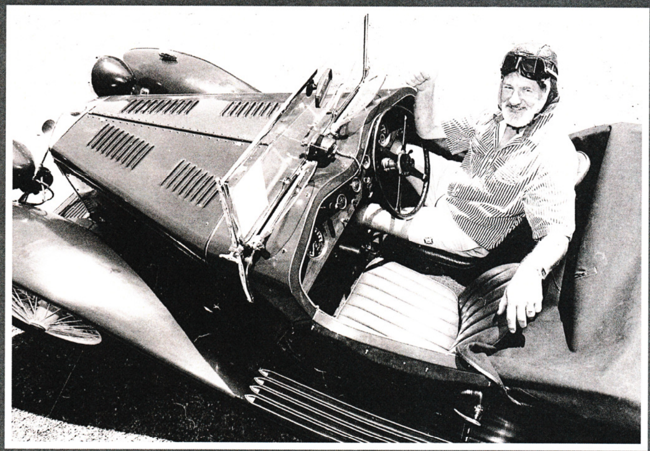
THE RILEY NINE ENGINE.
WORKSHOP PRESENTATION

ALLAN JAMES BOOTH



Allan James Booth

16 APRIL 1941 - 5 MARCH 2018

Allan Booth was an enthusiastic Riley owner and builder and a go-to man for any Riley technical matters.

In the late ‘90s he was asked to produce this paper for a Riley Club workshop meeting in the Waikato.

The paper provides a concise and detailed description of the Riley 9 engine, its maintenance and tuning.

Historian.RileyCCNZ@gmail.com

INTRODUCTION

When I was first asked to make this presentation the subject was *"Riley 9 Camshafts", with emphasis on what I had done to improve the performance of my own car. I readily agreed thinking I could cover it in 15 minutes with a further 15 minutes question time.*

Brian Baker subsequently informed me I had two hours to waste and the subject was now *"9HP, Engines, Magnetos, Tuning and Camshafts".*

Frankly, I didn't know where to start as I didn't want to bore post-war enthusiasts with a lot of information which is basically available in many excellent publications.

I decided therefore to approach the task from the viewpoint of the aforementioned post-war enthusiast (or any other uninitiated person) who sees the light and obtains a pile of 9HP engine parts and he wants to put together a reconditioned engine with some performance improvements.

I've tried to identify the various models to help with interchangeability and give a few hints that I've found helpful in overcoming some of the problems.

Engine Models

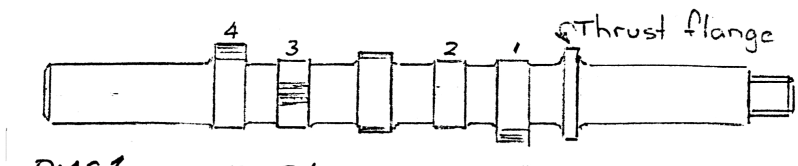
The first stage is to identify the various models as not all parts are readily interchangeable. As the Mark 'X' prototype engines and the first Mark 1 production models are very rare today I will start with the Mark 2 model.

Marks, 2, 3 and 4

These engines which were fitted up to April 1929 differed only slightly in areas such as gudgeon pin retainers, internal oil manifolds and the exhaust manifold which originally exited opposite No. 4 cylinder. However, all these components are interchangeable.

The engines featured low compression pistons (approx. 1/8" below the cylinder lip), the crankshaft had 1 1/2" dia. main bearings with 1 9/16" dia. big end bearings.

The camshafts were not supported by the front timing cover housing and forward thrust was taken by an integral flange against the rear of the front camshaft bearing. **(See diagram 1)**

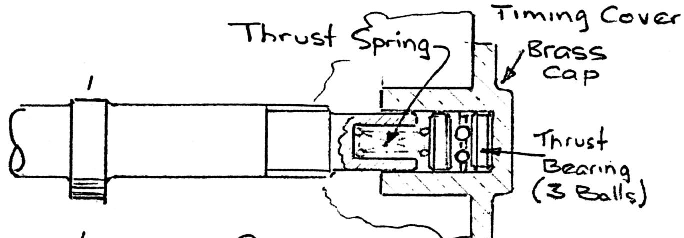


DIAG.1 – EARLY CAMSHAFT

The rockers were fed by an external piping system and ignition was by moving coil magnetos driven off the narrow inlet timing gears.
The crankshaft 2:1 drive was a simple helical gear with a special generator drive nut threaded and pinned onto the crankshaft. The idler gear had a substantial thrust collar between it and the pin cap to stop forward movement and take thrust.

Mark V

Fitted from April 1929 until the 1931 series started at Chassis No. 6012013. The crankshafts were extended so that they were supported by an extra bearing in the front timing cover. The forward thrust was now taken by a spring in the centre of the shaft operating against a hardened thrust pad and ball race. **(See diagram 2)**



DIAG. 2 - LATER CAMSHAFT THRUST

Compression ratio was raised by fitting pistons which came to the top of the cylinder block with a slightly raised profile.

Narrow timing gears were still used but the idler gear flange was extended and the thrust collar replaced with a keyed thrust washer.

Most other details were the same as the Mark 4 but interchanging is only possible if the correct timing covers are available.

Mark 6

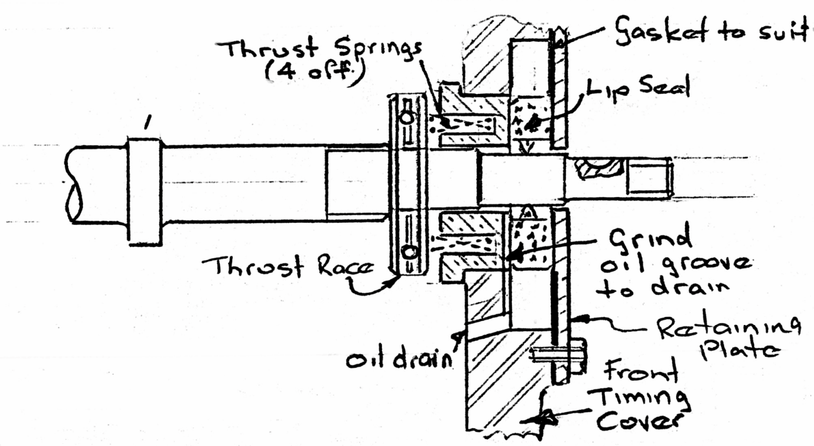
These engines had the wider timing gears and the internal rocker feed and were fitted from Chassis No. 6012013 (1931 models).

Generally speaking Mark 5 and 6 engine componentry is interchangeable except the Mark V cylinder head does not have rocker feed drillings so it can't be used on Mark 6 without modification.

Crankshaft 2:1 gear had the generator drive incorporated in one piece and was fixed to the crankshaft with a taper pin.

Mark 7

Introduced with the Kestrel sloping radiator series in 1933 (Chassis No. 6019800 onwards). The fan was now standard and driven from an extended exhaust camshaft. The front thrust was modified to a four spring system running on a thrust bearing. **(See diagram 3)**



DIAG. 3 - FAN EXTENSION THRUST AND LIP SEAL MODIFICATION

The crankshaft big ends increased to 1 11/16" dia. with more robust connecting rods. Coil ignition was now standard with the distributor driven off a skew gear behind the inlet camshaft gear.

The rear timing case was redesigned to take the distributor shaft mounting.

Interchangeability with Marks 5 and 6 is possible with only minor modifications.

Merlin Series

This series was introduced in 1935 models from Chassis No. 66M101 onwards, with a large number of modifications making interchangeability quite difficult.

New 6.6:1 compression pistons were fitted with a lower gudgeon height and shorter, more robust con-rods. The crankshaft rear main bearing was increased to 1 5/8" dia. and big ends to 1 7/8" dia.

The oil pump was now a single plunger type with an oscillating body and an oil filter was fitted as standard. The rocker box lids were round with a more positive cam locking action and rocker oil feed reverted to the external pipe system. The cam followers and lag tappets were also redesigned.

GENERAL RECONDITIONING HINTS

[a] Crack Testing

Before commencing, have the crankshaft crack tested, as fatigue stress over the years can cause premature failure even without raising the power output. It is also probably a good idea to crack test con-rods as well.

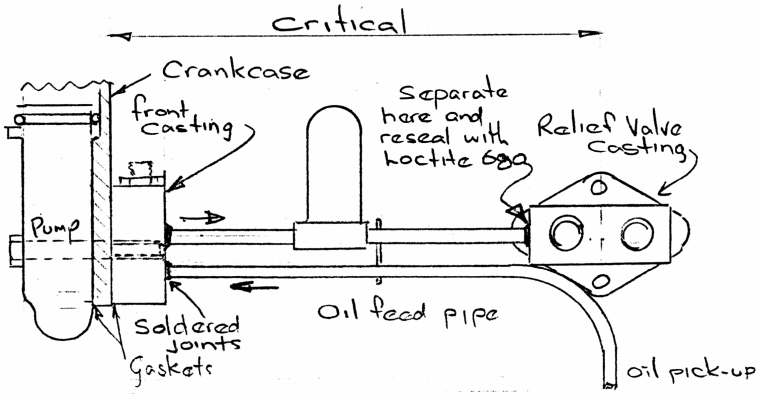
[b] Oilways

Clean out all oilways thoroughly. This means removing all crankshaft plugs and the copper feed pipes to Nos. 2 and 3 Journals. You'll be really surprised how much gunk has built up over the years.

The crankshaft must be preheated before removing and resoldering the copper feed pipes. Using new pipes saves cleaning out the existing pipes.

Check the internal manifold for cracks around the soldered joints. These can let air into the oil lines with subsequent loss or erratic oil pressure. Resoldering these joints is difficult as the distance and angle relationship between the front casting and the relief valve casting is critical to ensure a good seal with the oil pump. With no positive stops the relationships are lost as soon as the solder melts.

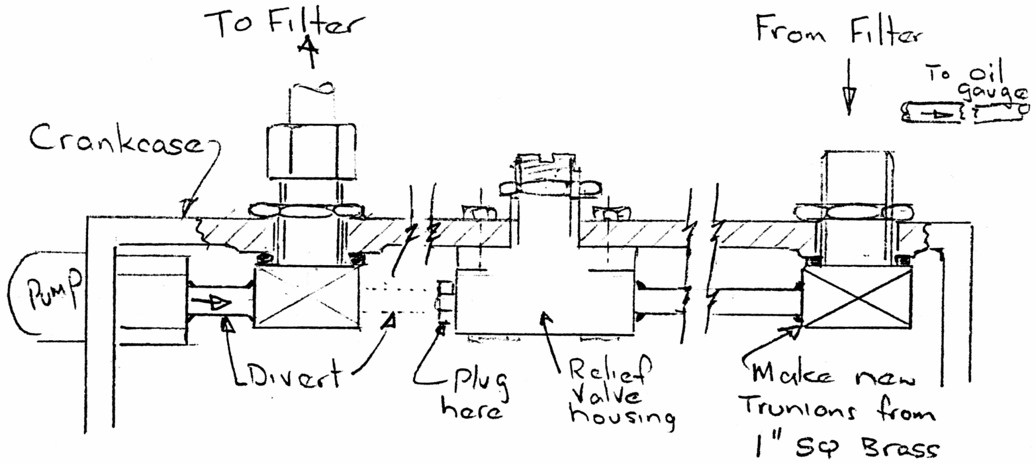
A simple method to overcome this problem is to separate the two parts at the centre casting **(See diagram 4)**. Then mount the oil pump/front casting in place and the relief valve in its place using LOCTITE 680 as the setting medium.



DIAG 4 - INTERNAL OIL MANIFOLD

[c] Oil Filter

It's probably worthwhile fitting a full flow oil filter. This can be quite easily done by diverting the pump exit pipe to the exterior of the engine. There is already a raised pad cast into the cylinder block wall, so a 13/16" hole is all that is required. The oil is then fed through an oil filter and back to the relief valve manifold via the pressure gauge take off hole. **(See diagram 5)**



DIAG. 5 - MANIFOLD MODIFICATION TO TAKE FULL FLOW FILTER

[d] Oil Pumps

Problems result from wear of the aluminium or bronze body due to the action of the plungers and the holes in the brass eccentric links slogging out. Reconditioned pumps are available on an exchange basis and the links can be braised and redrilled.

A simple test of pump condition is to place fingers over the three oil holes in the body and with the rear hollow plunger in place pull out the front solid plunger. A good pump will produce a crisp popping sound.

[e] Balancing

Balancing can make a big difference to the smooth running characteristics of an engine and I believe the starting point should be getting the pistons the same weight. It is surprising how much difference there is even in a new set of pistons.

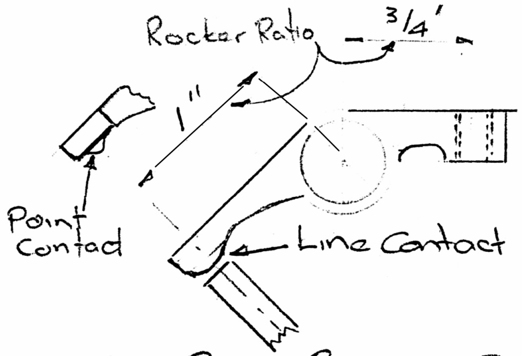
Con rods should also be weighed in total and the little ends and big ends weighed separately. Adjustments can then be made by carefully removing the required amount of metal with a coarse file. Crankshafts should be dynamically balanced with the clutch fully assembled which is a process better done by a specialist.

[f] Camshaft Bearings

The four bearings will probably be worn but can be easily drilled and re-bushed. The front bearings are pulled out from the front, but the rear ones require a long drift to knock them out through the rear of the block.

[g] Rockers

Rockers should be inspected to ensure there is a point or line contact only between them and the valves. Riley used two systems to achieve this. **(See diagram 6)**



DIAG 6 - ROCKER DETAILS

Either way the faces should be at least cleaned up on a grindstone making sure they are not flat as it will make it difficult to set tappets accurately as burring occurs.

[i] Cam Followers

These should be inspected and the flange reground if wear is noticeable.

[j] Crankshaft End Float

Crankshaft end thrust is taken on the white metalled flange on the rear end of the front main bearing. The correct end float is 0.002" and is obtained by using a special cutter on the white metalled face.

Check the end float with a feeler gauge after mounting the crankshaft in the rear half of the timing case with the thrust washer, and 2:1 pinion mounted in position. When it is correct the parts need not be disassembled, but can be mounted directly into the crankcase.

[k] Timing Gears

These become very noisy when worn but new sets are very expensive. It is possible to reduce timing gear noise by taking a very fine feed line from the rocker feed system and dripping oil directly onto the inlet timing gear. Make sure you do not starve your rocker feed.

OIL LEAKS

[a] General

Like most British cars of this and later eras, Riley are prone to oil leaks from a number of points. However, the use of modern technology goes a long way to eliminating or substantially reducing this problem.

I replace all paper gaskets with LOCTITE 515 Master Gasket which sets only between the mating surfaces and any excess dissolves in engine oils or fuels.

Do not use silicone based compounds for this purpose as excess silicone can break free and in its cured state will block oilways very easily.

I use LOCTITE 515 between rocker box and cylinder head rear timing cover and crankcase, front and rear timing covers, and on water outlets.

I also use it on both sides of the cork sump gasket to overcome compression set and the need for retightening.

[b] Rocker Lid Gaskets

I make these out of a black silicone compound but I use a spare rocker box with the shaft removed. Thoroughly clean lids and squeeze compound around the perimeter. Coat the top edge of rocker box openings with oil to act as a release and place on the boxes very gently. Gravity will ensure the compound takes up the correct form. Excess can be trimmed away once it is cured.

To maintain a tighter clamp squeeze the lid spring clips together or fit mechanical clamps.

[c] Fan Extension Shaft

The felt seal in the front timing cover can be replaced with a standard 1 1/2" x 5/8" dia. x 3/8" thick lip seal. The only modification being the need to grind an extra drain channel across the brass bearing face. **(See Diagram 3)**

[d] Distributor Shaft

Fit an 'O' ring (1" x 3/32") in the groove on the mounting shaft. This will stop oil escaping while still lubricating the inner shaft.

[e] Generator Flange

If oil escapes from the flange with the generator mounted then the oil slinger on the generator drive dog is not doing its job. The likely reason for this is the 2:1 crankshaft gear touching or too close to one side of the timing cover. Scrape the cover to give approx. 0.010" clearance all round.

IGNITION SYSTEMS

[a] Magneto

Riley fitted two types of Magneto; the most common being the moving coil types made by BTH or LUCAS which were mounted on a trilobal flange on the timing covers and driven direct from the timing gear.

The second was the SCINTILLA MOVING MAGNET type which was considered more reliable due to the lack of centrifugal stress on the coil. This mounts the same way as the distributor and drives from the skew gear behind the inlet camshaft gear.

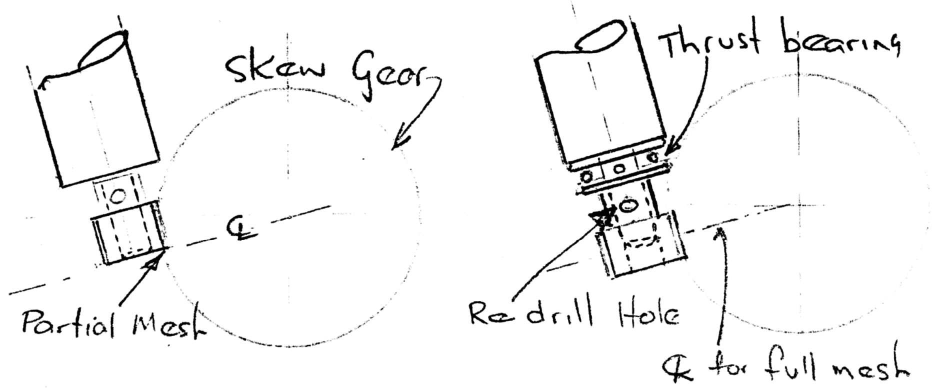
With modern epoxy encapsulation materials there is no reason why the BTH and LUCAS magnetos shouldn't give years of reliable service.

[b] Coil Ignition

Standard LUCAS coils and distributors were often used by Riley with one very important modification.

On the main shaft a 31/32" x 1/2" dia. x 1/4" thrust bearing was placed above the drive gear and the 1/8" drive pin was 1/4" lower down the shaft.

I have come across a number of Riley 9s with the drive gear hard up against the mounting shaft to utilise the standard distributor shaft. If this is done the drive gear will not be fully meshed with the skew gear, causing it to slog out. **(See diagram 7)**



DIAG 7 DISTRIBUTOR DRIVE POSITION

TUNING AND PERFORMANCE IMPROVEMENT

[a] Raising Compression

7.5:1 domed head pistons are available in both MERLIN and PRE MERLIN configurations. Made by OMEGA in the UK, these solid skirt pistons are very well balanced, and do not foul valves even with Brooklands camshaft lift.

Another route is to plane up to 1/16" off the cylinder head and a similar amount from the block. If taking more than this make sure there is sufficient material between waterways and pistons and valves have ample clearance.

[b] Carburettors

The fitting of twin 26mm ZENITH's to the standard engine raises power from 32BHP at 4500rpm to 36BHP at 4500rpm. The use of twin 30mm ZENITH or S.U.s in the sports engines (TWIN EXHAUST CAMSHAFTS) increases power to approximately 41BHP at 5000rpm.

[c] Cylinder Head Modifications

Opening out the inlet ports to 30mm dia. is relatively easy once the valve guides are removed. This will give a noticeable improvement in low down torque as will polishing all ports and fitting an extractor exhaust system.

Any further cylinder head developments require extensive welding to reduce spark plug size to 14mm dia. and fit larger valves into the flattened off compression chamber. This brings specifications similar to one of the Brooklands racing heads.

Freddie Dixon also ground a pent roof shape into the head which even today is considered the optimum cylinder head design as it improves flow around the valves.

CAMSHAFT TIMING

The design and timing of camshafts can have a very significant effect on power output of an engine. This is because to get more power more mixture must be sucked into the cylinders and compressed so valve opening distance, opening time and positions have a direct relationship to maximising mixture.

Before discussing camshaft options in detail I think we should summarise what is happening in the engine relative to the camshaft timing diagrams and also the meaning of the terms used.

[a] General Principles

Using the standard Riley 9 timing diagram in Figure 8(a) as an example, the two graphs represent the two crankshaft revolutions each cylinder completes for one cycle. The left hand graph represents the inlet cycle and the right hand the exhaust.

The cycle commences at the Top Dead Centre (TDC) on the inlet diagram with the inlet valve starting to open allowing mixture to be sucked in until 50° After Bottom Dead Centre (ABDC) when it closes. The mixture is then compressed until it is ignited just before the crankshaft reaches TDC. The second revolution commences, represented by the right hand exhaust diagram, with the gases expanding until the exhaust valve starts to open at 550 Before Bottom Dead Centre (BBDC) allowing gases to escape and remaining open until 30° After Top Dead Centre (ATDC).

It will be noted however, that the exhaust valve does not close until 300 into the next inlet cycle, which means both inlet and exhaust valves are open at the same time, ie. they overlap.

[b] Valve Overlap (see Fig. 8a)

The period in which both inlet and exhaust valves are open at the same time, ie. fresh mixture is starting to enter the cylinder while exhaust gases are still being extracted thus increasing induction speed.

Percy Riley is credited with the discovery of the value of valve overlap in increasing engine power for which he was granted a patent in 1903.

[c] Duration (see Fig. 8a)

Duration refers to the period measured in degrees of crankshaft rotation in which the valves are open.

Duration of exhaust camshafts do not seem to vary greatly whereas inlet camshafts are made with widely varying characteristics.

Factors influencing the choice are the idling economy and torque characteristics required. There is always a trade off in the search for more power as low speed running smoothness and economy are sacrificed.

[d] Lobe Centres (See Fig. 8a)

The position, measured in degrees of **crankshaft** rotation of **maximum value opening.**

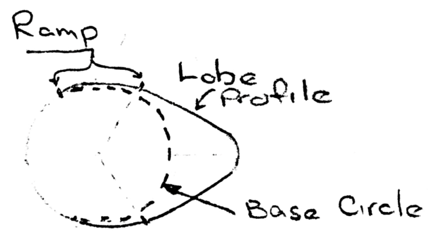
Again the lobe centre position of exhaust camshafts do not seem to vary greatly, however inlet lobe centres vary depending on the engine characteristics.

As a general rule the closer the lobe centre is to the horizontal axis the greater the power output but the rougher the engine runs at idle and low speeds.

Lobe centres are an easily measured position for setting the timing from basics as they cancel out the effects of tappet clearance or silencing ramps.

[e] Silencing Ramps

Ramps are used in modern camshaft design to quieten tappet noise and reduce stress in overhead gear. They are a very slight taper leading into the lobe proper and have a total lift equal to the tappet clearance divided by the rocker ratio. **(See diagram 9)**



DIAG 9- SILENCING RAMP

[f] Rocker Ratio

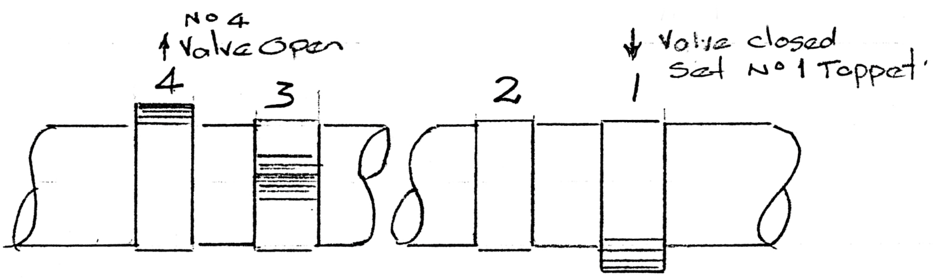
The mechanical advantage gained by the differing lengths of rocker arm around the pivot on overhead valve engines. **(See diagram 6)**

[g] Tappet Clearance

Correct tappet clearance is critical to engine performance as .004" extra clearance means that the valves can open approximately 100 later and close 10° earlier, significantly shortening the duration of valve opening.

[h] Setting Tappets

On 4 cylinder Riley engines the firing order is 1243 which means that cylinders 1 and 4 are always at opposite positions to each other as are cylinders 2 and 3. **(See diagram 11)**



DIAG 10 - TAPPET SETTING SEQUENCE

Therefore: set No. 1 cylinder tappet when No. 4 is fully open
set No. 2 cylinder tappet when No. 3 is fully open
set No. 3 cylinder tappet when No. 2 is fully open
set No. 4 cylinder tappet when No. 1 is fully open.

CAMSHAFT DESCRIPTIONS
Diagrams 8a to 8d

[a] Standard Camshaft Profile (Fig. 8a)

The standard Riley 9 camshaft has a cam lift of 0.187". With tappets set at 0.002" the inlet camshaft opens at TDC, has a lobe centre at 250 after the horizontal axis and closes 500 BDC.

With 0.003" tappet setting the exhaust valve starts to open 550 BBDC has a lobe centre 12 1720 before the horizontal axis and is fully closed 30° ATDC. This gives a valve overlap of 30°.

This configuration gives a free revving, smooth idling engine with good economy.

[b] Twin Exhaust Camshafts (Fig. 8b)

For many years Riley enthusiasts have fitted twin exhaust camshafts to their Riley 9s in an effort to improve performance. The greater duration of an exhaust camshaft fitted on the inlet side allows the inlet valve to open earlier (30° BTDC) and close later 55° ABDC). It also brings the lobe centre closer to the horizontal at 12 1/2° before. The result is approximately 10% extra power increase at the expense of smooth idling and low speed characteristics.

Most published data about twin exhaust camshafts lists the opening at 250 BTDC and closing 50° ABDC the same as the Imp Profile. However, with a 265° duration camshaft these figures are only obtainable with very loose noisy tappets. The Imp inlet duration is actually 255°.

[c] AJ711FB Profile (Fig. 8c)

This is a modern profile with 0.234" lift and relatively long silencing ramps. Hence, the tappet clearance of 0.009" inlet and 0.015" exhaust. In the search for a suitable modern profile we were looking for increased performance without the harshness of the twin exhaust concept. The use of long ramps also places less strain on the overhead valve gear.

Much of the improved performance, (which is approximately 10-15% more than the twin exhaust layout) stems from the greater cam lift allowing more mixture into the cylinders.

While both inlet and exhaust duration and lift is greater than standard camshafts the lobe centres are virtually the same. This gives a free revving engine with considerably more power and very smooth idling.

[d] Key Modified AJ711FB (Fig. 8d)

While the AJ711FB profile meets the idling and performance characteristics we were looking for, it is possible to improve power output even further by using a stepped Keyway to bring the inlet lobe centre closer to the horizontal axis. By moving the lobe centre 10° the inlet opens at 20° BTDC and closes 50° ABDC which is the timing Riley used on later 1 1/2 litre Sprite engines.

The results are extra torque at medium speeds enabling the engine to slug along more in top gear.

However, this extra power is gained at the expense of the standard profile's smooth running characteristics.

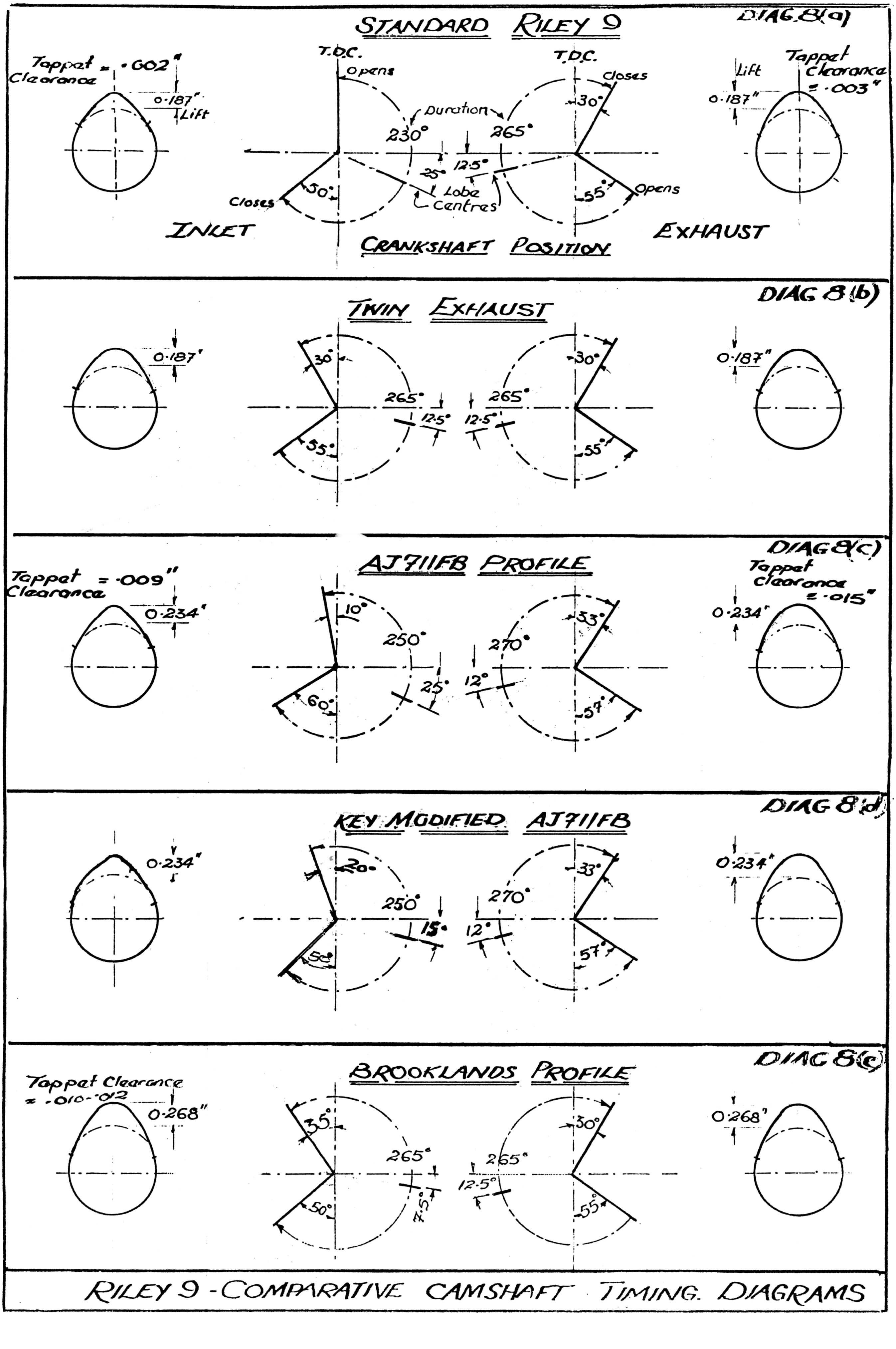
[f] <u>Brooklands Profile</u> (Fig. 8c)

This is a basic racing profile with a lift of 0.268" and the lobe centre much closer to the horizontal axis (7.50). Idling is quite rough and tappets tend to be noisy with large clearance and short ramps, but of course power is significantly improved for high speed racing.

[g] <u>General</u>

The AJ711FB profile is a very versatile one which can be applied to any standard camshaft without building up the lobes or undercutting the base circle excessively. Performance improvement over the twin exhaust setup is very significant and the engine still runs more smoothly.

I would not recommend the use of such high performance camshafts without first crack testing crankshaft and conrods as we could be looking at close to 50 BHP when combined with high compression pistons and twin carburetion.



RILEY 9 - COMPARATIVE CAMSHAFT TIMING DIAGRAMS

SETTING CAMSHAFT TIMING

As soon as non-standard camshafts are fitted timing marks on gears can become useless.

I have found lobe centres to be the best way to establish the correct settings as a dial gauge can easily establish maximum valve opening and the effects of ramps or tappet clearance are cancelled out.

The procedure is to set No. 1 piston at TDC - withdraw the idler gear and turn the inlet camshaft to give maximum value opening. Turn the crankshaft approximately 102° and re-engage the idler gear. (You will need some type of protractor).

Turn the crankshaft (with idler engaged) through the remainder of the inlet cycle to TDC and continue to the exhaust lobe centre approximately 258° after TDC.

Disengage the idler gear and without disturbing the crankshaft or inlet gear turn the exhaust camshaft until No. 1 exhaust valve is fully open. Re-engage the idler gear.

Check the opening and closing positions of both inlet and exhaust valves which should roughly correspond to one of the diagrams in figure 8.

At worst you should be no more than one tooth out. Make sure you turn camshafts clockwise to open valves sooner and anticlockwise to open valves later.

OILS

Do not use modern multi grade high performance oils in older engines. The additives used are designed to operate at much higher temperatures and can cause problems.

Choose an oil made from a heavier base crude so it will tend to cling to working parts that may stay idle for long periods.

PENRITE make oils specifically for older engines. Their HPR range is blended with a full additives package suitable for older cars with overhauled engines and will increase oil pressure 10-15psi when hot.

PENRITE SHELSLEY engine oils are suitable for older engines which have not been overhauled. They are blended with anti-wear, anti-corrosion and anti-foaming agents but not detergents so they do not disperse accumulated sludge through the engine.

Synthetic oils such as Mobile No.1 can be used satisfactorily in an overhauled engine once it is run in. This is because the friction properties are so good that pistons will not bed-in properly during running in.

Synthetics have been known to reduce engine running temperatures by 10-15°C in some high performance Jaguar engines.

For a cheaper alternative in an overhauled older engine DUCKHAMS 20W-40 seems to be a modern oil based on a heavier base crude.

Other specialist racing oils such as KENDALLS may have suitable grades.

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