Reviving my Maimed Goshawk

By Hamish McNaught, a 20 year old Electrical and Electronic Engineering Student

Background to the engine failure:

Sublime summer heat, wind in my hair and the quaint purring of my 20/25 at 55 miles per hour; nothing could be better. Well, that's what I thought on the way back from Bicester Heritage after a Sunday Scramble, the first proper car show that I had attended for over eighteen months. A delightful event nonetheless, and a marvellous opportunity to be an anorak, rivet-count and chat to people just as enthralled by the old car bug as I am.

To really start this account, I need to rewind to 9 years ago, at the RREC South of England Rally at Wellington College. We had picked up my grandfather's 20/25 from a local automotive mechanic, as GTR 31 was running hot and losing water. Nothing to worry about I thought, such is the juvenile way of life when you are 11 years old. I succinctly remember a large vat of de-ionised water being poured into the radiator and the vestige of which was placed in the back with me. At this point, I should point out that de-ionised water, distilled water and rainwater are the only types of water that you should be putting into a pre-war Rolls-Royce cooling system, along with a blue antifreeze mixture.

Back to the point; on the serene journey back from Crowthorne, GTR 31 went into a sweltering frenzy and the temperature gauge erratically moved with the frivolity of a young scout learning semaphore. My grandfather did exactly the right thing, by pulling over and letting the engine cool before proceeding home again. To memory, this was one of the longest journeys GTR 31 had been on in the last 10 years. Within my better memory, GTR 31 always ran searingly hot, hence why we were nervous to go on journeys over 15 miles.

GTR 31 in all his glory at Bicester, hours before the catastrophe!

Off to Bicester we went, and about two minutes later the temperature gauge was reading about 110 degrees Celsius. I completely ignored this, as my father and I had worked out that the gauge was wrong and must have been reading about 40 degrees too hot. We had verified this with an infrared thermometer, so before anyone points the gun at the operator, I did check this!

The car ran absolutely beautifully at about 60 miles per hour and we arrived at Bicester in very good time. If only I knew about the harsh realities of what was to follow that day. In I hopped to drive on the way back, followed my autopilot starting procedure and the car spluttered into life with the guts of a limping B series engine. I quickly shut the engine off, transferred over to the magneto in about 2 minutes and we were running. I am not sure if the onlookers were more surprised about a Rolls-Royce failing to proceed at the first hurdle, or at the form of dark magic I must have had to cure this agricultural coughing.

About 7 miles from home, all was going well until I heard a very faint chopping noise, exactly akin to that of a Chinook helicopter. With the finely tuned aviation ears of both myself and my father, we passed this noise as just that. At this point I should say “the best laid plans of mice and men gang aft agley”. The noise was amplifying at an increasing rate until the almighty thunder of the Huayra surged through my Goshawk engine, I felt this vibration through every bone in my body and just as I thought it couldn’t get any worse, GTR 31 had turned into the Flying Scotsman, and it had swiftly bought steam back to Didcot for the first time since the Beeching Reforms!

At this point, we were very close to an exit slip-road and I managed to nurse my car into a service station car park to assess what exactly had just happened. Fortunately, I did not turn the engine off. If I had done so, the engine almost certainly would have seized due to the colossal temperatures within the cooling system, and we really would have been in very expensive trouble. Besides the point, we were quickly recovered back home, the car ran under its own power into the garage and then we had to deduce the monstrosity that had just occurred.

Initial post incident inspection:

Initially, my father and I thought that the head gasket had failed, and that the resonant thumping noise may have been gases escaping around the failed part of the head gasket. Also, the car used to be very smoky upon start up, which lead us to believe that the head gasket may have been letting small amounts of condensation into engine. Actually, it is due to the sheer length of the exhaust, about 4 metres, that causes a smoky exhaust on a cold start.

Engines tend to run very hot when the head gasket fails, and our thinking was that whilst the temperature gauge was showing erroneous results, perhaps there was a hotspot where the temperature bulb was taking a direct measurement – at the back of the engine where the Goshawk engine is known to get very hot due to the single, front entry water pump inlet.

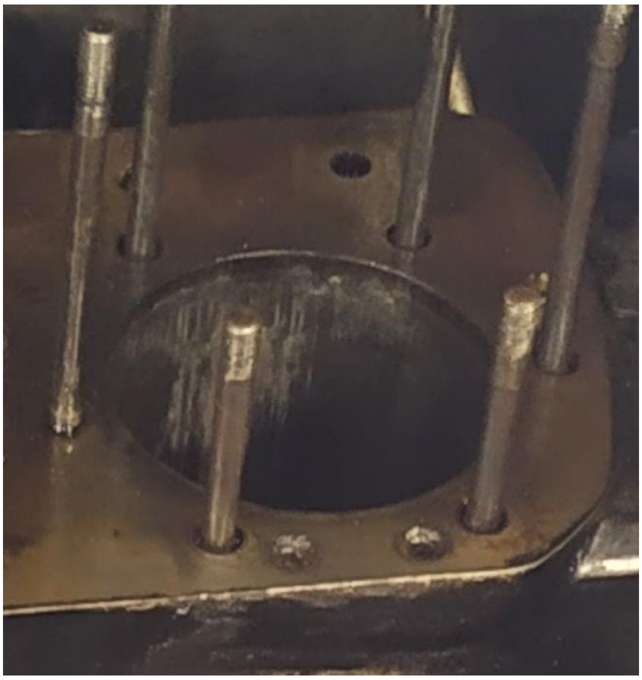
We knew that we needed to remove the cylinder head from the car, although between my father and I we had pretty rusty mechanical experience. My father had built an AC Cobra in a previous Century as well as maintaining his 1973 MGB in a past life, although we were not sure of how to do this.

Thankfully, my friend Simon Hiscock was ready to help. He is a mechanical genius and very experienced with rebuilding veteran, vintage and classic tractor engines. After a quick message to him, I felt ready to remove the head, whilst carefully following Simon’s succinct advice; gradually undo the head nuts, working from the centre outwards and ¼ of a turn each time, until all of the nuts are loose enough to undo by hand.

At this time, we thought that the head was stuck, as we could not lift it up and it was very solid and not moving. What to do at this point? Enlist the screwdriver that built the Titanic of course! My father duly removed said screwdriver from our tool arsenal, and he gradually ‘broke the seal’ between the head gasket and cylinder head until we could lever it upwards by knocking in wooden chocks between the block and the head to ensure no damage was imparted to either surface.

We managed to lift the head up about 3 inches until it became stuck on a stud due to electrolytic corrosion. This was no issue as we used a rubber mallet to knock the head up until it smartly lifted up off the studs and we could finally see into the cylinders!

Upon removing the cylinder head (about a 4 hour job for anyone interested in changing a Small-Horsepower head gasket), there was an abhorrent amount of metallic deposits all over cylinder one, and there was scarring about 1.5mm deep in the bore, as shown below:



The vertical lines of lighter colour are where the piston rings have scraped the honed layers of cast iron away, most likely due to the aluminium piston expanding and the cast iron cylinder contracting. This metallic deformation was most likely caused by intense friction due to the lack of oil, which could have been washed away by steam circulating under a failed head gasket. Further, when localised friction occurs, a hot-spot is created which is where the majority of deformation occurs, hence the scraping on the bore.

Another tell-tale sign of piston ring failure could be seen when removing the carburettor from the offside of the block:

The oil deposit seen in the aperture of the intake tube. Obturation should occur within a fuel-air intake system, although this gas tight seal (how the vacuum suction effect is created) has failed, and oil has been pushed up into the intake manifold by cylinder number 1. The spark plug on cylinder 1 was also covered in heavy black oil, indicating further failure in obturation.

From these two images, I believe that the effect of problem has been perspicuously shown. However, I have not shown exactly why this localised heating, obturation failure and scoring has occurred. Therefore, we needed to remove the engine from the car to pinpoint why this engine ran so hot.

Finding a garage to carry out the engine work

Unbeknown to me was just how difficult it was to obtain a sensible estimate for an engine rebuild on these cars. We had a budget in mind but not the values over £25,000 which I heard from at least five different companies. Clearly, I could not in any way afford this, so my thinking was becoming very panicked as to what I would do next.

I quickly realised that I had to do the vast majority of the work myself to keep the labour costs down as this was really the largest part of the estimates that I was provided with. However, much to my annoyance, many companies have various forms of insurance and they do not cover a ‘non-employee’ or visitor to work on a car in their facilities.

My father and I started looking around for local classic car garages who may have been slightly more welcoming to a young chap with a stricken Rolls-Royce, and my father had an epiphany; how about the brother of the chap who owns the 20/25 locally to us, perhaps he could help?

Sure enough, a quick visit to Manor Garage, Wantage by my parents and we had struck absolute gold. An instruction to clean the engine bay thoroughly and take apart and label the ancillaries, and I could bring the car in to start work within the next few weeks once some space had been made and projects had been completed.

So, within the next few days, Simon my friend who happens to be a vintage tractor enthusiast very kindly helped me to move GTR 31 from my previous home in East Ilsley, on a trailer, to Manor Garage. We carefully backed the car into the bay and the rest, as they say, is history!

GTR 31 Loaded onto Simon’s trailer – I am very grateful for his help, especially for giving up his time on a Saturday morning!

Introducing the Manor Garage team

Richard Chapman is the Director and Owner of Manor Garage, Wantage. His business provides servicing, maintenance and restoration of all quality post war British cars, especially MG and TR cars. He is a very highly skilled mechanic and engineer (he won't like me saying that!) and has a plethora of knowledge on engines, with a specialism for gearboxes.

Richard has two mechanics working for him, Old Steve (Steve Proudlock) and New Steve (Steve Webb). They are both excellent mechanics who very kindly looked after me, made me feel welcome and taught me so many skills when it comes to old cars. We spent countless hours laughing away in the workshop and learned so much together. Furthermore, Mark, who is a very good friend of Richard's, was also very supportive of my project and was particularly good help when we were trying to get the engine back into the car.

Removing the engine from the chassis:

This task seemed fairly straightforward to me, but after 20 hours I seriously began to lose my patience. In all, there are hundreds of fiddly fixtures and fittings, pipes, rods and springs that have to be very carefully removed before even thinking about removing the engine from the chassis. It even took us 2 hours to loosen the retaining screws that held the rubber engine mounts in place!

At this point in the process, progress really began to curtail and I remember coming home very frustrated because I spent hours over singular fittings that simply refused to budge. It was a great test of patience not helped by the summer heat and my eagerness to get things moving. With hindsight, I would not have tried to rush this part so much and I can bet the engine would have been free much quicker.

Further to this, I learned that there is no such thing as metric or imperial when it comes to a Rolls-Royce, just whatever fits! The hassle was relentless but thankfully we made it in the end. The crucial part of this stage is photographing 'before and after' of every part that comes off. Needless to say you would be going round in circles should this be skipped. Further, it would be useful to note down the size of the fitting once removed, to hasten the refitting process.

Just before we removed the engine, we removed the radiator bracing and bonnet rests, unfixed the radiator and taped up the ends of loose electrical connections, to ensure our safety as well as some damage prevention.



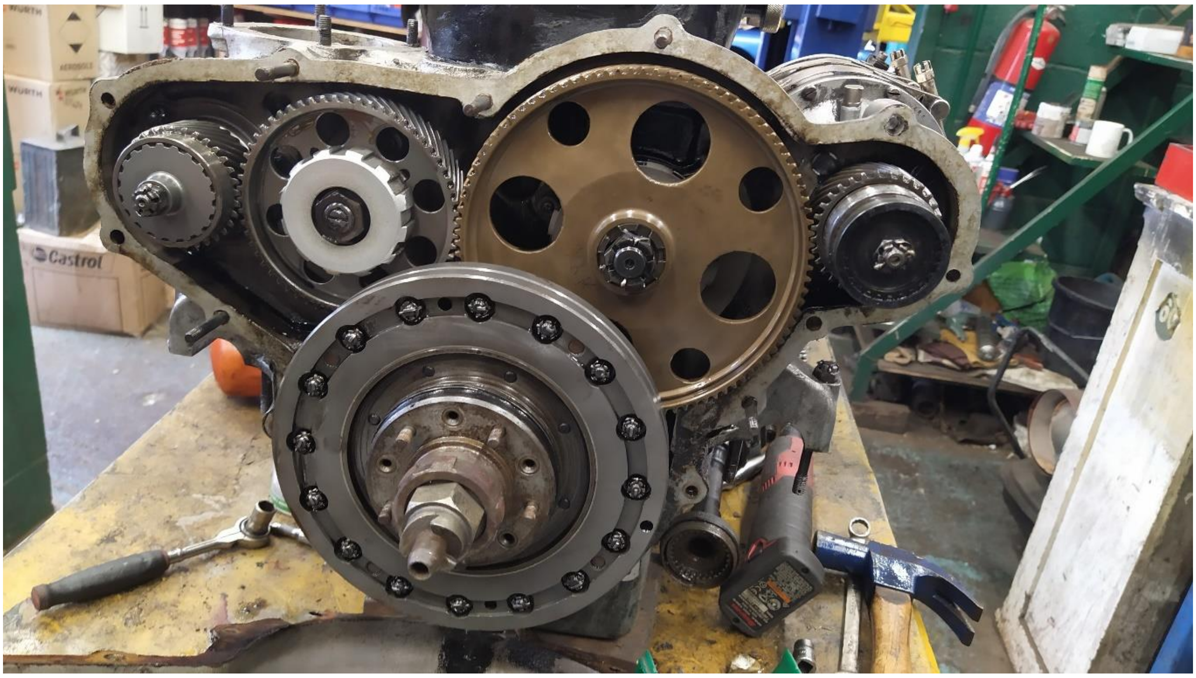
After all of this hassle, we managed to remove the engine from the chassis with a 1.5 tonne engine crane, lots of wood, a moveable trolley and 4 pairs of eyes watching every inch of movement. It is handy to have lots of people on the engine because there are just so many parts that could be knocked, scraped or damaged in the removal process.

After wheeling the engine from the garage to the workshop, I removed all of the ancillary pieces, including the magneto, coil tower and the final studs which would get in our way. After this, I removed the sump from beneath the crankcase which was another rotten job due to the crud that is dislodged, as well at the tightness of the bolts which hold the block in place. Be prepared to swear and bruise your hands at this point, because it will happen!

I should mention that having an oxy-acetylene torch is a must if you are to attempt this removal part yourself. Some of the nuts and fittings literally weld themselves together and the only way you will remove these is with the application of heat and ring spanner. I managed to fold the oil pipe that feeds the timing gears into a piece of fusilli due to my ignorance; a £180 lesson well learnt.

Upon removing the sump, you will be presented with the fascinating piece of engineering which is the bottom end of the engine.

The pipes feed oil to each of the main bearing caps, which is ingenious because it minimises the risk of the bearings pinching on the crankshaft, which has disastrous consequences. You will also note the infamous crankshaft vibration damper, which was one of R’s masterpieces.



Here is the front of the small-horsepower engine. Again, this design was highly advanced and also bomb proof, because there are no chains or belts to fail. Just gears with the integrity of mill wheels! You can see why Lawrence of Arabia said that a Rolls-Royce was worth more than rubies in the desert, just look at how advanced this looks for a 100 year old design.

Once we had removed the pistons, connecting rods and big end bearing caps from the crankshaft, we carefully removed the clutch from the flywheel, then the flywheel from the end of the crankshaft. Once complete, we unwound the vibration damper from the nose of the crankshaft. Care must be taken as there is a Woodruff key which stops the damper from rotating independently of the timing gears.

After this step, we removed the cylinder block from the crankcase, which required a small amount of effort to break the Weld Seal joint. This is a 3 man job because the block weighs just over 50 kilograms, 1 cwt in old money. Interestingly, the flywheel weighs about the same as the cylinder block. In layman's terms, the engine has to overcome an inertia of 50 bags of sugar before it can even think about kicking into life. The higher the inertia, the greater the initial force required to rotate the crankshaft. As this particular rotating assembly has a large inertial mass, it requires more force per unit area to increase the revolutions of this engine compared to say, a BMC C Series engine, hence why the Goshawk engine produces a very strong amount of torque from low rpm.

Once the block is removed, we spun the crankcase over and removed each main bearing cap individually, and zip-tied them together such that they would go in how they came out. At this point, I think engine rebuilding is more about not making silly errors than actually engineering the machine to do its intended job!

We then carefully removed the crankshaft, smothered it in oil and graphite paste (to prevent rust, surface corrosion and damage) and placed it in a bed of bubble wrap safely away from any hazards.

What actually maimed my Goshawk?:

As many an enthusiast will know, the Achilles Heel and weakest link of the small-horsepower engine is the cooling system. Why is this, you may ask, when R designed the Goshawk with a gear driven water pump, which is driven with a 1:1 ratio off the distributor drive, thus the water is pumped round the block at a rate which is directly proportional to the actual speed of the engine. Furthermore, the engine is actually ‘self-cooling’ and can suffer complete water pump failure due to the thermosyphon effect that is apparent in every R designed engine.

The thermosyphon effect is a scientific principle which is very similar to convection currents in air. As warm water rises through the engine block, its density decreases and thus it flows up the feed tube to the top of the radiator. At this point, the water that flows through the radiator is cooled by the air and subsequently the density of the water is increased so it flows naturally down through the radiator to the exit point, where it circulates to the engine block due to the pushing of the warmer water molecules at the top of the radiator. This process is infinite so long as it is in the ‘closed-loop’ state, which means it is fail-safe for the engine.

Unfortunately, this process only works when the flow of water is completely unrestricted, and after many years of use, these engines silt up like a British canal. If the engines sit for a long period of time i.e. winter storage, corrosion more than likely occurs in the water jackets. Fundamentally, this is totally dependent on the type of water and coolant that you use. I know for a fact that in West Berkshire, the water is very hard, and therefore unsuitable for use in an engine. Unfortunately, this water found its way into the radiator for 8 years, and this contributed to the diabolical corrosion that I found in the water jackets.

Once the flow of water is inhibited even slightly, the thermodynamic cooling effect of the water reduces, and therefore the operating temperature of the engine increases. I need not delve into the disadvantages of increased (above specified) coolant temperatures, although it makes your engine inefficient, risks greater unreliability and has the potential to cause very significant damage.

In this case, the corrosion was at least 2 inches above the base of the cylinder block. This meant that the water could not circulate fully around each of the cylinders and therefore the thermal energy produced by the internal combustion process could not be dissipated around the engine effectively. This thermal energy increased in value, which caused metallic deformation and ultimately caused the piston to ‘pick-up’ the cylinder.

This image demonstrates the build-up of calcium, magnesium, rust and various crud from the radiator core. If one uses de-ionised water with a 50/50 mix of coolant (blue) then the likelihood of this corrosion forming is significantly reduced. Mr Keuning also suggests flushing out the system twice a year, which is a good prevention procedure. In essence, it is vital to keep this water circulating and not stagnant. If the car is to be laid up, use a greater ratio of inhibitor in the system. The cost will inevitably be greater but your investment will be worthwhile in the long-run.

Inspection and analysis of damaged parts:

On the very left of this picture, one notices that the piston rings have fused themselves into the piston, and the leading edge of the piston is very heavily damaged. This only occurs during intense heat distortion within a cylinder. According to my own calculations, the temperature must have reached at least 660 degrees Celsius, as this is the point where aluminium warps.

The photo on the left demonstrates what a bore should look like (perhaps slightly glazed) and a destroyed bore as a result of intense overheating.

The photo on the right shows the damaged piston next to a perfectly good piston. The contrast between the two is almost unbelievable.

Upon a thorough inspection, Richard and I were actually very surprised to discover that only two parts had been destroyed, those being the number one cylinder in the block and the number one aluminium piston. I have previously explained why this damage occurred, but I will share with you my critical, engineering analysis of what happened.

The cylinder block and therefore the bore is cast iron, and cast iron deforms at approximately 700 degrees Celsius. The piston is milled from solid aluminium, and aluminium undergoes thermal distortion at 660 degrees Celsius. Therefore, the temperature within that cylinder must have been at least 680 degrees to deform the two surfaces.

Standard cylinder wall temperatures are approximately 185 degrees Celsius under extra urban driving conditions, therefore a rise of 500 degrees Celsius occurred within a small transient for this to occur.

This rise in temperature, in my opinion, was a result of lack of lubrication due to steam entering the cylinder bores and literally obliterating and removing any traces of oil due to the high pressure of the water. As oil floats on water, the water would have expelled the oil from the cylinder bore surface, consequently resulting in metal-to-metal contact.

Metal-to-metal contact, with a lack of lubrication means a very high amount of friction. Friction occurs when atoms of two differing surfaces (i.e. the piston rings rubbing against the cast iron bore) rub against each other resulting in a localised increase in resistive force and temperature due to energy lost during exertion.

This localised heating due to friction raised the temperature of the two metals, causing both to deform. Most likely, the piston would have deformed first, probably expanding outwards and gouged into the bore, causing the heavy scoring and metallic deposits on the bore.

The steam would have entered the bore due to the already hot water vaporising and travelling into the number 1 cylinder due to the vacuum created by the downward stroke of the piston. As we know, gases naturally move from areas of high concentration to low concentration in a process known as diffusion, and that is what occurred here.

The process of restoring Y6K's cylinder block:

I thought this stage would be quick, yet the block went through no less than 7 different processes before being ready for reassembly. This was longest part of the project, with work starting in October 2021 and finally finishing in March 2022. I am very grateful to Steve Taylor of Alpine Eagle for sharing his wisdom with us on how to restore the block back to its former glory.

1. Physically removing the corrosion from the cylinder block

Firstly, I took the two water jacket side-plate covers off from the block. You must take extreme caution in this process because the risk of damage you could incur to the cylinder block is severe.

I started by using a flat head screwdriver that perfectly fitted the screw heads that held in the plates. I would advise cleaning all of the screwheads and smothering them in WD40 to ensure that no deposits are left in the heads. I lightly tapped the screwdriver into the screws with a heavy hammer to ensure full contact of the screw was obtained. After this, I used a spanner on the neck of the screwdriver, pushed my bodyweight behind the driver and very gradually applied torque to the spanner in the hope that it would turn the screws.

About 80% of the screws were removed this way, although the remainder just would not budge. Richard suggested that I used a hand operated impact driver which was an excellent idea. Again, I ensured that the block was held securely in place, then I tapped the driver into the screws with moderate pressure until they started turning. One can feel the force required so do not be tempted to use any power tools whatsoever, it will lead to disaster.

After removing the side-plates, I was presented with this absolute monstrosity:

The photos show the layer of corrosion that had developed all around the internal surfaces of the cylinder block, within the water jackets. This is a very common issue on Goshawk engines and I am sure that this is the cause of most engine failures generally on pre-war Rolls-Royce cars.

To remove the crud, I started by using a telescopic magnet which proved to be fantastic at removing the majority of the crud that was sitting in between the cylinders; I must have removed at least 8 lbs worth of material before even scraping the crud out. I then scraped out the crud with a blunt screwdriver and firm force, which then removed about 2 lbs worth of rust and corrosion.

If you are just doing a water jacket clean out, which I suggest you do every 5 years, it would be a good idea to pour caustic soda into this cavity to ensure that all of the rubbish is cleared out, because there are some nooks and crannies that are impossible to remove material from by hand.

2. Drilling out and removing the copper tubes from the water jackets

Whilst I was away at University, Richard drilled out and removed all of the copper tubes from the jacket, to ensure the next stage of the cleaning process was as effective as possible. This took him 4 hours to do and I would suggest it is a job for a skilled mechanic because there is an extremely high risk of damaging the block if you misplace the drill.

Richard used a pillar drill to ensure the drill bit remained on the same Y-axis plane and did not cut away any of the cast iron block. One must remember that the copper tubes are swaged into the cast iron, so there is hardly any tolerance between the copper tube and the small bore that it takes up in the block.

For the more stubborn tubes, Richard used a hand drill on a low setting to minimise the risk of damage to the block.

You can hardly tell that the pipes are made from copper! A scary demonstration of why you should always use an inhibitor in your coolant system, and flush it every sixth months.

3. Chemically dipping the cylinder block to remove the embedded corrosive deposits.

Unfortunately, I don’t have a before and after of this process, yet I can tell you that the difference was night and day!

On the suggestion from Alpine Eagle, Steve took the block to Malmesbury Metal Strippers and Cleaners, who chemically cleaned the cylinder block for me to remove all of the rubbish from the block. This process took a number of days yet provided a new lease of life for the block. A very cost effective job costing just over £200.

4. Boring out the cylinders to take new sleeves and pressing in new sleeves

Before the machining job, we had the imperative decision of whether we should bore out and fit oversize pistons, or sleeve the block and go back to standard size pistons. Before the procedure, my engine block had been machined to +0.030” by Brunts of Silverdale in 1991.

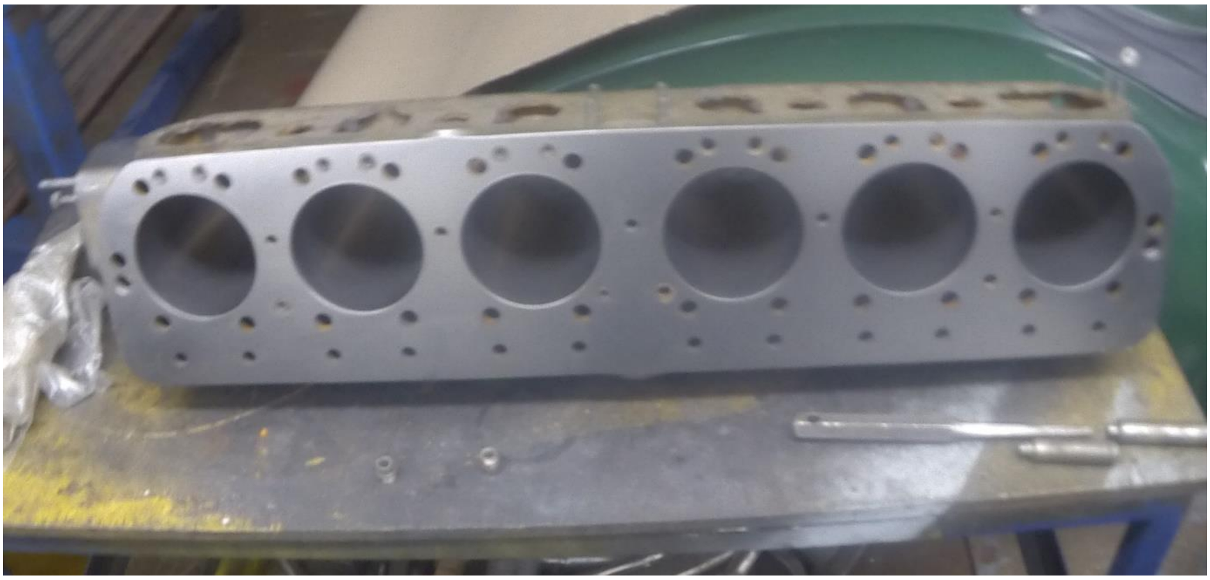
With this in mind, we evaluated the availability of larger pistons, as well as the effect of an even greater bore size in the engine. Increased bore size would give me greater power and torque, yet if another rebuild was required in future I would have to sleeve the bores and go back to standard.

Eventually, we decided that the best idea was to re-sleeve the bores back to the original size for a number of reasons. Firstly, a sleeved block ensures that the block will last longer because you can always take away more sleeve metal if another rebuild is required in future. Furthermore, the sleeves ensured that we did not affect the structural integrity of the block, because we were not sure of how much cast iron we could remove before having too little material; the consequences of this may have been catastrophic because thinner metal is more likely to deform and cause failure again.

After this decision, I found a full set of aluminium pistons on eBay for £450 which was an absolute bargain if I say so myself. They were new old stock, had a complete set of rings and were Hepworth Solid Skirt pistons, which were the recommended pistons for none other than Hythe Road in the 1960s and 70s.

Once the pistons were obtained, we acquired a set of liners from Thorntons in Telford then went to Paul Gardias of Gardias Engine Services, Witney.

Paul machined out the bores, pressed in the liners, then matched the pistons to the liners ensuring a tight fit with the piston rings in place. He did an excellent job and this process was completed for under £1000. An image below shows the freshly machined block and you cannot see that sleeves have actually been pressed into the block.



5. Fitting the new copper tubes into the water jacket

To guarantee that the reconditioned block was watertight, the next step was to swage new copper tubes into the block. These copper tubes are the only seal between the head studs and the water jacket within the block, so the upmost of care must be taken to carry out this work perfectly.

For a perfect watertight seal, we took each individual tube and used sandpaper to ‘key’ the ends (about half an inch up each tube) to obtain a rough surface for the Loctite to adhere to. Next, we keyed the apertures which the copper tubes sit in within the cylinder block, for the same reason as before. You just cannot afford for any water to get past these tubes otherwise your engine will destroy itself.

Alpine Eagle very kindly lent us their swaging tool for the tubes, which enabled us to perform the operation correctly. Firstly, we covered both ends of the tube with Loctite 542 (Pipe Sealant), then placed the copper tube into roughly the right place such that there was an equal amount of copper protruding at each end of the block. We then hammered the tubes at each end with the conical tool seen in the photograph above to press the ends into the cast iron. This was repeated until there was no visible gap between the copper tube and the cast iron block. Then, we swaged the tube into the block with the swaging tool. This was completed by hand and feel, until a good seal was felt, and a visible tight fit was observed.

6. Pressure testing the water jacket

Once the block was rendered water tight, we had to ensure that the engine was capable of holding its water, and also that the block was not cracked or damaged in any other places. This process was completed at Gardias Engine Services, and Paul ensured that the block was watertight. The only issue we found was a pin head sized hole at the rear of the block.

This was no matter because there lay a very simple solution. Richard drilled out the hole as to open the aperture, then we fed in a large rivet and angle ground it down to become flush with the rear section of the block. We then applied liquid metal around the rivet head, and leak tested the seal by applying water over the rivet head and blowing air at 20 psi around the inside of the rivet. There were no bubbles present, so the rivet fitting was deemed satisfactory.

If you come across a hole in the block, never be tempted to weld it. Severe changes in heat can cause catastrophic damage to a cast iron block and it will only be good for holding wine bottles, rather than 6 aluminium pistons.

7. Ceramically sealing the block to ensure that the porosity of the cast iron is reduced as much as possible

Once the block was rendered watertight, we took it to a company called Ultraseal in Slough. Ultraseal specialise in complex sealing projects for various engineering companies. It was Alpine Eagle’s recommendation to take the block to them, to reduce the risk of porosity.

Porosity is the microscopic spaces that occur between atoms within a given substance. In a cast iron engine block, the rapid movement of warm water under a fair amount of pressure, i.e. above atmospheric pressure, can find its way through the Fe atoms and leak. To the naked eye, this would appear as a light bubbling. Over time, this can cause rust if the engine is not regularly used and eventually results in severe corrosion making an engine unserviceable.

To mitigate this risk, Ultraseal apply a microscopic layer of ceramic seal which coats the inside of the cylinder block in the water jackets. This seal covers the cast iron which, in theory, should provide a barrier between water and the metal. Upon the application of ultraviolet light, one would be able to see the ceramic coating.

This is not an imperative step but I would highly recommend it if you are seeking the perfect standards of Sir Henry.

Jobs completed in the meantime:

Identifying, sourcing and buying parts

This process took many hours indeed, along with research, phone calls and inspections. My main concern was that the engine would be returned to exact original specification, therefore I needed to source the highest quality parts on the market, regardless of the cost.

The best method I found, was to take pictures of the parts that I required and send them to the parts seller, to ensure that what I would be receiving would be exactly the same part as expected. Rolls-Royce engines run on very fine tolerances, so having an incorrect thickness of gasket, for example, could lead to catastrophic damage.

Be prepared to travel great distances to find what you need. I took many a journey between home and Fiennes, as well as quite a few trips to Alpine Eagle to ensure that what I was putting back together was correct, and to diagnose parts that needed changing such as the high speed jet on my carburettor, an essential part for solid, economical running.

This was the one area of the rebuild where I was happy to spend money, as there is no worse feeling than being uncertain of a parts condition when you are running the engine at fast road speed, because you will be on tenterhooks expecting the worse.

The rebuild of an engine should inspire confidence and allow you to focus on the driving rather than the condition of a vehicle. Do not try to save money here, you will regret it.

Clutch rebuild

Seeing as the clutch and flywheel were apart, it seemed an appropriate time to change the clutch linings and renew the clutch system, such that it would not need changing in the near future. If you had the flywheel off in situ, this job takes no longer than 4 hours. If the engine and gearbox are in the car, this job would take 2 days.

A clutch rebuild for any single plate, dry disk type RR clutch is straightforward and does not require a great deal of skill; just patience and a little bit of willingness to learn. Firstly, I had to strip and remove the old linings from the driven plate and the rear plate, as well as inspecting the steel disk for wear.

To take the clutch apart, one must remove the 8 large bolts which sit on the rear of the flywheel. You will need an impact driver to remove these bolts as they will be incredibly tight. They sit above stiff springs which enable the engagement and disengagement of the clutch mechanism. Essentially, when you press the clutch pedal, each clutch finger is acting against two springs, which equalises any undue vibration.

Once the large bolts have been removed, the rear plate of the flywheel will come free. You will be able to see the steel driven plate and it will be surrounded by clutch dust. Always assume that this dust contains asbestos, and make sure you take the correct precautions to remove it. I sprayed the dust with WD40, wore goggles, gloves and mask and hoovered the dust.

The steel plate can be easily lifted up and will reveal the lining on the crankshaft side of the plate. This lining is held in place by 8 nuts which screw onto 8 adjacent studs which sit in the flywheel. Once removed, the assembly comes out as a plate.

When you have the two linings free, one must drill out all of the copper rivets from the linings. This is a rather fiddly job and will take an hour or so to complete. Upon removal of the linings, I cleaned the two carrier plates and rubbed them over with wire wool to remove any traces of rust and corrosion.

The next task was to inspect the driven plate. To do this, we placed the plate on the lathe and placed the nose section in a 3 jaw chuck on the lathe. We slowly engaged the lathe and ascertained that the driven plate was balanced and that each section was offset from the former. This is crucial because it helps the two clutch linings to bind which is what you feel when the clutch 'bites' at the top of the pedal throw. If the sections were all aligned to create a flat face, the clutch would engage very aggressively making a most uncomfortable engagement and would over stress many components within the drive train.

You will often find 'bluing' on the faces of the driven plate. This is a design flaw within the Royce clutch because it overheats rapidly during the process of transmitting drive from the engine to the gearbox. The heat remains within the clutch and, in some cases, will rip apart the linings and distort the thin and flexible driven plate.

To renew the linings, one will need a setup as below:

You will need three tools; a hammer, a wide faced centre punch and a thin faced centre punch, each with the ends ground down to a flat finish rather than a spike. To tap in the rivets, one places in the copper rivet such that the larger face is resting on the wide faced centre punch. Then, you tap the thin faced centre punch onto the narrow end of the rivet until the copper has been peened into the face of the cast iron carrier. Remove the plate and lining from the setup and ensure that the lining is flush to the carrier and that the rivet is tight. Repeat this process until all rivets are replaced. Fiennes will very helpfully send you the correct amount of rivets.

Below is how a completed lining should appear:

This is the lining from the flywheel carrier. It is imperative that the copper rivets sit correctly in the depressions of the lining otherwise your clutch will not work properly and the lining will disintegrate.

Cleaning the crankshaft oil catchers

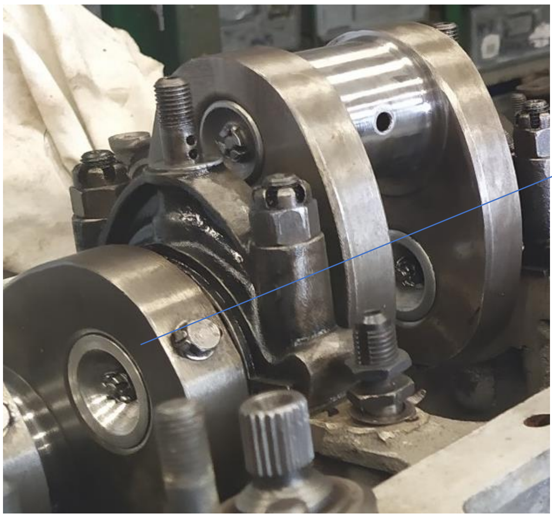
Before the addition of full flow oil filters, early cars relied upon centrifugal force to remove the impurities and contaminants from engine oil. Goshawk engines rely on sludge traps within the crankshaft to remove said contaminants and it is therefore essential to clean these traps when completing an engine rebuild. I would highly recommend following this process if you have recently acquired a pre-war RR, regardless of known engine condition. You will save yourself time and money in the long run whilst having the confidence that the oilways in your engine are clear and free of dirt.

To clean these, I used a pot of cellulose thinners, a large and small diameter paintbrush as well as compressed air at the end to blow out the remaining sludge that remained. This process requires no skill whatsoever other than applying the cellulose thinners to the contaminated sludge traps.

I plead you to be methodical in this process, so start from one end and work to the other. Carefully remove each trap, clean the cavity in the crankshaft as well as the trap itself and the long bolt that holds the two traps together. Renew the washers on either end of the bolt then lock the castellated nut in place with a cotter pin. Select a size of cotter that fits snugly through both the nut aperture and the bolt aperture, then wrap both legs of the cotter around the castellated nut. It is very handy to have a pair of long nose pliers for this job, preferably with a slight shoulder on them to get to the tricky bits.

After you have cleaned all of the sludge traps out and blown them out with compressed air, one needs to remove the nuts on the counterweights and drill out any built up oil from here. Further, if you have the big end bearings removed, I would advise you to drill out the oil holes in the journals. This is imperative because any slight starvation of oil flow to these journals will cause rapid bearing wear and greatly increase the risk of a bearing picking up.

It has been recommended to me by many fellow enthusiasts that one should fit a ‘full flow oil filter’. Not only does this help to rid the oil of its contaminants in suspension, it also allows you to run your car on multigrade oil which will permit improved oil flow at start-up as well as better oil pressure when the car is hot. This filter also increases the interval of sump-off cleaning you should carry out; from 10,000 miles with no filter to 20,000 miles with the filter.



This is one of the many crankshaft sludge traps. It's job is to catch the thick and heavy oil contaminants which pass through the drilled oil holes on the crankshaft journals.

Distributor strip and rebuild

For this process, I followed the instructions outlined on Stephe Boddice's website. This is a 2 hour job and requires stripping down, cleaning and putting back together. If you are a stickler for authenticity, I would advise you to purchase an original type 'pocket condenser' from Ristes to replace the rather ugly modern barrel condenser modification that exists upon many Goshawk engines. If you are to insert the original condenser, be sure to re-wire the ballast resistor back into your ignition circuit.

Oil pump strip and rebuild

For this process, I followed Stephe Boddice's instructions once more. My oil pump was completely overhauled by Brunt's of Silverdale in 1991 and was in perfect condition. I rebuilt it on the premise that it should be perfectly clean and I wanted to verify my knowledge of the oil flow system on the Goshawk engine.

The pump design itself is another stroke of Royce's genius. It contains two straight cut gears meshing with each other, thus pumping the oil through the engine. One must remember in fluid dynamics, a mechanical pump pulls liquid around a system rather than pushing it, just the same as a pump within a central heating system.

In this case, the oil pump pulls the oil from the gauze filter via the suction pipe, and this effect of fluid movement causes the oil to flow from an area of high concentration to low concentration around the engine. The oil flow that is produced by the pump is proportional to engine speed, because the pump is directly driven from the timing gears.

On the Rolls-Royce oil pump, one can alter the oil pressure applied by the pump by placing a specific amount of 5 thou stainless steel flat washers beneath the pressure relief valve. This valve opens a spring loaded aperture which permits oil to the timing gears as well as the cylinder head. To ensure a healthy flow of oil, resting idle oil pressure, when hot, should be 10-12 psi and over 15 psi depending on gear, road speed and engine rpm.

Crankcase Cleaning

While I was away at University, Steve Webb at Manor Garage very kindly cleaned the crankcase for me. He used an industrial steam cleaner, then blew the crankcase with compressed air to remove all water droplets. After this, Steve applied a solution of domestic surface cleaner onto the aluminium and applied it with a fine Scotchbrite pad. This produced a marvellous period-looking finish without being polished to the nines. After this, he applied a ceramic coating to repel oil and water deposits to keep the crankcase clean when in service.

On the inside of the crankcase, Steve used cellulose thinners to remove all traces of oil and carbon, then blew this out with compressed air and finally wiped over with a clean cloth. After this, he used a razor blade (single edge with a stiff blade) to remove the remaining old Wellseal and gasket material from the surfaces of the sump and crankcase. This job took 2 hours to complete.

Oil Sump cleaning

When the sump came off the engine, there was not too much sludge and carbon build up present because my grandfather changed the oil in the engine regularly. I can't emphasise this point enough if you do not have a modern oil filter fitted in the engine.

When taking the gauze filter out of the sump, be sure to mark its operating position because the outlet holes at the bottom of the filter lead into the suction takeaway pipe in the sump. If you orientate the filter the wrong way, the suction pipe will be starved of oil and the oil will not flow around the engine.

Once you have the filter out, it is worth dismantling the cork float level and renewing the cork floats. Meanwhile, the best way to clean the sump is to half fill it with either cellulose thinners or paraffin. Use sufficient eye protection and gloves, then gently dislodge all of the oil deposits from the sump. This should not take any more than half an hour to complete.

When cleaning the filter, I would advise a complete strip of the filter, and let it sit in a pot of cellulose thinners for an hour to completely dissolve all of the sludge that forms at the bottom of the filter. This is a point to note for general maintenance too; always make an effort to clean out the metal fitting at the bottom of the filter, because this is where all of the crud in the oil is dropped and amasses during general engine operation.

Painting the block upon return

Once the block was returned from having all of its specialist engineering work complete, I painted the block in a heat resistant, semi-gloss black paint. Painting is important because it will reduce the risk of surface corrosion that can form on a cast iron block, and is also visually appealing when lifting the bonnet to show off your latest project!

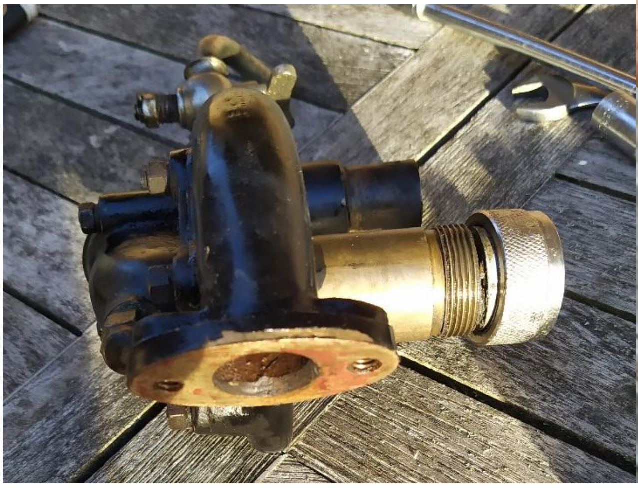
To paint the block, I masked up all of the nooks and crannies then I lightly keyed the surface with 400, 600, 800 and 1000 grit sandpaper, rubbed down with sugar soap then applied three coats of paint, with the same process applied to the water jacket covers and the tappet chest covers.


MADE
IN

Water Pump Rebuild

Another job to complete was rebuilding the water pump, to ensure that it would deliver the crucial coolant flow to the reconditioned block for many years to come. This job took me about two hours; a very straightforward job which was mainly focussed on stripping out congealed water pump grease from the main driving shaft which has the impeller attached on the end of it.

I also stripped and cleaned the nickel plated spout and drain tap assembly directly below the water pump. I cannot stress how important it is to ensure that the valve moves freely and that the spring which retains the tap is free from gum, well lubricated and operational. When my engine blew up, all of the steam was extinguished out of this nozzle, which allowed the high pressure steam a safe passage out of the coolant system. Had the drain tap valve been seized, the engine block would almost certainly have self-destructed due to the immense pressure that steam exerts within a confined space.





This central wooden 'stop' is made from lignum vitae, which is the densest wood known to man. It has self-oiling properties, which is why Royce used it to allow the impeller to spin against it.

Rebuilding process:

Main bearing nip

The first job to complete when reassembling any pre-war engine is to ascertain that the crankshaft will run perfectly within the main bearings that retain it. In a Rolls-Royce six cylinder engine, the crankshaft runs in seven main bearings, which was a stroke of genius by Sir Henry Royce.

On very early six cylinder cars, engineers had significant problems with smoothness and rigidity. Sir Henry quickly realised that the crankshaft required rigidity and strong supports to resist its natural tendency to flex under the extremely high torque that his engines produced. One method to counteract this was to place more main bearings in the crankcase to run the crankshaft in, which substantially reduced the risk of flexing and cracking within a crankshaft.

However, when a crankshaft runs in as many main bearings as this, the theoretical centre of axis that the crankshaft turns about must be in exactly the same position within every main bearing otherwise the crankshaft will pick up one of the bearings leading to engine failure. This process is covered by line boring, although main bearing nip is the very first part of the process that you must check.

Main bearing nip is a process, rather than a procedure, which ensures the white metal bearing shell will not slip inside the bearing housing. It is a very complex process to understand, but it is straightforward to check. In layman's terms, the total circumference of the bearing shell must be slightly longer than the total circumference of the housing. To raise the circumference of the white metal shells, two nip plates are placed between the faces of the pair of bearing shells. These plates apply a compressive force into the bearing shells, resulting in the bearing shells literally pushing themselves into the bearing housing. This force must not be too low, otherwise the shells will rotate about the crankshaft when torque is applied to the big end of the crankshaft. If the compressive force is too large, the bearing shells will be under very high tension and may crack or disform under load.

To check your main bearing nip, follow exactly the procedure set out on Stephe Boddice's website (http://www.boddice.co.uk/bpic2558.html). You will not go wrong and he succinctly explains how to check it. If you do not have the desired clearance and you need to increase the gap above and below the nip plate, one has to accurately file away the top of the plate until the correct specification is achieved.

Every single main bearing was within specification, so we could proceed further without having the main bearings white metalled and line bored.

Checking bearing wear

After we had checked the main bearing nip, the next job was to check both the main bearing shells and big ends bearing shells for wear. To check the big end bearings, Richard and I visually inspected each bearing surface and ran our fingers over the surfaces to ensure that these were not heavily scratched or damaged.

White metal bearings can often disintegrate if they are very old and the appearance will look as if someone has chipped the surface away with a fine screwdriver. If you see this, then unfortunately you will need to have your bearings re-metalled. Furthermore, if you know that the bearings are particularly old, then it is worth refreshing them.

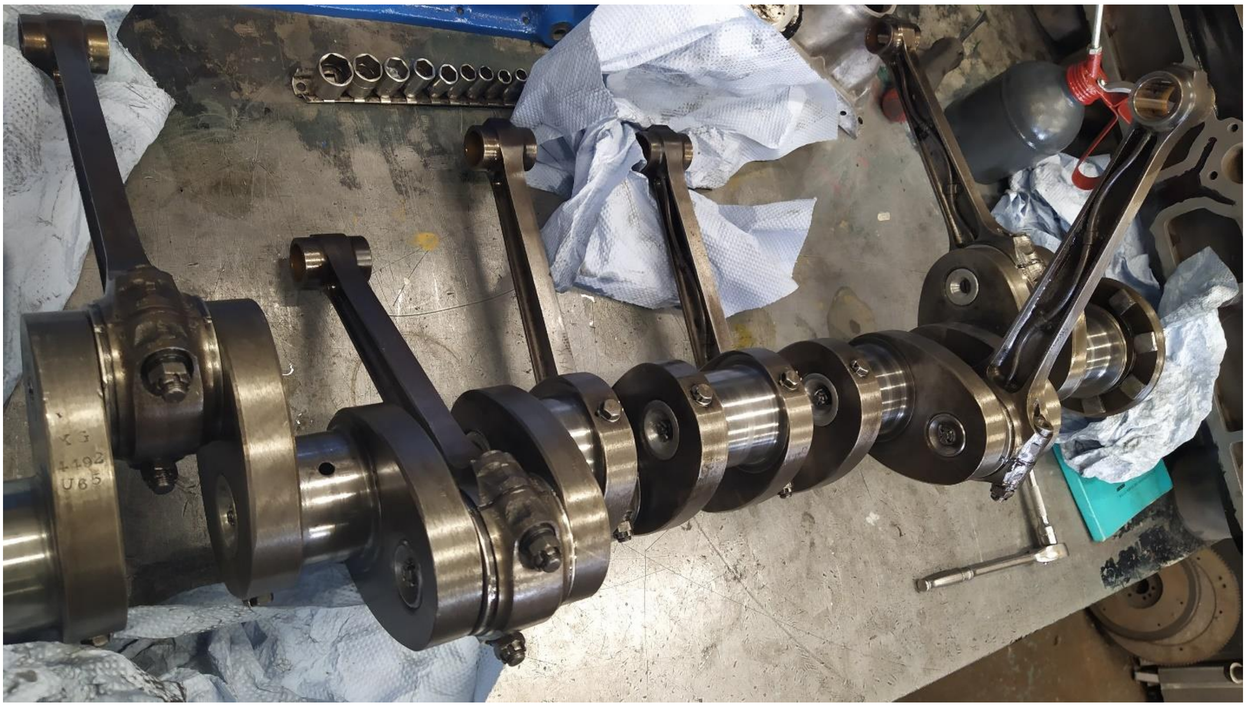
Brunts of Silverdale rebuilt Y6K in 1991, and they completed all of the white metalling on the main and big end bearings. As my engine had only completed 14,000 miles since then, the bearings had negligible wear. This was tested with a bore test indicator and comparing the internal diameter of all bearings. We also were very fortunate in that some of Richard's customers are advanced engineers, and they inspected the bearings to reassure us that we could proceed with them.

Checking big end freedom on crankshaft journals

Before placing the crankshaft back into the crankcase, Richard and I needed to check the freedom of the big ends on the crankshaft journals. We placed all of the connecting rods onto the crankshaft, then lifted this assembly between two pieces of wood.

Once lifted, we literally turned each conrod through 360 degrees, both clockwise and anti-clockwise, to ensure that there were no tight spots or imperfections on the rotating surfaces. We found that the conrods were stiff but once moving were smooth and felt like a tight fit, so we were very pleased with this.

The final check was to ensure that we had a clearance between the journal webs and the outer bearing faces. If there is no clearance, rubbing will occur which could damage the outer face of the bearing and lead to further failure on the inside running surface of the bearing shell.



What I found fascinating was the presence of the original fitter's stamp on the far left journal web on the crankshaft, which reads "XG 4492 U65". My guess is that XG is the initials of the machinist, but not sure as to what the other two numbers could mean. On an unrelated note, some later 20/25s and Derby Bentley's have extra weights added to some of the journal webs to increase torque and rotational balance. The crankshaft weighs about 25 kilograms or half a hundredweight in old money.

Fitting and securing the crankshaft into the crankcase:

After we had checked the big end freedom, we carefully removed the six conrods from the crankshaft. We placed the clean crankcase on a set of 4 wooden blocks, to avoid damaging the aluminium on the crankcase, then ensured that all of the surfaces on the crankcase were clean and free from debris.

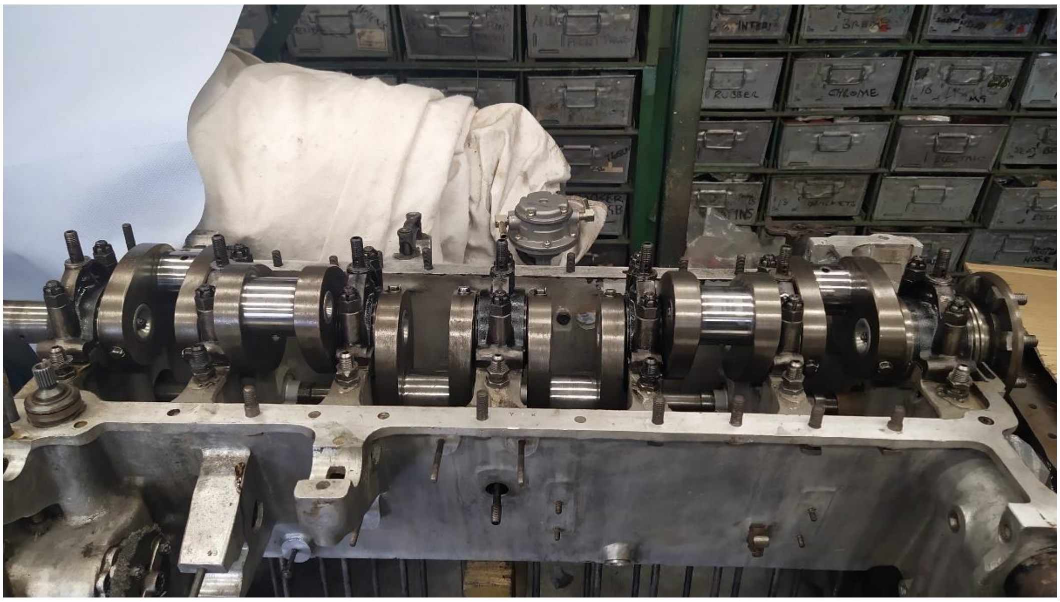
Following this, we fastidiously placed the lower main bearing shells onto the main bearing holders on the crankcase. This is a critical part of the rebuild because one must ensure that the shells are not only placed in their corresponding positions, they must be orientated the correct way. This is made easier as Rolls-Royce stamped 1-7 across the oil galleries in the crankcase, with a square box, bearing number on the top and reference number below. In this case, my reference was "R49". When holding a main bearing shell, you will see a number stamped onto one of the top faces where the shell is split. This number should be orientated in the same way as the number on the oil gallery.

Once you are sure that you have positioned the main bearing shells in the correct place, ensure that the bearing shells are secure and fitting well within the holders. Subsequently, rub a small amount of Graphogen assembly paste onto each bearing shell. Then, with two people, lift the crankshaft and place it onto the bearing shells, verifying that the crankshaft is orientated the correct way.

After the crankshaft is laid onto the shells, place the shims onto the top face of the lower shells and pull through the securing studs. These studs are machined to have a larger diameter around the mid-point of the bearings, such that they are secure and will not twist under load. Next, rub more Graphogen onto the upper bearing shells faces then place the caps onto the corresponding bearings. Once again, it is essential that these caps are fitted into their correct positions.

The final part of the process is to secure the caps down onto the main bearing journals. Work from the middle outwards, as the central main bearing, number four, is 1.5 times wider than the other main bearings. This will also assist in settling the crankshaft as you systematically tighten it down to specification, or lack of! Work from number four outwards and tighten down the bearing caps gradually. Do reference Stephe Boddice's website for the recommended torque settings; it is well known that Sir Henry banished the use of torque settings and instead relied upon the skills and feel of his mechanical fitters.

You may be very alarmed to find that the crankshaft will not rotate after this – not to worry, all will be explained!



View of the crankshaft secured in position.

Fitting the flywheel to the crankshaft

It is vital that you have a completed clutch assembly before progressing any further with the rebuild. At this point, you will need to attach the entire flywheel onto the crankshaft, and it will be very fiddly to work on the linings once the assembly is mounted to the crankshaft.

The flywheel is very heavy indeed, my estimation is that it is at least 50 kilograms or 1 hundredweight. As you load the flywheel onto the crankshaft, this will inevitably bend the crankshaft very slightly, this slight bend will set the crankshaft straight and you will now be able to turn the flywheel. Don't be fooled into thinking that it should be easy to turn, it will be stiff and require a lot of torque to overcome the inertia of over 70 kilograms.

There is a spigot bearing within the mating end of the crankshaft, do make sure that it is serviceable and rotating smoothly before placing the flywheel onto the end. There are 8 bolts with square headed ends to retain them in place. When tightening the nuts onto these, follow the process as if you are tightening a modern car wheel into place. Work on diagonals and progressively such that the two faces sit perfectly square, thus the engine will run without undue vibration. Once completely tight, i.e. red face tight with a tweak, peen over the ends of the bolts to lock the nuts into place. You could also use Loctite for this and peen, which is how I tightened the nuts into place as a fail-safe.

After I secured the flywheel and knew it was turning freely, I secured all of the main bearing castle nuts into place with cotter pins. The correct, Rolls-Royce method to secure these nuts is to twist the cotter pin, place through the castle nut, and twist both legs around either side of the castle nut. From the picture, you may notice that I utilised a different method which involves pulling one leg of the cotter pin over the top of the castle nut and one leg wrapped around the castle nut.

The crankshaft and flywheel now fitted together. If there are any tight spots in rotation, this is where you need to address the issues, which will most likely be a bearing pinching due to incorrect bearing nip calculations. Do not fit the oil pipes onto the main bearings until you are convinced that the assembly rotates perfectly. Please see my video on Goshawk Engineering to see how the flywheel should rotate.

This setup is so beautifully machined, and it is this extra detail which helped the engines to run so smoothly and reliably.

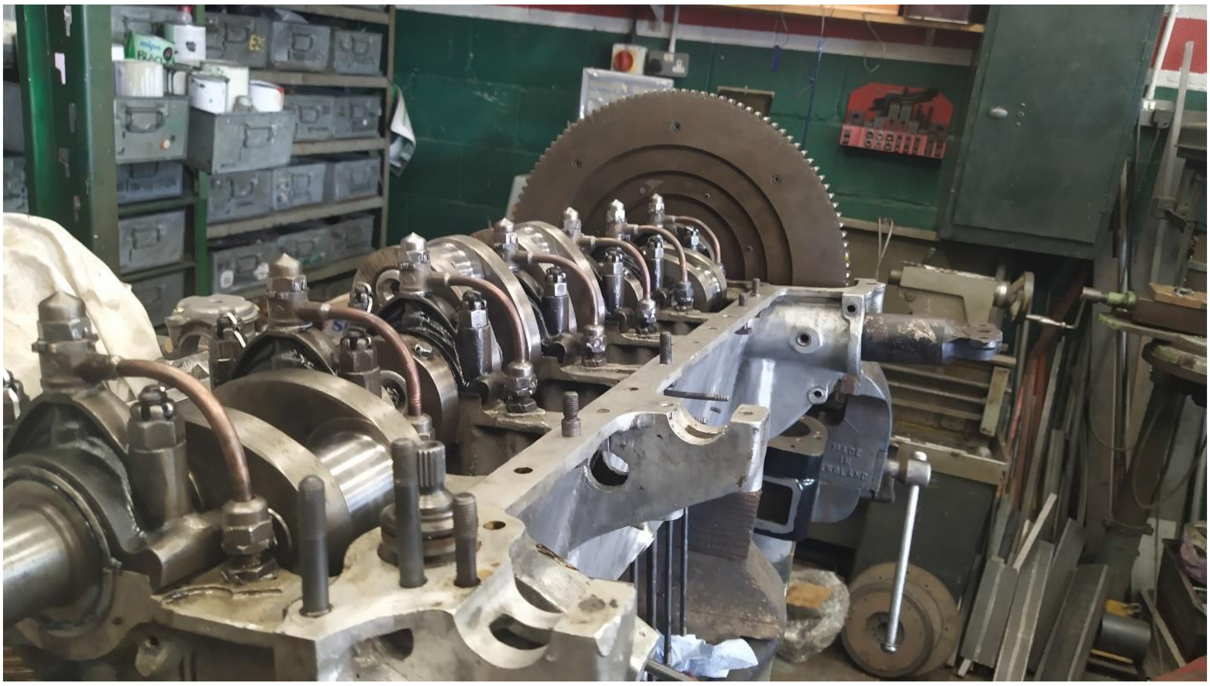
Replacing the main bearing oil feed pipes

At this stage, you will need to replace the copper pipes back onto the main bearing feeds. These pipes deliver pressurised oil into the main bearing shells, therefore their cleanliness is imperative to achieve desired operating smoothness. There are 7 caps which have a conical structure and they hold the delivery pipes into place as well as catching any sediment which occurs during engine operation. When carrying out a bottom end de-coke, I would highly recommend removing these caps and cleaning them because they fill up with a treacle like consistency, and you need to avoid this blocking the drilled oil passages and contaminating the main bearings.

I placed the pipes in a pot of cellulose thinners, and blew through them clear with compressed air, then used a very small pipe cleaner to remove any grit and built up carbon. Once I cleaned the pipes, I checked the integrity of the soldered joints as well as their oil retaining properties.

I had to resolder two of these pipes, so I used a brazing iron, plumbers flux and silver solder. It's a hassle to get the joint correct but again, you must ensure that the joint is leak proof and strong such that the maximum amount of pressurised oil reaches the bearing. Leave the joint to cool for 90 minutes, pressurise with air and check that it does not leak.

Once content with the condition of the pipes, fit them to the main bearing caps, and use a full set of new tab washers to lock everything into place. This is a highly overengineered set-up, but it does minimise the risk of oil starvation to the main bearings.

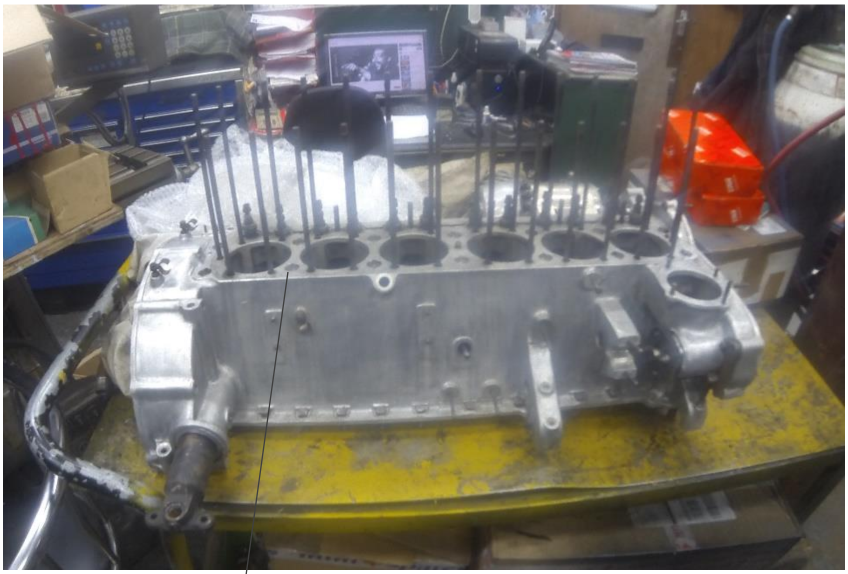


Main bearing oil delivery pipes fitted, with the caps tightened down.

Placing the block onto the crankcase

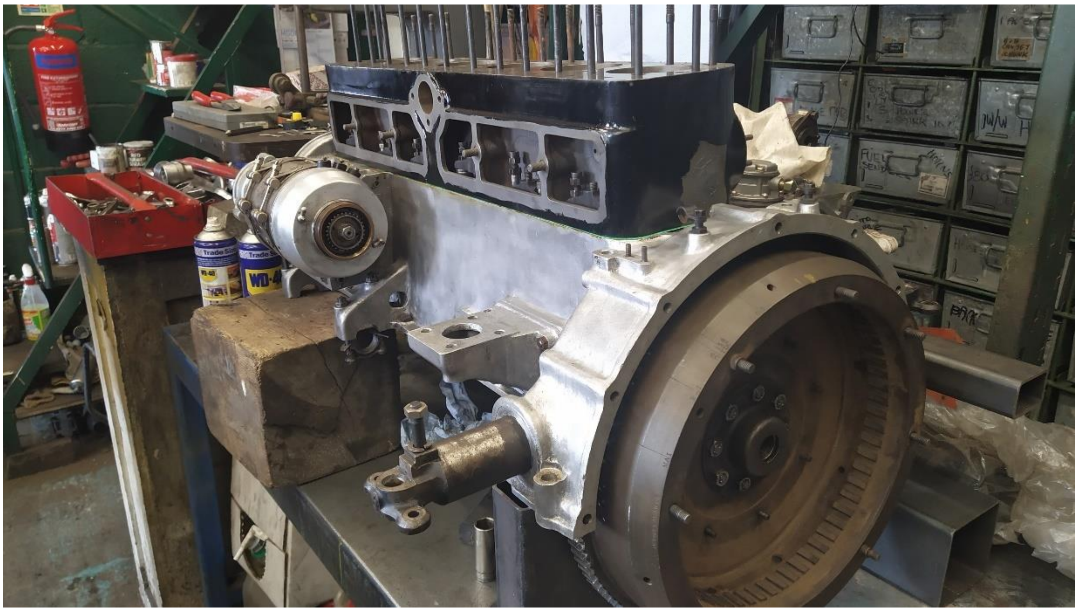
At this stage, we flipped the assembly through 180 degrees such that the studs were vertical. You must sprag the flywheel and ensure that the oil feed pipes are clear of any obstacles, to avoid damage. Richard and I placed the block on wooden V supports and used two metal blocks on the engine bar supports to ensure a firm base.

When the crankcase is in the standard position with the head studs facing the ceiling, we scrubbed the top surface as below:



Prepare this surface with a razor blade to remove any old gasket material, then place a layer of Wellseal with your finger over all of this flat surface, before gently lowering the 'crankcase to block' gasket down on top of the Wellseal you placed with your finger.

Next, orientate the block such that the fan support aperture is above the nose of the crankshaft, then lower the block gently and evenly onto the crankcase. Personally, I used four steel tubes and secured nuts above them, such that there was an even pressure applied to the joint and it would subsequently seal correctly.



Rear view of the block lowered onto the crankcase.

Frontal view of the block lowered onto the crankcase. It is here where one appreciates the physical depth of the engine.

Preparing the con rods

There are a number of points that you have to check on the conrods before assembling the engine any further. Firstly, you need to check that the conrods are straight, not twisted and not cracked; this is highly unlikely as they are a formed from a single piece of cast iron, so in fact hark back to R's locomotive days.

The second point you need to check is that the oil pipe that runs up the piston is riveted down securely, and is clear from dirt and debris. This pipe delivers pressurised oil from the big end bearing up to the little end and gudgeon pin. The small horsepower engine is known to develop little end knock on high mileage cars, and it is usually due to a blockage within this little end oil delivery pipe.

This wavy pipe is the oil pipe that delivers the oil to the little end of the piston. It is secured in 3 places with clamps that are riveted in position, and you must check that these rivets are secure.

Once you know that this pipe is clear, you must ensure that all of the oil cavities in the con rod are clear. Finally, you should pressurise the pipe and ensure that air does not leak from it, otherwise you will need to rectify this here.

Fitting the gudgeon pins and pistons to the conrods

To fit the pistons onto the conrods, you will need a bucket of boiling water, 12 circlips, 6 gudgeon pins, a socket and bar that have the same diameter as the gudgeon pin and a set of long nose pliers. This is a two man job, due to the fiddly nature of the work.

Whilst the gudgeon pins and pistons were heating up in the water, Richard and I orientated the conrods in the correct position, and carefully laid them out on a clean working surface. The conrods need to be positioned with the oil pipes facing the centre of the engine. On cylinders 1-3, the oil pipe faces towards the flywheel, and on cylinders 4-6, the oil pipe faces towards the nose of the crankshaft.

Once you have these correctly orientated, you must ascertain how to position the piston onto the conrod. On the oil scraper ring shoulder, there are square and circular holes cut into the recess. The circular hole must face the camshaft side of the block and the square cut hole must face the carburretor side of the block. These holes regulate the amount of oil that flows around the piston as the oil scraper ring pushes and pulls the oil in the bore.

Hold conrod number one, with the oil pipe facing your right hand. Take the gudgeon pin and knock it through the centre of the piston until it is home and you can see the circlip groove on either side of the pin. Align the circlip within the hole then allow it to spring into the groove; you should be able to twist the circlip through one complete rotation without it going stiff, otherwise you have not seated the gudgeon pin correctly.

We completed this process in about 1 hour, then left the pistons to cool before checking the circlips again.

The pistons resting on the bores. Notice how the drilled holes all face towards the camshaft side of the engine. Note the depth of the pistons, this assists with the enormity of the torque that this engine produces.

Piston ring spacing within the bores

The original piston ring gaps are actually far too tight and do not allow for the much larger expansion of materials due to the higher temperatures incurred during internal combustion, which is a result of using much higher octane fuel. Therefore, the modern rule of thumb is to apply 0.004” ring gap per inch of bore. On a 20/25, the diameter of the bore is 3.3 inches, therefore we applied a ring gap of 0.0132”.

To set the ring gap, place the ring into its desired bore, then with a feeler gauge, measure the gap between the two ends of the piston ring; either remove the ring and file off material or if the gap is correct, place it up and down the bore to ensure the gap is even throughout the bore. You will also do yourself a favour by ascertaining that the block was machined with the correct parallelism. This is a very tedious process, although once correct, you will be rewarded with an effortlessly smooth and balanced engine, as the compressions will be near enough identical.

Piston ring alignment on the piston

As with most parts of an engine rebuild, the positioning of piston rings on a piston and where they sit within the cylinder is a much debated topic. Once again, if you search this on the internet there are a myriad of differing opinions, so it is best to follow common sense and the laws of physics.

If you were to view the engine from the nose of the crankshaft, it turns over in a clockwise direction. When a charge is fired by the spark plug at the top of the cylinder, the gas force is applied to the top face of the piston, which drives the piston down the bore. This force is applied to the connecting rod which is driven down through the bore, and exerts this force to the crankshaft which means that the linear motion of the piston is converted to rotational motion of the crankshaft.

When this downward force is applied, an equal and opposite force is applied up the connecting rod which forces the piston into the left hand cylinder wall. Furthermore, the force of the explosion from combustion forces the piston down the bore, with the thrust applied down this left hand face of the bore.

With this in mind, it is a good idea to not place any ring gaps on this thrust side of the cylinder. Therefore, Richard and I placed the ring gaps around the non-thrust side of the piston, whilst making sure that no gaps were directly above or below each other. As there are 3 top rings, we placed these ring gaps 60 degrees apart, with the oil ring gap placed in another gap.

N.B. Never place the ring gaps above the gudgeon pins, as this can lead to gas blow by, which will glaze the bores and render the cylinder useless.

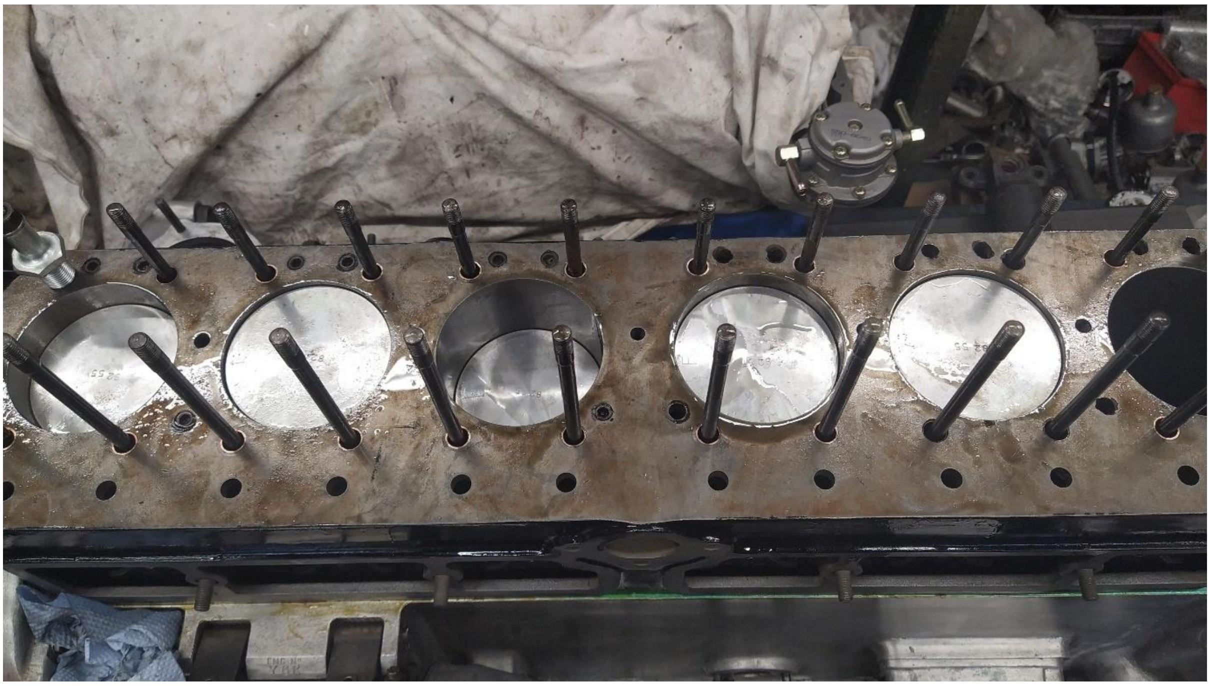
Dropping the pistons into the bores (and a broken piston ring!)

When the piston ring gaps are correct, you can prepare your cylinders for taking the pistons. You will need a piston ring compressor that matches the diameter of the bore and also, use a compressor that has two bands, otherwise you will snap a piston ring!

To prepare the bores, liberally apply oil around the whole of the cylinder, and rub it in with your fingers, following this, apply a generous amount of oil around the piston, and on the inside surface of the piston ring compressor.

Place the piston and connecting rod assembly in the desired bore, then clamp the top of the piston with the ring compressor, being careful not to twist it which could lead to the piston rings being misplaced. Put the compressor on the top of the cylinder, strike the top edge of the compressor with a rubber mallet until it sits firmly within the cylinder. With the handle of the mallet, apply a light force to the top face of the piston and it should slide neatly into the bore.

Richard and I followed this process for all 5 pistons, as a piston ring snapped on the first piston we attempted to fit. The piston went stiff and we were very worried that it may have damaged the inside surface of the freshly honed cylinder. Luckily, the ring had snapped within the compressor, so after a quick call to the chap we ordered the pistons from on eBay, we had all 6 pistons in their respective cylinders.



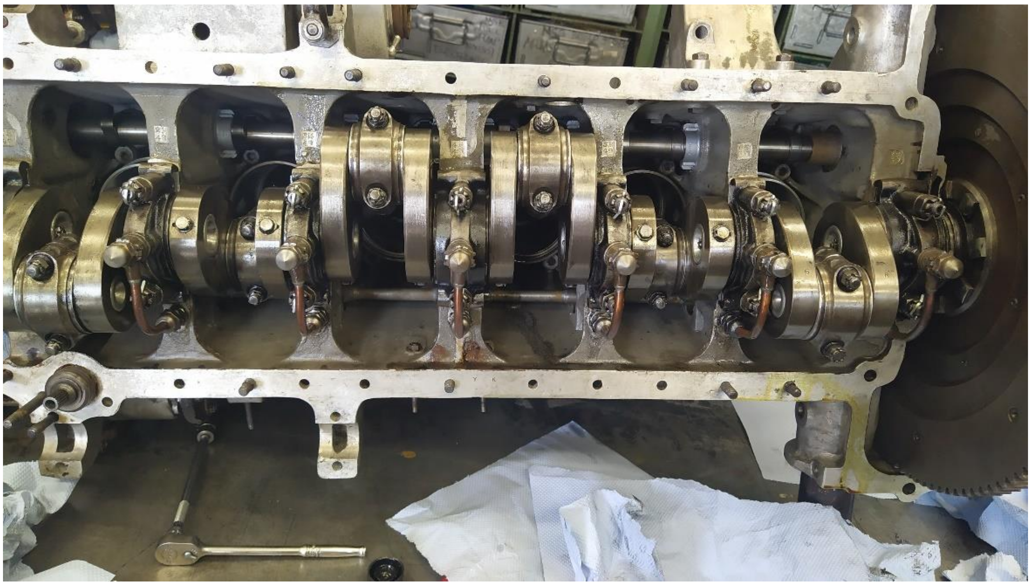
The view of the fitted pistons within the cylinders, a real sense of progress was felt here.

Fitting big end bearings and shims to the con rods

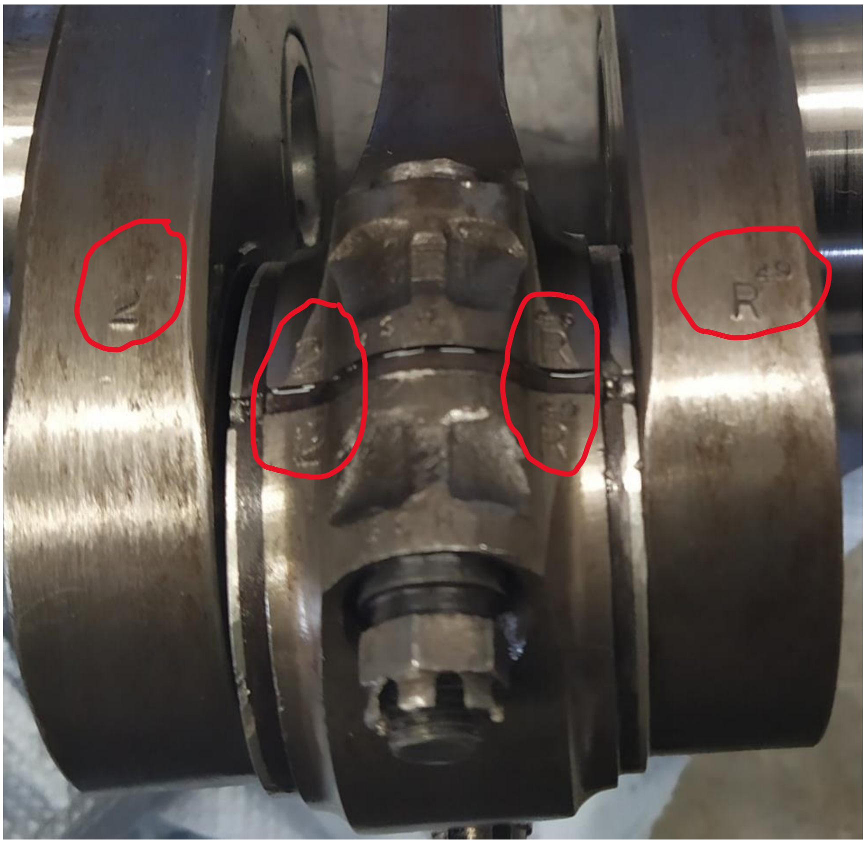
Realistically, this process should be followed after fitting each piston into the cylinder. Once the piston is sitting in the bore, guide the piston down gradually until the two big end bearing cap securing bolts are straddling the crankshaft journal. When you have this position, place the upper bearing shell into the con rod, ensuring that you have it orientated with the number in the correct position.

Fit the two shims in their positions (these are also numbered), then fit the lower bearing shell into the cap, and begin to tighten the bearing cap down. This is a very gradual process and you must not overtighten these. The castle nuts should be tightened then followed by a 1/8 turn tweak. Turn the flywheel over and ascertain that there are no tight spots in fitting.

Proceed until all 6 big end bearings are fitted, and turn the engine over for at least 20 revolutions. When satisfied that the pistons and bearings are all turning freely, give each castle nut a tweak then secure in place with a cotter pin through each nut, following the Rolls-Royce method mentioned earlier.



All conrods secured onto the journals. Notice the small socket drive we used, to avoid overtightening the bearings.



You can just make out that all the stamped number '2's are facing upright. Circled for clarity.

Oil pressure and oil circulation check

For this process, we followed Stephe Boddice's instructions on how to check you have oil going in the right places. The link is attached here: http://www.boddice.co.uk/bpic2566.html

Fitting sump

Before fitting the sump onto the crankcase, we pushed through all of the sump bolts, cleaned up the threads with wire wool, then prepared the mating surface with Wellseal, before affixing the crankcase to sump gasket. Tighten down each fitting with a spring washer and nut and check that the seal is even and that there are no obvious gaps.

Cleaning the cylinder head

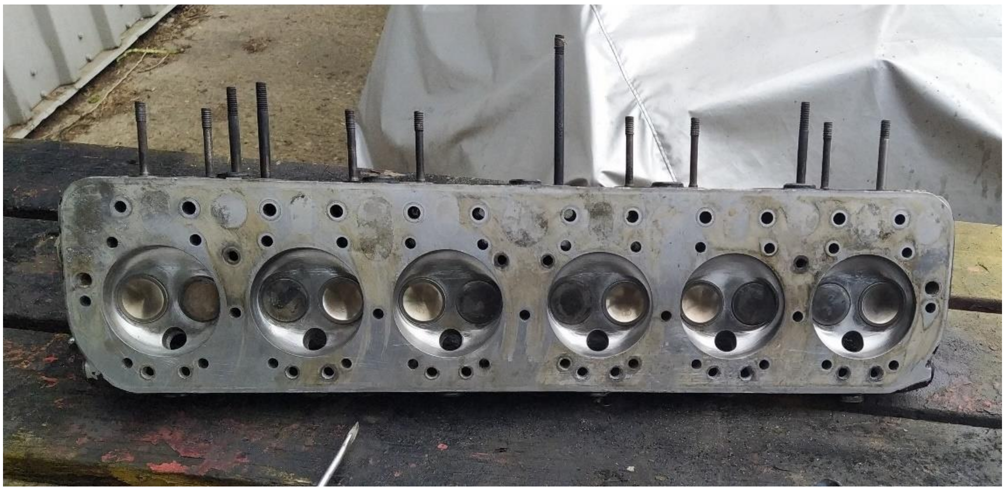
My cylinder head was 25 years old, but had done hardly any miles. Richard and I checked the condition of all the valve springs, checking that they were tight and had no cracks. We checked the valves and valve seats for cracks and obvious signs of wear.

New Steve had a brilliant idea of using a brass wire-wheel on a drill to clean the built up carbon deposits, so I set to work and very carefully removed all of the built up rubbish. This forms as a result of too rich a mixture and not taking the car for long enough journeys to clean the top of the chamber. The material felt gritty and was very stubborn, so the job took about 2 hours.

The end result was fantastic and it was satisfying to have a very clean cylinder head going onto a fresh engine. Just be sure to blow the head through with compressed air to remove any contaminants.

Before:

After!: The larger valves with the slight depression are the inlet valves, and the smaller valves are the exhaust valves. These have been changed in the past to run on unleaded fuel, but it is a safe option to run with a lead replacement additive.



Fitting cylinder head gasket and cylinder head

Before placing the head gasket onto the block, smear grease onto both sides of the gasket, which will assist in the sealing process. Once the gasket is in place, gently lift the cylinder head then lower down very carefully, being sure that the head is going down perfectly level. Once fully down, place a new set of spring washers onto all of the studs, then hand tighten the head nuts.

At this stage, David Axe very kindly pointed out how to tighten the nuts. He suggested working from the middle outwards, progressively and gently in a pattern that works outwards. Once this is complete, do not use a torque wrench, use an 8 inch ring spanner and give each nut a tweak, starting from the centre of the head and working outwards. This method ensures that the cylinder head sits flush with the gasket, which will minimise the risk of leaks further down the line. Leave this to sit for 48 hours, then re tighten.

After the head has been sufficiently tightened, replace the push rods and the rocker arm assembly above the cylinder head. Use a little oil on all of the surfaces to provide smooth operation on start up.

Valve timing and crankshaft vibration damper

This is the hardest part of a Rolls-Royce engine rebuild. The instructions are ambiguous on all websites, mostly because the writers simply do not understand the meanings behind the markings and why you have to set the timing in a specific way.

I created a video on my YouTube channel, Goshawk Engineering, to explain this and also how to set the valve timing correctly, so please refer to the video here: https://www.youtube.com/watch?v=xzh_f_ruMlM

Replacing ancillaries

As we removed each part systematically, it was pretty straightforward to put everything back in its correct position. Take care when fitting the oil pump, oil pipes and control levers. I would suggest replacing the magneto control levers, but wait until the engine is back in the car before replacing the inlet and exhaust manifolds as well as the remaining ignition, carburation and hand throttle control levers.

The finished engine ready to go back into the chassis. We placed the spark plugs into the apertures to stop contaminants entering the cylinders.

Replacing the engine into the chassis:

Arguably the toughest part of this project was putting the engine back into the chassis. It took no less than 5 hours from having the engine in the crane to securing the engine to the gearbox with two studs. It required no less than 6 people to complete this function and it was absolutely excruciating; trapped fingers, gouges to the skin and to the onlooker, this was brain surgery.

With hindsight, I can highly recommend removing the Autovac out of the way as well as covering the engine with bubble wrap because this will help to avoid any scratches and bumps which are inevitable when replacing the engine back into the chassis. Furthermore, I would recommend jacking up the gearbox to its desired height and have a car jack in place beneath the engine as it is unbelievably hard to align the two parts together.

There is only one way to put the engine back into the chassis, and that is to drop it in from above the chassis rather than below it. We lifted the crane gradually and had a person on either side of the engine with tow rope to guide the engine around the steering column and to stop it swinging, much like the operatives on the ground when a crane is moving RSJs into a house.

What we found difficult was aligning the gearbox and engine. One must remember that the gearbox drive that protrudes from the bell housing is splined, therefore the application of a little oil (not grease) will assist in slipping the shaft into the clutch output drive. To push the engine home, use a large lever on the nose of the timing cover and lever it off the front cross member.

It is beneficial to place two studs on either side of the bell housing, then be prepared to screw the nuts and washers onto the studs to draw the engine to the gearbox. It is important to do this evenly otherwise the engine and gearbox will not sit together properly. Do not be tempted to use a sealant around the faces and do not use a gasket around the joining surfaces. You will inevitably have a slight leak here because the only oil seal is a simple scroll running in a depression to wash the oil back into the sump.

If you were to seal everything up, the oil would run around the clutch, cover the surfaces and impair the working of the clutch completely. Also, more heat would remain inside the working area of the clutch, which could distort the spinning central drive disk, and would make your clutch slip under load.

View from underneath the car; it looks so uncluttered which is the beauty of the Royce design

Preparing for the initial start-up:

Once the engine is placed back in the car, it is necessary to prime all of the oil pipes within the engine. To do this, Richard and I removed the oil pressure gauge pipe which sits above the main oil gallery feed. Richard turned a fitting on the lathe and placed this where the pressure gauge pipe sits, then we placed a rubber hose with a jubilee clip over the fitting, and ran the hose back to an air fed oil gun. We pumped in 2 litres of Castrol 20w50 oil, waited 5 minutes then pumped in another litre into the pipes. After you have fed oil to the pipes, wait for 30 minutes then fill the sump with oil until it reaches 1 gallon on the gauge.

The next job is to set the ignition timing, on both the battery and magneto ignition. It is imperative to set the timing from the flywheel end of the car, **so do not be tempted to turn the engine over with the starting handle, otherwise the crankshaft damper will wind up and misplace your timing.**

Set the flywheel to 'BAI' – battery advanced ignition. Remove the distributor cap, and note where the rotor arm needs to point to align with the number 1 cylinder high tension lead. Remove the cam from the distributor tower, then adjust and lower such that the points are just opening with the rotor arm pointing at the number 1 HT lead. Replace all fittings and your ignition timing will now be set. Set the spark plug gaps to 0.025" and use either NGK AB6 or Champion D16 plugs. NGK seems to be better for continental use and Champion are more responsive for country road driving, as they have a lower electrical impedance than the NGK plugs which are designed for a post war car.

Brim the tank with fresh petrol, and ensure that the Autovac tap has its full range of movement. Use 92 RON petrol, and use a suitable ethanol stabiliser to protect your fuel system, otherwise your fuel tap will look like this:

Rubber and ethanol do not mix! The ethanol infused petrol sat on the rubber gasket and literally dissolved the rubber rendering the tap useless; a big fire risk!

Initial start-up:

Firstly, retain the Castrol XL 20/50 which was used in the priming process, as this oil will contain the assembly graphite grease, which will help to eliminate any possibility of oil starvation on the initial start-up of the engine. Slowly turn the engine over by hand for at least 30 seconds with the spark plugs out and have someone watching the oil pressure gauge; it should reach 10 psi and if not, rectify this issue before proceeding.

Visually check that no oil is leaking out from any of the pipes, and do a final tighten with a spanner just to ensure that the pipe fittings are tight. Then, check that all of the fuel lines are secure and tight, especially below the float chamber.

Then, check the level of coolant in the radiator, this should be just below the circular pipe which is about 4 inches below the filler cap. Turn the engine over again and ensure that there are no bubbles forming in the coolant, which would be an indicator of a loose jubilee clip or improper fitting of the head gasket.

Now, turn the battery on, sit in the car, and have two operators next to the engine, one on either side and both with large fire extinguishers. Firstly, turn the engine over on the starter motor for at least 10 seconds, watch the oil pressure rise.

Immediately after, turn the fuel on, set the carburation lever to strong, and do not touch the starter carb lever. Instead, hold the foot throttle open about ¼ of its way down. Now switch the ignition lever on, and turn the engine over. This is a very nerve racking moment, and the engine will appear to take forever to actually start. Whatever you do, do not touch the starter carb, it will wash the sparse amount of oil from the bores and wear down the bores very aggressively.

After three attempts, the engine should start, and now you should gradually hold the revs at a fast idle, with your eye fixated on the oil pressure gauge. The two operatives should watch for any leaks, and your soul job is to ensure that you have sufficient oil delivery to the engine.

At this point, keep the engine running on your right foot, then gradually advance the ignition lever and weaken the fuel mixture. You should run the car for 20 minutes like this, with variation of throttle opening at or above 1000 rpm. The reason for doing so is to lightly load all of the operating surfaces, whilst certifying that oil is getting to all of the moving parts. Please do not be tempted into holding the engine at a steady speed, and do not idle the engine slowly.

After 20 minutes, switch the engine off, then remove the rocker cover, take the rocker arms off, and retorque the head gasket with an 8 inch ring spanner. All that’s required is to ‘tweak’ the nuts such that they are firmly holding the cylinder head in place. Do not use a torque wrench at this stage, or you will jeopardise the integrity of the head studs, as they breach their elastic limit at 22 ft lbs.

Replace the rocker arms, reset the clearances, then you will be ready to follow my running in process.

Bedding in the clutch, and how to operate the Goshawk clutch:

To correctly bed in the clutch, one must understand exactly how it operates and as a result of this, how the driver should operate it to avoid malfunction. Firstly, I shall explain how the Goshawk clutch works then I will explain the need for bedding in the clutch.

The Goshawk clutch is a single plate, dry disk clutch which is bolted directly to the back of the flywheel. The clutch, in basic terms, transmits the torque produced by the engine directly to the gearbox. The Goshawk clutch consists of two friction linings and a single spinning disk plate, aka the single plate dry disk. To transmit the torque of the engine to the gearbox, the Goshawk clutch operates on a sandwich principle, thus two friction linings press against each other, which catches the spinning disk in between them. Under an ideal situation, the two linings will bear down firmly enough such that the central disk turns at the same speed as the two linings.

Upon disengaging the clutch, the rear friction lining carrier, the pressure plate, is pulled out of operation via four operating arms, which are actuated by a central thrust bearing. The clutch pedal is directly linked to the thrust bearing, and as you push down on the clutch pedal, the thrust bearing moves linearly towards the engine, away from the gearbox. The outer washer contacts the four operating fingers, which in turn pulls the pressure plate away from the spinning disk. This mechanical action is controlled by 8 springs, which ease slow movement and therefore smooth and positive operation, this process is known as critical damping by absorbing unwanted vibration which can be transmitted during both engagement and disengagement.

To bed in this type of clutch, the friction linings need to ‘bite’ into the central spinning disk. If the linings glaze, much like brake shoes, the operation of the system will be impaired because the clutch will slip and ineffectively transmit the torque of the engine to the gearbox. This type of clutch slips when the pressure plate does not press firmly onto the spinning disk, or the rear lining literally polishes the central disk rather than mating with it. Therefore, a process of driving which involves traffic light pull aways, light incline starts as well as a considerable amount of gear changes would be most beneficial to bedding in this type of clutch.

If one was to drive in fourth gear for a prolonged period of time, it would not hamper the bedding in of the clutch, but it would not benefit the roughing up of the friction lining surfaces which is necessary to avoid any possibility of clutch slip. Furthermore, the operating fingers need to be accurately adjusted such that the rear friction lining sits perfectly square on the spinning disk. If you do not adjust the fingers correctly, the lining will operate under an uneven pressure, which will severely increase the likelihood of clutch slip because it will not seat and press firmly into the central disk.

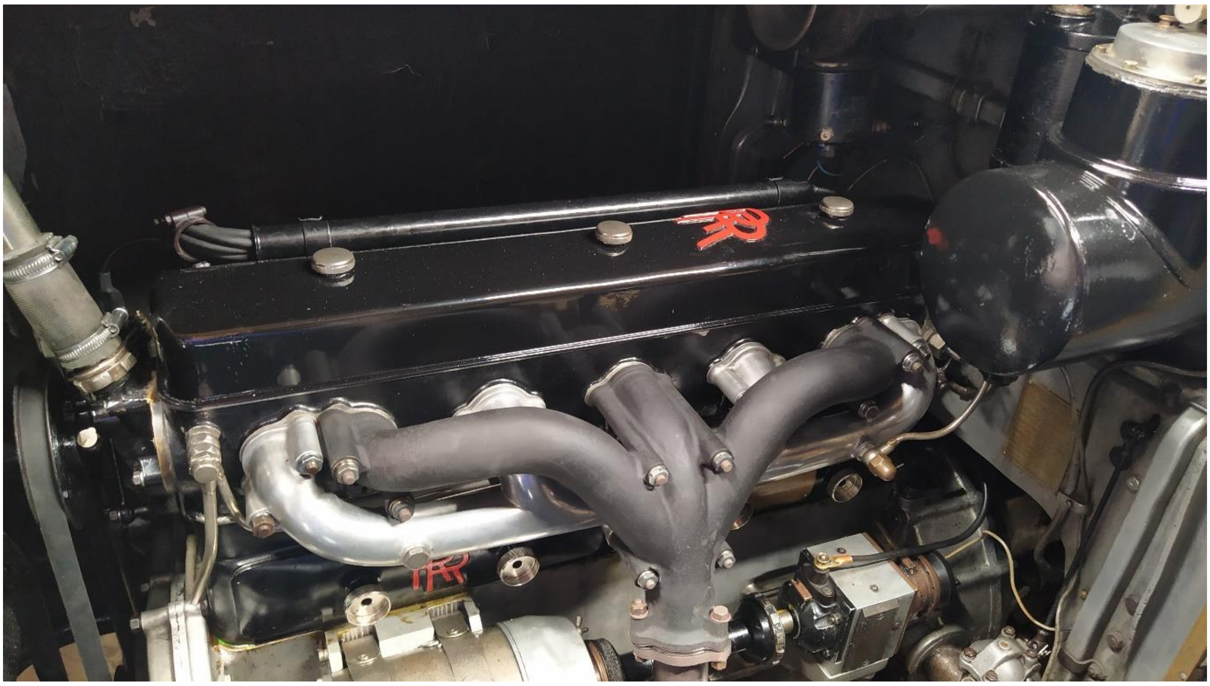
To operate this clutch flawlessly, one must only apply the throttle once the clutch is fully engaged. One of the drawbacks with this clutch design is that the heat is not effectively dissipated from the mechanism. This intense heat due to friction can distort the central spinning disk, which will lead to clutch slip because a warped disk will bounce off the inner clutch lining mounted directly to the flywheel.

When manoeuvring the vehicle, use a slow speed of throttle, pre-set by the hand control, and use the pedal like an on off switch rather than gradually. Sometimes, this may be very difficult, say, when entering a garage. However, the car will travel very slowly indeed before stalling. By utilising the clutch in this way, you will prolong its life for as long as possible. It is disparate to the Silver Ghost clutch, and will not tolerate any form of slip, such as starting from rest in 4th gear; it will simply overheat and fail, ending up with a central disk looking like this from GWE 31.

Evident on this clutch disk is a supreme amount of soot, most likely from the linings starting to burn. Further, the gaps between the segments are far too large and irregular, caused by extreme distortion. The plate itself is very thin indeed and has a tendency to develop hairline cracks beneath the segment gaps, so be aware of this.

This plate is damaged beyond repair due to the operator using too much throttle and not letting out the clutch quickly enough.

The finished product:



I painted the RR logos red in keeping with the experimental theme of the engine. It has much higher compression than a standard 20/25 engine and I like the caddish look that it gives; a statement of ultimate power.

After all of the final adjustments, I polished the aluminium inlet manifold carefully, by rubbing it down with steel wool, then building up layers of polish until it had a semi-reflective shine. The exhaust manifold was a much more difficult job because they develop a lot of surface corrosion. For this, my father and I stripped back the corrosion with coarse sandpaper, then used a Brillo pad to soften any lumps.

After this, we washed the manifold with washing up liquid and an old sponge, then used barbeque cleaner to remove any stubborn contaminants. We then lightly sanded the surface with increasingly fine sandpaper until a smooth finish. Once the surface residue was removed, we applied two coats of black matte, very high temperature exhaust paint.

The end result is so much cleaner and more smart than the tatty look of a rusty exhaust manifold; it is just not Rolls-Royce.

Tests for after completion:

The first test to conduct once your engine is together is a vacuum test. This test provides a succinct reading into how effectively the engine is drawing in the fuel air mixture from the carburettor. The reading you see is the difference in vacuum between standard atmospheric conditions and the vacuum that occurs in the inlet manifold. An engine is essentially a pump, therefore it needs to be drawing a sufficient amount of gas into the cylinder otherwise it will be running inefficiently.

Ideally, the engine needs to idle with a vacuum of 20 inches of mercury, and when you depress the throttle, the gauge should flick to zero vacuum then briskly ascend to approximately 25 inches of mercury, before returning to 20 inches of mercury at idle again. You are looking for the needle to hold itself steadily in the ‘green’ zone. If the gauge needle fluctuates, either rapidly or slowly, there is a fault with the mechanical system that needs addressing.

The vacuum gauge in use. As the valve timing was incorrect at the time of use, the white gauge needle was flickering at 13 inches of mercury during engine idle at 500 rpm.

At the 750 mile mark, my friend Alastair Broadwith suggests a compression test on the engine, under both wet and dry conditions. This test is an engineering tool that measures the leakage of gas from the cylinder, on a cylinder by cylinder basis. This test is useful because it provides an indication to head gasket seal, piston ring seal as well as general engine condition.

I followed Alastair’s advice, which was to test all 6 cylinders under a dry condition, with all spark plugs removed and the throttle jammed fully open on the pedal. To complete the wet test, follow the same procedure but squirt three shots of engine oil into each cylinder with an oil gun before taking the compression measurement.

	Dry bore	Wet bore
Cylinder 1	115 psi	125 psi
Cylinder 2	120 psi	130 psi
Cylinder 3	120 psi	125 psi
Cylinder 4	120 psi	125 psi
Cylinder 5	120 psi	125 psi
Cylinder 6	120 psi	130 psi

My analysis of these results is that cylinders 3 through 5 were almost completely run in, and the front two cylinders needed a little more running-in. According to physics, this engine will be run in when the dry and wet test results for each cylinder are very similar to each other. As demonstrated, cylinders 1, 2 and 6 require slightly more running in.

My reasoning behind these results are that cylinders 1 and 2 undergo the most cooling, because the water pump inlet is between these two cylinders, so the cool water from the radiator outlet hits these surfaces first, hence the greatest amount of heat dissipation occurs at this position. In running in, slightly higher operating heat is advantageous because it allows the running in surfaces to run in closer tolerance to each other, which results in an improved obturation within a cylinder.

Cylinder 6 is also operating at a cooler temperature because it is situated very close to the Autovac inlet take off. This cylinder always runs slightly rich compared to the other five because the fuel air mix going into number 6 inlet valve will have a reduced amount of air during an Autovac lift event, which enrichens the mixture, therefore this cylinder runs slightly cooler as the rich mixture transfers less heat to the cylinder compared to a lean mixture, as the rich mixture burns more rapidly than a lean mixture.

Finally, one should check the spark plugs at 100 mile intervals. Not only will these provide a solid indication of how well you have set up the infamous Royce carburettor, the plugs will show you if there is an issue with the internals of the cylinder and piston, which will be portrayed as thick carbon build up or oily deposits on the electrodes.

How to run in the engine:

This is a hot topic amongst all classic car enthusiasts and drivers, and there is almost certainly no right answer. However, there are incorrect methods of running in an engine and these poor methods can have unfavourable consequences.

Running-in is the process of bedding in metallic surfaces which operate in conjunction with each other, i.e. piston rings within a cylinder bore. The idea behind running in an engine is primarily to ensure that the piston rings make a good seal with the cylinder bores, such that excess oil and combustion gases do not pass the rings. Secondly, this process should account for any metal to metal contact within the engine. This is the crankshaft running in the bearings, the crankshaft journals running within the big end bearings, the pushrods actuating the rocker arms and the rocker arms depressing the valves.

The risk with running in is that these metal to metal contacts either fail and rub together with a lack of lubrication, causing friction and inevitably failure, or contrastingly, the bedding in does not take place and the surfaces run with too much clearance, thus leading to a malfunction within the mechanical system.

Clearly, one must ensure that the correct bedding in occurs with minimal direct metal to metal contact. Running in oil is a very useful tool within an engineer's armoury, although it will not guarantee successful running in. Running in oil is slightly abrasive and is highly refined oil, which contains no anti wear additives. This oil therefore permits a very small amount of wear within the engine, which is beneficial to the process because it ensures that mating surfaces are matched and therefore run cooperatively.

Furthermore, when a cylinder is machined with a cutting tool and eventually honed to a dull and scratched finish, slight imperfections within the surface will always be present. One uses the running in oil to very slightly wear down these imperfections, as a machinist would file burrs down to a smooth finish; you are copying this process just on a larger and more complex scale.

My personal running in instructions, for the first 1,500 miles are below, which are followed at your own risk:

1) Ensure that the oil and coolant levels are sufficient.
2) Start the engine with as little choke as possible, then control a fast warm up idle of approximately 1000 rpm.
3) Vary this engine idle with your foot throttle and do not let the engine sit at a continuous idle for more than 30 seconds.
4) Once the engine has reached operating temperature, wait for the idle oil pressure to fall to less than 30 psi, then drive off.
5) When driving, vary engine load, by varying the amount of throttle and gradient that the engine endures.
6) Do not push the engine hard, do not labour the engine, and never hold it at continuous revs in conditions such as motorway/dual carriageway driving.
7) Run the engine for at least 90 minutes without switching it off, such that a good heat cycle is achieved.
8) Do not be afraid to rev the engine when changing down gears, this is a slight increase in load so is a positive transient during running-in.
9) For the first 100 miles, stay below 30mph.
10) For 100-400 miles, stay below 35 mph, with very short bursts of 40 mph over 300 miles.

11) For 400-500 miles, stay below 40 mph. The engine should now feel slightly more free revving and responsive.
12) For 500-750 miles, stay below 45 mph.
13) For 750 miles onwards, stay below 50 mph.
14) After 1,500 miles, the engine will now be completely run in.

How to setup and adjust the pre-1934 Royce automatically expanding carburretor:

To correctly adjust your carburettor, all you need is a flat head screwdriver and a small socket set. Before adjusting anything, ensure that your air valve is sealing properly and the piston drops from the high to low position in 1.5 to 2 seconds. If it drops too rapidly, your mixture will be far too weak on the overrun and if it drops too slowly, the mixture will be overly rich, causing bore wash within the cylinders. Both situations need to be avoided, and ideally you need the mixture to be spot on, not rich or weak.

Once your air valve is adjusted correctly, cleaned with petrol and lint free, ensure that your ignition timing is bang on the marks as per my aforementioned instructions. Check that all 6 spark plugs are operational and that the ignition system is set up to the handbook. If your ignition timing is wrong, it will be impossible to achieve the perfect carburettor setup.

Once these points are satisfied, take the car for a 30 minute journey and get the engine to full operating temperature. At this point, set the throttle control lever 1/3 of the way up on the throttle quadrant, set the mixture control lever to the centre and the ignition lever to the centre of its quadrant; this should give you a steady 400 rpm idle.

At this stage, unscrew the air valve from the top of the carburettor with the engine running, and the engine should stop once you have unscrewed the valve through two complete revolutions. If the engine stops before this stage, the penny washer at the bottom of the air valve assembly needs to be moved away from the shoulder of air piston to enrich the overall mixture. If the engine stops after more than 2 turns, the mixture is too rich and you need to move the penny washer toward the shoulder of the air piston. This setting is ensuring that the correct amount of air is flowing over the low speed jet at a steady idle. If the washer is at the wrong height on the piston, either too much air will be flowing through the carburettor at idle or petrol from the high speed jet will be affecting your idle mixture.

After your penny washer height is set, fully retard the ignition, set the mixture control lever to the centre and the throttle as slow as you can get it, i.e. in line with the ‘D’ of closed. At this very slow idle, unscrew the lock nut on the low speed adjustment screw, and turn it anti clockwise until the engine speed rapidly reduces – hastily turn this nut anti-clockwise until the engine speed rises again and take it further until the engine speed slows and chugs again. This is far too rich, so now you need to work ‘backwards’ in gradual increments to achieve the correct idle mixture. Turn the low speed jet nut clockwise, listen to the engine speed rise, reach its peak then weaken slightly again. As soon as the idle speed slows at the weak side of this peak of engine revs, lock the nut on the adjuster.

Now, fully advance the ignition, and raise the throttle to wide open. The engine will be racing at this point. Unscrew the high speed jet adjusting nut, and turn the nut clockwise fully until the carburettor starts to pop and spit, this is fully weak. Now, turn the nut slowly anti-clockwise until the engine speed rises, plateaus then falls again. Turn the nut clockwise, wait for the engine revs to rise then very gradually turn the nut again until the engine revs drop slightly on the weak side of this peak and lock the adjuster nut with the screw. At this point, turn the slow speed jet by 1/16th of a turn, and the engine revs should reduce very slightly.

To check the correct idle speed setting, start to slow the engine speed right down and retard the ignition. At the ‘D’ of closed throttle, you should have a lumpy idle, yet when you strengthen the mixture by two notches, the idle should be very slow and smooth. If you observe this, you have set the idle mixture perfectly.

Take the car on the road, and you should find that the engine runs ‘spot-on’ on the flat at the centre of the quadrant. If you weaken the mixture by two notches, the engine will run 5 degrees hotter. If you observe this, your carburettor mixture is perfectly set. If you don't observe this, adjust the mixture as necessary and you should find that you have a power boost with the mixture setting two notches rich.

Risk mitigation for your pre-war Rolls-Royce engine

These points are purely my own opinion and you follow these at your own risk.

- Use Bluecol coolant and change this every six months, at a mixture ratio of 1:1. 1 part de-ionised water to 1 part Bluecol.
- Only use oils approved for use with classic and vintage cars, such as Morris Golden Film, Castrol Classic and Penrite.
- Use SAE 30 oil if you do not have a full flow oil filter fitted and change this oil every 1000 miles.
- Use SAE 20w50 if you have a full flow oil filter fitted and change this oil every 1500 miles, along with the filter element. I would thoroughly recommend fitting one of these as the oil sludge produced by these engines is alarming.
- Run on standard, non-super unleaded petrol. Super unleaded has too high an octane rating for the 5.25:1 compression ratio and your car will not benefit from this. However, do be cautious about the percentage of ethanol within fuel, and consider the use of an ethanol reducing additive such as Castrol Valvemaster.
- If the temperature of the water goes above 95 degrees Celsius, stop the car immediately.
- Check that the oil pressure relief valve is set correctly, and that you have a sufficient feed of oil to the cylinder head and pushrods.
- Carry out a bottom end de-coke every 10,000 miles.
- Check your spark plugs regularly for correct gap and for indication of mixture. Too weak a mixture will overheat your pistons and too rich a mixture will wash the bores resulting in premature engine wear.
- Always warm up the engine for at least 5 minutes, at a fast idle, prior to driving off.
- Do not idle the engine for prolonged periods of time, this will also lead to increased engine wear.
- Do not be afraid to push the engine, this will help to minimise bore glazing.
- Always check that you have a sufficient amount of oil and coolant in the engine before driving.

Acknowledgements to those who have helped and assisted me through this endeavour:

Thank you very much to the following businesses who assisted me with my project:

- Steve and Ben at Alpine Eagle Limited
- Allan Glew at A.J. Glew Limited
- Steve at Ristes Motor Company Ltd
- The whole team at Fiennes Parts Ltd
- Malmesbury Metal Strippers and Cleaners
- Paul Gardias of Gardias Engine Services
- Stewart Parkes of Parkes Restorations
- Jonathan Wood at Jonathan Wood Vintage and Thoroughbred Restorations Ltd
- Ultraseal (Slough) Limited
- eBay
- Manor Garage, Wantage

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- The International Club for Rolls-Royce and Bentley Enthusiasts (RREC) for their online forum, in particular the Technical (Pre-War) Section. This pays dividends when checking technical details or for problem solving.
- Steve and Ben of Alpine Eagle Restorations, for letting myself and Richard rack their brains for information, and for guiding us on how to restore the cylinder block.
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- Nicholas Simons, for his advice regarding the crankshaft vibration damper as well as oils and lubricants.
- Alastair Broadwith
- Andrew Whittaker
- Keith Ward
- The book, ‘Survivor’ by Charles Vyse

The Old Boy, ready for many more adventures