HISTORIC RACING Technology

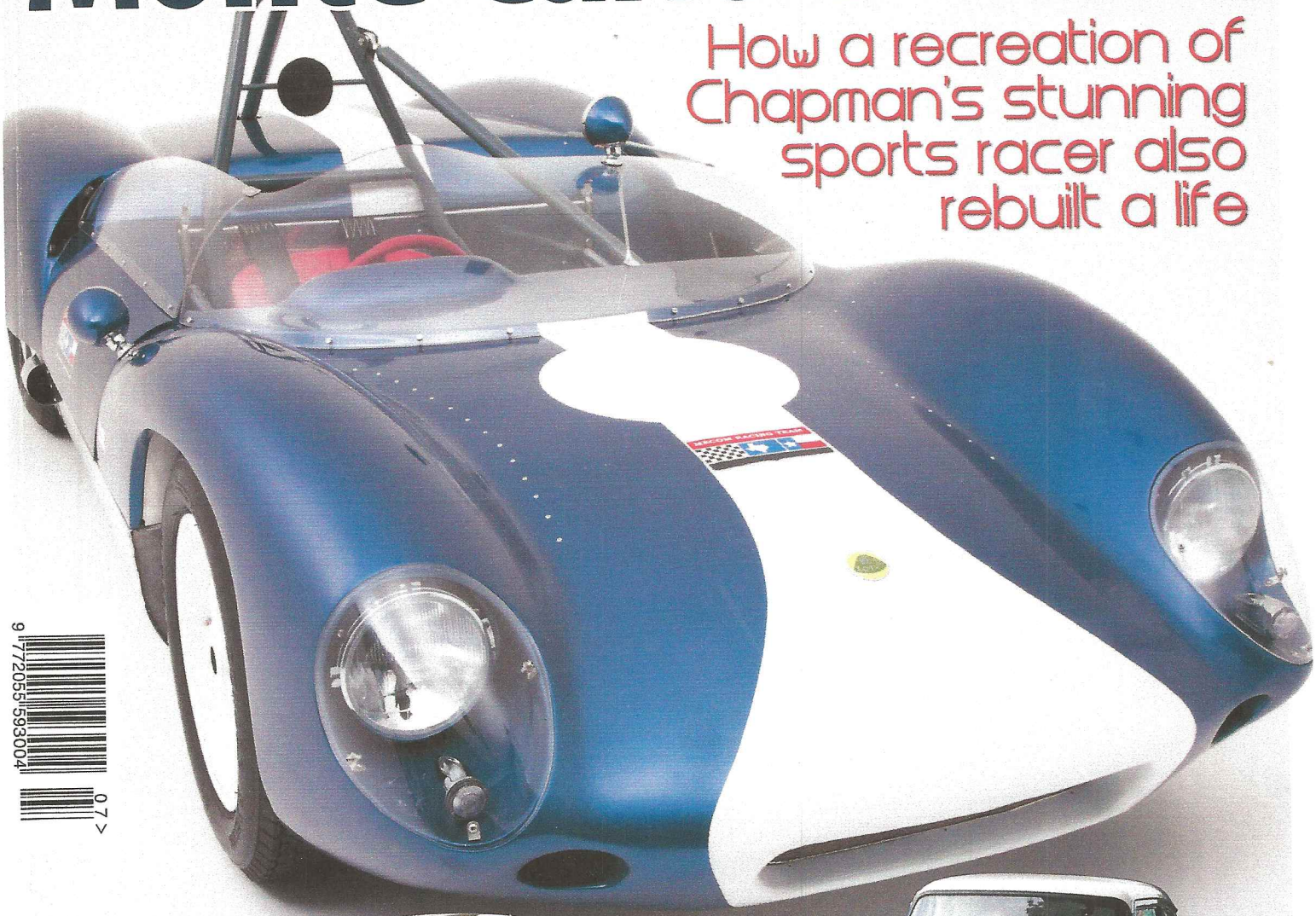
Winter 2016 Issue 7 UK £6.99 USA $12.00 www.racetechmag.com

Today's technology in yesterday's cars

Lotus 19 'Monte Carlo'

Monte Carlo or bust

How a recreation of Chapman's stunning sports racer also rebuilt a life

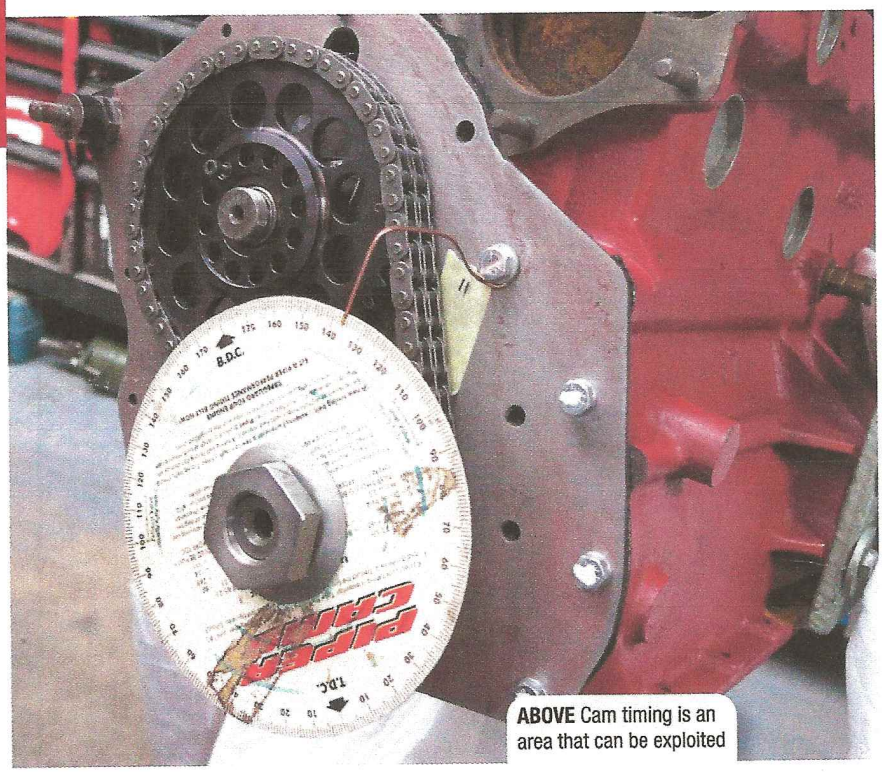


Austin Healey 3000 engine analysis

"Moment of madness!" Austin A40 build project

PLUS Metal stitching • Appendix K explained

9 772055 593004 07



ABOVE Cam timing is an area that can be exploited

PLAYING THE ODDS

Bill Rawles offers tips on engine preparation for Healeys

THE name Rawles is synonymous with Big Healeys. Accomplished Healey racer Bill Rawles also restores and prepares them under the banner of Bill Rawles Classic Cars.

Like the other engine builders we've spoken to he is quick to emphasise the importance of a good quality crankshaft. "A steel crank is a must to make the engine hold together," he notes.

The Big Healey engine is limited by the same torsional balancing issues as any other straight six. Theoretically, it has perfect first and second order balance, but this oft-quoted property of the straight six layout assumes an infinitely rigid crankshaft. In reality, anything up to a couple of degrees of flex can occur, at which point the firing of cylinders slips out of phase and the engine becomes dangerously unbalanced.

There are various ways to tackle this. A stronger crankshaft, lighter reciprocating components and a torsional damper integrated into the crank pulley all help.

"We've found it's essential to run a proper damper on the front of the engine like an ATI Super Damper," comments Rawles. "Without that, the harmonics in the crankshaft limit the engine speed you can reach."

His approach is pragmatic and like others he believes that attempting to over-engineer this fundamentally simple unit can backfire: "I think these engines reached their extreme back in the Nineties when people were breaking things regularly in search of an extra one or two horsepower. Since then everyone has pulled back a bit."

One example he gives is the compression. Rawles reckons the optimum compression ratio on high quality pump fuel is around 11.5:1 for racing. Some engine builders go higher, but that runs the risk of detonation unless you're using specially formulated race fuel, which is banned in a lot of historic events. This comparatively conservative compression ratio improves reliability and also causes the engine to run a little cooler.

GAS FLOW

It's a similar situation with gas flow, he explains: "Over the years people have taken more and more out of the heads, but it doesn't really work. The trick is to keep them quite small so you increase the gas velocity going into the engine. We used to flow bench our own heads, but with modern CNC machining the off-the-shelf competition heads are now so good that we don't need to.

"You can get big valves too – about 1.5 mm larger than standard – but you see no difference at all. We use proper racing valves with a wasted and fluted design, but size-wise they're completely standard. The danger of using big valves is that they get so close to each other they split across the seats."

One area that has benefitted from recent work is cam design, he explains: "We're running a new cam from Sideways Engineering in Sweden at the moment and the car has suddenly jumped to the front. It's an interesting configuration – it's got a bit more lift than the usual Healey cams and it's got a lot of duration, but the timing is quite retarded. The power curve is smoother now and it pulls right the way from about 3,500 rpm."

However, while there are still gains to be made in performance, the Big Healey's greatest strength remains its longevity.

"Where the Healey comes into its own is endurance racing," he says. "At events like the Spa Six Hours they just keep going."

It's a comment born out of personal experience. Two years ago at the Spa Six Hours, the Rawles car finished 17th overall, beating 91 other competitors, including E-Types, Cobras and GT40s. While the more exotic cars may have the edge on pace, the 3000 has the staying power required to claim some serious scalps in long distance events. Just as it was in the Sixties. HRT

POWERFULLY UNCOMPLICATED

Robust, solid and straightforward, the BMC C-Series found under the bonnet of some Austin Healeys has been developed to give a performance its original designers could only dream about, as Chris Pickering recounts

THERE'S a persistent myth about the Austin Healey 3000 engine. Pub bores across the land will tell you that the BMC C-Series straight six was originally designed for use in a truck. While that's not strictly true – unless you count the Austin Westminster – it's not hard to see how the reputation came about.

This is a robust, uncomplicated engine. It uses a pushrod valvetrain with a single camshaft housed in the cylinder block and two valves per cylinder. In production trim, both the cylinder head and the block were made from cast-iron, while the crankshaft is a simple five-bearing affair, only designed to rev to about 6,000 rpm. Early 2.6-litre versions in the Austin Healey 100-6 even came with a four-port siamesed cylinder head, complete with a disastrously inefficient integral intake manifold.

On paper, it doesn't sound like the most promising basis for a competition car, but its torquey delivery and barrel-chested soundtrack has won the Big Healey engine legions of admirers over the years.

Austin Healey made three main variants of the 3000, and these days the Mk1 and Mk2 cars are most sought after for racing. While the Mk3 may be the quickest and the most powerful 3000 in production trim, it uses a heavier rear axle, along with a stepped chassis at the back, which limits how far the ride height can be dropped for circuit use. Conversely, the extra ground clearance and increased suspension travel make it the most popular choice for rallying.

Austin Healey used a variety of camshafts and carburettor configurations, resulting in power outputs ranging from 117 bhp in the 3000

JME Healeys

ABOVE A wide variety of different carburettor setups have been used, but the so-called tri-carb configuration offers the best performance

ABOVE The Austin Healey 3000 is now more popular than ever as a circuit racer

Andy Swift

Mk1 (and the six-port variant of the 100-6) through to 148 bhp in the road-going Mk3. Under the bonnet, however, the engines are fundamentally the same.

RECIPROCATING ASSEMBLY

In-period, even the works cars ran a relatively mild state of tune, which included standard con rods, a small increase in compression ratio and what would these days be considered a fast road cam. As such they were good for around 200 bhp, but the best FIA-legal historic engines are now comfortably over 280 bhp. So what's the key to getting the best out of them?

The answer lies partly with the use of modern materials. Design modifications tend to be quite conservative – modern Healey pistons for instance, look much the same as their 1960s counterparts – but contemporary materials lead to a virtuous circle within the engine.

High-strength steel con rods, forged pistons and modern ring technology allow the engine to withstand higher combustion pressures. At the same time, these parts are significantly lighter than those used in-period, which reduces the loads on the reciprocating assembly. This, combined with modern crankshaft design using lighter, stronger steel, helps the engine to rev a lot more freely.

Renowned Austin Healey racer John Chatham has first-hand experience of the benefits this can bring. As a driver, his racing career spanned nearly four decades and included factory drives with BMC on events like the Targa Florio. Half a century on he's still one of the top race preparation specialists for the marque.

"The works engines used a forged steel crank and we had them revving to 7,000 rpm in the Sixties, but the standard engine tries to blow itself apart at about 6,400 rpm," he recalls. "Nowadays, our competition engine will rev to 8,000 rpm without breaking – we don't use all of that because there's no point, but it will safely go there."

There are a handful of dedicated parts suppliers that make this sort of performance possible. The largest is AH Spares, which manufactures and supplies a range of fast-road and competition parts under its AH Performance sub-brand, including all the reciprocating assembly components.

Made from gas-nitrided EN40B steel and cross-drilled, the AH Performance competition cranks are significantly lighter than the stock items. Although the fundamental geometry such as the stroke is unchanged they feature a modern streamlined web design that helps to reduce windage and oil drag. They are supplied in either 8 or 12-bolt configurations to suit the company's lightweight flywheels.

The steel H-beam rods that make up the next part of the assembly are shot peened, with EN24V big end bolts. They use slightly larger big end bearings than the original Austin Healey design, providing greater strength.

Omega Pistons also serves the Austin Healey race market, as the company's general manager, Andy Baker explains: "We do a lot of forged pistons for the Big Healeys, but it's one of the few applications where there's still a demand for cast pistons."

Omega's cast piston is very close to the original design, he explains. It features a slight dish but there are no valve pockets or indentations. The forged piston, on the other hand, is a completely flat top design, which raises the compression ratio slightly, but it's still about as simple ▶

as a racing piston gets.

"There's nothing particularly clever about the design," comments Baker. "If you look at a race piston for something like a Jaguar XK you're permanently fighting detonation, but we never have any problems with the Austin Healeys. It's one of those engines that just works."

CYLINDER BLOCK

The relative abundance of Austin Healey engines means that original blocks still tend to be used for race engines. Generally speaking, these castings – the youngest of which is nearly half a century old – are still up to the job, but it pays to prepare them carefully.

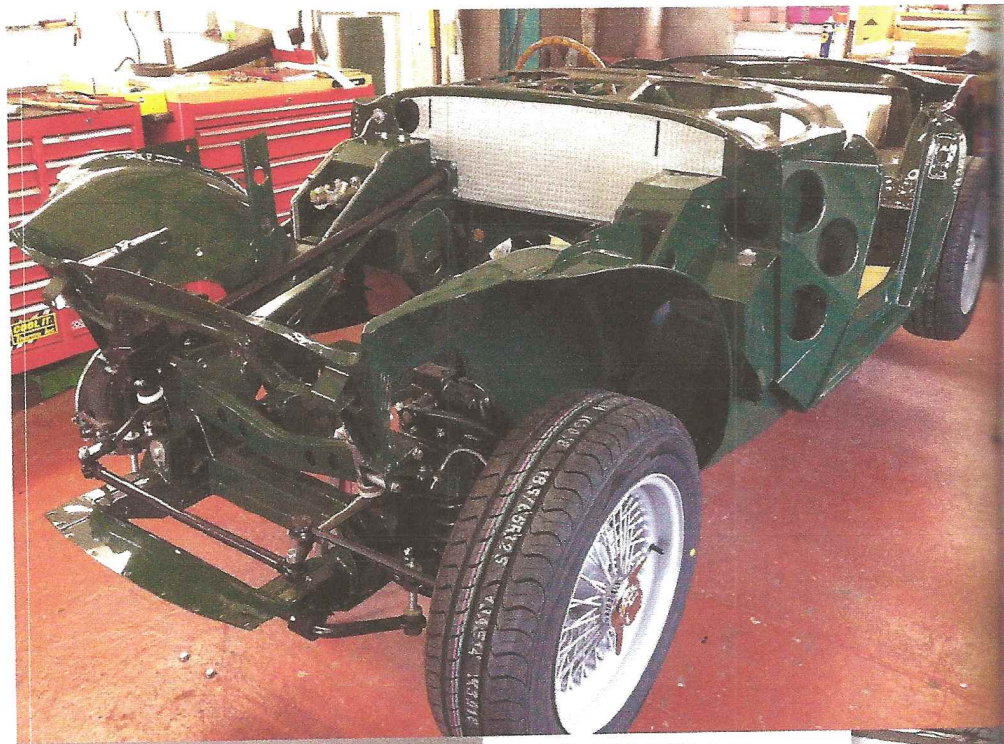
"It's a good strong engine; it's very rare that you see anything go bang in a big way, but if you take an old BMC block or head you can see the porosities in it," comments Chris Everard, managing director of JME Healeys, an independent specialist based in the old Healey factory at Warwick.

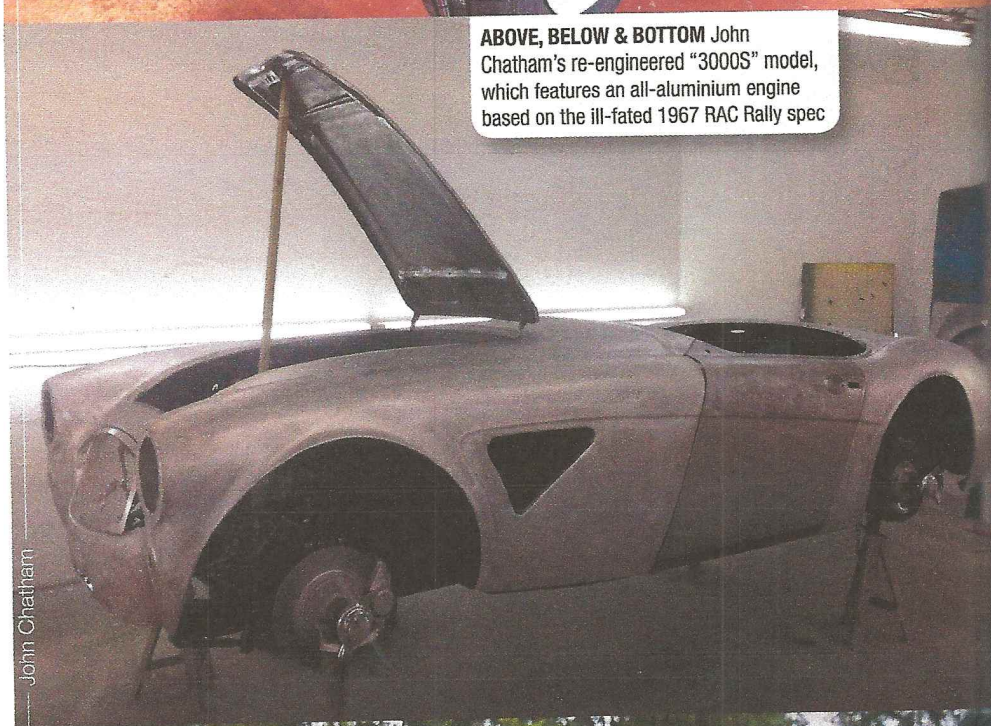
"You notice casting issues in other areas too. Some engines have got a lot of slag inside the cooling galleries, which affects the flow of water. As a result you get some engines that run considerably cooler than others, due to the individual casting."

By default, JME acid dips the blocks it works with to remove sediment, but access can make it tricky to take the concept any further. The area around the water pump isn't too bad, but around cylinders five and six the cooling channels are virtually impossible to reach.

However, once up to speed, cooling doesn't tend to be a problem. "You very rarely see an engine overheat once you've got decent airflow through the radiator," says Everard. "The only potential problem comes when you're stationary – there's no real cowling between the radiator core and the fan, so it doesn't draw very effectively. A lot of people add electric cooling fans for when you're in the paddock or maybe on the warm up lap, but once you're racing you don't need them."

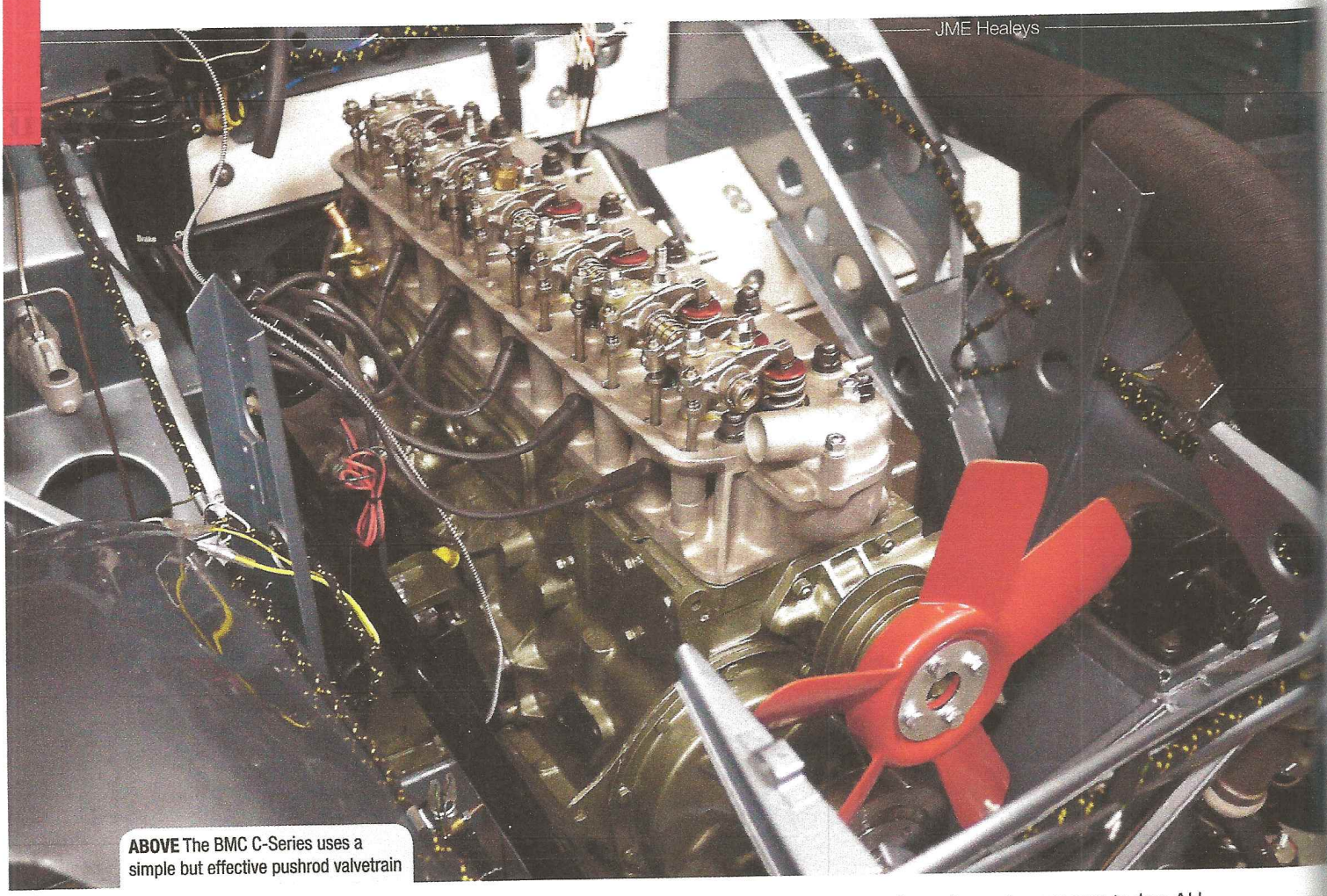
In-period the Austin Healey 3000 was only ever homologated with the standard cast-iron block, which means that teams hoping to compete under ▶





ABOVE, BELOW & BOTTOM John Chatham's re-engineered "3000S" model, which features an all-aluminium engine based on the ill-fated 1967 RAC Rally spec

John Chatham



JME Healeys

ABOVE The BMC C-Series uses a simple but effective pushrod valvetrain

the FIA's Appendix K historic regulations have to follow suit. However, that's not quite the full story.

The 3000's last major international outing was due to be the 1967 RAC Rally, for which the factory pulled out all the stops. This included the development of a prototype aluminium engine block, which resulted in a dramatic weight saving. A handful of these blocks were produced, but an outbreak of foot and mouth disease meant the rally was cancelled and the 3000 never saw action again with the works.

At least one of the aluminium blocks was later used in private hands by John Chatham, who has since developed his own version in conjunction with BAW Engineering. "It's a direct copy of the works development aluminium block with some minor strengthening modifications," he explains. "It's around 50 per cent lighter, which leads to tangible benefits in terms of handling, acceleration and braking. It also means the steering is much lighter – even with a high ratio steering box."

Chatham supplies the aluminium blocks for non-FIA race engines and fast road cars, including his own re-engineered 3000S model, which also features lightweight aluminium bodywork and a straight cut 'Tulip' gearbox with a competition overdrive, effectively resulting in a six-speed transmission.

TOP END

While aluminium blocks might be outlawed, alloy heads were used on the works competition cars from 1961, and as such they're considered a must-have for serious racers today. AH Performance produces a range of fast road and race heads, supplied ported, polished and ready to fit.

Externally, these are identical to standard cast-iron items, but they offer several key advantages. First and foremost, they shave the best part of 20 kg (35 lb) from the top of the engine, which has a marked effect on the handling. Aluminium also has much better thermal conductivity than cast-iron, which improves heat transfer. ▶

ABOVE Many of the road-going cars use twin carbs

JME Healeys

Finally, the standard heads are prone to cracking between the valve seats, but the aluminium heads don't seem to suffer the same issues.

Porting is a major factor, with heads opened up around the inlet valves to improve flow. Most engine builders do not tend to deviate that far from the standard valve sizes, though, explains AH Performance's Gary Pinks: "The standard valves are already quite large, so people tend to concentrate more on the ports and the cam profile."

AH supplies a range of bespoke cam profiles for fast road, race and rally use, alongside a replica of the factory camshaft from the 3000 Mk3 (also used in some of the earlier competition cars).

"We used a lot of computer simulation to optimise the new camshafts," Pinks explains. "The competition profiles are completely new, so these really are the most modern high tech cams available today. They offer vastly improved volumetric filling efficiency, which ultimately means more power."

Ironically, although Austin Healey 3000 pistons do not require recesses for valve clearance, the bores do. "If you're going to run a full race camshaft you need a pocketed block, because the valves are angled outwards and the lift and duration are such that they would strike the side of the bore otherwise," Pinks explains.

Take a closer look at the sort of cam profiles used on these engines and you can see why the pockets become a necessity. Fellow camshaft supplier Piper Cams uses 528 thou of lift and 328 degrees' duration on its full race cam, compared to 360 thou lift and 270 degrees' duration on the standard road cam.

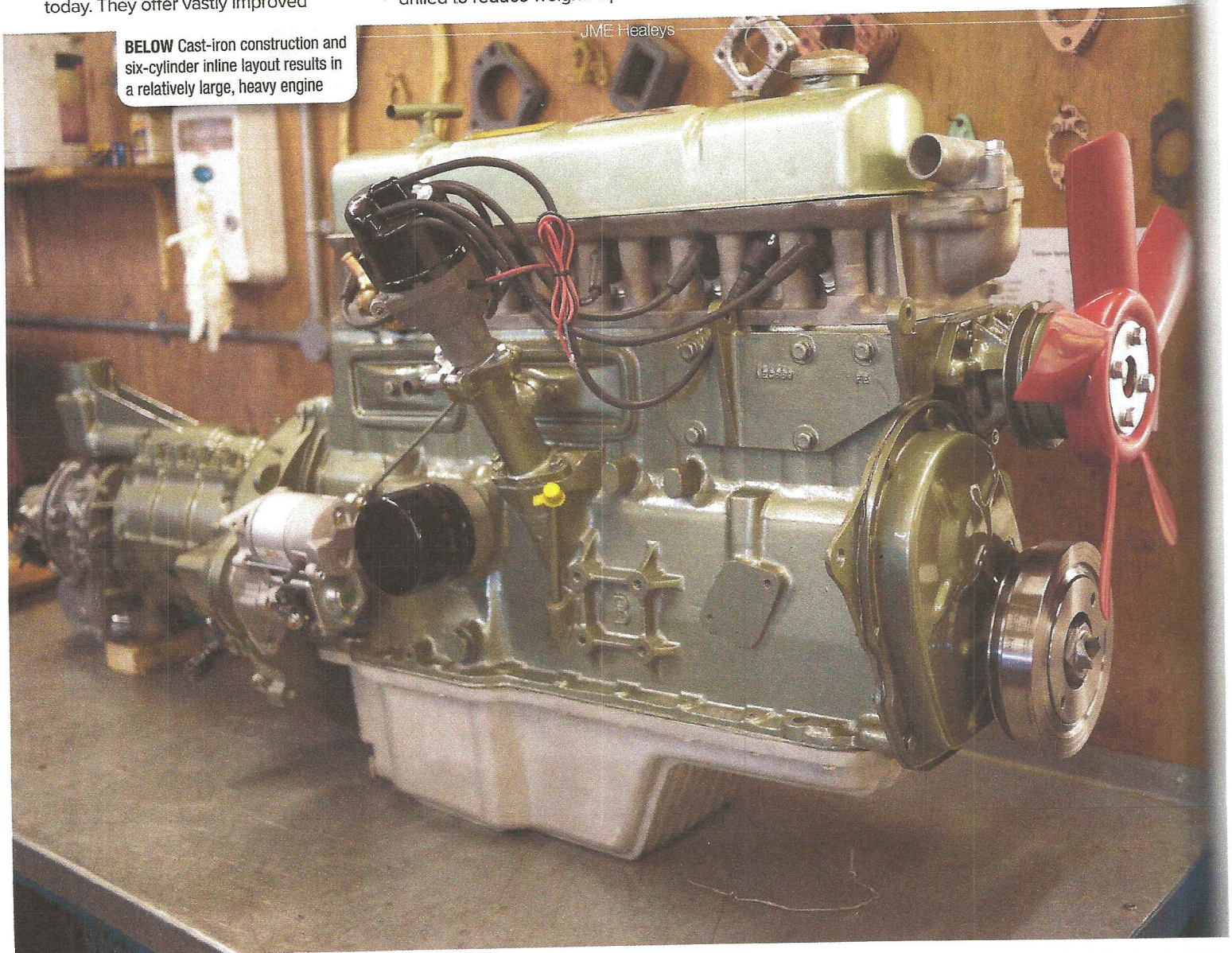
Material choice comes down to budget, explains Piper Cams technical director John Crabb: "Billet cams cost more than forged steel, but they can be gun drilled to reduce weight. Options include superfinishing and diamond like carbon (DLC) coated steel followers."

For high lift cams, solid steel rocker pedestals are often used in place of the standard aluminium items. This mod dates right back to the original works cars and it not only improves the strength of the pedestal, but helps to locate the rocker shaft more effectively, preventing fretting and improving valve control at high rpm.

ANCILLARIES

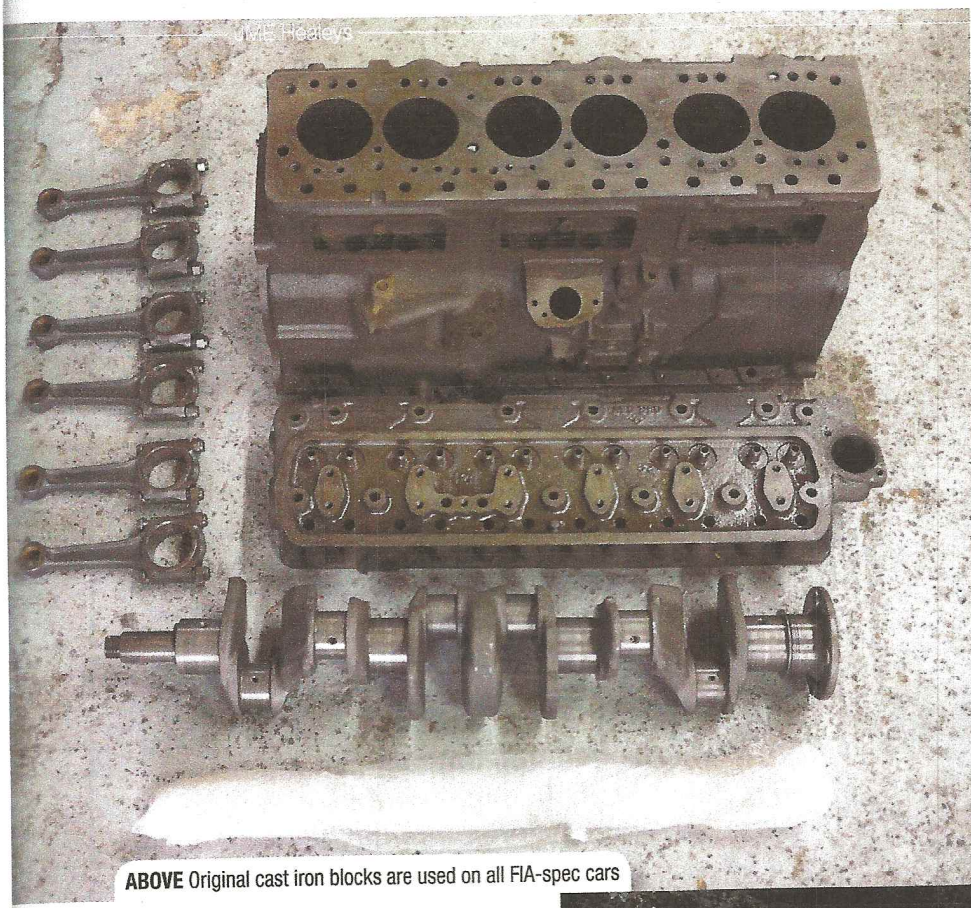
Lubrication is generally not a problem on the 3000 engine, although it does tend to lose a bit of oil pressure over time as the big ends and the main shell bearings wear. On road car engines, it's quite common to counteract this with a high capacity oil pump, which extends the rebuild life of the engine, but it's not recommended for competition use.

"Even on a race engine you don't need more than 45 or 50 psi and the standard



JME Healeys

BELOW Cast-iron construction and six-cylinder inline layout results in a relatively large, heavy engine



ABOVE Original cast iron blocks are used on all FIA-spec cars

oil pump is very good," comments Everard. "The sump is quite large – it holds about 8.5 litres – but the oil pump can shift all of that within a couple of rotations. Using a high capacity oil pump on a high revving race engine just risks shredding the drive gear and if that goes you'll know about it!"

Under FIA Appendix K all Austin Healey 3000 engines must run a wet sump, so decent baffling is essential. An aluminium sump is also a popular addition, which offers reduced weight, improved strength and better cooling.

Of course, those aren't the only points to consider. Higher compression, made possible by modern internals, means that race engines now have to be fitted with high torque starter motors. Outside of Appendix K, it's also common to fit an alternator in place of the original dynamo.

Firms such as Mallory Ignition can provide an electronic ignition conversion where permitted. For those limited to a period distributor the works-type Lucas unit with its preset timing curves offers more advance than the standard unit.

FUELLING AND IGNITION

Quite a variety of different carburettor setups were used in period, which means there's a plethora of potential options for a modern historic racing engine, but in reality everybody uses Webers. As Everard explains: "A set of triple Weber 45 DCOEs is the setup you need to go racing, even on the 100-Six. It's bolt-on horsepower. That said, the Webers are actually quite poor at low speeds. Triple SUs make the car a lot more tractable across the rev range, but they haven't quite got the same oomph at the top end."

Just as in the Sixties, race and rally engines tend to be quite similar under the skin. The main difference is the choice of carburettors and camshaft.

"The secret to the Healey engine is getting everything to work together," Everard concludes. "It's all about understanding the right compression ratio for the engine; getting the valve timing, ignition and fuelling right. They're time-consuming engines to set up and it's important to have the right equipment." HRT

ABOVE The Austin Healey 3000's greatest successes in-period came in rallying and it continues to be a popular historic rally car