HISTORIC RACING Technology

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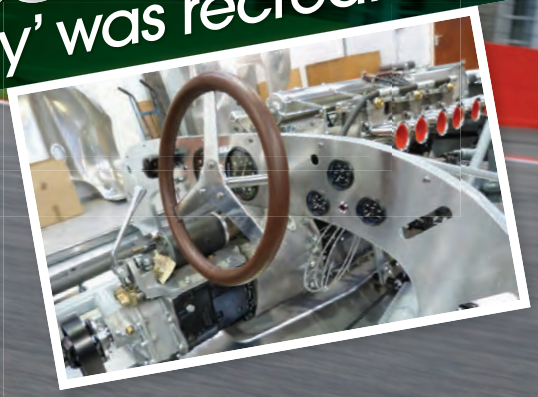
Launch Issue SPECIAL

Lister is back

How the Lister Jaguar 'Knobbly' was recreated



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The Beast of Turin

Lister is back

How the Lister Jaguar 'Knobbly' was recreated

> **"They are, bolt-for-bolt, as original as they can be, and I'd say they're closer to original spec than 90 per cent of the Listers out there"**

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Tel +44 (0)20 8446 2100
Fax +44 (0)20 8446 2191

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EDITOR
Chris Pickering

EDITOR-IN-CHIEF
William Kimberley

CONTRIBUTORS
Nick Mason
Zak Brown
John Simister
Andy Swift

CONSULTANT EDITOR
Mark Skewis

ART EDITOR
Paul Bullock

WEB MANAGEMENT
Joomlaholics.com

ADMINISTRATION/ SUBSCRIPTIONS
Vikki Amour

SALES EXECUTIVE
Mike Norman

COMMERCIAL DIRECTOR
Maryam Lamond

PUBLISHING AND EDITORIAL DIRECTOR
Soheila Kimberley

HISTORIC RACING Technology

841 High Road, Finchley
London N12 8PT
Tel: +44 (0) 208 446 2100
Fax: +44 (0) 208 446 2191

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Welcome to Historic Racing Technology

WITH so many publications out there covering classic and vintage cars you may ask why the world really needs another one. After all, just about everything from the Edwardian days onwards is already covered in some way, shape or form.

The answer is that we're striving to bring you a unique perspective, one that focuses on the task of racing, restoring and maintaining these cars in the modern era. In particular, it's about the way that modern techniques are merging with traditional craftsmanship to safeguard some of the most important designs in motorsport's long and rather splendid history.

To some the idea of modern intervention will ring alarm bells. But the fact is that just about every active historic racing car contains elements of contemporary technology. Whether it's the use of modern seals in the fuel system to protect against chemical corrosion or a thermal barrier coating on the exhaust manifold to prevent a priceless engine from overheating, 21st century technology is at work in even the most authentic vintage racers.

It's thanks to the skill and ingenuity of those in the classic racing industry we can still witness a Lister Jaguar flat out down the Lavant straight at Goodwood or a Porsche 906 sweeping through Tertre Rouge at Le Mans. Without the facility to provide spares and consumables these glorious machines would be consigned to a museum somewhere, collecting dust. Instead they continue to thrive as living, breathing legends. And that can only be a good thing.

Chris Pickering
Editor

Historic cut-off date introduced

By **Chris Pickering**

THE FIA has agreed to set a cut-off year of 1990 for official historic status. Likely to apply for the next 10 years at least, the decision has led to the creation of a new working group to look at the regulation of more recent post-historic vehicles.

The group's responsibilities will include defining technical regulations for these modern classics, which will operate outside of the existing Appendix K regulations.

"We cannot ask cars of this age to comply with fully modern regulations, so it will be a mixture of old and new," commented Vincent Caro, head of the FIA's historic department. "It's a little bit like the Appendix K regulations; there are some things which can be updated and some things which cannot be changed without comprising the originality of the car."

The year is seen as something of a watershed, explained Caro: "1990 was a key year regarding technology in a lot of categories. After that you see an increased use of electronics on the car, plus new materials and different crash test requirements. We need a dedicated group of experts who are able to deal with these things."

One of the issues tackled by the new working group will be how to regulate categories such as Group C, where technical regulations laid down before 1990 continued to apply into the Nineties. In such instances, it's likely that the cut-off will be extended to cover later cars, although this has yet to be confirmed. HRT

Motorsport to be allowed on Britain's public roads

By **William Kimberley**

Races, rallies, hillclimbs, motorbike races and other motorsport events could be seen on British roads. It follows British Prime Minister David Cameron's announcement while opening the Williams Advanced Engineering Centre in early July that he will do away with the need for an Act of Parliament to be able to close roads. Instead, the responsibility will be devolved to local councils which will consult with communities on road closures and safety measures. The legislation will feature in the Deregulation Bill, scheduled to go to the House of Commons in the autumn. It means the measure will be on the statute books before Parliament breaks up in spring 2015.

While this is primarily seen as an opportunity for Formula One to race around the streets of London, the reality is that it will make classic rallying in particular far more viable.

"I can announce today that we are going to enable more road races for GB motor sport," said Cameron. "We think this will be really useful to British motorsport: more races, more events, more money coming into the country and more success for this extraordinary industry." HRT


Photos: Marcus Dodridge

HTP extended

By **Chris Pickering**

FOLLOWING a meeting of the World Motorsport Council, the FIA has announced that the Historic Technical Passport (HTP) will now be valid for 10 years. The 26-page document, designed to verify that a car conforms to its original technical specification, is a requirement for any event registered on the FIA's international sporting calendar, including those taking place in the driver's home country.

When first introduced, the HTP was valid for the life of the vehicle and there was widespread opposition to the FIA's original decision to introduce a five year renewal period. It can cost upwards of £1,000 to put a car through the HTP inspection, leading some racers to dismiss it as a money making scheme. The lifespan of the document has since been extended to 10 years, but it is still proving a controversial move.

The FIA maintains that there is a sound justification for regular renewals, however. "Some of the cars that are racing do not correspond to the HTP anymore, so a periodical review gives a way to re-check them and make sure they correspond to the HTP and the Appendix K regulations," explained Vincent Caro, head of the FIA's historic department.

To a certain extent, this role is already performed by race scrutineers, but the FIA argues that is not enough. "The [scrutineering] system has its limits," commented Caro. "In some countries you have only one or two scrutineers who are appointed to deliver feedback to the FIA on items that don't comply with the HTP."

Under the new system, every HTP will need to be renewed at some stage. Those issued from last year onwards, following the new template, will be valid for 10 years. Earlier HTPs will remain valid for five years from the point they were issued and will move onto the new 10-year format once renewed. HRT

Indy 500 double-winning Maserati claims another first

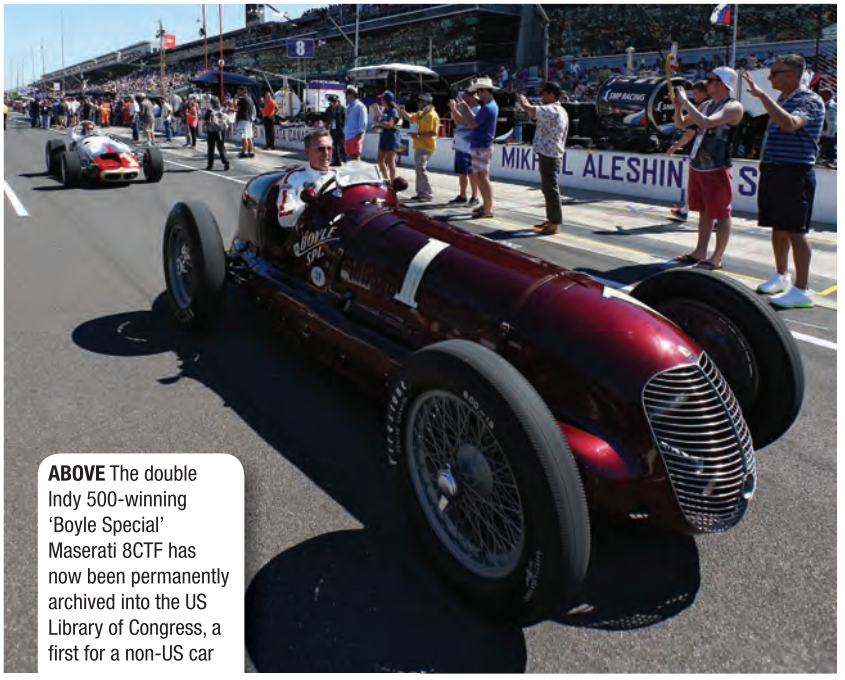
By **William Kimberley**

THREE quarters of a century after winning its first Indy 500, the 'Boyle Special' Maserati 8CTF – serial number 3032 – was pounding around the track again driven by 3-times Indy 500 winner Johnny Rutherford. Its original claim to fame was that it was driven to victory at the Indianapolis 500 in May 1939 and then again a year later by American racer Wilbur Shaw, making it the first car to claim more than one Indy 500 victory.

The Boyle in the Boyle Special was 'Umbrella Mike' Boyle, a colourful and controversial labour leader, an associate of the infamous gangster Al Capone, who ruled Chicago's most-powerful electricians' union for more than a half century. The umbrella tag came about as it was a device to collect 'tributes' or 'donations' from people who sought his support or protection for various 'business' projects. He also loved motor racing and so became a team owner, continually entering cars in the Indy 500 from 1926. Eight years later, one of his cars took the chequered flag for the first time when 'Wild Bill' Cummings drove the No 7 Boyle Products Special/ Miller in a record time to earn a record purse of $29,725.

While Maserati is happy to claim the kudos for the car today, it was an unknowing participant in the Indy 500 in 1939, the eve of Europe plunging into its second world war. The 8CTF was quietly purchased by Boyle and shipped to Boyle Racing's headquarters where it was finely prepared by crew chief Harry 'Cotton' Henning who was renowned in his day for running an operation that was second to none.

This twice-winning Maserati has now also become the first foreign car to be honoured by the Historical Vehicle Association (HVA) and permanently archived into the US Library of Congress, a new initiative to authenticate historically significant cars. Recorded under the US Secretary of the Interior's Standards for Heritage Documentation, the documentation will remain part of the HVA National Historic Vehicle Register and Historic American Engineering Record (HAER). It joins the 1964 Shelby Daytona Coupe (CSX2287) and the first-ever fibre glass dune buggy, the 1964 Meyers Manx. HRT



ABOVE The double Indy 500-winning 'Boyle Special' Maserati 8CTF has now been permanently archived into the US Library of Congress, a first for a non-US car

NEWS

New historic apprenticeship scheme

By **Chris Pickering**

THIS summer sees the launch of a new apprenticeship programme from The International Guild of Specialist Engineers. Designed for companies that specialise in historic vehicle engineering, the new programme is intended to provide young technicians with specialist skills that are not necessarily covered by a typical modern apprenticeship.

"It's recognised that we need to provide new blood," said Roger Waters, training consultant to The International Guild of Specialist Engineers. "Unfortunately the existing apprenticeship schemes tend to focus on the needs of routine servicing on modern cars. We have set up this programme to provide the sort of person who can strip and rebuild classic vehicles, aware of the fact that if they take a part off the car, they may well end up having to make a new one."

A key part of the scheme will be the understanding of classic and vintage technology. Mechanical ignition and carburettor fuel systems will be included in the curriculum, along with special training modules on subjects such as air-cooled engines, wire wheels and race preparation.

The apprenticeship lasts for three years, with eight weeks of tuition per year, split into two-week blocks, taking place at a training centre in Nottingham in the UK. The idea of this structure is to provide technicians who can get stuck in from day one, said Waters. "We want to teach them the basics so they can feel worthwhile – and indeed start earning money – from the moment they go to their employer."


Photo: Desmond Small

ABOVE The International Guild of Specialist Engineers has launched an apprenticeship programme aimed at those who want to strip and restore classic cars

Another key incentive for companies in the UK is that government grants should take care of the apprentice's tuition fees. In some instances, schemes to encourage small businesses to take on apprentices may also provide additional funding.

The International Guild of Specialist Engineers hopes to find placements for around 15 students this year, with the courses starting in September. The organisation was established in 2013 to promote and serve the interests of engineers and businesses in the classic car industry.

Further details of the apprenticeship scheme are available on the guild's website (TIGOSE.com). HRT

Allard Chrysler roars back in unique partnership

By **Chris Pickering**

EUROPE'S first dragster, Sydney Allard's 1961 Allard Chrysler, could soon be driving again under its own power. Owned by the National Motor Museum in Beaulieu, the car has been undergoing a restoration project led by volunteer enthusiasts known as the Allard Chrysler Action Group (ACAG) since 2007.

Two years ago the 354 cubic inch Chrysler Hemi blown engine was fired up for the first time since 1964. Since then the car has made regular loud (but static) appearances at shows, while the ACAG continued to raise funds to complete the restoration.

The car was officially handed back to the museum as a working exhibit in July 2013, but there is still work to be done on the transmission.

"A heavy clutch is not ideal for parading – the car will never race again due to its uniqueness, value and modern safety regulations – and new clutch parts have arrived from the USA," said ACAG founder Brian Taylor. "Also, modifications to the Ford gearbox back in the 1960s weakened the casing and it now needs to be replaced. We have located a period correct replacement LH drive 1948 Ford gearbox casing and once it has arrived in the UK, work can continue."


Photo: Stuart Mitchell

LEFT The 1961 Allard Chrysler, Europe's first dragster, has been brought back to life following a collaboration between the Allard Chrysler Action Group and the National Motor Museum

The partnership between the ACAG and the National Motor Museum is believed to be unique.

"As far as I am aware, such a task has never been completed on an iconic exhibit in the UK by a group of private individuals working in partnership with the museum that owns it," commented the museum's director of collections, Andrea Bishop. "The ACAG raised the funds, researched, promoted and publicised the project and provided the expertise and people to carry out the work. It truly is an amazing achievement and a fantastic model for other groups to follow." HRT

Lightweight E-type Jag reborn

BELOW The 11 existing Lightweight E-type Jaguars will soon be joined by six more, hand-built by Jaguar to the original specifications

Photo: Jaguar Heritage

JAGUAR Cars has announced that it will build six brand new Lightweight E-types to the exact specification of the 1963 originals, including the straight-six 3.8-litre engine and aluminium body. The company had originally planned to make 18 special GT E-types, but stopped after the 12th one had been built. These six are the so-called 'missing' cars, the remaining chassis numbers having lain dormant, until now.

The Lightweights were homologated for GT competition by being designated as standard E-type roadsters fitted with a number of options that varied from car to car. However, the main modifications included all-aluminium monocoque and aluminium body panels, aluminium-block, wide-angle head, dry-sumped 3.8-litre XK engine with fuel injection, and aluminium hardtop. All chassis numbers carried an 'S' prefix. They were raced in period by names such as Graham Hill, Jackie Stewart, Roy Salvadori and Briggs Cunningham while today the remaining 11 Lightweights are regular front-runners in the historic motorsport scene.

The six new Lightweights will be hand built in-house by Jaguar craftsmen from the original plans and specifications. The original Lightweight carried approximately 114 kg (250 lb) less weight than a standard E-type, due to its all-aluminium body and engine block, a lack of interior trim and exterior chrome work and a host of further weight-saving features, including lightweight, hand-operated side windows.

Jaguar expects a high demand for these six Lightweight E-types. Established Jaguar collectors, especially those with historic race car interests, will be prioritised amongst those potential customers who express interest. HRT

New Williams Heritage division placed in trusted hands

By **William Kimberley**

DICKIE Stanford has been appointed to the position of general manager for Williams Heritage, a new division of Williams that oversees the maintenance and public demonstration of the team's historic Formula One cars. Until now he has been the F1 outfit's race team manager.

He began his long career with Williams in 1985 as a mechanic on Nigel Mansell's FW10 and worked his way up to chief mechanic, before becoming team manager in 1995. He remained in that position for 10 years before stepping back to spend more time with his family. In 2010 he returned to take up the reins once again as race and test team manager and helped guide it through a difficult period. After seeing the team through a successful winter ahead of the 2014 season, he has now decided to retire from life on the road for a factory-based position.

As general manager of Williams Heritage, Stanford will report to Jonathan Williams and have responsibility for the highly experienced Williams mechanics that maintain the team's historic racing cars at the Williams Grand Prix Collection in Oxfordshire, the largest private collection of Formula One cars in the world. He will also help manage the regular series of events and promotional activities that the cars take part in each year such as the Goodwood Festival of Speed.

Speaking about Stanford's new role, Sir Frank Williams, founder and team principal, said: "A team of our longevity has many historic assets that need to be cherished and preserved for future generations to enjoy. Dickie combines strong mechanical knowledge of our cars from his time as a mechanic, with first class operational and logistical skills honed as race team manager. He is therefore perfectly placed to take on the day-to-day operational running of our historic car programme and provide support to Jonathan in ensuring that Williams' Heritage programme goes from strength to strength. I would personally like to add my thanks to him for his services to the team during his time as race team manager."

"I have a lot of passion for the company and its heritage and the opportunity to take charge of our historic car programme is too good to turn down," said Stanford. "With the formation of Williams Heritage as a distinct division within Williams, we will be well placed to ensure that our legendary cars continue to be well looked after and can be showcased to Formula One fans for many years to come." HRT

10 years of inspiration and brainstorming

"This will change our sport for the better"
Ben Bowlby, Director of Motorsport Innovation, Nissan

www.racetechmag.com

Top row, left to right: Cabinet members Kirsty Andrew, Martin Anayi, Prof Mark Gillan, Roger Griffiths, Bernard Niclot, William Kimberley, Gilles Simon, Ulrich Baretzky, John Iley, Darren Cox, Bruce Crawley, Prof Joe Katz. Front row, left to right: Dominic Harlow, Dr Bob Larsen, Willem Toet, Soheila Kimberley, Pascal Vasselon, Alex Hitzinger, Peter Wright, Ben Bowlby

DISRUPTIVE TECHNOLOGIES

The case for and against

Come and join the debate!

The question is fundamental to the future of motorsport. Does it have a role in exploiting new technologies, even if they are disruptive and can be costly, or should they controlled and even discouraged?

Join **Ulrich Baretzky**, Head of Engine Development at Audi Sport and **John Iley**, Performance Director at Caterham F1 who once again will be chairing the 2-day debate.

Key Cabinet members who have confirmed their attendance include:

Bernard Niclot, Technical Director, FIA

Steve Eriksen, Chief Operating officer, Honda Performance Development

James Key, Technical Director, Scuderia Toro Rosso

Nicholas Chester, Technical Director, Lotus F1 Team

Darren Cox, Global Motorsport Director, Nissan

Pascal Vasselon, Technical Director, Toyota Motorsport GmbH

Roger Griffiths, Director of Motorsport Development, Andretti Autosport

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Date: 1st-2nd December 2014

Venue: Birmingham City University, Thinktank
Millennium Point, Birmingham, UK

BIRMINGHAM CITY University

thinktank
Birmingham science museum

Hotel du Vin & Bistro

From the cockpit

At what point does race preparation compromise originality? **Nick Mason** tackles this thorny issue

GOOD MORNING. My name's Nick and I'm a recovering historic racer.

Well, that was my response when sitting on a panel at the Collier Museum symposium last year, when challenged by a fellow panellist to justify the modification of historic race cars from their original specification to something more akin to 'specials'.

It was a good point. If some of my cars are taken apart in 100 years to see how things mechanical were done, they' re going to be pretty surprised at the late 20th century piston technology encountered in such an early car. Then there's the modern spark maker, lightweight battery, shell bearings, steel con rods. But enough of my sackcloth and ashes.

Perhaps we should consider a little history. 50 years ago the concept of cars as historical artefacts hadn't really been thought about. After World War Two the dearth of cash, and any new racing cars, meant that motor sport was reliant on old cars being fettled in to something that could be used for competition. It seemed perfectly reasonable to hack the body off a 3-litre Bentley and stuff a 4.5-litre engine into it. Add some hydraulic brakes, triple S.Us, electric fuel pumps, lighter mudguards, and smaller wheels with wider tyres and hey presto... a racing car!

> **"With unlimited spending most historic engines can be transformed into the mechanical equivalent of the incredible Hulk"**

Oddly the Brits then spent another 30 years sneering at the Americans for over-restoring and chroming their old bangers, which, in the great scheme of things, seems rather like the pot calling the kettle black.

While this was going on most of the manufacturers had far more important things to think about than retaining their older models as future exhibits, or references, for the next generation. Particularly as a number of early post war cars were – in my opinion – some of the worst ever made (feel free to discuss).

CUSTODIANS

The reality is that we have to rely on individual private curators to look after most of these historic objects. Even now, in a more enlightened age, there are simply far too many cars for the museums and manufacturers to retain. Even a company such as Mercedes, which is one of the leaders in this respect, would need to have a vast facility to look after literally thousands of models to cover every variation of their heritage. Just running their most exotic competition cars is a major task, and anyone who enjoyed the sight and sound of the great pre-war racers at Goodwood last year owes a debt of thanks to Mercedes and Audi for having this vision. Ferrari – post Enzo – is also committed to the importance of heritage, and the ever developing and improving Ferrari Classiche is not only worthy, but I suspect a modest profit centre. But remember – it's only thanks to the privateers that many of Enzo's greatest cars still exist. If he'd had his way, they would all have been scrapped soon after their racing life was over!

But the world's still full of motors looking longingly for an enthusiast to cherish them. It's a web dating service opportunity – and we need

ABOVE The setting may be a little unorthodox, but Nick's Maserati 250F is highly original

all sorts of those enthusiasts. Some to venerate originality; others to recreate, or even resurrect, something from a basket of bits. Perhaps we need more co-operation between these different schools of thought? We can't legislate on this, only advise. As far as racing is concerned the most effective form of control is the invitation. Be it from the HGPCA or Goodwood, or any other desirable venue.

This is where the racers run in to trouble. More reliable brakes sound sensible, but where do you stop? Ceramic discs instead of drums?

The roll cage is another contentious point. They do look terrible, but they give no advantage, and the same is true of a full-face helmet. This has to be left to the driver to decide. I've seen the result of an open face helmet accident and worn the full face in an open car ever since. And the engine? With unlimited spending most historic engines can be transformed into the mechanical equivalent of the incredible Hulk. Transforming performance to a level never dreamt of in period.

So, If the driving's too wild, or the car clearly over-modified, the possibility of a lack of that invitation improves racing manners, often brings the car back to a more period spec ... oh, and sometimes helps the value upwards as well.

Historic racing gives huge pleasure not only to the competitors. It's great to be thanked by a spectator for getting the car on track, but let's also find as many ways as possible to ensure accurate and sensible restoration. In some cases, for that really unique and original car, let's keep it exactly as it was when it won in period, and hammer around Silverstone in something a little less important. HRT

The next big thing

Zak Brown, a racer and entrepreneur on both sides of the Atlantic, believes turbo cars from F1's golden era offer historic racing's next growth area

WHAT does the future hold for historic racing? The last few years have seen the sport go from strength to strength and that raises the question of where we go from here. Personally, I predict that the next big area for growth will be turbocharged Formula One cars. Obviously motor racing is embarking on a second turbo era, but it's the first one – that golden age of the 1980s – that sets the pulse racing. And there's a lot of horsepower that still needs to be unleashed.

Those turbo cars are not as unreliable as you would think, and parts are not as hard to come by as some might suppose. It was really encouraging that Lord March took the first step in attracting 12 or 13 turbo cars (including my ex-Ayrton Senna Lotus-Renault 98T) to the 72nd Members Meeting at Goodwood at the end of March. Clearly there are a lot more than that out in the world and I believe a full grid from one of the most storied eras in Formula One would pull a huge crowd wherever a race for those fantastic cars was to be held.

There is now a generation of people in their forties, myself included, who grew up watching the turbo era and that is what makes them so popular today. Collectors have all sorts of criteria when it comes to what they like and the turbo cars tick a lot of boxes with me.

I like cars with provenance, that have won races and been driven by the best back in the day. All but one of the Formula One cars in my collection has won a World Championship Grand Prix (my 1992 Benetton B191B was the car in which Michael Schumacher scored his first podium), but every one of them has been raced by a world champion. Hunt, Lauda, Mansell and Hakkinen are great names to connect to any car. And they are not just 'any car', they are marques that are synonymous with the excellence in Formula One: McLaren, Lotus, Ferrari, Williams. I have a pretty exacting set of parameters when it comes to collecting historic cars, but that's what works for me.

Driving such wonderful cars is a thrilling experience, but one that must be treated with the utmost respect as there is no such thing as a small repair bill when it comes to Formula One cars of any era. If you want to drive a racing car at ten-tenths then it's much better to climb into a contemporary machine to gain that intensity. It's safer too. Many collectors – myself, Steve Tandy, Richard Meins, Roger Wills, Joe Twyman and Gregor Fisken spring to mind – race their historic cars but also compete in modern sports cars as well. Trying to find that last tenth in a million-dollar car can get very expensive.

BEST FEELING IN THE WORLD

Cost is the biggest obstacle that any historic car collector faces. You don't just need money to buy the cars, you need plenty of it to maintain them before you ever get round to finding the time to enjoy them. Some of these cars require radically different specialties and it's always better to find mechanics to work on them who were familiar with the car when it was new. It's difficult to find one person who understands a car from the 1970s as well as one from 2001 as there are so many idiosyncrasies. If you have a large collection of cars then you need a large and diverse staff to work on them. I am very fortunate that my racing team, United Autosports, also looks after and maintains my historic collection. Not many people have that luxury.

I am always on the look-out for cars and I am very fortunate to be able to indulge my passion for the rich history of motor racing. It's not cheap, you need plenty of patience and, at times, it can be very frustrating. But when you get behind the wheel of something so wonderful, it's the best feeling in the world. HRT

BELOW Brown was feted by one national newspaper as 'the next Bernie Ecclestone'

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The Beast of Turin wakes from a 100-year sleep

Is this the greatest comeback in motorsport? **Chris Pickering** reports on the restoration of a 28.3-litre monster poised to return to action after a century of slumber

Photos: Stefan Marioram (stefanmarioram.com)

ABOVE Emerging from the shadows: the S76 nears completion

ONCE the world's fastest car, briefly owned by a mysterious Russian prince and recently rediscovered after a lifetime hidden on the other side of the world, the story of Duncan Pittaway's Fiat S76 is nothing short of remarkable.

Finally awakened from its century-long slumber, 'The Beast of Turin' is one of two cars built by Fiat over the winter of 1910 and 1911 to capture the World Land Speed Record. Although, technically speaking, you could argue it's now both cars. The rolling chassis is believed to be that of the earlier car, which set a new flying mile record of 116 mph at Saltburn Sands in Yorkshire in 1911. The engine, meanwhile, comes from the second car, the rest of which was dismantled by Fiat after the First World War.

Pittaway acquired the remains of the car in Australia and brought it back to the UK in 2002. At the time it was essentially just a rolling chassis – rusty, somewhat mangled and missing its running gear. Like a lot of Edwardian racing cars it had been 'modernised' in the 1920s. This had apparently involved replacing the gargantuan 28.3-litre engine, and the rather bulbous body required to conceal it, with something smaller and lighter.

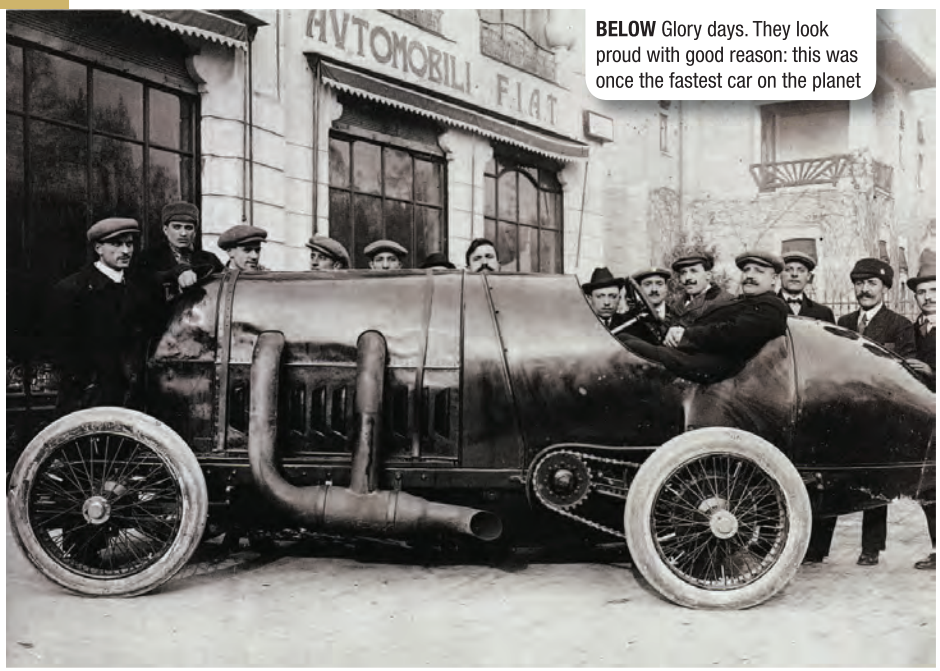
When first discovered in the 1950s the chassis and axles were thought to be that of an earlier Fiat S74, but Pittaway has found compelling evidence to confirm that it is, in fact, the missing S76. "The chassis is certainly Edwardian. It's certainly a Fiat and it's quite different to the S74 racers and the standard Fiat touring cars of that era," he says.

There are a number of other features that back this up. Due to the exceptionally tall engine (measuring nearly 1.3 metres) the centre line of the crankshaft runs 200 mm below the centre line of the chassis. This layout is quite unlike any other car of the era and it results in the sprocket shafts from the transaxle passing through a pair of distinctly large holes in the chassis side rails.

All this could have remained largely academic, of course. Except, after much negotiation, Pittaway managed to acquire the engine from the second car. Between the two, he now had enough original S76 parts to make the restoration viable.

HEART OF THE BEAST

History hasn't been entirely kind to the racing cars of this period. At the beginning of 1909 the fledging sport of grand prix racing was effectively put on hold in Europe. France was the spiritual home of the sport, having hosted the ▶



BELOW Glory days. They look proud with good reason: this was once the fastest car on the planet

first recognisably modern closed-road grand prix in 1906. But after the event's third running (frustrated, some have suggested, by the success of foreign teams such as Fiat and Mercedes), the organisers pulled the plug. Almost overnight, the focus of European motorsport switched to collecting speed records.

This prompted a sudden rash of large-capacity machines, built to go very quickly in a straight line. Although the S76 was the biggest of the bunch – and at 28.3 litres believed to be the biggest purpose-built car engine of all-time – it wasn't quite the oddity it now appears. What's more, it was surprisingly advanced in a number of areas.

"Fiat made the best engines in the world at the time," comments Pittaway. "Almost everyone else had blocks made up from pairs of cylinders or even individual cylinders mounted onto the crank case in groups, but Fiat used an integrated monoblock design. It's also an overhead camshaft engine at a time when virtually everything else was sidevalve, with roller rockers and three valves per cylinder (one inlet, measuring nearly five inches in diameter, and two exhausts)."

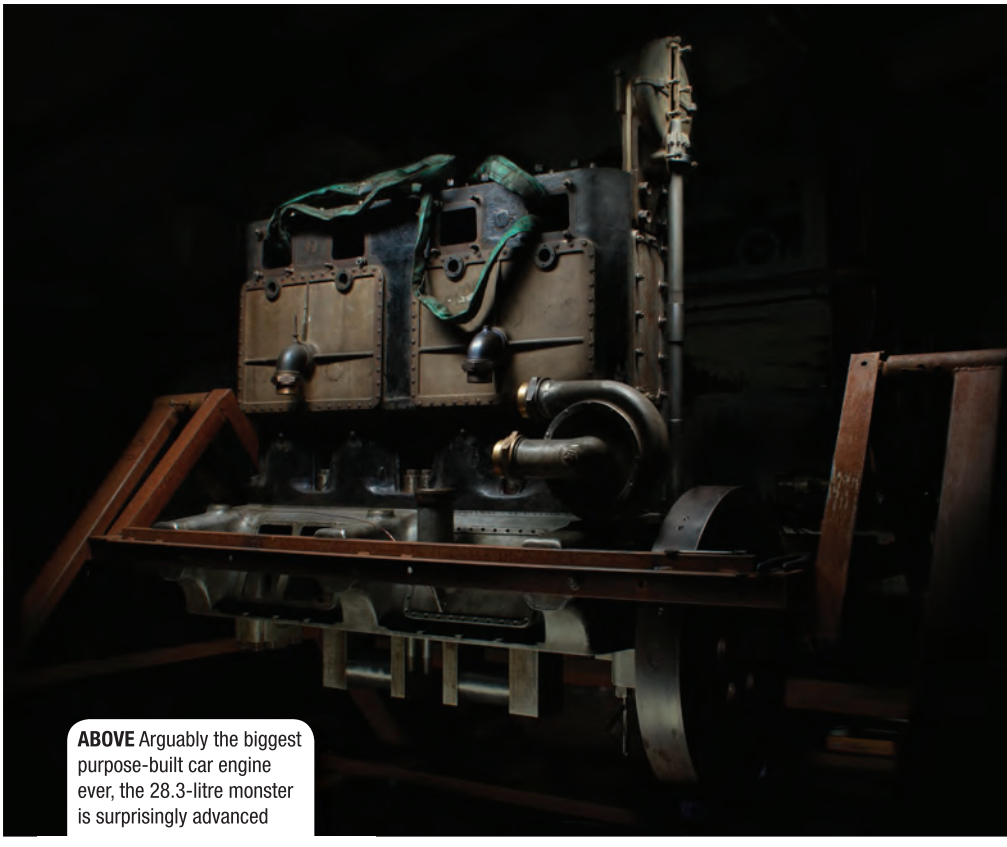
Using a little artistic licence, you could even claim it had variable valve timing. Faced with the prospect of using a starting handle to crank an engine where *each cylinder* displaces more than 7 litres, the Fiat engineers fitted a clever sliding camshaft system. When engaged, additional lobes on the camshaft hold the inlet valves open until about 40 degrees before top dead centre, without which, even at a modest 4.7-to-one compression ratio, it would be impossible to turn over by hand.

In true Italian fashion, there's also a multi-spark ignition system. Developed by Bosch, specifically for the S76, it uses three spark plugs to initiate combustion simultaneously across different areas of the S76's vast combustion chambers. The result is 300 bhp at 1,000 rpm with a maximum engine speed in the region of 1,100 rpm and something like 1,800 lb/ft of torque.

ENGINE WORK

When Pittaway dismantled the engine it turned out to be in reasonably sound condition. There were, however, a few issues. Notably, there was damage to the bore and pistons where two of the cylinders had seized.

"The S76 has full pressure lubrication with copper oil pipes riveted along the conrod carrying oil from the big end to the little end," he explains. "It's a very old-fashioned idea and one that generally doesn't work very well. As it moves, the reciprocating forces on the conrod tend to fatigue the oil pipe and it can break, at which point the little end seizes. That was exactly what had happened in two of the cylinders here, and the pistons promptly picked up on the cylinder walls, ▶



ABOVE Arguably the biggest purpose-built car engine ever, the 28.3-litre monster is surprisingly advanced

overheating the conrods."

All four pistons used in the rebuilt engine are new, formed by Bodycote HIP using a hot isostatic pressing (HIP) process and then machined by Pete Cutler of Cegway. Externally they're identical to the originals but, in order to overcome the lubrication issue, Pittaway has switched to a fully floating gudgeon pin design. By allowing the gudgeon pin to rotate freely in the little end and the piston this should help to prevent future issues.

The big end and main bearings were manufactured by white metal specialist Formhalls. Special moulds and jigs were required for the mammoth castings, which were then precision machined. Radial grooves were used to feed the big ends, with edge mud gullies to supply a consistent oil supply to the main bearings.

This method has made the bearings stronger by eliminating the need for elaborate cross-grooves. Next came the precision line-boring of the main bearings, after which the bearings were cleaned and de-burred then trial fitted before final installation.

New conrods have been installed as a precautionary measure, explains Pittaway: "The conrods were badly discoloured by the heat from the failed little ends, which is likely to have fatigued and weakened the steel. Were one of the rods to break, the remaining flailing piece would smash the crankcase and block so it would have been unthinkable not to replace them."

Of course, that's easier said than done when each conrod is half a metre in length. Pittaway approached a number of specialists, only to find they couldn't accommodate the job on their machines. Eventually Harper Engineering came to the rescue, manufacturing exact replicas of the original rods.

The only other modification lies with the shaft-drive system that supplies drive to the valvetrain. Originally based on a single solid shaft, it spans a distance of over a metre, running vertically up the back of the engine.

Pittaway expects the great cast iron block to grow by as much as 5 mm due to thermal expansion. Systems like this usually feature some sort of mechanism to accommodate that change in length, but for reasons that aren't entirely clear the Fiat engineers decided to forego this practice.

"Looking at the engine, the back of the crank case where the shaft attaches had fatigued and cracked. I'm certain this was due to the shaft acting as a kind of tether," says Pittaway. His response has been to cut the original shaft in two and introduce a sliding coupling between them, all hidden from view inside a brass sleeve.

TRANSMISSION

One of the most time-consuming aspects of the rebuild has been recreating the gearbox. Believe it or not, at first glance the S76 transmission bears a passing resemblance to a modern transaxle layout.

In an attempt to squeeze everything into the confines of the S76, Fiat turned the transaxle through 180 degrees. The engine-speed propshaft runs underneath the mid-mounted differential into the four-speed gearbox. Instead of carrying on in-line, the output shaft exits in the opposite direction, running forwards above the input shaft ▶

BELOW The gearbox and oil pump pictured with the frame for the bodywork

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ABOVE The internals of a gearbox that has to cope with nearly 2,000 lb/ft of torque

and into the differential. From there the drive goes out through the chassis rails via two sprocket shafts to a pair of enormous drive chains.

It's all done for packaging purposes, remarks Pittaway: "Like any racing car, the Fiat engineers wanted it to be as small as possible. There's a modern assumption that Edwardian racing cars were all huge monsters, but they went to a great deal of trouble with the packaging and it's more or less as small as it possibly could be with a 28.3-litre engine."

Recreating the gearbox was to prove a deceptively big job. Fortunately, copies of the original design drawings from 1910 still exist in the Fiat archives, but they are only general assembly drawings and the first task was to break these down into more detailed component drawings. Pittaway – a surveyor by trade – did this himself, fabricating what parts that he could over the next four years, and project-managing the manufacture of the rest via various specialists in their particular field.

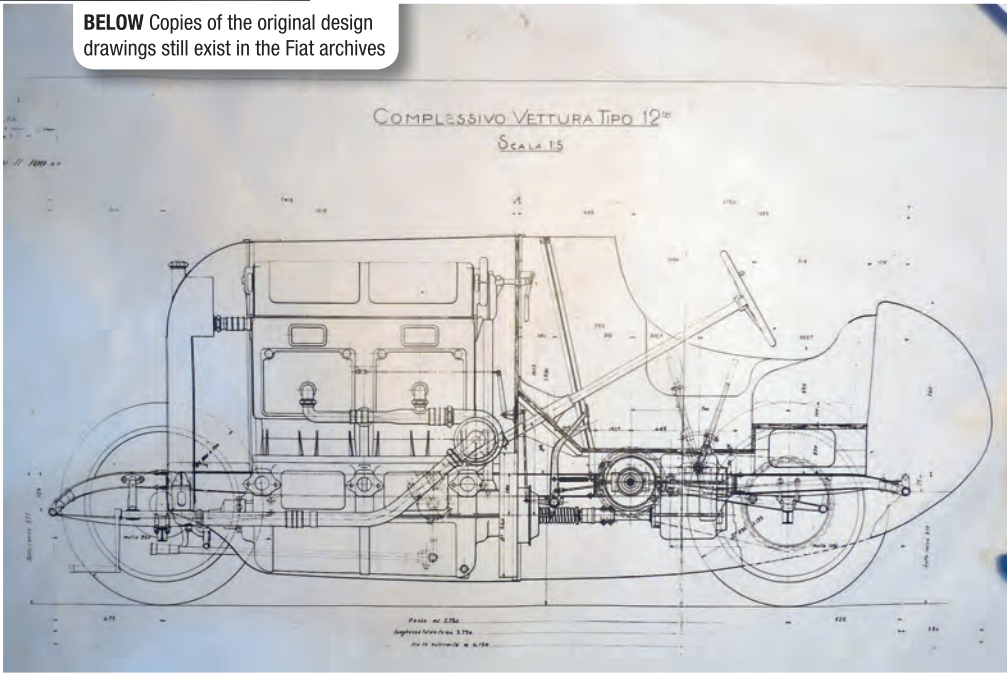
CAST DOUBT

"They allowed me to understand and specify each individual component so that the resultant gearbox matched exactly to the original Fiat design," he says. "A number of the specialists cast doubt about the size and weight of some components, suggesting we should beef-up the shafts and splines given the potential torque from the engine, but it was essential that we stuck to the original design which, after all, worked perfectly well in its day."

There are some nice touches evident in the gearbox. Like the later Bugatti grand prix cars, the sliding gears are on the main shaft instead of the layshaft, for example. This reduces momentum in the gearbox, leading to a quicker, smoother gearchange.

Perhaps the most surprising aspect of the gearbox is just how light it is, though. "If you were designing a gearbox to sit behind a 28.3-litre engine with the best part of 2,000 lb/ft of torque you'd perhaps feel safer specifying something a little bigger, but it is all as per the original drawings," says Pittaway. "The gears are all drilled full of holes, the shafts are all hollow, but obviously it worked in-period." ▶

BELOW Copies of the original design drawings still exist in the Fiat archives



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ABOVE Recreating the outer skin has been one of the toughest parts of the project

Photo: Roach Manufacturing

BODYWORK

The Beast of Turin's outer skin has been the most frustrating part of the project to get right. Various drawings and photographs of the car have survived, but they show it from a variety of different perspectives, in different light and with varying degrees of picture quality. Nevertheless, using these, Pittaway built up a picture of what the car looked like in 3D, sketching out the details by hand. "Trying to translate that research to the mind of the coachbuilder proved to be a fun but laborious process," he says. "Several iterations of the body design were produced and then scrapped in the pursuit of the correct shape."

After calling in a few favours with a local carpenter, Pittaway was able to complete the timber buck in his own workshop. The aluminium skin was another team effort, headed by Somerset panel beater Adrian Breeze, with Southampton-based bodywork specialist Roach Manufacturing looking after the detailing, bonnet and undertrays. Meanwhile artist and photographer Stefan Marjoram – who also happens to be the official film maker for Bloodhound SSC – has been documenting the whole process in spectacular detail.

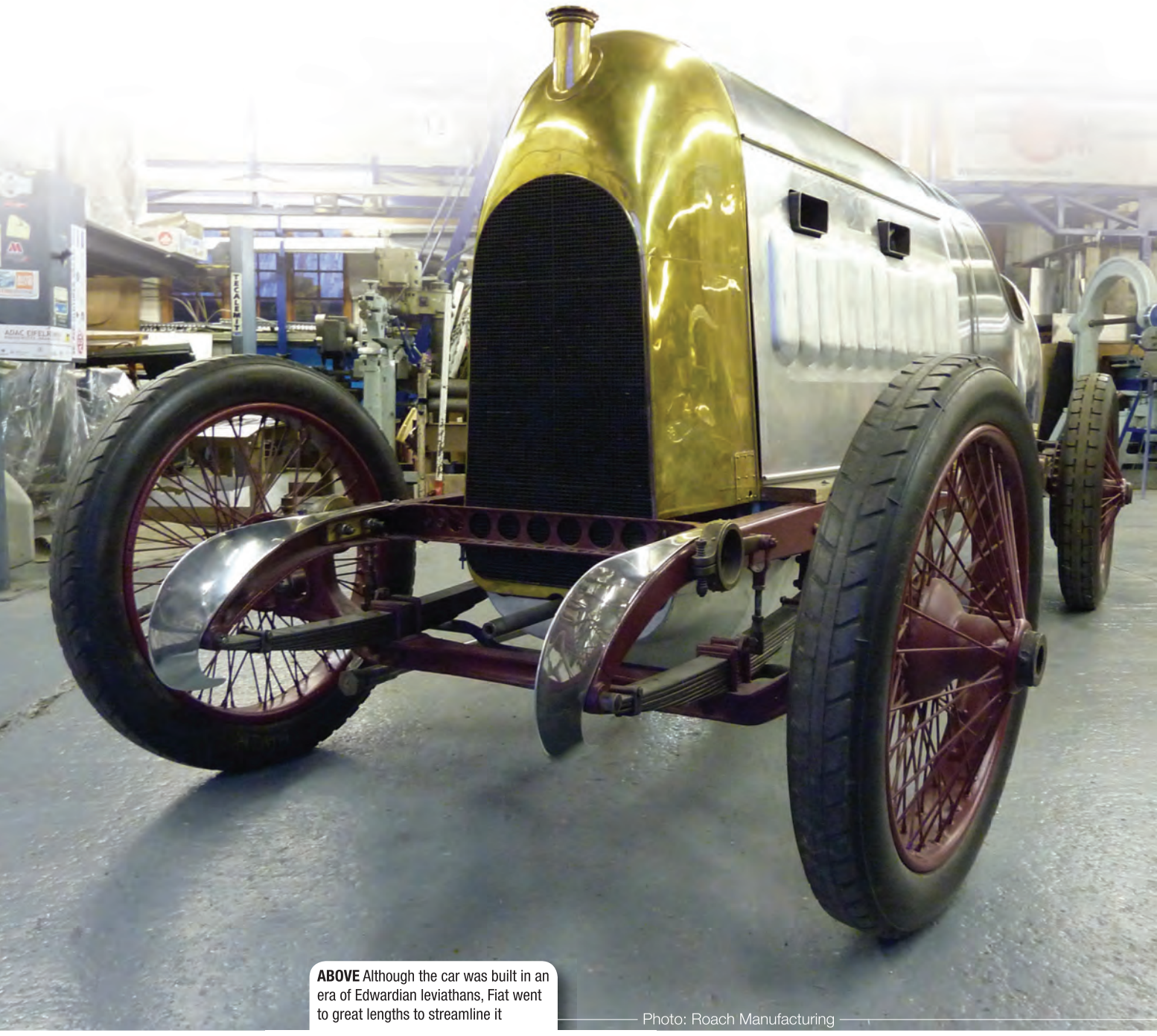
> **"Even something as simple as the rounded-off radiator design was cutting edge in 1911"**

As the contours of the car began to emerge for the first time in a century, it added to the sense that the S76 has been misunderstood, Pittaway recalls: "It's important to put the bodywork design into the context of its time and ignore the familiar streamlined shapes which came years later. This was four years before the outbreak of the First World War and Fiat's first serious attempt at streamlining when almost all other racing cars were built with no concessions to aerodynamics at all."

Even something as simple as the rounded-off radiator design – so familiar by the 1920s – was cutting edge in 1911. Added to that, the S76 bears an elegant pointed tail, not to mention fairings for the front axle and dumb irons. In a somewhat lethal-looking acknowledgement of aerodynamics, it even has a pointed tip on the end of the starting handle.

Another misconception surrounding the car is its size, says Pittaway: "It looks rather bulbous from the side because it's so tall, but it's actually very narrow and appears completely different head-on."

LEFT & BELOW The body buck used to produce the S76's elegant pointed tail



ABOVE Although the car was built in an era of Edwardian leviathans, Fiat went to great lengths to streamline it

Photo: Roach Manufacturing

In fact, at 2.75 metres, the wheelbase is less than that of a BMW 3-Series. More to the point, the radiator is only 400 mm wide and the body is only 700 mm at its widest point, making it a deceptively compact machine... at least if you ignore the 1.5-metre-high bonnet line.

SETTLING OLD SCORES

Unbeknown to Fiat, the era of the great Edwardian leviathans was to come to an abrupt end in 1912 when Peugeot unveiled its groundbreaking double overhead camshaft engine. Grand prix racing was promptly restored with a new set of regulations and the small, nimble machines made possible by this new technology were predictably dominant.

By the end of 1911 the car had passed to enigmatic Russian prince Boris Soukhanov, who hired racing driver Arthur Durray in an attempt to break the flying kilometre record in December 1913. Their chosen location was a public road running along the seafront from Ostend to Middelkirke in Belgium.

Durray repeatedly managed to record one-way speeds in excess of 134 mph – considerably faster than the 200 hp Benz that held the record. But hampered by bad weather and even the disruptive efforts of the local tram service, he never managed to perform a satisfactory return run. Not long after, Soukhanov disappeared, thought to have fled to the Far East as revolution began brewing in his native Russia, and the S76 was denied another chance to prove its performance. At least at the time.

"The road that Durray used still exists, following the original route," says Pittaway. "I've often thought it would be fun to take the car there and see how fast it will actually go." He admits this is something of a pipedream, but there's surely room for one more twist in the incredible story of The Beast of Turin. HRT

Mustang: 50, but still wild

The Ford Mustang has become a mainstay of the historic touring car scene. **John Simister** unearths the secrets of a racing icon

IT'S 50 years since the Ford Mustang first rumbled onto the automotive scene. And right from the off, Ford's charismatic pony car made its mark on motorsport.

Half a century later, the first generation Mustang is one of the most popular and competitive options on the historic touring car scene. This year sees a number of special events to commemorate the anniversary, plus a celebratory race (the Shelby Trophy) for small-block Ford V8s at September's Goodwood Revival meeting.

The Shelby name is deeply entwined with racing Mustangs, the firm's GT-350 versions having a high-profile presence in the Sports Car Club of America championships from 1965 to 1967 (winning the B-production class in all three years).

Photos: Chris Teagles

ABOVE & TOP RIGHT Alan Mann raced Mustangs successfully in period, although the red and gold colour scheme is a reference to the team's later Ford Cortinas

Photo: Dave Young Photographics

It was in Europe, however, that a Mustang scored its first big competition success, taking first and second in class on the 1964 Tour de France. These Mustangs – 'notchback' coupés rather than the fastback body style of the GT-350s – were run by Alan Mann Racing, a private British team which enjoyed strong backing from Ford and which won the European Touring Car Championship the following year with its famous red-and-gold Cortinas. Alan Mann moved on to Ford Falcons, Cobra Daytona Coupés and Ford GT40s among other things, but Mustangs continued to race on Europe's circuits. All of which means there's a healthy posse of Mustangs in historic racing today, and detailed FIA documentation as to the homolgated specification they should follow.

One of the most successful is the example of Alan Mann's son, Henry, which we feature here. He races under the Alan Mann team name and in the red-and-gold livery, although back in the 1960s that livery never actually appeared on the Alan Mann Mustangs, most of which were red all over. However, Alan did restart his racing team in 2004 to take part in historic races, and this time his Mustang was painted in the red-and-gold team colours.

The car that Henry races today is a 2011-2012 build into a replacement bodyshell, using many of the components from the car Alan campaigned from 2004. Appropriately, Henry and co-driver Mat Jackson won the inaugural Alan Mann Trophy race in this car at Donington in 2012, Henry regaining the lead on the final lap of this race held in memory of his father who had passed away earlier that year.

V8 MUSCLE

A Mustang is a simple car, with famously robust components. Or is it? Its 289 cubic inch (or 4727 cc) V8 engine was designed to produce an easy 200 bhp, while the 'Hi-Po' option (High Power, effectively Shelby Cobra specification) made 271 bhp. "So when we get maybe 430 bhp at 7,300 rpm on a Holley carburettor, as in the Mustang, or 450 bhp in GT40 form, the details become rather more critical," says Mark Mathieson of Mathwall Engineering, who built Henry's engine. And it's the details that really count.

Mathwall Engineering was started in 1967 by Stuart Mathieson (Mark's father) and Peter Wallace, who had both previously worked with Alan Mann. So there's a neat historical link here between Mathwall and Henry's racing Mustang, but there's nothing old-fashioned about the way Mathwall goes about things today. Mathieson joined Ricardo after gaining his master's engineering degree, and went on to Ilmor and its reincarnation as Mercedes-Benz's Formula One engine operation.

What Mathwall does not do, though, is create an entirely new 'historic' engine from all-new components. "We pride ourselves on providing original engines," Mathieson says, "using good engineering and technology we can legitimately apply.

"The first thing is to understand the requirements: type of car, type of racing, type of driver. Then we approach the problem in a holistic way, rather than just bolting on the latest whizzy bit. We use the original block and head castings as in the FIA homologation papers and ▶

apply our knowledge to them."

There are lots of sources of these engines in the US thanks to the millions made in period, but the supply has been dwindling and a recent scrappage scheme there has brought a step change in availability, he explains: "Our contacts there will assess the parts, then we do it again here. It takes us five man-days of invested effort to prepare a block."

Other engine parts, however, can be recreated provided they conform to an approved specification. "We remanufacture the main bearing caps to the Ford HiPo 289 specification, and we're very attentive to detail on the fasteners, designing them to eliminate stress and fatigue problems. These are high-grade fasteners to the original design, not aftermarket ones which might have the wrong stretch," explains Mathieson.

Mathwall re-line-bores the crankshaft and camshaft tunnels and decks the top faces of the cylinder banks, and of course the cylinders are bored and honed. The cylinder heads allow a bit more creativity within the original castings, because the understanding of port design and gasflow has grown a lot in the last half-century. "We've developed ports on our own flow rig," says Mathieson, "and we CNC-machine every head to the specification we have developed. There's no hand-finishing because it's too inconsistent."

On a standard 289 head the ports start very flat then turn through 90 degrees, so better flow needs a steeper port, he explains: "We do this with a detail change around the bottom radius at the back of the valve seat." Mathwall uses standard valve sizes as in the regulations – "Others may fit larger ones," Mathieson speculates – but there is scope for better-flowing valve heads and three-angle valve seats.

Mathwall's crankshafts and connecting rods are machined in-house from billet steel to a computer 'print', then heat-treated before finishing. The pistons, too, are made to print but by an outside supplier, their crowns shaped to optimise the compression ratio as they encroach into the combustion chambers while still clearing the opening valves. Mathwall also designs its own camshaft profiles, again with the benefit of a half-century's knowledge, and the Ford V8 camshaft's lobes operate conventional flat-faced tappets rather than disallowed roller followers.

> **"The V8 was originally designed to produce an easy 200 bhp ... we get maybe 430 bhp"**

But there are gains to be had here, too, compared with the state of the 1960s art. Better manufacturing techniques bring better, lower-friction finishes, mirror-like on the contact patch between cams and tappets, and Mathwall makes its own lightweight valve-spring retainers and original-design, but stronger, cast and heat-treated rockers. It's about reducing flexibility and inertia in the valvegear and ▶

BELOW The Mustang originally made 271 bhp in uprated 'Hi-Po' form, but these days well over 400 bhp is possible

ABOVE This is the second Mustang that Alan Mann Racing has built for historic competition

Photo: Dave Young Photographics

so getting more out of the camshaft.

Better techniques bring benefits to the bottom end, too. “Bearing technology has come on a long way,” says Mathieson. “We have very tight tolerances on the camshaft and main-bearing tunnels, so we can use bearings with a much tighter clearance. That reduces oil flow, which would increase friction with the wrong sort of oil. It takes two days just to size and fit one crankshaft.”

The right oil, then, is vital, despite the Ford V8’s outward simplicity. The engines are initially run on Joe Gibbs Break-In oil, a mineral oil heavily dosed with zinc and manganese phosphates to protect the valvegear from scuffing while still allowing the piston rings to bed in. Thereafter it’s typically Joe Gibbs XP6 synthetic racing oil, a 15w50 grade. “Getting the notion of oil over to customers is difficult when they just want to use what they have always used,” says Mathieson, “but running-in is vital if the engine is to be pushed to its limits. Everyone expects more and more out of these engines, so installation and preparation must go hand-in-hand.”

Other aspects to which Mathwall pays great attention include the crankcase breathing system, gaskets and seals. Oil consumption is a worry in long-distance races such as the Spa Six Hours, so an oil separator built into a rocker cover reduces the amount of oil mist that escapes into the catch tank. Oil seals are of heat-resistant Viton where needed. “For the head gaskets, the machining on the block and head faces must be very, very good so we can use steel shim gaskets,” says Mathieson. “The head-stud locations are not ideal, being widely spaced, and the heads want to part company with the block. So the stud design and stretch, and how they cope under cyclic loads, are vital.”

Mathwall sets up the engines, including carburettor settings, using bench-test exhaust systems which mirror as far as possible those to be fitted to the car, says Mathieson: “We also supply the ignition system if we can, usually an MSD (multiple spark discharge) one but a Mallory distributor with points if the race series requires it. The more of the setting-up we can control, the better, because this is a very high-risk business. The engine can go straight into a customer’s car, prepared by someone we don’t know, and if there’s a problem they might blame the engine.”

To get round this, Mathieson has a plan. “There’s no logging of what the engine does, so we’re developing a prototype data-logging box which sits in the centre of the vee. It monitors engine speed, throttle position, oil pressure and temperature, water temperature and ignition advance, and we’re proposing that using such a box would give clarity if there’s a problem. Our intention is to issue it with a new engine, to monitor the initial running, and then it can be used afterwards if it’s deemed legal. It just monitors engine health, so there’s no competitive advantage.”

UNDER THE SKIN

You have just read a lot about the engine, but there is a lot to say because the engine is the heart of the car. It’s an expensive heart, too, with a Mathwall V8 costing between £25,000 and £29,000 in Mustang guise.

The Mustang to which it is fitted gets ▶

BELOW Sourced in the US, the Alan Mann Racing Mustang was converted to right-hand drive to race on Europe's predominantly clockwise circuits

a lot of detailed preparation too. "We bought this one in 2008," says Henry. "It had been a road car in California."

He and his engineer Brian Lewis, who built those Tour de France Mustangs for Henry's father back in the 1960s, sent the bare shell to Gartrac for blasting, seam-welding and the required bracketry. They also added a roll cage from Andy Robinson Race Cars in Basingstoke. The result is a shell usefully stiffer than that of the team's 2004-built Mustang, whose shell lives on with a new owner.

It retains all-steel panels (apart from the glassfibre bumpers), unlike the slightly later Ford Falcons which used many fibreglass panels and which nowadays, controversially, employ the roll cage as a structural member. So it's not a light car at 1240 kg; 40 kg over the model's Appendix K homologated weight of 1200 kg despite the Perspex side and rear windows and the stripped interior.

At a cursory glance, the Mann Mustang looks impressively period-authentic with just the mandatory modern Corbeau racing seat, roll cage and Racelogic lap recorder to remind us we're in the 21st century. One significant departure from this particular car's originality, however, is that it has right-hand drive to better suit the clockwise direction of most circuits. This required an RHD steering box from an Australian-market Falcon. Whichever side the streering wheel is set, though, the steering is very heavy on racing tyres (Dunlop CR65 MkII as mandated for the UK's Masters race series, here in a 5.50 M15 size).

"The steering was so heavy that at one meeting it was hard to apply enough effort to catch a slide which sent me into the tyre wall," Henry reports, "so now we've fitted a bigger steering wheel [a handsome Moto-Lita]. The Mustang doesn't really want to turn. You have to provoke it, make it take a set, then slide through the corner."

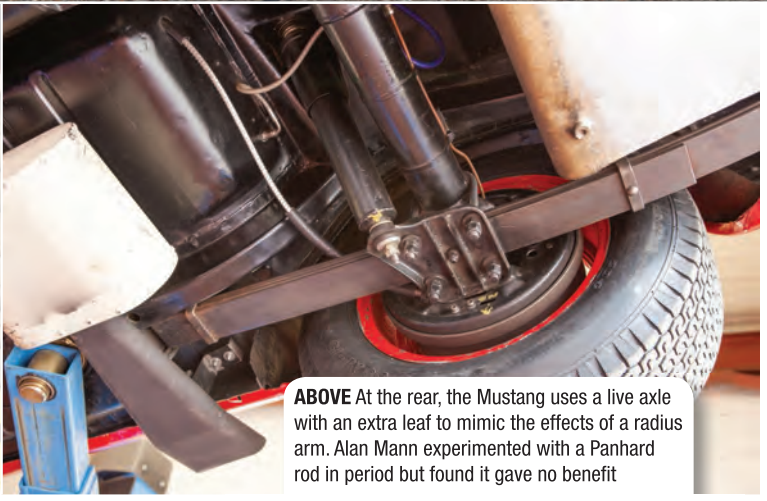
That's despite some very obvious negative camber at the front wheels, achieved while keeping the original suspension pivot points and wishbone dimensions. Maybe the hub upright forging has seen the benefit of some heat-assisted bending? "In period the teams were using balljoints with extended pins to alter the geometry," Brian reveals, "but we don't do that now." There is a new steering drop arm, though, machined to the original dimensions.

The dampers are Koni telescopics all round. Spring rates are free but the springing medium and location must be as original. Obviously those rates are high, and in the rear leaf springs there's an extra leaf in the front half of the spring to bring some of the benefit of, effectively, a radius arm. "Alan tried a Panhard rod in period to improve axle location," Brian recalls, "but there was no advantage." The front anti-roll bar is thicker than standard, as you would expect, and the suspension bushes are nylon.

As for the transmission, the gearbox is the same type of Borg-Warner T10 unit as Alan Mann used in period. The differential, however, is a plate-type limited-slip device rather than the original spring-type unit, which Brian says was 'all-or-nothing' in its action. Also very evident from the underside is the twin side-exit exhaust system with its rebuildable silencers, made by the late Mustang exponent Jim Morgan (who worked with the team in the 1960s) and scoring 102 dB on the noise test (the limit is 105 dB). Most other racing Mustangs take the exhaust right to the back. Silencers are required for most races but not Goodwood, so the team

ABOVE Specially developed silencers allow this Mustang to use a side-exit exhaust, while many require a full-length system

ABOVE The Mustang uses a relatively conventional double wishbone layout at the front



ABOVE At the rear, the Mustang uses a live axle with an extra leaf to mimic the effects of a radius arm. Alan Mann experimented with a Panhard rod in period but found it gave no benefit

> **“An extra leaf in the front half of the spring brings some of the benefit of a radius arm”**

removes them for that event. It releases a little more power, but, admits Henry: “Mostly, we do it for the drama.”

The aluminium alloy wheels of a typical five-spoke American design are a departure from the steel wheels used in period, but look terrific. They cover brakes much as used in period, with homologated four-piston calipers and ventilated discs at the front but simple drums at the back. Then, moving inside the Mustang, in a neat piece of Ford fellowship we find the instrument binnacle from a Mk1 Lotus Cortina containing modern Stack instruments. The original Mustang instruments are still in place, as the regulations require, but are non-functional. Few gear levers are as hefty as this one, and there’s a reverse lock-out to avert potential disaster.

In the boot sits an aluminium-cased, bag-type racing fuel tank from ATL, its contents fed to the Holley carburettor by, appropriately, a Holley fuel pump. And returning to the engine and its bay, we find the expected silicone hoses and beautifully-finished aluminium tanks, plus a factory-fit tower brace and factory-spec lightening in the bonnet stiffeners.

PODIUM RECORD

The whole car is beautifully prepared, road legal and even has an MOT. Building it cost around £80,000 in total, for which Henry has a car that has helped him to a podium finish in every race it has entered apart from one at Donington earlier this year, when the coil failed. All of this has been in a car built to the spirit of the rules as well as to the letter, whereas others might – for example – use new block and head castings made of better modern metal.

“You can pay £42,000 for a top-spec engine like that,” Henry observes, “with titanium rods and a hollow crankshaft, but we paid around half that and it will do 25 hours between rebuilds. What we have is as far as you can go with a legal engine.” HRT

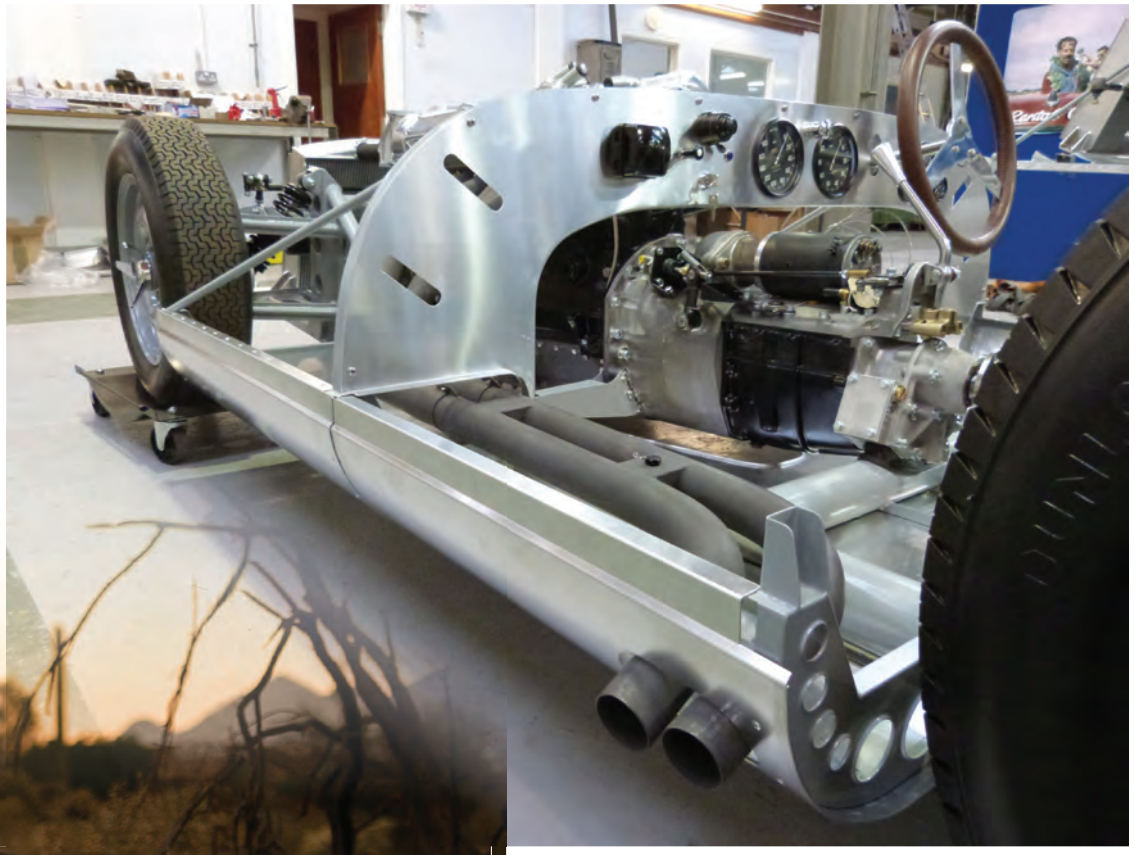
Return of the Knobbly

60 years on from the birth of iconic British sports car maker Lister, the Lister Jaguar 'Knobbly' is being recreated for historic racing. **Chris Pickering** investigates

IN JULY 1954 a small sports car firm set up shop in the suburbs of Cambridge. Born out of a family business that made wrought iron gates for the town's ancient colleges, Lister Cars rapidly went on to challenge the might of Ferrari, Jaguar and Maserati on the world scene. Almost as quickly as it emerged, however, the brand withdrew from racing; its exit was triggered partly by the death of charismatic works driver Archie Scott Brown. But now, 60 years on, Lister is back with a limited edition run of the iconic Lister Jaguar.

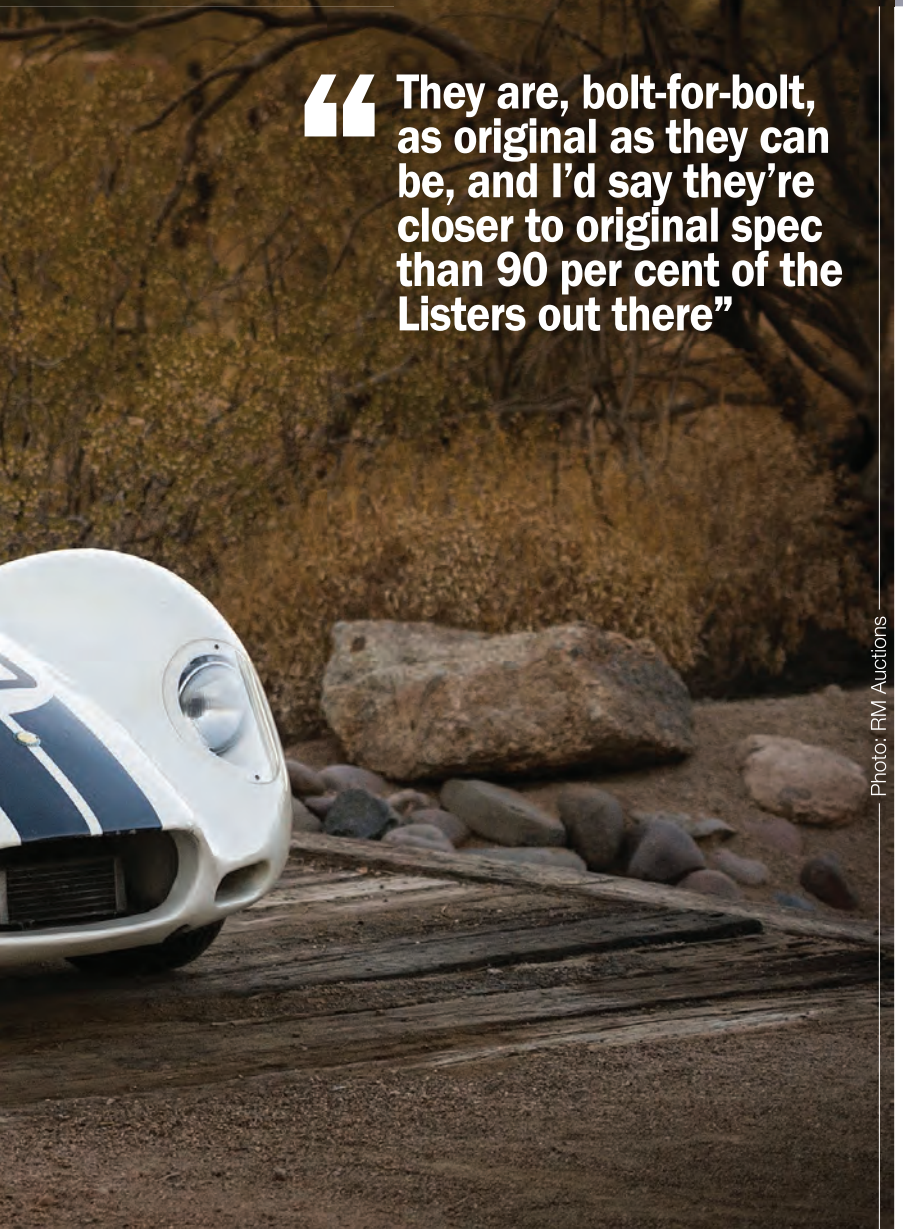
On the face of it, the idea of walking into a showroom in 2014 and ordering a shiny new car for historic racing may sound like something of a contradiction in terms. But the limited run of 10 'continuation' cars will be built to the exact 1958 works specification, using the original jigs and drawings. A number of the original engineers are even involved with the project, including company founder Brian Lister. And should you wish to go racing, each car will come with an FIA HTP passport, allowing it to compete in international historic events.

"When we first approached the historic racing organisations and said, 'We're going to build 10 new cars, will we be able to race them?' it became clear very early on that everything needed to be exact," explains Lawrence Whittaker, managing director of Lister Cars.



RIGHT The new cars are built to exact period spec, including a painstaking reproduction of the Jaguar D-Type gearbox

BELOW From humble beginnings Lister went on to challenge the sports car elite. Now it's back…



"They are, bolt-for-bolt, as original as they can be, and I'd say they're closer to original spec than 90 per cent of the Listers out there"

Photo: RM Auctions

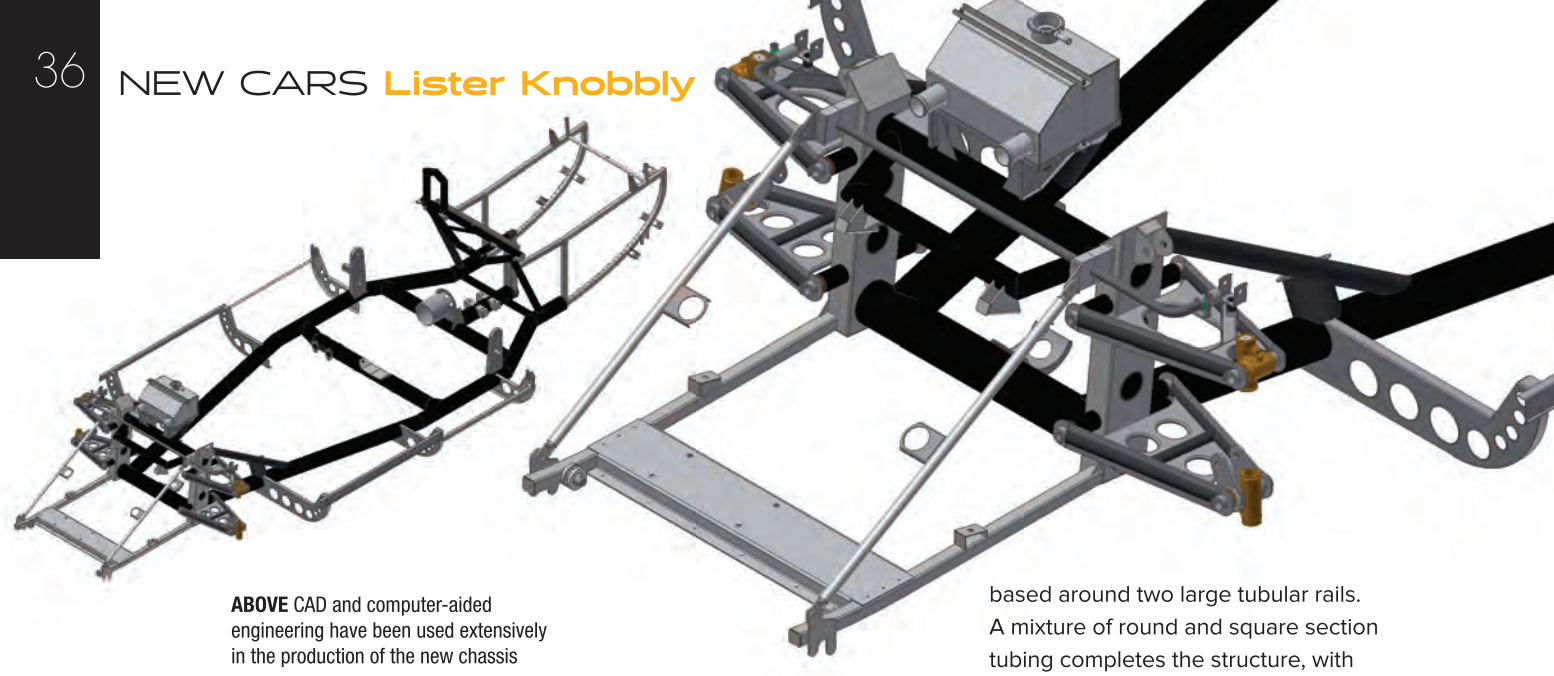
"There's no point trying to improve the car with modern technology if it won't be allowed to race. They are, bolt-for-bolt, as original as they can be, and I'd say they're closer to original spec than 90 per cent of the Listers out there."

The level of attention to detail is deeply impressive. Lister has even gone to the lengths of remanufacturing a batch of Jaguar D-Type gearboxes at huge expense. In fact, the only real deviations from period spec are bolt-on additions to comply with the FIA's Appendix K regulations for historic motorsport, such as fire extinguishers and safety harnesses.

Just as in the fifties, the chassis is manufactured by George Lister Engineering (still in Cambridge, although now a few miles down the road from the original Abbey Road site). Founded by Brian Lister's grandfather in 1890, the two companies have always been separate entities, with much of the engineering work sub-contracted back to the family business.

"The thing is, Brian Lister was 25 when he started Lister Cars and although he was a skilled engineer he didn't come from a motor industry background. He relied heavily on the companies around him," Whittaker points out.

Then as now, the engine and bodywork are outsourced, but the remainder of the production largely takes place in-house. A section of the factory is cordoned off for car production, nestling between the rows of machinery producing everything from food processing machines to electron microscope components. ▶



ABOVE CAD and computer-aided engineering have been used extensively in the production of the new chassis

BUYING A PIECE OF HISTORY

As it turns out, Lister Cars' recent resurgence took place virtually by accident. A few years ago Whittaker, along with this father, bought what they believed to be an original Knobbly as a restoration project. On closer inspection, it emerged that the wide-angle Jaguar D-Type cylinder head used on the original Listers was missing. Worse still, neither the body nor the chassis proved to be original.

"When we actually got down to it, it turned out that none of our car had been built in the Lister factory," explains Whittaker. "It's something we've since encountered a lot. The factory only produced a very limited number – something in the order of 35 cars – but there are far more out there today. I know of at least six Lister replicas that are currently being produced for historic racing outside of the factory, and it's not unheard of for people to try and pass these off as period cars."

Rumour had it that the original plans still existed in the factory, so the pair arranged a visit to see if there was anything that could help with their project. "When we got there they had all the blueprints, all the chassis jigs, all the body bucks and a lot of original parts still in storage," recalls Whittaker. Suddenly it seemed like there was the possibility of reviving not just their car, but Lister Cars itself.

Almost immediately the plan hit a stumbling block, however. Although the engineering company possessed the physical assets, it transpired the rights to the brand were owned by Laurence Pearce, who'd acquired the car company from Brian Lister in the mid-eighties and gone on to produce the FIA GT Championship-winning Lister Storm.

The pair flew over to Portugal in May 2013 to meet Pearce and, after a certain amount of haggling, a deal was eventually struck. Along with parts of the intellectual property owned by Shapecraft founder Clive Smart, Lister Cars was reassembled as a single entity for the first time in 25 years. And with the 60th anniversary fast approaching it seemed like an ideal time to bring back the firm's most celebrated model.

Photo: Newspress

ABOVE The first of the continuation bodies shown alongside the original Lister chassis jig

CHASSIS

Under the skin, the new Listers are identical to their '50s forebears. The chassis is a semi-spaceframe affair, based around two large tubular rails. A mixture of round and square section tubing completes the structure, with plate and angle sections for the outriggers. By the end of the Knobbly's competitive career, plans were afoot to replace this twin-tube design with a more complex spaceframe, but they never came to fruition. The modern cars follow the definitive 1958 layout, using the original factory jigs.

The entire car is now held in a comprehensive CATIA CAD model, which can be broken down into sub-assemblies and from there into component drawings, such as individual chassis tubes. This geometry can be fed straight into a CNC cutting machine, which ensures the complex angles and curvatures are replicated precisely from the original drawings, giving the best possible joints.

"CNC machining is a very useful tool," explains Mark Hallam, a director of George Lister Engineering Ltd. "Obviously they didn't have that in the '50s. The same goes for the sheet metal work – we now use CNC punching machines and CNC brake presses for sheet bending. The end result is much the same as doing it manually, but it enables us to produce a more consistent result."

In preparation for the welding process, the tubes are purged with argon gas to prevent oxidation and improve weld penetration. This has no direct effect on the weight or torsional rigidity of the chassis, but it increases the strength and corrosion resistance of the joints. Ultimately, the TIG welding is still carried out by hand, just as it ▶

ABOVE The Lister Jaguar is elligible for a wide range of historic events Photo: RM Auctions

would have been in the fifties.

Once the chassis has been welded, it's sent out for powder coating before returning to the factory for assembly. At the same time, the front wishbones and the rear De Dion assembly are fabricated in-house, along with the stub axles and king pins. The hubs are machined from steel billet, although these days CNC lathes and milling equipment are used in place of manual machines, again working from CAD data. In another nod to modern technology, the suspension components are all X-ray checked before they're allowed onto the car.

Bit by bit, the rolling chassis begins to take shape, complete with 16-inch Dunlop Racing wheels and knock-off spinners. It can then be lowered onto the floor in time for the engine to be dropped in. Next come ancillaries such as the fuel and oil systems, followed by the brake pipes and the wiring loom.

INVALUABLE

Having access to the engineers and mechanics who worked on the cars in-period has proved invaluable, says Whittaker: "After we'd acquired the company, Brian [Lister] came down to the factory to meet us all and he couldn't have been more helpful. He's been a fantastic source of knowledge and we regularly speak to him on the phone, along with other members of the original team like Colin Crisp and Dick Barton."

Perhaps the most crucial revelation was to come with the chassis thickness. During the early stages of the project the team inspected a number of reputedly original cars and found them to be made of anything from 14 gauge to 18 gauge steel tube. When they consulted Brian Lister a surprising explanation emerged. "It turned out the works cars were all built in 14 gauge, but if someone like Cunningham in the States wanted to buy a car in kit form they'd supply a thicker chassis to prevent them outperforming the works cars," reveals Whittaker. "In fact, what's regarded to be the definitive book on early Listers actually gives the wrong figure for the works cars, probably for this reason. Without Brian's input we'd never have known any differently."

At times, Lister displayed an almost Chapmanesque approach to weight reduction. The first iteration of the car didn't even have headlights, Whittaker explains. This led to uproar from the other manufacturers, resulting in a swift rule change that saw the front end of the 'Archie' Lister restyled into the familiar Knobbly.

The same fanaticism can be seen in other areas of the car. Huge care was taken to machine out the insides of the hubs, for example, producing a concave design that saves three or four kilos per corner. Another story tells of how Brian Lister would refuse to let the cars out onto the track with more than a litre of oil in the 5-litre dry sump tank.

> **"Laser scanning techniques and electronic measuring arms have been used to capture the geometry of missing parts in exact detail"**

"The cars that Brian made in 1958 were 787 kg and he went to a lot of effort to save weight," comments Whittaker. "In one instance, we found a car that had put on over 100 kg since then simply because of all the non-original parts that had been added to it over the years."

Meticulous attention to detail has gone into recreating all the parts and the new cars are said to weigh virtually the same as their 1950s counterparts. In many instances the original drawings still survive, but elsewhere laser scanning techniques and electronic measuring arms have been used to capture the geometry of missing parts in exact detail. "There's nothing we haven't either been able to make or source to period spec," notes Hallam. ▶

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Perhaps ironically, some of the hardest chassis parts to re-manufacture were the once-plentiful MGA stub axles and steering arms, he explains: "We had to reverse engineer them and make them from scratch. Each one is machined from solid then heat-treated and crack tested."

Lister always enjoyed a good rapport with other manufacturers. Having begun in 1954 with Bristol engines, the company flirted with Maserati powerplants briefly before establishing a relationship with Jaguar that lasts to this day.

The young Brian Lister rapidly became friends with Jaguar founder William Lyons, who actively encouraged him to use the company's engines. Such was the extent of this support that many of them were actually supplied free of charge.

For the 1958 season Lister used the ultimate 3.8-litre evolution of the Jaguar D-Type engine. These days the company turns to renowned classic racing specialists Crosthwaite and Gardiner for an exact replica of the engine, built around a correct period cylinder block. Sourcing these can be an issue, Whittaker explains. The same block was used briefly in other Jaguar models, but not in any great quantity; those which have survived have to be minutely inspected for cracks and other defects before they can be used. Such is their rarity that Lister is looking into the option of casting a limited run of new blocks, but the cost implications would be considerable.

"It's already an expensive engine to re-manufacture," comments Whittaker. "I think we're the first company to make a complete D-Type engine for a long time. Jaguar's heritage department rang us up, because they were interested to find out where we were getting them from."

DRY SUMP SYSTEM

Everything else on the engine is brand new, built to an authentic specification that includes the crucial wide-angle 35/40-degree alloy cylinder head. Quite unusually for its day, the D-Type engine used in the Knobbly featured a dry sump system. Faithfully reproduced here, it not only improves the quality of the lubrication, but helps to counter the considerable height of the double overhead cam engine, lowering its centre of gravity and cutting down on frontal area. Unlike Jaguar, however, Lister never used the D-Type's Lucas mechanical fuel injection system. Instead the engine breathes through a trio of Webber 45 DCOE carburettors, re-manufactured using the original sand casting process. The result is a gloriously vocal 330 bhp at 6,750 rpm.

Encouraged by Carroll Shelby and Jim Hall in the US, Lister also offered a Chevrolet V8 engine option, which went on to be hugely successful in SCCA competitions. So far, Whittaker says, interest in the continuation models has centred around the Jaguar-engined cars, but the factory also offers a Chevrolet option using the 283 cu in (4.6-litre) cast iron Small Block engine found in the first-generation Corvette. Clearly this engine has a tremendous amount of tuning potential, but supplied to 1958 Lister spec it actually produces somewhat less power than the Jaguar unit at 315 bhp. Coupled to a significant (184 lb) weight increase, it can't quite match the athleticism of

BELOW Stirling Moss en route to victory at Silverstone in July 1958 with Lister Jaguar MVE 303

Photo: Newspress

ABOVE The 3.8-litre Jaguar straight six features the correct wide-angle cylinder head

the six-cylinder cars. Lister estimates that the 0-100 mph sprint will take around 10.1 seconds in the Jaguar and 12.1 seconds in the Chevrolet, with top speeds of 181 mph and 168 mph respectively.

The ubiquitous nature of the Chevy Small Block and the 4-speed Corvette gearbox make them easy to find. Unfortunately, the same cannot be said for the Jaguar gearbox, which in some cases has been converted to the later Moss unit found in the E-Type. Determined to stick to the original recipe, Lister has commissioned what's thought to be the first batch of D-Type gearboxes since the '50s.

The product of this painstaking labour is a four-speed synchromesh gearbox, complete with a Plessey hydraulic pump driven off the output shaft. This is another remnant of the running gear's Jaguar origins. On the C- and D-Types this was used to drive a brake servo, but on the Knobblys (old and new) it's blanked off in favour of a simple manual system for the 12-inch Girling disc brakes used front and rear.

"The gearbox was definitely the hardest part of the project," says Whittaker. "Re-manufacturing it was a complete nightmare, and obviously we could have bought a complete Moss gearbox, which isn't that different. We spent something in the region of £100,000 getting that first gearbox right, so we're obviously going to lose money on that car, but it's important to get these things right."

THE BODY BEAUTIFUL

Unfettered by wings, yet carefully sculpted to reduce drag, the Lister bodywork typifies late '50s sports car design. The dramatic contours that gave rise to the Knobbly tag are the result of a concerted attempt to shed every last square inch of unnecessary frontal area.

Just as with the engines, the Lister bodies were a masterful exercise in outsourcing. The shape itself was honed in the Jaguar wind tunnel, once again with the blessing of William Lyons. Incredibly, while this was happening, Lister's other major home-grown rival, Aston Martin, was engaged in building the body buck.

Here again, Lister's fastidious approach to weight saving can be seen in action. Along with the hollow hubs and the thin-walled tubing in the chassis, the Knobbly was offered with the option of magnesium alloy bodywork. This more or less halved the weight of the panels (albeit at twice the price) but it proved to have a major drawback. In May 1958 Archie Scott Brown was duelling for the lead of the Spa sports car race when his Knobbly swerved off the road and rolled into a ditch where it erupted into flames. Lister's star driver was thrown clear during the accident, sadly later to die in hospital, but the ferocity of the ensuing fire was linked to the use of magnesium. Unsurprisingly, all 10 of the continuation models will be built in aluminium, hand-formed by Somerset-based panel beater Adrian Breeze using the original buck.

RETURN

By the time you read this, the first of the new Knobblys should be ready to return to the track. Deliveries are expected to commence during the summer, with the remainder following on later this year.

Predictably, given the amount of work that's gone into the new cars, they don't come cheap. Expect to pay around £249,000 for a Jaguar-based car in track specification, excluding taxes and delivery. But with originals fetching upwards of a million pounds in good condition (and Jaguar D-Types commanding considerably more), you could argue it's something of a bargain.

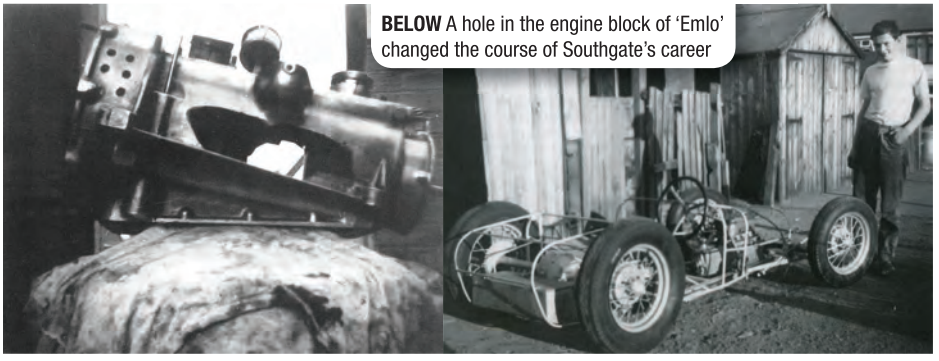
Intriguingly, this might not be the end of the story, either. There are, of course, other models yet to be explored from the Lister back catalogue and Whittaker's parting shot raises an interesting possibility: "It just so happens that Crosthwaite and Gardiner has one of the four-cylinder Maserati engines sat on the shelf. That for me is very interesting. If we could make a Lister Maserati, that would be very special."

Another classic Lister reborn in time for the firm's next big anniversary? Don't bet against it. HRT

Big bang theory

From the Indy 500 and Can-Am to rallying's special stages, and F1 through to the Le Mans 24 Hours, Tony Southgate's cars have won trophies and admiration. But as **Chris Pickering** discovers, it was a sound every racer dreads that shaped this legendary designer's career...

THEY say it's good to start your career off with a bang. Of course, generally this expression is meant figuratively. For Tony Southgate, however, it took on an altogether more literal aspect as he stood staring at the four-inch diameter hole that had just been punched clean through the crankcase of his Austin Seven Special.



BELOW A hole in the engine block of 'Emlo' changed the course of Southgate's career

Just three races in, the abrupt exit of one of the engine's conrods was to signal the end of Southgate's driving career – at least for the foreseeable future. Strangely enough, though, it was also during this moment that the young engineering apprentice realised he wanted to make a career out of motor racing.

His car was a tiny low-slung device known as Emlo, built for the 750 Motor Club series. It had a long tapering nose and a set of dainty wire wheels. There were drum brakes, live axles at both ends and a 747 cc four-cylinder side valve engine so old the blueprints could be found on the Ark. At the time this was still a perfectly competitive racing car – certainly if you ignored the gaping hole in the engine – and yet most of the technology wouldn't have seemed out of place in the 1920s. Motor racing was about to embark on arguably its greatest period of engineering innovation, however. Over the next few decades technology was to change beyond all recognition – and the young engineer with the Austin Seven was set to play a leading role.

EARLY DAYS

Southgate started off in 1961 as a draughtsman working for Eric Broadley at Lola, a man he describes as a joy to work for and "the quintessential English boffin". He got his big break in 1967 when Dan Gurney asked him to come over to the US and join the design team for his Indy 500 cars. He had worked on oval racers at Lola – one of which even took victory in the Indy 500 in 1966 – but he had never been to America, let alone Indianapolis.

By 1968 Southgate was chief designer for the Indycar project and he opted for a monocoque chassis shaped a little like a Coke bottle. The main priority was to get the centre of gravity as low as possible, with the fuel concentrated around the centre of the car to minimise balance changes throughout the race. He promptly ditched the elegant rocking arm front suspension used on the 1967 car in favour of a more traditional outboard setup. This outwardly retrograde step placed the spring-damper unit back in the airstream, increasing drag on the high-speed ovals, but it helped to eliminate unwanted flex. It proved to be the right move.

"That year the Lotus turbines were at Indianapolis," Southgate recalls. "They went like the proverbial off a shovel, but everybody hated them because they just sounded like jet planes. About 10 laps from the end of the race we were doing well and Leonard in the leading turbine car stopped. Our man Bobby Unser inherited the lead with a turbo Offenhauser engine in the back and the cheer when that Lotus stopped was phenomenal. Dan finished second in another Eagle with his pushrod V8 and Denny Hulme was fourth with a Ford twin cam-powered example."

It was a watershed moment for the young engineer, who had left England in a supporting role and now returned in the spotlight as an Indy 500-winning designer.

After a stint at BRM, Southgate moved to Shadow. The team was started in the US by Can-Am racer Don Nichols – a mysterious character who was rumoured to have been a US intelligence agent in the Far East prior to going racing. Part of the deal was that Southgate would design a new Can-Am car alongside the team's Formula One chassis. This was to be powered by a monstrous twin-turbocharged 8-litre Chevrolet V8 producing a theoretical 1,200 bhp. Fuel consumption was optimistically stated at 2 mpg and finding a gearbox to cope with the engine's 1,000 lb/ft of ▶

ABOVE In conversation with Lotus legend Colin Chapman

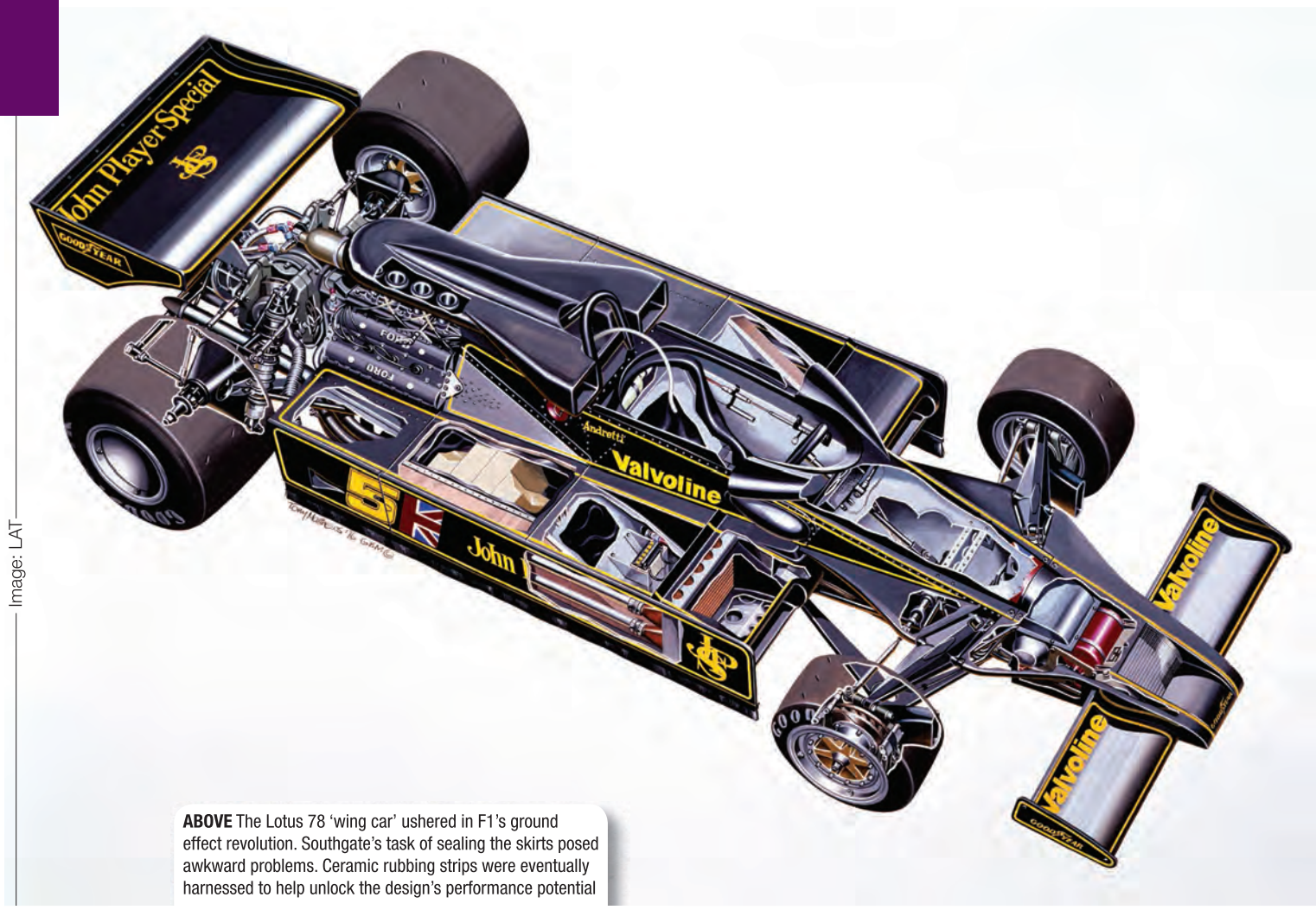


Image: LAT

ABOVE The Lotus 78 'wing car' ushered in F1's ground effect revolution. Southgate's task of sealing the skirts posed awkward problems. Ceramic rubbing strips were eventually harnessed to help unlock the design's performance potential

torque wasn't easy.

An interesting quirk of the Shadow DN2 was its turbocharger installation. "The earlier Shadows had the turbos mounted above the gearbox – the same as the Porsches of the time," recalls Southgate. "From a chassis designer's point of view, the weight was much too high up and further back than you'd like, so I decided to put one turbo on each side of the engine, as low as possible in the chassis. Initially the engine builders were very sceptical, saying it wouldn't give enough length for the exhaust pipes, but when we put it on the dyno the new layout actually produced more power. Not bad for a chassis designer!"

This concept was widely adopted and it's still in use today, but the DN2 never made anything like the power output the engine builders initially forecast. It wasn't until the team switched to the sleeker DN4 chassis and a smaller, naturally-aspirated engine in 1974 that it finally managed to overthrow the dominant Porsches and take the championship. Things were looking up in Formula One as well, although the team never managed to emulate its success in sports cars. By 1976 Southgate was on the move – and this time it was a chance to work with one of his own personal heroes.

PERSONAL HERO

Southgate was now considered to be one of the leading competition car designers of his day – something that hadn't been lost on Lotus founder Colin Chapman. Despite coming from the same 750 Motor Club background, Chapman was a generation ahead and Lotus had been competing in Formula One for the best part of two decades. Having dominated through most of the 1960s, the team now found itself in something of a lull and Chapman was in search of fresh blood.

"Chapman thought I was the new in-kid I think so he offered me massive money – twice what I was getting at Shadow," comments Southgate. "When I got there we had the Type 77, a distant relative of the Type 72 that that was extremely light, but also rather flimsy. The monocoque only weighed 52 lb (23.5 kg) and it transpired that most of the major components had broken or tried to break at some stage of the development."

For the following year Southgate found himself part of an all-star design team that included Colin Chapman, Tony Rudd and Peter Wright. A few years beforehand Wright – then a young aerodynamicist at BRM – had experimented with the idea of a Wing car. The concept had never made it beyond the wind tunnel stage, but the potential was there.

"Chapman loved all these unusual ideas," recalls Southgate. "He got Peter to work on the wing car idea as soon as he joined the team. They tried putting endplates on the underwing and the figures started to look pretty good. Then someone came up with the idea that they could fill the gap between the road and the wing and suddenly the performance was phenomenal – twice as good as anything we'd ever seen."

The wing concept was to prove a hit and it became central to the design of ▶

the new Lotus 78. Nonetheless, it did present a few practical issues. "I got lumbered with the job of sealing it," Southgate recalls. "I tried brushes initially – literally just nylon brushes. The next step was to put a diaphragm in them and then we ended up with a spring-loaded polypropylene sheet that hinged and a rubbing strip along the bottom. These would fold in like a letter box, so we knew that we were losing performance by reducing the surface area."

It seemed the only way that Lotus could get the skirts to move completely vertically was to make them slide, but that would have been illegal as a moving aerodynamic device.

Chapman's response was to put a bit of metal from the skirt to the chassis, which flexed like a leaf spring, so he could argue it was solidly attached to the chassis. "Amazingly, they let us get away with it," comments Southgate. "The secret about those, of course, was the ceramic rubbing strips. They'd go the whole race rubbing on the ground and there was no way you could touch them when the car got back into the pits; they'd burn your hand off."

In another example of Chapman's no-nonsense approach the designers found themselves arguing over the size of the McLaren wing, recalls Southgate: "Their rear wing appeared to be performing a bit better than ours and that pissed Chapman off intensely. Eventually he grabbed a tape measure, strode over to the McLaren and measured it. 'I told you,' he declared, '23 inches!'"

ARROWS

After a brief return to Shadow in 1977 Southgate went on to become part of the newly-formed Arrows team. Quite literally, as it happens: his final initial formed the 'S' at the end of the name, along with those of Franco Ambrosio, Alan Rees, Jackie Oliver and Dave Wass.

Following the success of the Lotus 78 there was talk of cars with so much underbody downforce that they'd no longer need conventional wings. Southgate was a keen advocate of the idea and hoped to beat his former boss to the mark: "I knew how Chapman thought, and I knew he'd be desperate to be the first car there without wings. That was a statement – he always wanted a car with inboard suspension when everyone else had outboard, or he wanted a car without wings when everyone else had wings."

Arrows' second-generation car, the A2 took this idea to the extreme. The whole body was fashioned into an aerofoil with skirts above and below. Underneath, it had a very long venturi section, shaped a bit like the hull of a boat that started right underneath the driver. To make this possible the whole of the powertrain was angled upwards by around four degrees.

"In the tunnel it was superb, it was generating twice the figures of the Lotus," comments Southgate. Unfortunately there was a problem: "The thing is you don't have to go round corners in a wind tunnel. Even though it had good downforce, the centre of gravity was far too high and the car performed very poorly. If I'd had the engine level, as per normal, it would have only lost around 200 lbs of downforce – that's a big chunk, but it would have still been competitive."

Jochen Mass drove the car a lot and later said he believed it would have worked if super-stiff suspension had been used to control the weight transfer. Southgate isn't convinced, but he still regards the project as an interesting exercise: "It was a fascinating car. The quickest it ever ran was without a rear wing. We put the rear wing on as a psychological thing for the drivers. With a Gurney right at the back of the rear wing it made the car a little bit more stable under braking but that was about all."

BELOW Pioneering days: the scale model of the wingless Arrows A2 (left) was superb in the wind tunnel. When it came to performing on the racetrack (right), going round corners proved a problem

Photos: LAT

GETTING MUDDY

Southgate's somewhat nomadic career as a freelance designer took in an unparalleled variety of cars and disciplines, so I'm keen to find out what he sees as the greatest challenge. Given the sheer number of options I'm expecting a moment's hesitation, but his reply comes instantly: "The most interesting car I ever worked on was the Ford RS200. It was far more challenging than a Formula One car, which was basically just four wheels and a fuel tank in those days."

Having recently cancelled the rear-wheel drive Escort RS 1700T rally car, Ford of Europe's motorsport boss Stuart Turner was on the lookout for new ideas. Southgate put forward a design that borrowed more from circuit racing ▶

BELOW The design freedom of the Group B regulations, for which he penned the RS200, excited Southgate

“The most interesting car I ever worked on was the Ford RS200. It was far more challenging than a Formula One car”

than traditional rally cars: “You could do virtually anything in Group B, so I came up with a mid-engined turbocharged four-wheel drive car with an aluminium honeycomb chassis. Ford clearly liked the idea as they contacted me to join the team in Boreham and start work on a prototype straight away.”

The quirks of rally car design rapidly hit home. For the purposes of servicing, the team wanted every bolt on the car to be the same size and they suggested 12 mm (just under half an inch). In Formula One anything over 8 mm was considered big and heavy, but Southgate reluctantly promised to limit the number of tool sizes that would be required.

Next came concerns over the aluminium honeycomb construction itself. “I soon began to realise that what the boys at Boreham really wanted was a Sierra with tubular steel subframes and the old Escort turbo engine somewhere in the middle,” he notes. Eventually the issue was resolved when Southgate offered to build prototype sills in aluminium honeycomb and the traditional spot-welded mild steel for impact testing. Upon the test the 18 swg steel box section collapsed instantly to almost half its original size, while the 22 swg aluminium version (filled with half-inch aluminium honeycomb) hardly budged. At a stroke the Ford engineers were converted.

Following the original proposal, the RS200 used unequal length double wishbones with twin outboard spring-damper units on each corner. This arrangement helped to give the car a generous eight inches of wheel travel, while a huge range of suspension mounting points allowed its geometry to be changed to suit all the different surfaces and conditions encountered in rallying. It was all a world away from the millimetrically constrained environment of circuit racing.

“It was an interesting project, and a most challenging one,” says Southgate. “With a rally car it not only has to work well on tarmac, but on mud, sand or snow – and you had to be able to change an upright in four minutes or a gearbox in nine minutes. Rallying wasn’t really my scene, but it was a new challenge and I came away with enormous respect for rally engineers after that.”

SPIRITUAL HOME

If the RS200 was to be Southgate’s most intellectually stimulating project, what followed was arguably the most rewarding. Having grown up in Coventry during Jaguar’s Le Mans glory days, he says it took “about a micro-second” to accept when Tom Walkinshaw offered him the chance to design a new Group C sports car for the marque.

The Jaguar XJR-6 debuted in 1985, just missing out on that year’s Le Mans 24 Hours. It used a 6.5-litre naturally-aspirated V12 based on the Jaguar XJS road car engine, coupled to a carbon fibre monocoque so stiff it bent TWR’s torsional stiffness rig on the first attempt at measuring its deflection. Eventually the team measured the completed car and found the overall structure to be good for upwards of 18,000 ftlb/deg – comfortably in excess of the Porsches that dominated at that time.

Aerodynamically, parts of the design were inspired by Southgate’s low-drag kit for the aborted Ford C100. The underfloor was dominated by a pair of huge diffuser tunnels, made possible by the use of 19-inch wheels which raised the height of the lower wishbones. TWR even experimented with exhaust blowing – this, don’t forget, was 1985.

It wasn’t until 1987 that the team started to pick up regular wins in the World Endurance Championship with a revamped car dubbed the XJR-8. ▶

Photo: LAT

BELOW *That* Le Mans finish with Jaguar's XJR-9 in 1988. It looks like a good photo opportunity but it later emerged that the formation finish had been arranged in case the ailing lead car needed pushing across the line!

This evolution model featured a 7-litre 720 bhp variant of the original Jaguar engine, later growing to 7.4 litres and 760 bhp, but reliability was still an issue and the long-distance races like Le Mans proved tough.

For the 1988 season TWR came with the updated XJR-9, which featured a number of aerodynamic updates aimed at maintaining the XJR-8's exceptional low drag figures, despite the addition of larger ducts for various cooling duties.

That year the team headed to Le Mans with a growing pressure to perform. As the race entered its final hours, one of the Jaguars had already gone out with transmission failure. Another, driven by Jan Lammers, was in the lead when it began to experience similar problems. The Dutchman came into the pits for the final refuelling stop with the car stuck in fourth gear and required a push start to get back onto the track. Tension mounted for the final few laps, with the second place Porsche closing in behind, but Jaguar went on to take victory at Le Mans for the first time since 1957.

"The reaction from the crowd was incredible," Southgate recalls. "Jan couldn't actually get back to the pits on that final lap because the spectators had swarmed across the track. Although the other cars were actually in fourth and 16th place, the three remaining Jaguars had crossed the line in what appeared to be a photo-finish. It wasn't for many years that anyone dared admit we were actually lining them up in case one of them needed to physically push the lead car over the finish line."

The TWR Jaguars went on to pick up the World Sportscar Championship in 1988. The team returned with an all-new design for 1989 – visually similar to the previous XJR series, but totally different under the skin with a new 3.5-litre twin-turbo V6 based on that used for the Metro 6R4 rally car. The engine was too fragile for endurance races, though, the old V12 being harnessed in the XJR-12 that scored another victory at Le Mans in 1990.

MAGIC OF FERRARI

Southgate's consultancy work included two notable collaborations with Dallara, the first yielding a particularly memorable phone call. Working on Ferrari's open-top 333SP was, he admits, "magical" but the project was burdened by expectation when they reached Le Mans.

> **"Everyone in Italy will expect us to win if we're quickest. When you go out for the next practice tomorrow, can you go slower?"**

"In practice we went quickest just like that," he recounts. "I thought, 'Bloody hell!' So I phoned back to Luca di Montezemolo and Piero Ferrari. For a moment there was silence on the phone and then they said, 'Can you go slower?'

"I said, 'What do you mean, go slower?'

"The reply came: 'Everyone in Italy will expect us to win if we're quickest. When you go out for the next practice tomorrow, can you go slower?'"

By the end of the '90s Southgate had worked for a number of the great motor racing dynasties, but he was about to play his part in founding one that thrives to this day: "One day I got a call from Gian-Paolo Dallara saying they were working on a secret sports car project for Audi. They had a great engine but they were having problems with the chassis and they wondered if I would be interested in helping."

Southgate ended up becoming a consultant to the team on both the open-topped R8R and the short-lived R8C coupe. One of the biggest advances during his time at Ingolstadt was the introduction of a paddleshift gearshift system. The idea had been around in Formula One for nearly a decade, but it had been deemed too complex and costly for sportscar racing. One day an engineer by the name of Erwin Gassner came to Ingolstadt with a system that his company Megaline had developed for motorcycle racing.

Impressed by the idea, the team commissioned a system and put it on one of the roadsters for testing. "After about 1,000 km we took it back to the workshop and took the gearbox apart," Southgate recalls. "I went into the transmission shop to have a look at the dog rings and I turned to the engineers and said, 'Did you notice anything odd about this?' The dog rings looked like new! We contacted Gassner, but he could only make three kits before Le Mans. Both the R8Rs had pneumatic shifts, plus a spare, but the R8C coupe, unfortunately, didn't get one."

Photo: Audi

Photo: Brooks/ LAT

ABOVE & BELOW Southgate collaborated with Dallara on major sportscar projects for Audi (above) and Ferrari

Come the race the team entered two coupes and two roadsters. They all had the same engine and gearbox, but the coupes – fitted with manual shifts – were both out with gearbox trouble after 12 hours. One of the remaining roadsters was then called into the pits for a pre-planned gearbox change – something which could be completed in a scarcely believable five minutes.

Southgate recalls the first time he witnessed the full procedure was during practice: "I've never seen so many stop watches! Joest organised it perfectly. You were only allowed four mechanics in the pit lane at any one time, but you could have as many people as you wanted working on it in the garage. There was a complete back end waiting on a crane and everything was snap connectors, including the brake and clutch, so it went together in a blur. The car was back on the ground with wheels on, underbody on and tail on in 4 minutes 56 seconds."

When it came to the precautionary stop during the race, the car went into the garage as if it was coming in for a brake pad change. Five minutes later it went out again with a completely new back end, plus new pads front and rear: "A normal pad change would have taken a couple of minutes on its own back then, because you could only do one thing at a time in the pit lane. We only lost about a minute and the car was like new."

In the end, the roadsters finished third and fourth, but it was a brief taste of what was to come. The following year Audi entered four cars, all of which were roadsters fitted with the paddleshift transmission. They scored an emphatic one-two-three victory at Le Mans in what was to become Southgate's last professional event. Exhausted, he went back to the hotel and resolved to retire.

The story doesn't end quite there, however. Not long after announcing his retirement Southgate bought a Sylva Phoenix and decided to go racing himself for the first time in four decades. Appropriately enough the series he races in is run by the 750 Motor Club. To date, none of the pistons have made a bid for freedom. HRT

SMALL BUT PERFECTLY FORMED

Dormant for over half a century, briefly converted into a two-seat road car and now racing again, **Andy Swift** discovers the unlikely story of this JP Formula 3

HISTORIC motorsport has come a long way in recent years. At high profile events you're now almost as likely to see a full-size race transporter as a homemade trailer. The level of complexity has gone up dramatically too, with more recent machinery entering the ranks.

Elsewhere, however, things can be rather more prosaic and redolent of a simpler time. Nowhere is that more apparent than in the 500 cc Formula 3 scene, where proprietary motorcycle parts and early '50s engineering rule.

> **"They realised they owned something highly unusual"**

Alan Croft and his JP embody the 1950s spirit and the story of how he came to race an unusual monoposto of the immediate post-war period is as fascinating as it is unlikely.

The JP was the brainchild of Scottish engineer Joseph Potts, whose family firm had supplied parts for Barnes Wallis's Tall Boy bomb during the Second World War. Once peace returned, the firm set about motorcycle racing and the move into the motorcycle-engined F3 of the time was a fairly natural one.

Croft's JP was bought from the works in 1951 by Ian Sutherland who raced the car through that season, though with only moderate success. Deciding the JP was uncompetitive, Sutherland advertised the car for sale and it was purchased by former fighter pilot James McCosh. Clearly finding civilian life slightly lacking in adventure compared to his wartime heroics, McCosh converted the JP into a side-by-side two-seater special, nicknamed Rebecca, and used it as a road car for four years – Cyclops single headlight and all.

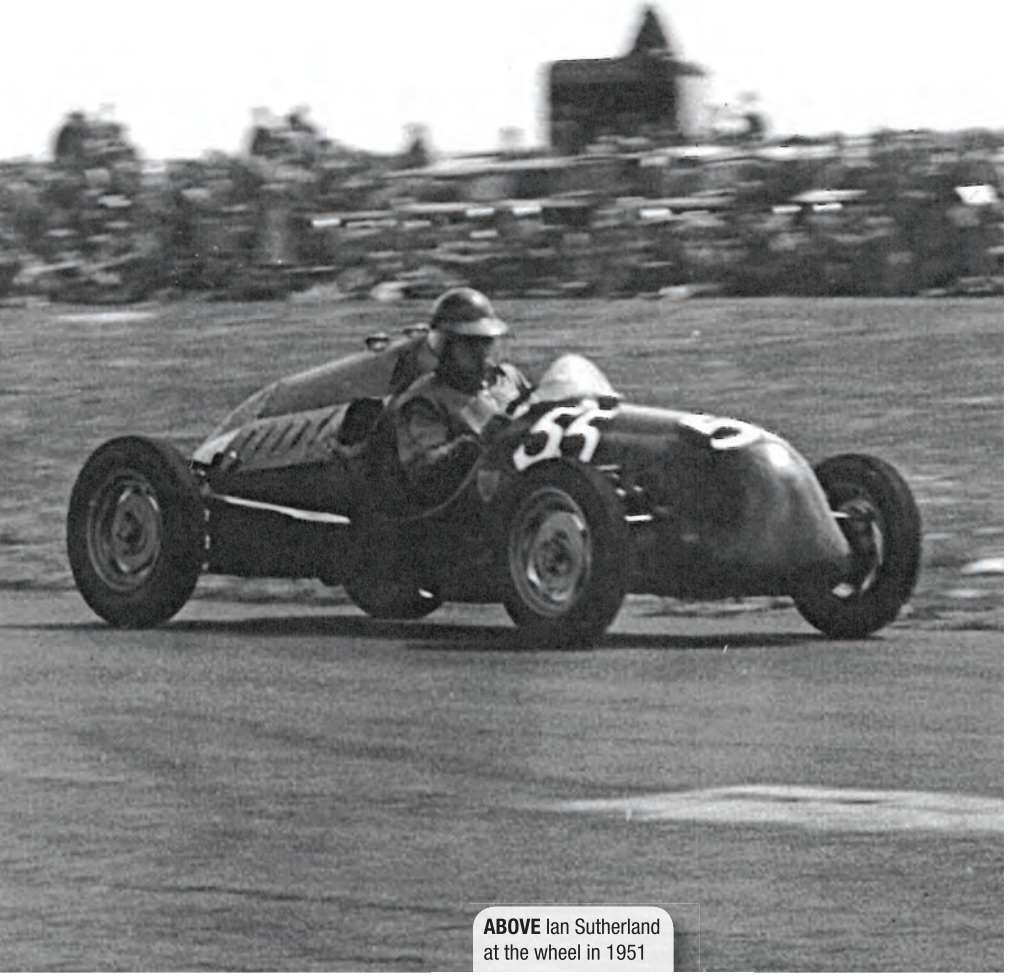
The car subsequently languished unused for almost 40 years, passing in ownership to a Mr Lee via a Mr Bancroft. Shorn of its bodywork and special Vincent Grey Flash engine, it fell into Croft's hands quite by chance. During convalescence from a heart attack, Croft's father, Denis, found himself in a hospital bed next to Mr Lee. A conversation about racing between Crofts elder and younger at the bedside sparked a discussion which led to them purchasing a rather sorry-looking rolling chassis for a token £100 in 1993.

A serial kit car enthusiast, Croft junior had initially planned to create his own special from the chassis but time and money interfered, leaving the JP to remain resting out of sight. At this stage, the Crofts didn't even know what they had bought and it was only a letter – and subsequent informative response – from the National Motor Museum at Beaulieu which filled in the blanks. The car's only distinguishing feature was a faint 'JP' logo on the still-original wheels. From that, they realised they owned something highly unusual and the idea of creating a special fell by the wayside.

BUILT TO RACE

Fast forward 15 years and finally the decision to rebuild the JP was realised, the car being transported to specialist Jim Taylor of Kirsty Racing in Sheffield. This quickly threw up questions regarding the nature of the work - and ones which plague all major automotive restoration projects: what level of originality is appropriate? Should the car remain static or be used as intended? What creates the car's identity?

ABOVE Back at the track after more than half a century



ABOVE Ian Sutherland at the wheel in 1951

In a bid to satisfactorily answer these fundamental questions, Croft delayed the restoration for 10 months while he researched the car and decided how he wished to use it. In the end, he decided that the intention was to use and race the JP and that assertion dictated the decision-making over the chassis work.

After so many years of benign neglect, the chassis itself had bowed considerably, with various areas also having deteriorated to the point that some of the original steel members had to be replaced – especially as several of these were spliced in as part of the two-seat conversion. The use of new steel in the chassis has meant Croft has faced questions about the true identity of the vehicle. “Some people have said it’s really just a replica but I was determined to race the car and I don’t think it would have done justice to the car to use it just for display,” he says.

Although Croft knew his intentions for the car, sadly no engineering drawings still existed. The cars themselves all differed to an extent, with only seven or eight today accounted for – and each is subtly different. This is the only early Mk1 JP known to remain. Using period photos of complete cars and a couple of bare chassis, Croft and his chassis builder were able to salvage as much of the original steel as possible, welding in new tubes where necessary.

Using a jig, the rebuilt chassis was as close as the team could manage to the way it left Potts’ workshop in 1951, barring a couple of minor modifications. After witnessing a sobering accident at Le Mans involving a 500 cc F3, Croft had slightly altered the specification of one of the curved spars above the driver’s legs. Rather than plate steel, this was now to be formed from tubular steel – with the agreement of the organising body. He also arranged for small flanges to be welded between tubes in the cockpit area in order to theoretically accommodate a roll bar, should one ever be installed.

With the chassis work complete, Croft returned the chassis to his own workshop where he decided, with no formal engineering training – or ▶

ABOVE The rolling chassis was purchased for the princely sum of £100 in 1993

experience in the field – that he would build the bodywork and complete as much of the mechanical restoration as possible. He purchased a metal-working lathe, tin snips and an English wheel and set about building not only the bodywork but also the fuel tank, seat and aero screen.

Croft started with the fuel tank. Using 16 gauge aluminium, rather than steel as would have been the case in period due to its ease of forming,

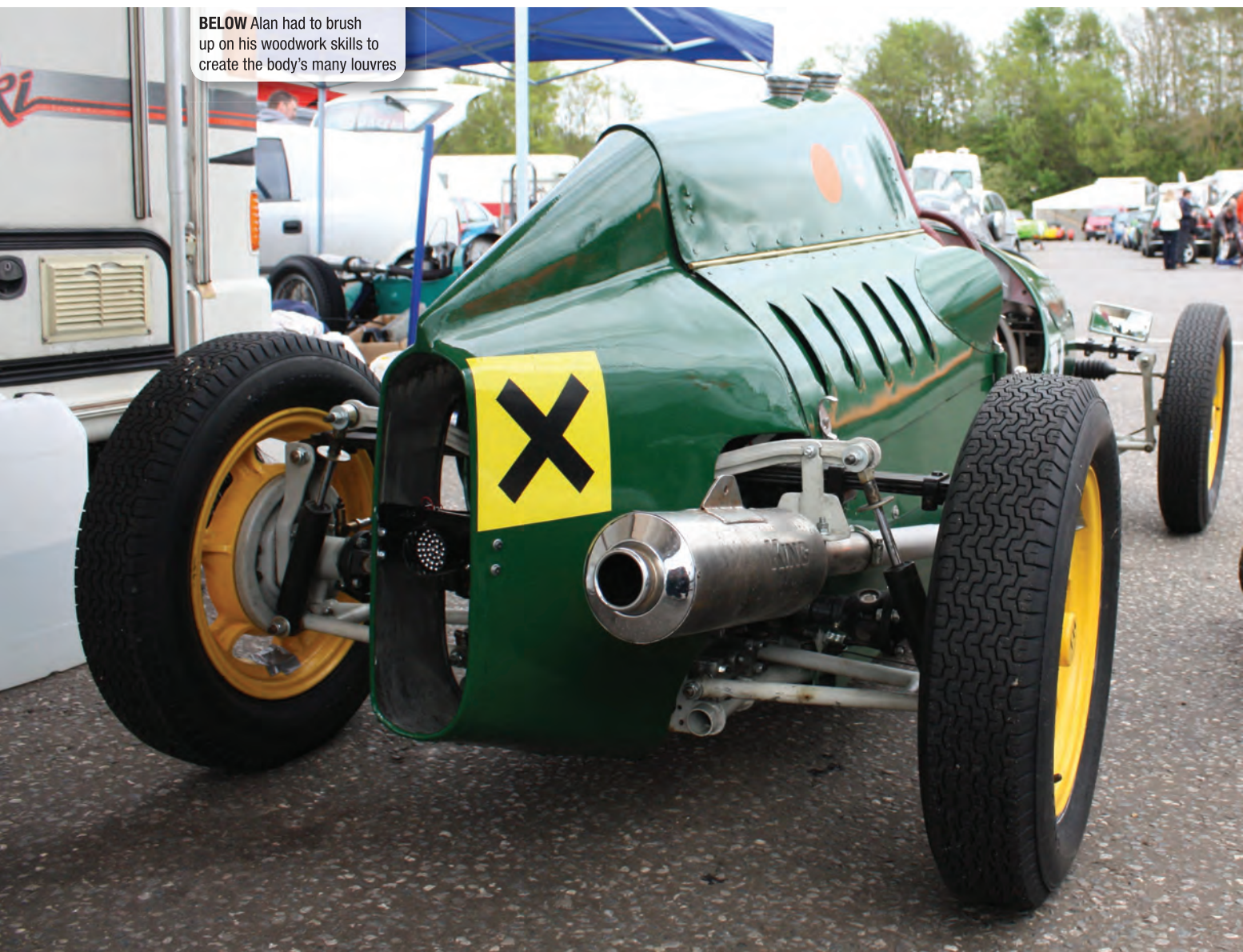
> **“This is true homebrew craftsmanship”**

he prototyped in cardboard before shaping any metal. A gravity-fed tank above the engine houses both fuel and oil, with an inch gap between the two to stop hot oil warming cool, volatile methanol.

This process continued throughout the car and Croft acknowledges that his skills improved as the car developed. He formed every curve and made every cut before sending the panels to a local aircraft welder to be welded. All this work was done simply from photographs and by eye. The result is remarkably cohesive, though Croft believes he may have made the engine cover about an inch too tall. “Making a new one gives me something to do over the winter,” he quips with a glint in his eye.

Having not done any woodwork since his O-levels, Croft also created a buck for the nosecone from ply – again with only a few photos to guide him. Once welded, he filled and sanded where necessary prior to painting and the quality of the curves is really quite remarkable. It may not be up to F1 autoclave standards, but this is true homebrew craftsmanship.

Woodwork skills were again put to ▶


BELOW Alan had to brush up on his woodwork skills to create the body’s many louvres

ABOVE After 21 years the JP's restoration is complete

the test when forming the body's many louvres. These are typically on the body's curves and required careful forming. Croft chiselled scallops into lengths of timber to act as guides and used a hammer to gently shape the louvres; this technique is all but identical to that employed by the coachbuilder who created the JP's original bodywork back in 1950.

In between, he found time to learn aircraft riveting and formed innumerable brackets, bushings, bearings and shims for deployment around the car. He tried using a hot air gun to create sufficient malleability to curve the Perspex aero screen but found it crazed the surface. Instead, resting it on a mould and leaving it in the Aga for half an hour achieved the perfect result with no crazing. He re-shoed the brakes using period items and period-correct riveting tool.

With the bodywork complete, it was time to consider painting the JP. Throughout the build, Croft has been fortunate to benefit from the expertise of friend Bill Tull, an auto engineer and a man with plenty of experience of 500 cc F3 cars. He offered to spray the car himself, leaving Croft to complete the prep work. Blessed with plenty of space, they set up a ventilated spray booth adjacent to the garage. All surfaces were treated with etch primer before filling and sanding in preparation for the main primer and top coat. Like the metalwork, the paint finish is remarkable given the tools at the guys' disposal – and an excellent incentive (were one needed) to avoid damaging the car out on track.

The original magnesium wheels, which had identified the car early during its tenure with the Crofts, were lightly shot blasted before painting. This was done with wet paint as powder coating makes spotting cracks in the delicate wheels almost impossible.

Ultimately, dark green bodywork with yellow wheels was chosen, Croft explains: "It was green with silver wheels in period but, truthfully, I wanted it to look a bit like a Lotus."

The chassis and bodywork were by far the most time-consuming and demanding aspects of the job. Mechanically, the car was fairly sound with the original hubs and transverse leaf springs being retained. The original Girling dampers have been replaced with fresher Mini items, but the originals have been kept for posterity and provenance.

GOOD VIBRATIONS

The JP inherited its considerable size (relative to many of its rivals) partially as a result of it having been designed to accommodate engines of capacity up to 1000 cc. Originally the car was fitted with a 500 cc single-cylinder four-stroke Vincent Grey Flash engine. This was sold off in 1960 and fitted to a motorcycle, but its whereabouts, somewhat remarkably, is known to Croft and one must wonder whether car and engine might one day be reunited. If he has aspirations as such, Croft remains tight-lipped. In place of the rather special, genuine Grey Flash engine, a period Vincent unit has been tuned to a similar specification by Bob Culver and installed.

The big single-cylinder engine creates problems of its own, Croft explains: "I'd been warned about vibration during the

build. It's absolutely essential to use Loctite, nyloc bolts or spring washers everywhere, otherwise everything just unbolts itself and drops off when you hit the track!"

perspective, not an effort to replicate the unique dynamics of Ferry Porsche's mighty Auto Union GP cars of the 1930s.

True to the spirit of Joseph Potts, Croft has started to campaign his JP,

> **"I'd been warned about the vibration ... it's absolutely essential to use nylocs everywhere"**

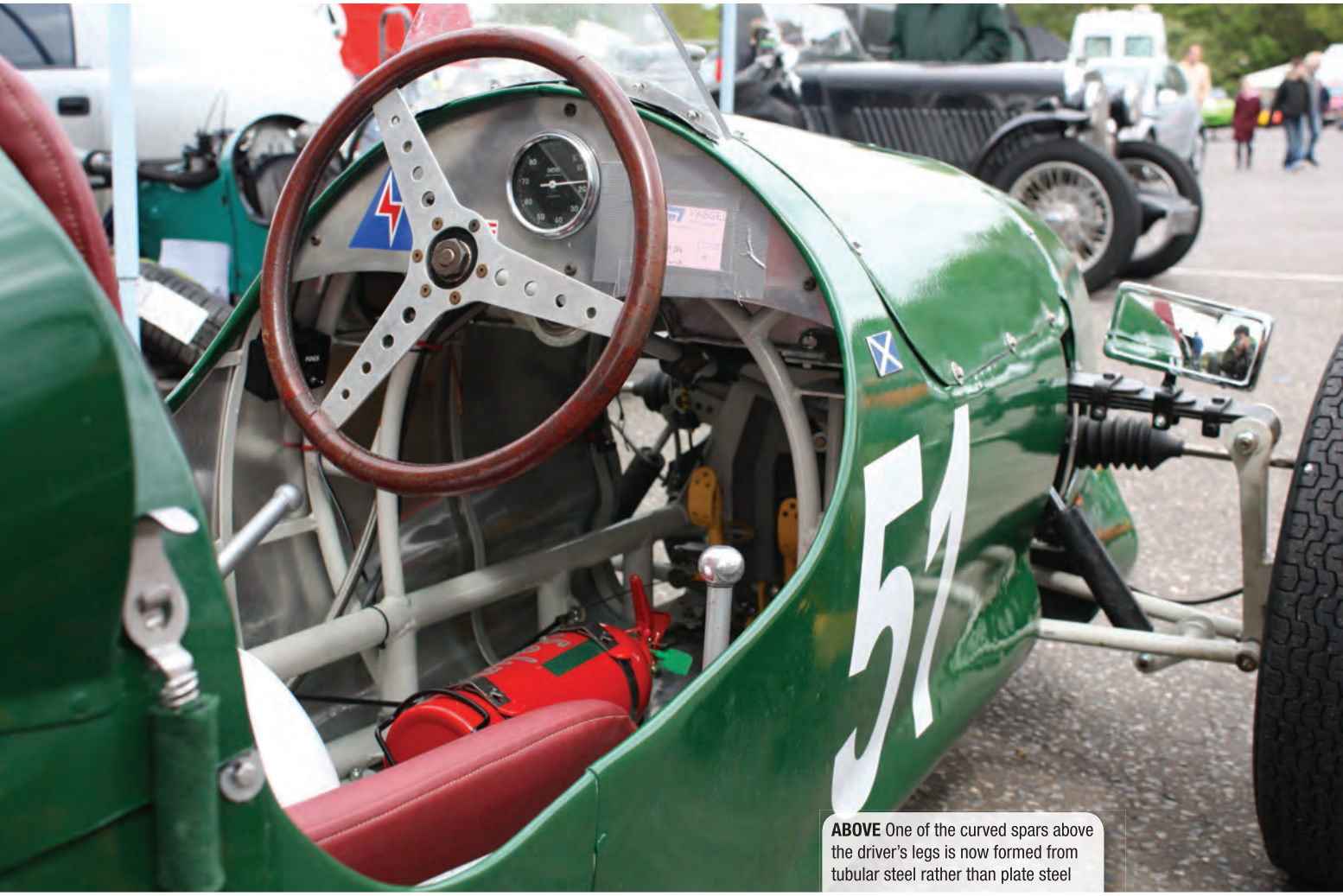
The original Albion TT gearbox was supplied with the car but has been put to one side and a more prosaic period Norton laydown unit installed in its place. The car makes do without a differential.

The motorcycle drivetrain ancestry explains the 500 cc movement's adoption of mid-mounted engines. During the immediate post-war period, these powerplants were cheaper and more easily available than highly tuned car engines. With sequential gearboxes and chain drive, it was the simplest solution from an engineering

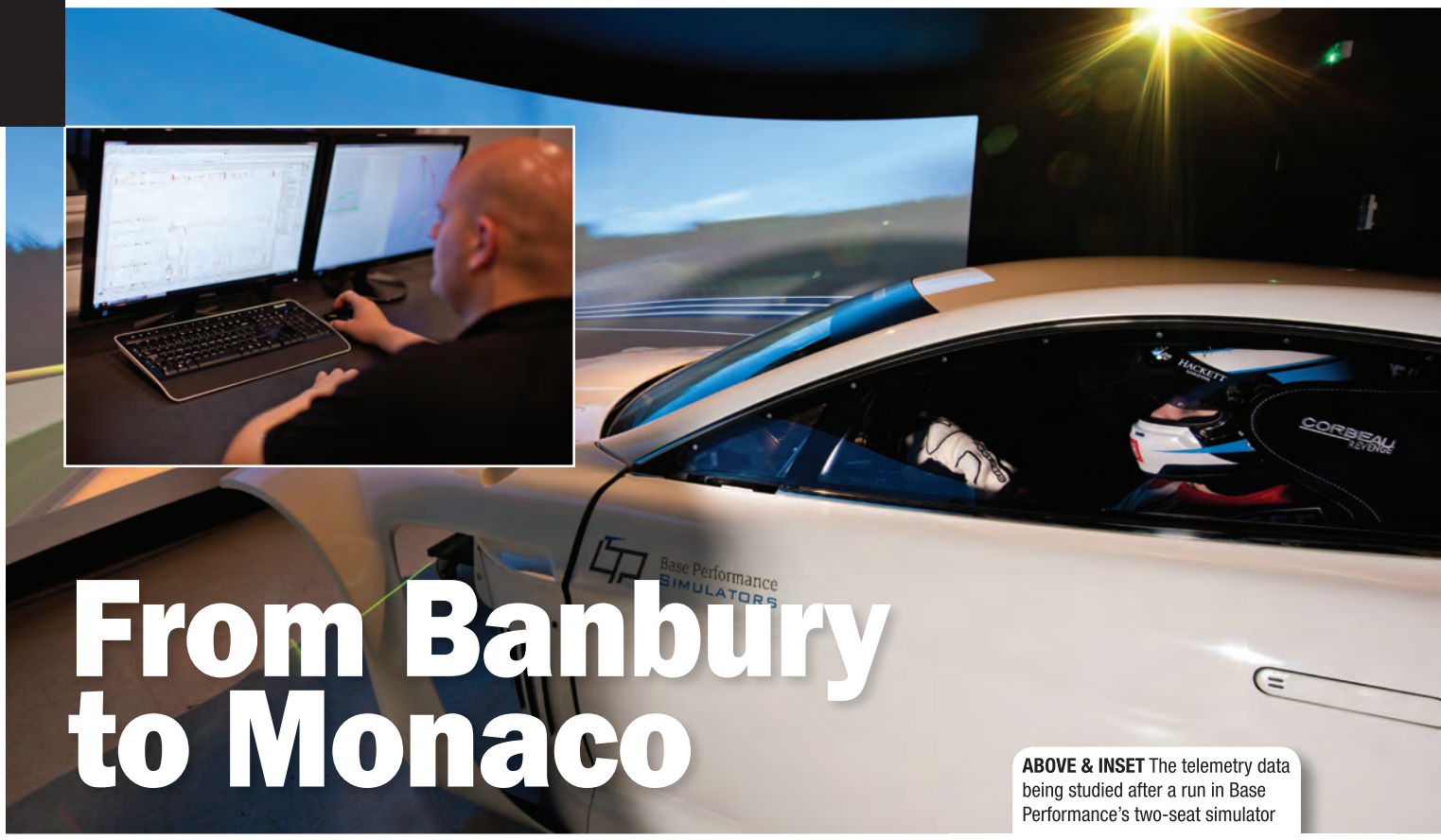
21 years after he first bought it on a whim. He has now raced it twice and looks forward to as many events as his now depleted funds will permit. He describes the car as terrific fun to drive: "It's not quick per se but it certainly feels fast. Part of the technique is to use your bodyweight to balance the car so you really need to hang out of the cockpit. With no differential, the back end skips about like a go-kart but that's part of the fun! I'm never going to win any races as the car's so heavy and I'm still inexperienced but I just love being out there racing it."

The debate regarding the authenticity of a car where so much has had to be recreated is moot. Whichever side of the fence you sit on the matter of restoration, the continual history of this particular 500 F3 remains fascinating. It would almost certainly never have been seen publicly again without a restoration on this scale.

What cannot be denied is that the spirit of Joseph Potts and his contemporaries lives on in men like Alan Croft. The British race industry as we know it had at its genesis the endeavours of engineers – trained or otherwise – who simply wished to go racing in cars of their own creation. That post-war competitive urge and make-do attitude bred a generation of engineers who helped shape an industry which remains a global phenomenon. HRT



ABOVE One of the curved spars above the driver's legs is now formed from tubular steel rather than plate steel



From Banbury to Monaco

ABOVE & INSET The telemetry data being studied after a run in Base Performance's two-seat simulator

Why the historic racing world is increasingly embracing the use of simulators. By **Chris Pickering**

THERE'S an old adage that states the easiest part of a racing car to improve is invariably the nut behind the wheel. Clichéd it may be, but there's more than a degree of truth in that statement.

The problem is that it's not always possible – or economically viable – to arrange a test day at a particular circuit. Faced with this, professional drivers have been using simulators for circuit familiarisation for more than a decade. And now the historic racing world is increasingly embracing the same technology.

"Races like the Le Mans Classic and Monaco Historic Grand Prix are there to be enjoyed by the drivers," comments Darren Turner, historic racer and Aston Martin works driver.

In 2009 Turner established Base Performance Simulators, which offers in-house facilities to both classic and modern racers. "We've found that those drivers who have visited us for a few hours before the event to really learn every inch of the circuit, arrive on race day confident that they can do the job behind the wheel," he says. "They enjoy these really unique and special events more because they aren't worrying about which corner is coming up next and what gear they are supposed to be in."

The company operates two simulators – one set up as a single-seater and the other based on a GT car. Both use large panoramic screens and three high-specification projectors to create a fully immersive environment that fills the driver's entire field of vision.

Providing accurate motion feedback is notoriously hard to do in a simulator and can lead to a somewhat arcade feel. Instead, BPS relies on the visual cuing and a large set of speakers, coupled to highly realistic simulation software.

The simulator sessions take place at BPS's facility, just outside of Banbury. With the in-house capability to create both cars and circuits, all it takes is a relatively simple set up sheet filled in with the basic details of the car and the BPS team can prepare and install a bespoke model into one of the two simulators.

Once the car and circuit have been loaded, a member of the BPS team runs through the controls of the simulator, which each have removable gear sticks to convert them from a modern paddleshift configuration to something more representative of a historic car. Dip the clutch, select first, and you pull out of the remarkably detailed virtual pit lane and onto the circuit of your choice.

"While real track testing can never be substituted, using a simulator can complement other pre-event preparations to make sure the driver arrives as well prepared as the car," says BPS business manager Ella Barrington. "Once you're in the simulator, it's almost impossible not to believe that you're screaming down the Mulsanne straight."

Once the run is over, the BPS staff can get to work with a host of modern data analysis tools. Using live telemetry data it's possible to go back through the run corner-by-corner, reviewing lines and looking at areas where time is being lost.

Far from being a gimmick, simulators have firmly established themselves in the racing driver's armoury. Unlike a conventional test session, they eliminate the costs associated with fuel, tyres and insurance. And best of all? It's guaranteed not to rain. HRT

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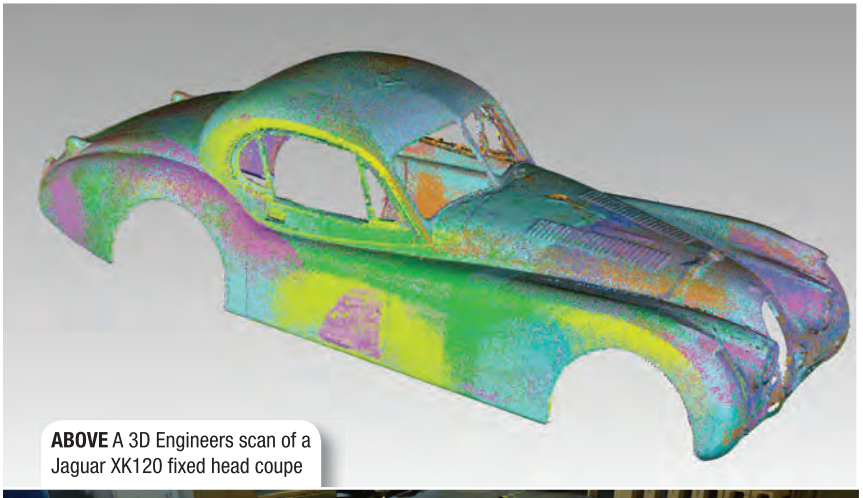
When the only way forward is reverse

Out of parts and ideas? **Chris Pickering** discovers that all is not lost

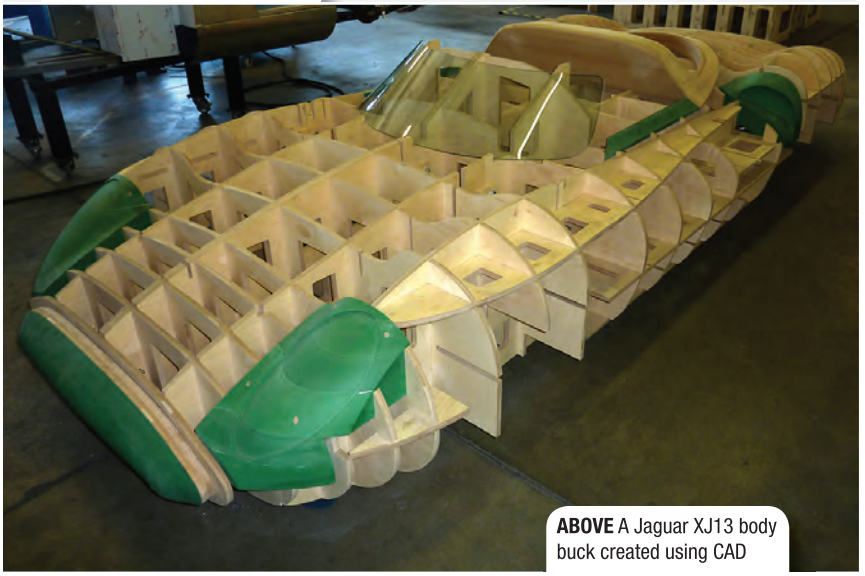
REVERSE engineering is a term that crops up time and time again in connection to historic racing. Almost by definition the cars tend to be out of production. To make matters worse, many of them are also extremely rare with spare parts scarce or simply non-existent.

Faced with the prospect of manufacturing your own spares – or even a complete duplicate of a car – you must first be able to capture all the details of the original. Fortunately, the fusion of traditional engineering skills and modern techniques mean it's now possible to do this with an unprecedented level of accuracy.

One of the most powerful tools in reverse engineering is 3D scanning. There can be an almost sci-fi feel to watching a portable scanner at work, as it builds up a 3D image from a beam of laser light. But it shouldn't be viewed as the default solution, points out Stuart Brown, owner of 3D Engineers: "Sometimes people come to us with, say, a chassis to scan, but it's actually better for us to use a more traditional method."



ABOVE A 3D Engineers scan of a Jaguar XK120 fixed head coupe



ABOVE A Jaguar XJ13 body buck created using CAD

The company has drawn on a wide variety of reverse engineering techniques, working on projects ranging from a body buck for a 1917 Hudson Super Six racer to digitising the contours of a Ferrari 250 GTO.

Often, 3D scanning is the best tool for the job, but it's by no means a straightforward process. "There's a misconception that you just press a button and the job is over once the scan is finished," comments Brown. "In reality, nothing could be further from the truth. Scanning is only the first stage. Next you have to post-process the data and then generate a meaningful CAD model."

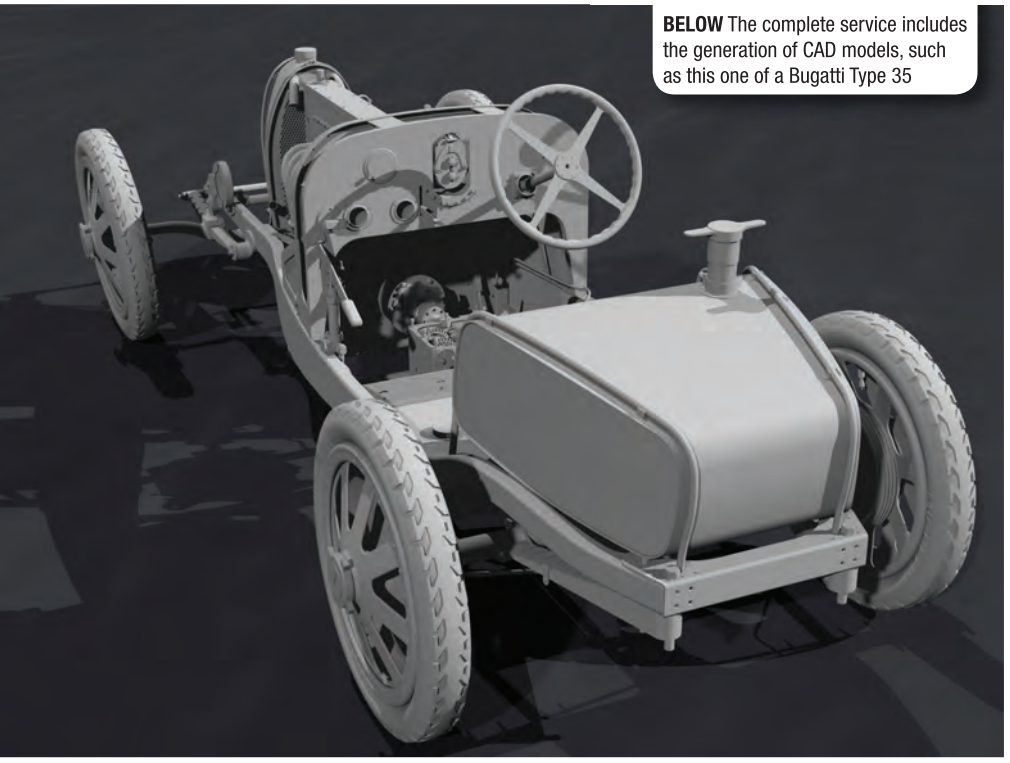
The process begins by taking a series of separate scans – typically 20 to 30 for a complete set of bodywork – using a portable scanner mounted on a tripod. This allows the scanner to be moved around, ensuring the overlapping scan data covers every inch of the car.

Typically each scan consists of between seven and 10 million points referenced to a common origin. The first part of the post-processing procedure is to join those points using a program that identifies common features between the scans and stitches them together.

The sheer quantity of data available can be almost unimaginable. To put things into perspective, aerodynamicist Malcolm Sayer used around 400 points (based on an X, Y, Z co-ordinate system) to define the shape of a Jaguar C-Type. (Admittedly, he used log tables and a slide rule instead of CAD software, but the principle is broadly the same.) A decade ago the hard probing machines first used to digitise car bodies took something like a week to collect 40,000. Now, the scanning system used by 3D Engineers is capable of capturing some 360 million points in a day.

The next step is to sift out any erroneous points and adjust for the cumulative errors that can build up as the scanner is moved around the car. This helps to refine the huge amount of data into something more manageable.

It also pays to think carefully about the level of detail that's required in the first place. Sometimes, ultra high



BELOW The complete service includes the generation of CAD models, such as this one of a Bugatti Type 35

accuracy scanning techniques simply aren't relevant to a body that's ultimately going to be formed by a human being wielding a mallet. Although it is possible to include hundreds of millions of points scanned at sub-millimetric accuracy, it's not necessarily advantageous to do so and it all adds to the cost and complexity of the project.

Once the existing geometry has been captured in a complete, usable form, the next question is whether the client would like it tidied up in any way. "We've had times where people have said, 'I like the rear wing on the left-hand side, but I prefer the front wing on the right-hand side,'" says Brown. "You end up cutting and mirroring sections of the car to get the customer what they want."

On other occasions, of course, the geometry is left very deliberately unaltered. Brown cites the case of a classic Ferrari that was known to have a significantly longer door on one side of the body than the other. This asymmetry was a simple quirk of the hand-built manufacturing process, but it had become part of the car's identity over time.

By carrying out the entire process in-house, 3D Engineers is able to modify the geometry where required as part of a one-stop service. What's more, it means the intellectual property held in the car stays in one place, never passing through the hands of a third party.

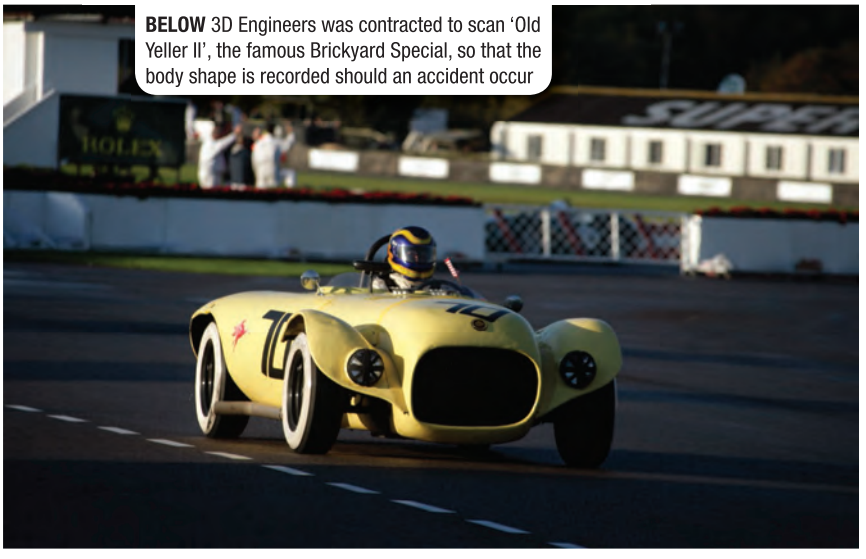
Once the CAD geometry is complete, Brown and his team use 3D printing to manufacture a scale model of the bodywork that can be presented to the client for approval. The CAD data is then used to generate patterns which are fed into a CNC cutting machine to create the buck. Again, this is not quite as simple as it sounds, and 3D Engineers has to liaise with the panel beater to discuss their exact requirements, incorporating various features into the buck design.

"What really sets us apart is that we offer a complete service from scanning [where used] through to post-processing, CAD models and bespoke buck production and design," says Brown. "We've reverse engineered more than 30 bodies now (as well as creating seven from scratch) and we've built up a lot of experience on the best techniques to use."

Another advantage is that the system is completely portable. Although 3D Engineers is based in sleepy rural Dorset, its clients extend as far afield as South Africa, Australia and the United States. Crucially, says Brown, the scanning system it uses is not only highly portable, but capable of working in almost any environment: "The equipment can operate in very limited space and with almost any type of surface. Many other systems have difficulty dealing with factors such as ambient lighting and car colour, but if you turn up at a workshop you can't ask everyone else to down tools for the day while you get on with the scan or alter the colour of the vehicle."

Recently 3D Engineers has experimented with 3D printing finished parts in metal, including various small-scale fixtures and fittings. The company has even helped a client create a whole 3D printed front valance for a Toyota MR2. The quality of these parts is said to be very good and Brown says we shouldn't rule out the possibility of rapid manufacturing being used to produce complete body panels at some stage.

For the foreseeable future traditional techniques such as aluminium panel beating reign supreme. But, fused with high-tech reverse engineering methods, they are enabling vehicles and parts to be created quicker, more economically and to a greater accuracy than ever before. HRT



BELOW 3D Engineers was contracted to scan 'Old Yeller II', the famous Brickyard Special, so that the body shape is recorded should an accident occur

If you can't stand the heat...

When your car is noted for its blistering paintwork, rather than its blistering pace, **Chris Pickering** says advances in materials and techniques can save the day

NECESSITY, so they say, is the mother of invention. And perhaps nowhere is this more evident on a historic competition car than on the exhaust.

In some cases, modern fuels and tuning techniques have led to exhaust gas temperatures that simply aren't sustainable with the original exhaust. On other occasions, noise limits that didn't apply in-period are forcing the use of quieter systems. And then there's the question of heat management – blistering paintwork, for example, may have been an acceptable side effect of the exhaust routing when the car was just another works machine with a job to do, but collectors are unlikely to see it that way on a million-pound investment.

BTB EXHAUSTS

"The historic market is particularly buoyant at the moment," comments Joe Ellis, managing director at BTB Exhausts. "In part this is due to the number of high-end recreations that are being built regardless of expense. These run to the same FIA HTP requirements as the original cars, but that still gives us scope to look at certain aspects of the design."

Authenticity is always a key factor, but the desire to win can be very strong in historic racing and Ellis says there is a very keen interest in engineering a competitive advantage: "The cars are still in-keeping with the historic ethos, but the owners who are competing inevitably want the best they can have. With advances in materials and techniques we can optimise the design."

Aesthetics play a part when it comes to any sort of modification. These

ABOVE Working on the GT40's infamous bundle-of-snakes exhaust system

BELOW Primary Designs has provided solutions for no fewer than 10 Williams FW07s

Williams F1/LAT

days, both the owners and the event organisers tend to place a lot more emphasis on a car's appearance, so additional silencers are hidden from view whenever possible and the original routing of the exhaust has to be retained.

"Many of the cars were never intended to run silencers at all. In that case we quite often have to get creative as to how we fit the silencers," says Ellis. "It's a lot easier to keep a car quiet if you can route the exhaust out the back, but if it raced with a side exit exhaust in-period then the event organisers will still want to see that. In some cases we can re-route the exhaust or provide additional silencers for testing, but you don't have that option if you're racing."

Silencing techniques can vary considerably depending on the car and the application. A high-revving four-cylinder engine like a Cosworth BDA in a Group 6 sports car, for example, produces very different frequencies to a large capacity, comparatively slow-revving V8 in something like a Lola T70 or a Ford GT40.

"For low frequencies, the capacity of the silencer needs to incorporate more expansion elements," explains Ellis. "For high-revving, high-frequency engines you would hopefully get away with traditional absorption elements, which are lengths of perforated tube surrounded by packing. But to get enough length and volume of silencing can be quite a challenge given the restricted packaging space on a lot of these cars that were never designed to run so much silencing."

Over the years, Ellis has seen a vast array of interesting machinery pass through his doors. The crowning achievement so far, he says, was working on the Spa Six Hours-winning Ford GT40 of Leo Voyazides and Simon Hadfield: "We were involved in that car right from the start when it was prepared and it's particularly gratifying to see the performance and reliability that they can get from a car that dates back nearly half a century."

PRIMARY DESIGNS

First-hand knowledge can be invaluable when it comes to historic racing cars. With growing interest in recent historics, such as Super Touring or Historic Formula One, many of the more experienced fabricators are finding themselves revisiting cars they worked on in-period.

Pat Barrett, now managing director of Primary Designs, gained his first experience of competition car exhausts at Williams Grand Prix Engineering in the early eighties. He cut his teeth during the F1 turbo era and has gone on to work on a huge number of contemporary race and rally cars, but historics remain something of a speciality.

"When we started Primary Designs pretty much the whole of the business was devoted to historic racing," says Barrett. He admits that Historic Formula One is something of a personal favourite: over the last 14 years or so, the company has seen no less than 10 Williams FW07s and five FW06s, along with a rich variety of cars from Shadow, Tyrrell, McLaren and March.

Despite the monstrous reputation of the turbo era cars, the exhaust systems are still relatively straightforward to work on, he says. Blown underwings (first used in 1983) can lead to more convoluted geometry, but the fundamentals are largely unchanged.

Some of the later Formula One cars use Inconel, or other high-temperature alloys such as Nimonic (both originally developed for use in Frank Whittle's early jet engines). In general, however, the company uses stainless steel for classic exhausts. Many of the older GT cars left the factory with mild steel, but it's not a material the fabricators like to use, says Barrett: "Originally stainless steel would have cost a lot more, but it's almost the same price as good quality mild steel now and it lasts a lot longer. The only real reason for using mild steel is if that particular exhaust isn't going to be used very often – maybe only a couple of races a year – and you want to keep it absolutely original."

All the company's pipe-to-pipe joints are welded manually using TIG, although an automatic seam welder is used for producing custom tube sizes from sheet material, Barrett explains. For stainless steel and particularly Inconel systems, the tubes need to be purged with argon backing gas, which adds an extra layer of complexity, but it's now become second nature: "When Inconel first appeared in Formula One we didn't really know what to make of it, but now most of our fabricators would prefer using that to other materials. It just comes down to things like welding speed and the rate at which you feed the filler wire in."

Primary Designs is often involved on the design side. Critical dimensions such as the tuned lengths are supplied by the engine builder, but after that it falls to Barrett and his team to engineer the best exhaust routing. ▶

Packaging tends to be the main concern. GTs and touring cars are typically more challenging than single-seaters, due to the more tortuous routes required to avoid things like outboard dampers and differential carriers. “It’s harder if you’ve got bits moving around in the area you might want to run the exhaust system, so it’s often easier dealing with the slightly later cars where they’ve got rocking arm assemblies,” says Barrett. “If you take a Can-Am car as an example, the trailing links on the suspension can be three feet long and they’ve got a huge amount of suspension travel by racing standards.”

The company also builds its own silencers in-house – typically using a perforated tube running through a stainless steel outer can packed with sound-absorbing materials. “The sound-absorbing materials have advanced tremendously,” notes Barrett. “In the early days they just didn’t last. We still try and make all of our silencers re-packable, but the service life has improved dramatically.”

ZIRCOTEC

For all the power and efficiency of a racing engine, something like 70 per cent of its energy escapes as heat. Most of this heads down the exhaust, where it’s dissipated along the length of the system or out of the tailpipe.

As a result, thermal management can be a very important part of exhaust development for historics – and one of the most effective ways of reducing heat transfer from the exhaust is to coat it with a thermal barrier coating like Zircotec.

To see some of the benefits in action, we headed down to the workshop of Historic Racing Technology columnist Nick Mason. Even after hearing much about Nick’s Ten Tenths collection, it takes your breath away to see it in the flesh. There’s a sea of mouth-watering exotica on display, yet pride of place has to go to the indescribably beautiful Ferrari 250 GTO.

Perhaps the most exquisite shape ever to grace the track, the 250 GTO was once simply another racing car, as Ten Tenths engineer Ben DeChair recalls: “There’s an interesting set of photographs of another GTO racing in the sixties, where they’ve clearly had cooling problems. In the first shot they’ve opened the bonnet vents to try and get a bit more airflow, but that clearly doesn’t do the trick. In the second shot there’s a gaping hole where they’ve just tin snipped a huge vent into the front end.”

At the time, of course, this seemed like a perfectly reasonable solution. But it’s fair to assume that it would raise a few eyebrows if you casually took a set of tin snips to the bonnet of a 250 GTO these days. Instead, like several of the cars in Nick’s collection, the team at Ten Tenths have opted for a rather less drastic solution.

Most of the exhaust system is coated with a ceramic thermal barrier coating from Zircotec’s Performance Colours range. This uses a plasma spraying process to apply a ceramic material (typically to a thickness of around 300 µm or 0.012”) followed by a second process that colours the surface to the desired shade. Zircotec claims this is capable of cutting the surface temperature by around 33 per cent, with corresponding reductions in radiative and conductive heat transfer.

Zircotec has also developed a product known as ZircoFlex. This is essentially a sheet of gold or aluminium foil, coated with a variant of the company’s ceramic material to produce a flexible multi-purpose heat shield. This too has been used extensively on the GTO.

“The exhaust pipes run really close to the underside of the car – to the extent that we’ve got ZircoFlex between the exhaust and the floor,” comments DeChair. “The whole of the engine bay is lined with ZircoFlex foil that’s been painted black. Everything from the footwells backwards to the back of the gearbox tunnel is lined with the material too, which helps to channel the heat out underneath rather than transferring it up into the cabin.”

Overall, he says this has led to a significant drop in both cockpit and engine bay temperatures. A modern aluminium radiator and an electrically-operated cooling fan also play their part, helping to protect one of the most valuable historic racing cars in the world. HRT

BELOW Zircotec’s plasma spraying process

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The lifeblood of racing

A whole new generation of lubricants and fuels is being developed to meet the challenges of historic racing. **Chris Pickering** and **William Kimberley** investigate

IF FUEL is the sustenance that powers a racing engine, then oil is the blood that pulses through its veins. And as budgets and the level of technical development have soared in historic racing, so has the amount of attention paid to specialist lubricants and fuel.

Like it or not, a lot of historic engines are now producing significantly more power than they did in-period. In some instances they're revving higher and the internal components are frequently built to tighter tolerances than they were originally, while the materials themselves are changing. Denser castings, for example, are leading to stronger blocks of outwardly identical design, while modern coatings and surface treatments are improving wear resistance and lowering friction.

Even if the engine remains completely standard the chemistry of the fuel is evolving, producing higher combustion temperatures and prompting questions over how the lubricant will react with unburnt fuel. In short, the oil spec that a car ran in-period is not necessarily the best choice for it now.

Relative to their performance, old engines place far greater demands on their oils and they break down the

ABOVE & RIGHT In tests with EB Motorsport, switching to Millers CFS 10w60NT Nanodrive oil liberated 15 bhp on this race-prepared Porsche 911 RSR

additives far quicker than a modern engine. Consequently, historic engine oils tend to feature far greater concentrations of anti-wear additives.

Typically, more liquid polymers are used in the oil's formulation to ensure its viscosity is less sensitive to temperature change. In the standard SAE classification (e.g. 20w50) the first number is the oil's viscosity index at room temperature, while the latter figure is taken at 100 deg C. Quite simply, the lower the number, the runnier the oil is at that particular temperature; long polymer chains added to the oil effectively prevent it from thinning out at temperature. The quality of these additives and their resistance to load is vital to maintaining this function.

As the chemistry has improved there is a tendency to run thinner oils in historic engines. In some instances, an engine that started off running a 20w50 may now run something as light as a 10w30 if the quality is high enough.

Running on carburettors and without the benefit of modern combustion chamber design, a certain amount of unburnt fuel will always make its way beyond the piston rings and into the oil. Consequently, engines running on pump petrol need a lubricant that's compatible with the ever-increasing levels of ethanol found in modern fuel.

Another danger is that general purpose modern oils are constantly evolving to make the most of advances in technology. Because they're not designed to cope with the specialist demands of historic cars, the changing additives and ingredients aren't necessarily evaluated for use in older engines. With a specially developed historic oil there's often far more information on what exactly lurks inside the can.

WHEN NEW MEETS OLD

There is just a chance that you may not have come across Millers Oils before now, or if you have, maybe just considered it as the purveyor of a lubricant which you are not going to let anywhere near your precious vehicle as you are not sure of its provenance. This is possibly the risk-averse attitude that's necessary with something that's so vital but about which there's a general lack of knowledge. However, in the case of Millers Oils, its lubricants have been proving themselves in different race and rally series around the world.

A British company based in West Yorkshire, where all the development work is done in its new state-of-the-art technical centre, Millers Oils' claim to fame is its nanotechnology lubricants. A term that's enough to frighten many a classic car owner by the concept, the company argues that its revolutionary oil, which won Race Tech's Most Innovative New Motorsport Product award in 2009, is a friend and not a foe that enhances and protects older engines.

"We have developed lubrication technology to meet the stringent requirements of the modern powertrain and we are able to apply this knowledge to a range of applications," says Nevil Hall, Millers Oils joint managing director. "For instance, fully synthetic oils such as Millers Oils' new Classic High Performance 20w50 NT have been specially developed to provide older engines with better wear protection and increased efficiency over traditional oils."

The 20w50 NT oil utilises nanotechnology in order to cut overall running costs and extend component life by reducing friction by up to a claimed 63 per cent. It provides a reduction in wear by up to 38 per cent compared to other synthetic oils of the same grade.

"When investing heavily in a classic car, why wouldn't you use the most advanced oil to maintain it?" asks Hall. "The fear that fully synthetic oils can't be used in classic cars is now way out of date. Oil technology has been transformed in the last 20 years and ▶

it's now seen by vehicle manufacturers as a crucial enabler for the continued advancement of engine and drivetrain technologies. Innovations such as nanotechnology can be applied to help owners protect their investment while enjoying classic motoring as the manufacturer intended."

For those still wary of adding a new lubricant, Millers Oils has created a helpline, which is based in its facilities in West Yorkshire. It is manned by experts to answer all questions about the use and compatibility of lubricants.

Another useful service that Millers Oils provides is the 'blood test'. For £29.95 + VAT for a MillerCare Basic service or £39.95 + VAT for a MillerCare Advanced, you can send a sample of your engine or transmission oil to them, whether it's a Millers Oils product or not, to get a detailed analysis of what's going on inside the engine or gearbox.

The difference between the Basic and Advanced service is that the former is a detailed report that covers all the test results showing, for example, high levels of iron, which could point to a deterioration of the cylinder liners or piston rings, while the Advanced report enables customers to do multiple samples to produce a trend graph. By submitting two samples over six months, for example, the customer can monitor an issue highlighted in the first test and see how it has progressed.

As Martyn Mann, Millers Oils' technical director, explains: "It's the only way to check the engine and transmission health accurately without doing a strip down or purchasing expensive exploratory tools."

RACING HERITAGE

In 1950 a small company set up shop in Southern California, producing racing oils for those competing on the dried up lake beds and abandoned airstrips in the area.

Founded by Bob Lancaster, Torco has gone on to introduce a number of pioneering features into motorsport lubricants. And with its TR-1 range, the company continues to cater to the vintage and historic engines that are part of its heritage.

Torco's philosophy was to start with the purest, cleanest base stock available. Lancaster leased his father's recycling refinery for his own use at night, and bought the purest refined neutral base stock he could find from Shell. He then ran this through the refinery a second time to create an exceptionally pure pale neutral stock.

"When a base stock is totally pure it can transfer heat better for exceptionally good cooling. It also has less volatility (vapourisation) and makes the oil do a better job of cleaning," explains Rob Lancaster, Torco's research director and son of company founder Bob Lancaster.

The real breakthrough, however, came with the chemicals that were then added to the blend. Torco was one of the first companies to use zinc dithiophosphate (better known as ZDDP) as an anti-wear additive. Plus, polymers were used to build the viscosity of the oil, so even though it had the film thickness of an SAE 50 it had the flow character of a much lower viscosity oil. Arguably, the Torco SAE 50 was the first true multigrade oil of its time and it would fall into what was later called 20w50. But more was to come.

"Heat, speed and load are the main enemies of motor oil films," says Lancaster. "Any one of these by itself isn't too concerning, but put all three together – such as wide-open throttle for any sustained period of time – and not much of any film is left to survive and separate moving parts, especially in the ring belt area."

In order to maintain an oil film under these harsh conditions Torco began introducing liquid molybdenum into its blends in 1973. "This moly is not a dimensional particle, like molybdenum disulfide, it's an oxide reaction keeping it soluble until a trigger to react with the steel is applied," says Lancaster.

"The ZDDP in the blend plays the primary role as an anti-weld agent, but it doesn't work like moly: it is a sacrificial reactor only," he continues. This means that as long as it is present in oil, it reacts just in time to negate asperity welding so that metal transfer does not occur. Over the years, this principle has been refined into the company's MPZ technology.

Aimed at all types of vintage racing, Torco's TR-1 range uses a development of the MPZ formula, with viscosities ranging from 10w30 to SAE70 (the latter, incidentally, is used for highly supercharged nitro methane applications). It's designed to provide excellent levels of protection, with particular attention paid to ring sealing and thermal stability.

ABOVE Torco can trace its origins back to the dried up lake beds and abandoned airstrips of Southern California

ABOVE & RIGHT This Cobra, owned by Grahame Bryant, uses XP synthetic oil, suitable for regular competition use and more heavily modified engines. Driven's HR formulation (right) contains extra corrosion inhibitors to protect cars that are used less frequently

GENERATION GAME

While historic racing engines often use quite different oils to their modern equivalents, the generation gap is wider in some disciplines than others.

Until quite recently, NASCAR continued to grapple with things like flat tappet camshafts and cast iron cam cores, with some of the best and brightest engineers in motorsport working on engines that followed a template set down in the 1950s.

"When we started developing specialist race oils for NASCAR the basic architecture and materials were still very similar to a lot of the historic engines," explains Lake Speed Jr, certified lubrication specialist at Driven Racing Oil. "Almost by accident, we ended up with a product that was very good for the historic market."

It was the valvetrain manufacturers who first encouraged Driven (then known as Joe Gibbs Racing Oil) to speak to vintage race engine builders. At the time, NASCAR engines were facing very similar challenges, with mainstream oils – both in road and race applications – increasingly geared towards modern coatings and materials.

"In most areas of historic racing you have to run the materials that would have been available in that era, and we had the right chemistry for that, almost by default," comments Speed. "You have to have the right base oils and additives. Advanced coatings in some of the modern engines change the oil chemistry massively. In a lot of instances you can reduce the number and quantity of additives dramatically [on a modern engine], but with older engines it's more about addition than subtraction: you're putting in extra components to work with the materials and the architecture."

A lot of historic race engines are taking advantage of modern surface finishing and machining techniques, which are in some ways pushing them closer to contemporary oil requirements. "An engine that traditionally ran a 20w50 mineral oil with a very high ZDDP content, may now be able to run with less zinc thanks to modern materials and techniques," he suggests. "That, in turn, allows you to introduce more friction modifiers. And switching to an advanced synthetic base oil also allows you to get the viscosity down quite a bit."

Thanks to reduced friction and lower viscosity losses the current breed of historic engines are not only producing more power than ever before, but doing so with a longer rebuild life and less chance of something going seriously wrong.

For occasional racers, Driven offers the HR range. This is a high zinc formulation, specifically designed for use in older engines, which contains extra corrosion inhibitors designed to work with leaded fuels. For more vigorous competition use, Speed recommends the company's XP range of fully synthetic racing oils. In either case, the use of running-in oil can be very important in historic engines, with Driven's range of BR 'break-in' oils specifically designed for the purpose.

Ultimately, a lot of it comes down to knowing which blend to use. "We're historic racers ourselves, which gives us the ability to provide some technical insight," says Speed. "Not just on the choice of engine oil, but also things like what transmission oil to go for or what coolant additive to use if you're running an iron block with an aluminium engine. We have a lot of experience both in NASCAR and historic racing that we can draw upon." ▶

A FINE VINTAGE

Just as lubricant choice can affect the health of your engine, finding the right fuel can be crucial. Highly supercharged engines, particularly those from the pre-war era, were often designed to run on methanol. And even when it comes to more conventional fuels the choice can be bewildering.

One of the key tasks is ensuring that the fuel is compatible with perishable materials such as rubber. Fuel cell bladders, fuel lines and other components can all degrade if presented with the wrong substances. The main concern is the ethanol content in a lot of modern pump fuels, but the toluene found in contemporary race fuels can also be an issue.

"It's not just the major components like fuel lines, but also things like O-rings and diaphragms," explains Freddie Turza, head of research and development at fuel specialist VP Racing. "The fuel system on some older cars is virtually irreplaceable, so we want to try to preserve and protect that as best as we can."

It's not unknown for collectors' cars to stand for long periods of time between events and VP's Vintage range is specifically designed to provide longevity. "If you leave the car for a year the fuel that's in there will still start and will not have degraded in any way," comments Turza. "No additives are required to prolong the life of the fuel - it is designed to provide that as standard."

The use of leaded (or rather unleaded) fuels remains another hotly contested topic in historic racing, and VP Vintage is offered in both forms.

Although hardened valve seats prevent recession at the actual point of impact - allowing regular unleaded fuels to be used in older engines - they can't replace the cushioning effect provided by lead additives. Normally this is not a problem, but it can result in greater loads being placed on the valvetrain. In extreme cases, the hardened seats can even end up being pushed back into the softer material of the head. Using a leaded fuel restores this energy-absorbing behaviour and allows a period cylinder head to be run without modifications.

The next most common concern is usually octane rating, Turza remarks: "Sometimes people over emphasise the importance of octane content. One or two octane numbers can be an almost irrelevant difference compared to ignition timing and mixture control. You can still detonate a 120+ octane race fuel with the wrong ignition timing, for example."

The octane requirements of historic competition cars vary hugely. Generally speaking, advances in combustion chamber design and manufacturing have led to better detonation resistance in modern engines than you would find in an older engine of similar specific output.

VP Vintage is rated at 100 RON in both its forms (with the leaded variant offering slightly higher octane in the real world, thanks to its greater MON rating). After that you get into modern non-oxygenated race fuels - many of which are also suitable for historic engines.

In total, VP produces over 70 blends of fuel. Occasionally the company receives requests for custom blends, but more often than not the requirements are already satisfied somewhere in the range, explains Turza. "You might find that a fuel designed for an obscure application on the other side of the world is actually the perfect blend," he notes.

Another advantage of using a specialist fuel supplier is the quality control, particularly for engines that have unusual requirements. "We produce our fuel in very small batches, so the consistency of the product is very precise," says Turza. "We also know exactly how old each batch is and how it has been stored, which isn't usually the case with pump fuels." HRT

ABOVE VP Racing Fuels founder Steve Burns (in the red shirt) with the company's chief chemist Duane Minazzi

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PFC CarbonMetallic pads

Performance Friction's CarbonMetallic pads have been a popular choice for road and track driving for decades. Continually evolving over the years, PFC has engineered the pads to improve all aspects of braking performance.

The CarbonMetallic range uses high tech composites, incorporating large volume amounts of special carbon materials (powders or fibres) in a metallic matrix that dramatically improves the thermal stability, stopping power, and noise characteristics of the friction material while yielding improvements in pad and disc wear.

The comprehensive range of CarbonMetallic pads includes fitments for a wide range of historic race and rally cars, with a variety of compounds offering different frictional characteristics.

Westwood Cylinder Liners

Westwood Cylinder Liners produces cast iron and ductile cylinder liners for historic cars of all ages. As well as providing a bespoke design and manufacturing service for one-offs and small batches, the company holds literally thousands of liners in stock for common historic racing applications. Past credits include machinery as diverse Auto Unions (in V12 and V16 form), Minis, BRM V16s, a Fiat S53 and even a Maybach tank engine.

Cast iron was the liner material of choice for the majority of classic and vintage engines in-period and continues to be a race-winning option today. For heavily overbored engines or those with a history of cracking (such as Group B rally engines and some of the 1980s Formula One turbo units) a ductile liner can provide additional strength.

Modern metallurgy has led to incremental improvements in the materials, but more significant have been the advances in machining methods. Techniques like diamond honing can now produce an exceptional surface finish while remaining true to the original design and material. Cast iron and ductile iron also allow a wide range of different materials and coatings to be employed on the piston rings, providing further benefits.

Bell HP5

New from Bell, the Carbon HP5 Touring is designed to meet and exceed the FIA 8860 Advanced Helmet standard. It uses the same aerospace-inspired carbon fibre technology as the Bell HP7 but features a much larger eye port aperture. Supplied with both a full visor and a 'peak' that can be used in closed cockpit cars, it's suitable for a wide range of modern and historic vehicles.

"The peak and visor configuration makes the HP5 the most flexible 8860 helmet we've seen. In particular, the HP5's design makes it exceptionally practical for spectacle wearers," explains Malcolm Sanders, managing director of MSAR London who specialise in FIA 8860 helmets and stocks the Bell range.

The HP5 is Snell SA2010 and FIA 8860-2010 approved. Its interior features a variety of padding materials to improve fit and the shell has been designed with drinks and radio systems in mind.

GST Racing Seals

GST produces a wide range of seals for motorsport applications. In particular, the company's high vacuum crankshaft seals have won praise for their ability to sustain vacuums of up to 25in Hg (0.85 bar).

Running high levels of vacuum significantly cuts down on windage, reducing the engine's losses and increasing power output, but it requires good quality seals. Minute levels of deflection in the crankshaft and the bearings can result in a loss of vacuum unless the seal is able to flex, so GST uses a duplex design, which incorporates two low-friction PTFE sealing lips. Essentially this separates out the two sides of the seal, allowing it to deform without losing pressure.

The same duplex seal technology can be applied to superchargers. The main seal on the input shaft from the gearbox to the air rotor has to cope with constantly varying levels of pressure, which means it can be prone to leaks, with either oil leaking out or air finding its way in. However, improved sealing prevents pressure build up and maintains lubrication.

VBOX LapTimer

Typically, the easiest and most cost effective part of a racing car to improve is the driver. Fortunately, there are a number of tools that help you to do this, including the new VBOX LapTimer from Racelogic.

Packaged in a compact, standalone unit that uses an in-built GPS system, the VBOX LapTimer provides a highly accurate measure of speed, lap count and rolling lap time. It also includes a sophisticated predictive lap timer that indicates whether the driver is on course to better his or her previous fastest lap. All of which is recorded through an integrated 20 Hz logging facility.

The secret weapon, however, is the new Delta V function that compares the car's instantaneous speed with the same point on the previous fastest lap and then displays that via a series of LEDs that change in both colour and intensity. This can be used in real-time to gauge improvements through higher corner-exit speeds, but it can also be used to identify time lost due to excessive entry speed and other analysis.

ATL fuel cells

ATL supplies fuel cells to some of the best known names in historic racing. Offering a wide variety of materials compliant with the FIA FT3 specification and above, the company can supply fuel cells to suit just about any historic racing application.

If required, the flexible inner cell can be integrated into an existing fuel tank, giving an authentic period look. Alternatively, ATL can supply a full tank assembly with an outer shell made from aluminium or carbon fibre. Virtually any shape can be catered for, thanks to an in-house CAD capability, while the company can even supply cardboard mock ups for clearance checks. A full range of off-the-shelf options is also available.

Pagid RSH brake pads

The Pagid RSH range of brake pads combines state-of-the-art competition compounds with shapes and sizes designed to fit a wide variety of historic applications.

Three different compounds are available, starting with the RSH 29E, which is designed for long distance racing. Offering medium-to-high friction with good thermal stability, it's said to provide excellent pad and disc wear characteristics.

In contrast, the RSH 42 is a medium to low friction compound. Aimed at classic rallying and small formula cars, where immediate low temperature response and an easy bedding in process are desirable.

Finally, the RSH 3 is a high friction metal-ceramic type compound, designed to provide a high initial bite and low thermal conductivity. Pagid says the RSH 3 is fade resistant up to 800°C, with a consistently firm pedal right across the temperature range.

A new take on old problems

Chris Pickering reports on a company that has used its expertise on some of the rarest cars on the planet

BANBURY-BASED clutch and flywheel specialist Helix Autosport was founded in the late eighties. Its first customers were teams running Group B rally machines, but alongside contemporary race and rally clutches, the firm rapidly began looking at historic motorsport.

"We gained a reputation for being able to do bespoke work for cars where the parts were no longer available," explains Alex Champion, design engineer at Helix. "Over the years we've done a lot of historic competition cars, so at the start of last year we decided to sit down and make a list of everything we'd done. That list became a catalogue of 25 pages, covering everything from vintage Bentleys to Group C cars."

Such is the variety of machinery that Helix caters for, working with some of the rarest and most desirable cars on the planet has become virtually routine. Champion reckons the firm sells a Ferrari 250 GTO clutch around every two months, for example. "For a 50 million dollar car, we certainly sell a lot of clutches," he quips.

For competition use, the design priorities are strength and weight. Using EN24T tool steel the company is able to dramatically reduce the size and weight of most flywheels – shaving up to 60 per cent off the mass in some instances. "These materials were around in the fifties and sixties, but they've become far more accessible now," notes Champion.

Everything is designed in CAD, allowing the engineers to calculate the mass and inertia of the flywheel before it's manufactured. It also means the team can check for clearances before committing to a particular design.

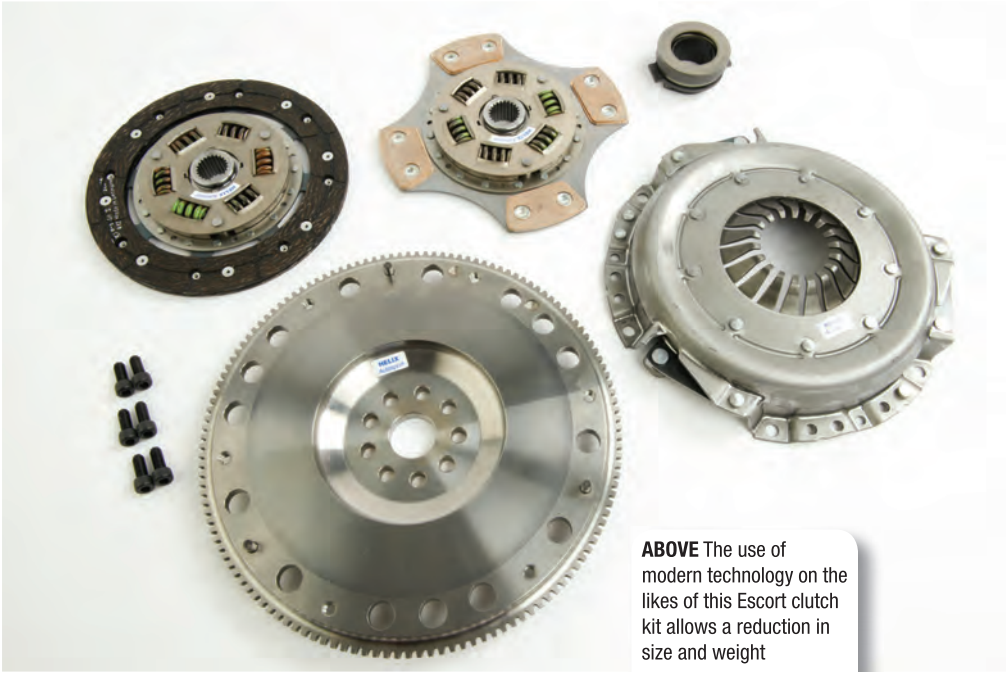
Once approved, the flywheel is machined using a three-axis CNC machine, then turned on a CNC lathe and dynamically balanced to within 60 gram-millimetres. Such accurate balancing is only possible with modern technology and it helps to reduce vibration, cutting down on crankshaft loads.

"Reliability and reduced inertia are the two biggest advantages for historic motorsport," says Champion. "Something like a three-plate 7.25-inch clutch can provide huge amounts of heat and torque capacity for very little weight and inertia. That's a very popular solution for the Goodwood guys, because it's such competitive racing."

Alongside the fundamental size and weight reductions, modern clutch technology offers a number of other advantages. A lot of early clutches use a coil spring arrangement with an array of manually-adjusted lever arms, but switching to a diaphragm-type clutch can dramatically improve reliability. "Coil spring clutches are so inefficient that it's not worth tooling up to deal with them," says Champion. "You simply cannot make a good quality coil spring clutch, so all our clutches use a diaphragm spring conversion."

Another significant modification is the use of modern ball race assemblies in the release bearings, in place of the graphite thrust bearings used on many older cars. Helix uses a small sleeve or top-hat piece machined from aerospace-grade aluminium to secure the new bearing, which means the original carrier can usually be retained. HRT

> **"We gained a reputation for bespoke work on cars where parts were no longer available"**



ABOVE The use of modern technology on the likes of this Escort clutch kit allows a reduction in size and weight

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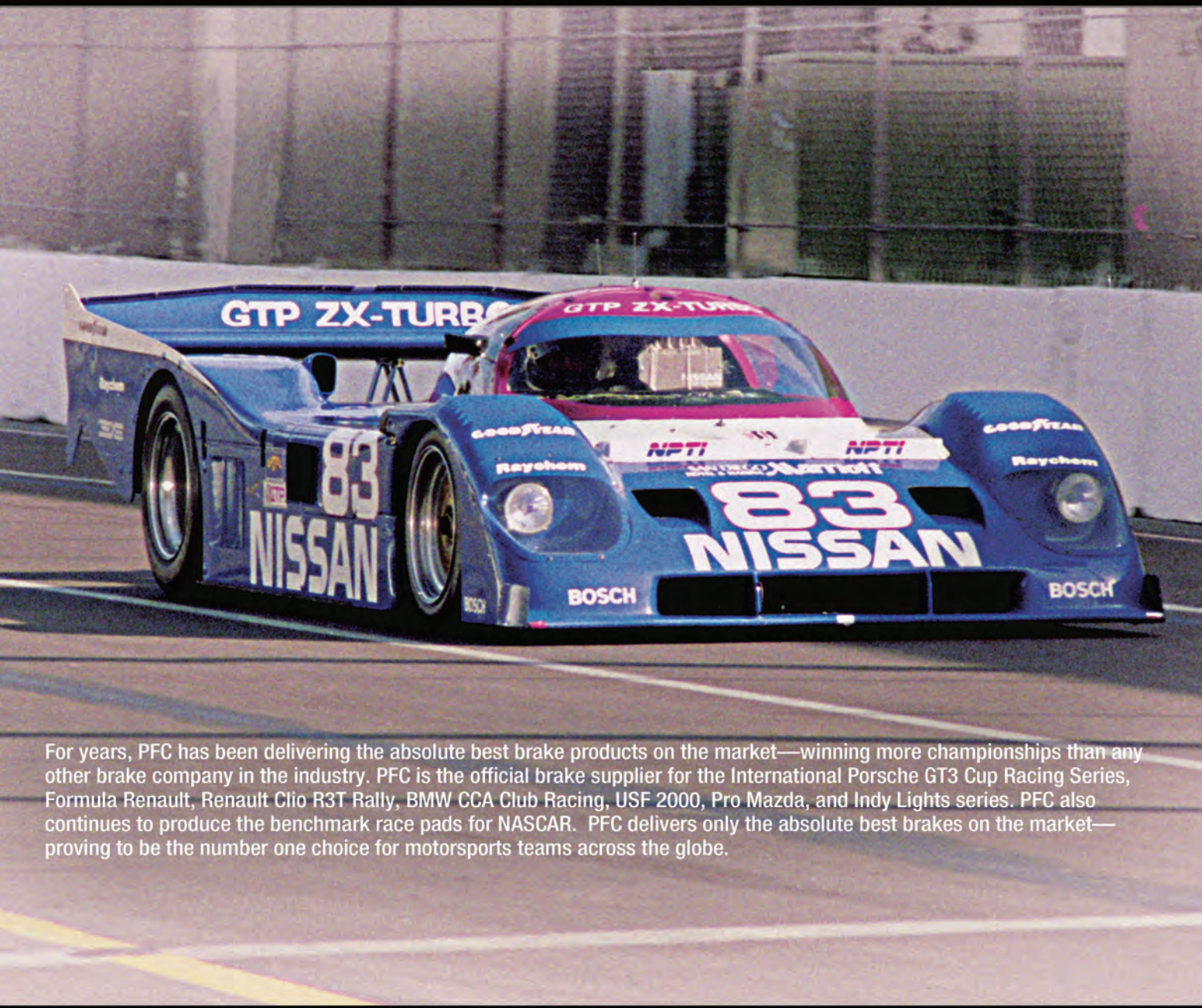

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+44(0) 1295 221 020