine that performs remarkably well.

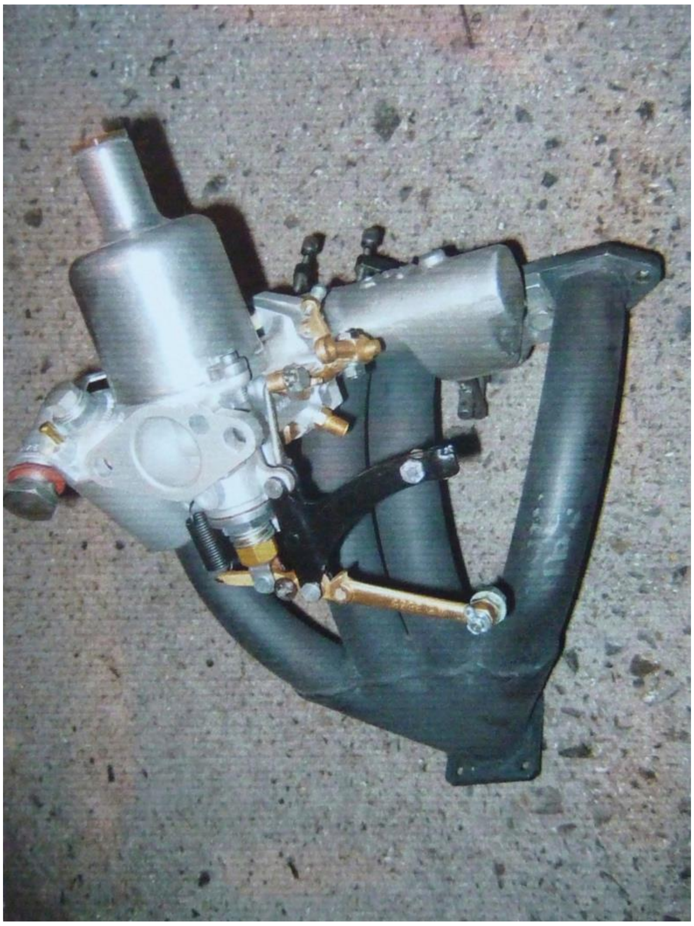
Many Chummy owners claim surprisingly good performance with the Updraft 22FZ Zenith carburettor in conjunction with standard early Austin cast-iron and alloy manifolds. However, I believe this might have more to do with the light weight of these cars, than efficient breathing of the engine, because the gas path is unarguably torturous.

My experience is that a side-draft 26VA Zenith mounted on the Ruby type standard Austin cast iron manifold does offer a slight increase in power. This is especially noticeable if the narrow throat of the inlet is opened up from the standard 0.75" Dia, to say 0.95" Dia and the internal corners nicely rounded.

However, I have a personal preference for SU Carburettors. They seem to suit Austin Sevens rather well, are often easier to set-up and being based on a variable jet principle, they enable any slight blockage to be easily overcome by tugging briefly on the choke. Back in the Sixties, many A7s sported twin SU carburettors but unless you plan to de-siamese your inlet ports, it now seems widely accepted that a single instrument will be more effective and of course a good deal easier to set-up. Whilst on the subject of jet blockage, I always employ a fuel filter. My preferred type has a fine brass mesh above a small glass bowl in which I often find small amounts of debris which are easily removed. One purchase of petrol in rural France on the 2017 Eurotour caused the glass bowl to become completely full of fine grit particles but happily, nothing reached the float chamber.

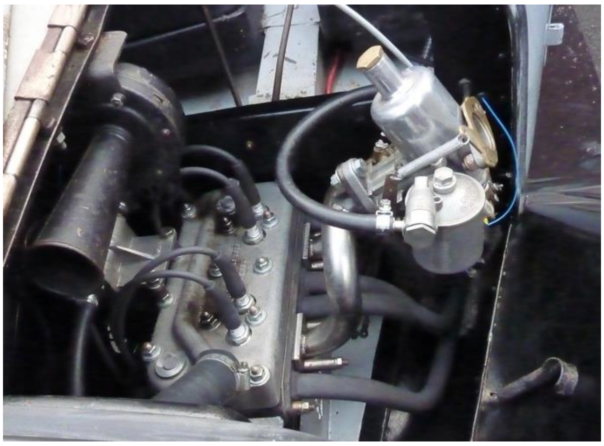
So what size and configuration of SU carburettor do I favour? Well, I have had good results with a 1.00" Dia (measured at the butterfly) horizontal sidedraft SU fitted to the standard Ruby style inlet/exhaust manifold; which seemed to give a further improvement in performance over the 26VA Zenith on the same manifold.

However, a more tasty option is a 30° 1.125" Type H1 SU mounted on an ALR (or similar) alloy inlet manifold with 30° flange, in conjunction with an 'bunch of bananas' steel exhaust manifold such as the one shown here made by Ian Bancroft.


Typical sporty manifold & carb' arrangement

This combination has worked extremely well for me for some years but fitting it in-place is not entirely straightforward. Firstly, there is no room for the centre manifold stud, so this must be blanked-off, which means the other studs need to be in really good shape. I have previously mentioned that Sir Herbert's offerings seem a little frail at ¼" Dia. so I always make mine $^{9}/_{32}$" Dia.

Access to several of the manifold nuts is also severely restricted with this particular exhaust arrangement, which makes the length of the studs somewhat critical. Even then, there is insufficient clearance to accommodate a conventional socket for tightening the nuts. So, I have resorted to an old box spanner with some material ground-off its outer surface. Clearly, for structural reasons, it is important not to overdo this grinding or let it get too hot which would destroy its temper. Happily, old box spanners are often made of excellent steel and my ground-down version has lasted many years.



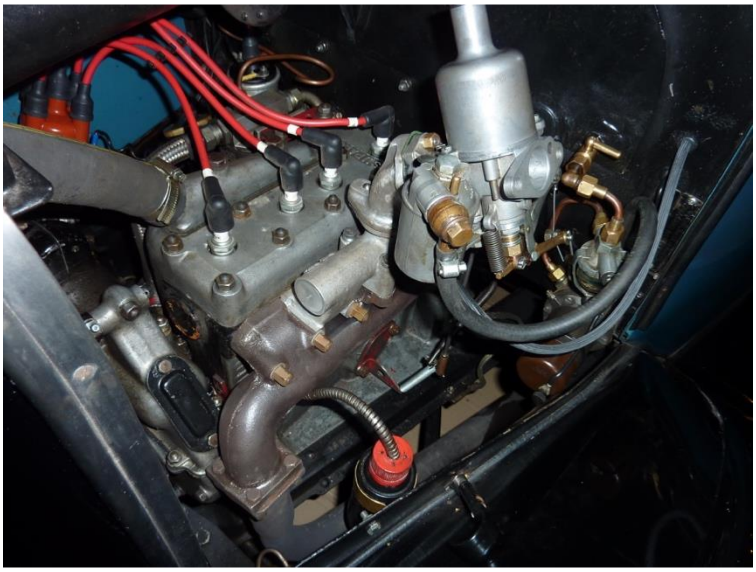
Swept exhaust on a powerful HA7C Chummy

Box saloons (and I guess Rubies) have plenty of room to accommodate a 'bunch of bananas' exhaust manifold but with a 'Chummy' it is more of a squeeze. An easier option in this case, is a swept four branch exhaust manifold such as that supplied by Pigsty Racing and a fine example can be seen in the photo on the left of one of our Club cars.

Clearly, with sports exhaust manifolds you have to make your own arrangements for connecting the exhaust pipe because standard exhausts will not fit directly. Actually, I have found that they sometimes don't fit terribly well even in unmodified cars.

Another interesting option is a Nippy manifold. Interesting, firstly because it will accommodate a standard exhaust downpipe and secondly because it seems surprisingly efficient. This efficiency might derive from a masterpiece of theoretical Longbridge calculation but some argue it is more likely a happy accident of design. Never mind, it works really well.

Unfortunately, the correct Nippy downdraft Zenith carburettor (the 30 VE1) has become an endangered species, the last one I saw for sale about five years ago was severely damaged and still had an asking price of well over £200. However, several other similar Zeniths make excellent substitutes and often come-up for sale at reasonable prices. There is also plenty of available information on suitable choke and jet sizes.



For those of us that prefer a variable jet in our carburettors, it is fairly straightforward to fit a 30 degree aluminium adaptor to a Nippy manifold as shown in the photo. Standard adapters are available but the ones I have seen are designed to take a 1.25" HS2 SU, which I believe might be slightly too big for my road engines.

However, with a little ingenuity, these adapters can be modified to take a 1.125" H1 SU and I am currently enjoying excellent results with this configuration. As a point of interest I am currently using a GG needle which seems about right.

The photo also shows my oil catch tank. The valve chest cover breather holes are blanked-off and an adapter connects (via a length of old outer speedo cable) to an old Brasso tin that has a ring of small holes in its lid. It works surprisingly well.

Since this photo was taken, I have added a short home-made inlet trumpet, fitted with a coarse gauze to prevent any unwanted large lumps of grit from entering the engine. It seemed a good idea and there is just enough room under the bonnet - but it has had no noticeable effect on performance. At some stage I propose to experiment with some form of air-cleaner cum silencer but for the moment, I shall continue to enjoy the noisy roar of the engine, especially noticeable on wide throttle openings.

Clutch

The benefits of even a slightly sporting engine will obviously be lost if the clutch is in poor shape. Therefore unless the linings are obviously fairly new, I invariably replace them when building an engine. Austin Seven clutch linings are not wildly expensive, they are dead easy to fit and it gives enormous peace of mind. Similarly, a set of new clutch springs is also a good idea if yours look a bit compressed compared to new ones which are typically 1.375" long. Incidentally, although some people recommend them - I have never felt the need for double clutch springs, even with fairly pokey engines. Maybe clutch slip is more frequently caused by oil sneaking into the clutch?

The above photos show a new clutch lining fitted to a flywheel. I use a mild steel 'dolly' of rivet head diameter held in the vice to support the lining side of the rivet and prop the flywheel in a horizontal position. I then use a lathe 'dead centre' to initially spread the hollow copper rivet before widening them a little further with the ball-pein end of a small hammer then finally spread it just enough to hold things firmly together. A similar approach is followed to re-line the pressure-plate.

A smooth operating clutch also requires the pillars, clutch levers and pivot pins to be in reasonable condition. New replacement items are available, mostly at reasonable prices except that a set of three levers will set you back approaching £30. No wonder it's common to apply weld to the worn faces and then file them to shape. Play in the lever pivots can sometimes simply be removed by replacing worn pins with lengths of 5/16" silver steel. Some books suggest removing wear with oversize pivot pins and reaming the pillars but this will do your reamer no favours because the pillars are hardened steel, therefore new items might be a better option. Woodrow tells us the pivot pins should be a press fit in the levers but I have found that this is not always the case.

Austin's recommended practice of bending the levers for adjustment, really does not appeal to me. I strongly favour the well established approach of drilling and tapping the clutch cover plate at the pivot points to take suitable (flat fronted) hex' drive grub screws. This approach is described very clearly in Woodrow (A4-26) and enables precise adjustment of the levers. Incidentally, a tiny amount of low strength thread-lock seems to prevent these screws from moving in service, whilst still allowing adjustment.

Fan spindle

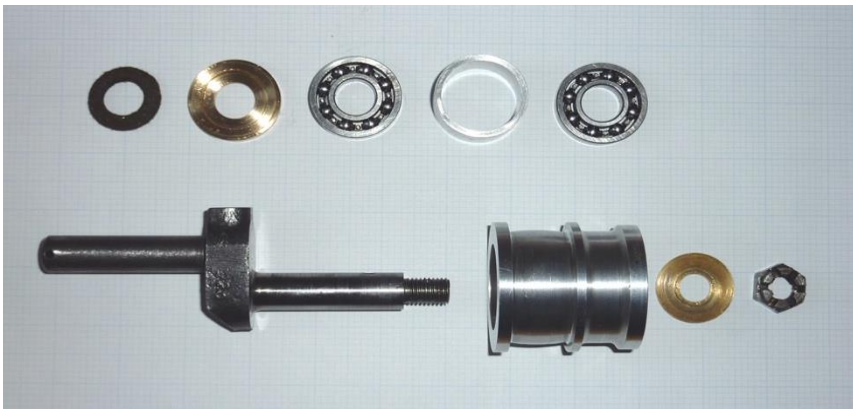
An interesting article on the (excellent) Cornwall A7 Club Website suggests that many of us might be driving around with our fan-belts too tight. The suggestion being that a tight belt will try to climb-up the flange rather than sit nicely on the peak of the convex pulley where it should be. Mine has definitely shown this tendency for some time and causes one side of the belt to wear rather too quickly. I therefore experimented with a much slacker belt and noticed an immediate improvement in its alignment without any noticeable loss of traction to drive the fan which might otherwise cause overheating.

I recently detected some unwanted play in the top (fan) pulley and decided it was probably time to fit new brass bushes. For some time the fan belt had been inclined to sit against the pulley flange causing that edge of the fan belt to fray. I have also noticed that the fan assembly is inclined to deliver spots of grease in all directions when the engine is running.

It seemed logical that the worn bushes probably caused misalignment of the pulley which in-turn led to the worn fan-belt but the reason for loosing grease was less clear.

A recent article in the 'Grey mag' mentioned the use of 'proper' ball races in a fan pulley and this aroused my interest. A quick rummage in by box of bearings soon yielded a pair of imperial ball races 1/4" wide, ½" bore and 1.00" outside diameter. I also found a suitable chunk of aluminium, and set about designing a new pulley.

Whilst measuring the Austin spindle, I noticed the drilling (for conveying grease) had been made from the front and left unplugged. This obviously lets grease reach the back of the fan, which being only a gentle push fit on the front boss of the pulley – seemed to be a likely source of the escaping grease. So, I decided to plug the front of this hole but not so far back as the radial drilling that feeds the bearings. The spindle is hardened on its outer surface but soft enough in the centre to carefully enlarge the hole to say 5/32" Dia and tap 2BA with a relatively low percentage engagement to avoid breaking the tap. Next, after degreasing everything, a 2BA screw was secured in position with Loctite and cut-off flush at the front end when cured. Finally, the cross-drilling for the nut split pin was restored.

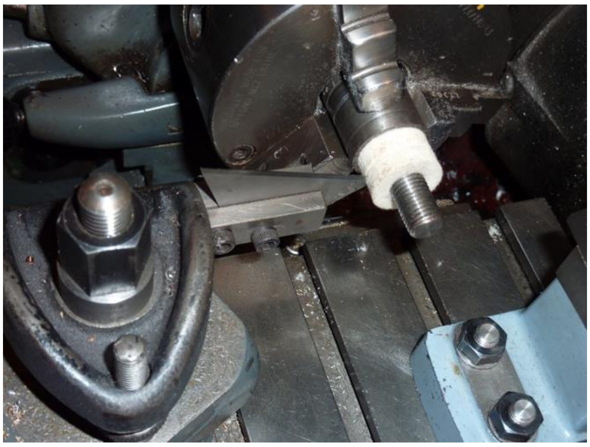


Spindle & components ready for assembly

The new pulley design was very straightforward and based on positioning the two ball-races as far apart as possible. The Austin felt seal housing was replicated by a light press fit brass bush to hold everything together. Finally, the bearings are separated by a simple alloy spacer.

The bearings were an easy push fit on the spindle and in the new alloy pulley, so, a spot of thread-lock was used to secure everything in position, obviously taking great care to avoid getting any on the bearing tracks.

The replacement felt seals that I have encountered are far too wide at about ½"and need to be cut-down to a thickness of around $^{1}/_{4}$" which means you can keep the remainder as a spare. Cutting can of course be achieved with the kitchen carving knife but a more accurate approach, is to hold the felt seal on a 3/8” mandrel in the lathe and cut it with a Stanley knife blade held in a simple clamp tool as shown in the following photo.



If you run the lathe at top speed and advance the cut very gently, the seal will only need to be a firm push-fit on the mandrel for it to remain in place whilst cutting.

Finally, everything was sparingly greased and adjusted to ensure a light compression of the felt seal. The pull of the fan exerts a gentle forward axial load when running, that seems to hold the steel insert against the brass washer at the front sufficiently well to prevent the loss of grease. This spindle has now done well over a thousand miles, spins very freely with no play and seems just fine. The relatively loose belt sits nicely in the centre of the pulleys and the former source of grease spray has been completely cured. Projects like this probably suggest that I have too much time on my hands, nevertheless it was an interesting exercise and quite rewarding.

Fuel pump

I personally favour the use of an SU electric fuel pump and therefore blank-off the aperture for the original mechanical pump on the near-side of the crankcase. A neat blanking plate can very quickly be sawn, filed and drilled from an offcut of 1/8” steel and it is an ideal opportunity to add a bracket to carry the bottom-end of a second throttle return spring as shown in the photo.

The next and final instalment (Part 5) will discuss how I assemble an engine.

……… Spanner

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.

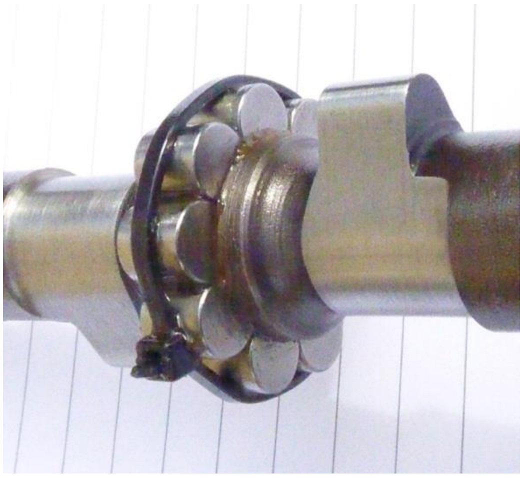
Fitting rings is a straightforward process but care is needed to avoid scratching the piston lands and sliding the rings over thin brass shimstock can help. Interestingly, modern pistons with narrow rings (thus lower contact areas) are designed to give lower bore contact pressures than their conventional 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.

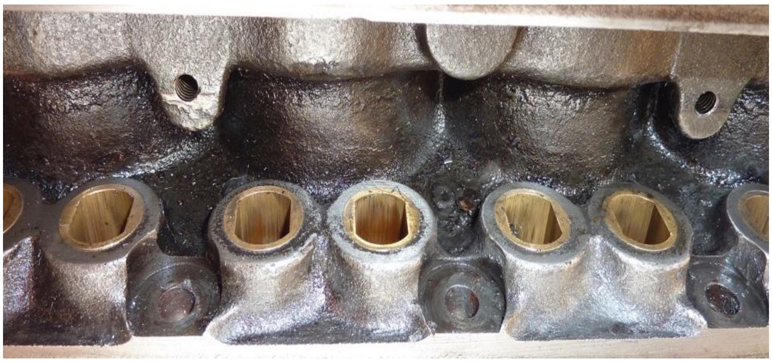


Centre rollers held by a Tie-wrap

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.

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



Machined tappet guides

shown in the photo on the right if using a high-lift camshaft.

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.

Camshaft assembly ready for insertion

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.

Improvised piston ring clamp

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

lengthened oil pump pick-up

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

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

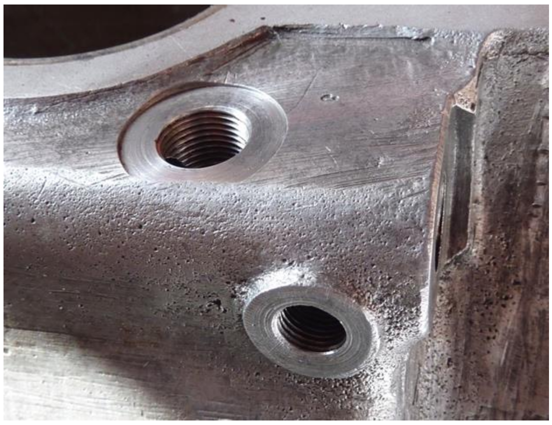
Cylinder head

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