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Setting the Pace

The story of how a near-dilapidated Austin A40 has become the car to beat in its class

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ON THE COVER

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Knight Racing Services Ltd

Silverstone Tourist Trophy 2020:
Winner Julian Thomas / Callum Lockie
Shelby Cobra Daytona Coupe / Ford 289

Goodwood Speedweek 2020:

Gerry Marshall Trophy
Winner Fred Shepherd / Andre Lotterer
Ford Mustang Boss / Ford 302

St Mary's Trophy Race 1
Winner Stig Blomquist Ford Galaxie 427
Second: Nicolas Minassian Studebaker Lark

St Mary's Trophy Race 2
Winner Adrian Willmott Studebaker Lark
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Whitsun Trophy
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Second Gordon Sheddon Ford GT40 Ford 289

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The Continuation Conundrum

THIS has been a horrible year for obvious reasons, but the historic racing community is extremely resilient. As will be read in the news, Continuation models is the name of the game. Bentley, AC Cars, Allard, BRM and Vanwall have all dug into their past to come up with something which they hope will attract a buyer.

Bentley Motors is producing 12 new supercharged 4½ litre Bentley Blowers as raced by Sir Henry 'Tim' Birkin nine decades ago while Vanwall is making six continuation cars of its 1958 championship winning car.

AC is taking a different line with its Continuation series and has launched a 'new' limited series of 12 special cars recreated from the 1963 AC factory Le Mans cars. The difference is that the new cars will be electrified.

To be honest, I am not sure what reproducing these models is about. I can see from the car manufacturers' point of view that it is a nice little earner while also underlining their heritage, and by limiting the number produced, it means that there is an air of exclusivity about them, which is what collectors like. However, the question I ask is whether anyone in their right mind would spend anything up to a million and a half pounds on a reproduction of Leonardo da Vinci's Salvator Mundi or Paul Cézanne's The Card Players. I'm not in that world, so cannot answer, but the dozen new "old" Bentleys have already been pre-sold, so what do I know?

One thing I do respect, though, is the skill that is going into reproducing the components. It is simply extraordinary what the various suppliers are able to achieve. It is craftsmanship of the highest order and more power to their elbow. It would be a tremendous shame if we lost them and their knowledge.

While I am hesitant about the 'Continuation' concept, I think that anything that can be done to maintain the interest in historic cars is a very good thing in an age that is becoming progressively anti car, or at least those powered by the internal combustion engine. Nothing beats the look and sound of a vintage, veteran, post-vintage thoroughbred or classic car and it would be a terrific shame if they were barred from the public highways or race tracks. HRT

William Kimberley
Editor

NEWS

Blower Bentley Continuation model takes shape

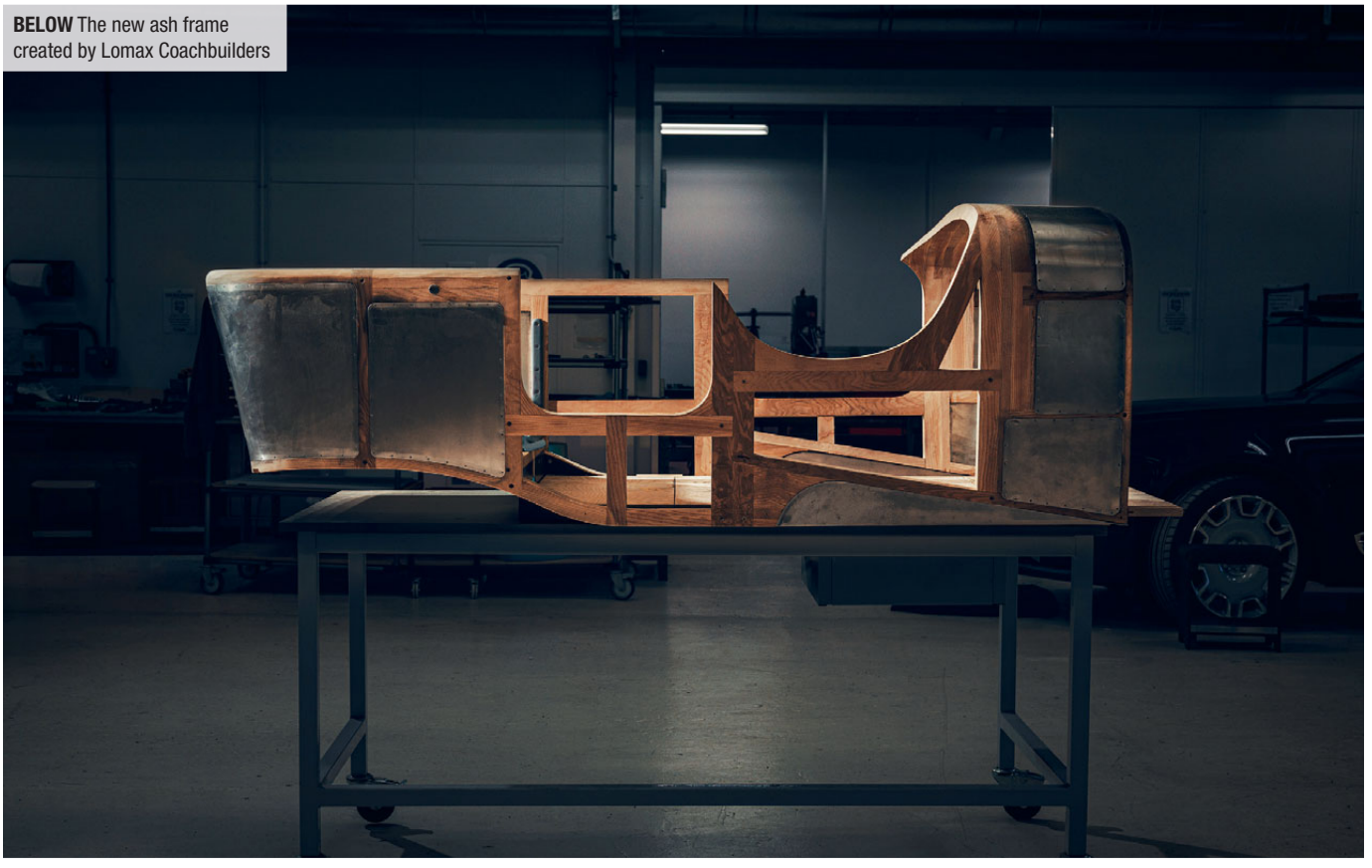
William Kimberley looks at how Bentley Motors is manufacturing 12 exact copies of the 1929 Blower Bentley using today's know-how and manufacturing technology in a car originally built nine decades ago

ASSEMBLY of the first new Bentley Blower in more than nine decades has officially started in a bespoke Bentley Mulliner workshop. 'Car Zero' is the engineering prototype for the Blower Continuation Series, a run of 12 meticulously engineered, hand-crafted, supercharged 4½ litre Bentleys built to the unique design of Bentley's own 1929 Team Car developed and raced by Sir Henry 'Tim' Birkin. The 12 cars together form the world's first continuation series for a pre-war car, and all have been pre-sold.

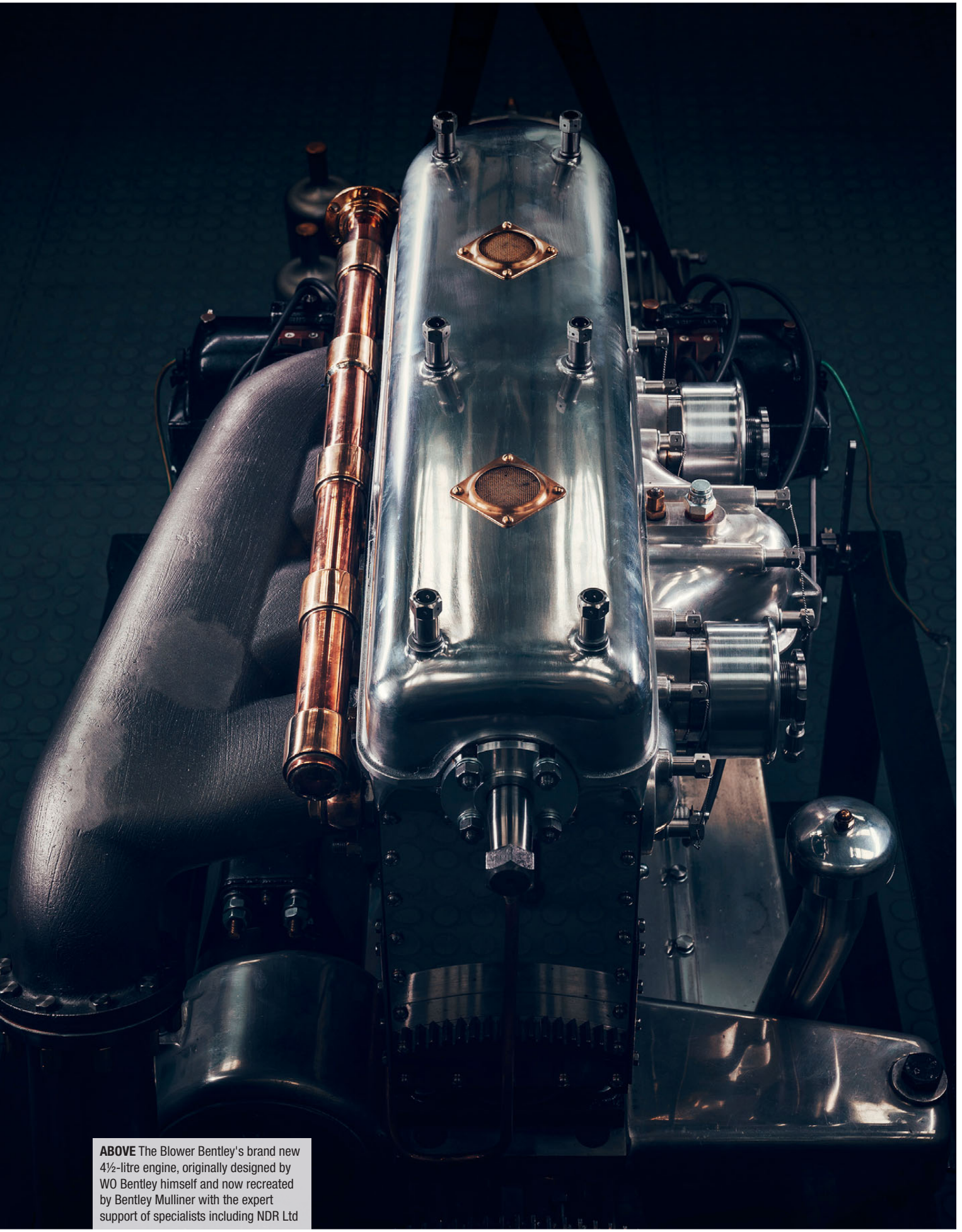
The first parts in the workshop are some of the most important. First to arrive was the chassis for the car – the backbone of the entire project, to which almost everything will be attached.

The fuel tank and radiator were next, as work was completed on the ash frame for the body. The first pair of headlights was delivered, while the mechanical aspects of the first car started to come together – the very first engine (complete with remade Amherst Villiers supercharger), the front axle assembly and the leaf springs.

As the 12 lucky customers choose the colour and trim specifications for their cars, the engineering team is working hard on assembling the running prototype in time for its ▶



BELOW The new ash frame created by Lomax Coachbuilders

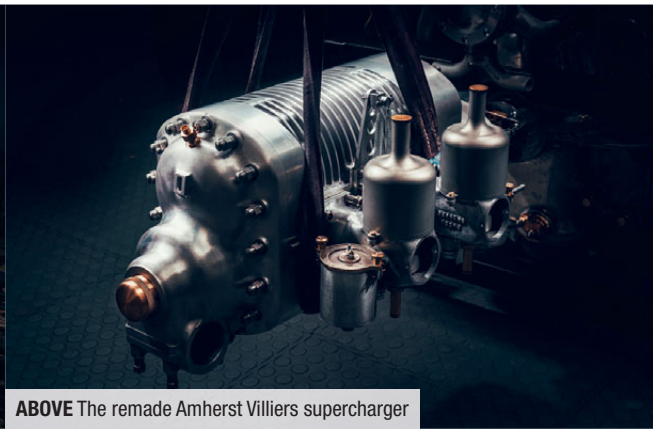


ABOVE The Blower Bentley's brand new 4½-litre engine, originally designed by WO Bentley himself and now recreated by Bentley Mulliner with the expert support of specialists including NDR Ltd

NEWS

ABOVE Bentley's own 1929 Team Car developed and raced by Sir Henry 'Tim' Birkin

ABOVE The ash frame



ABOVE The remade Amherst Villiers supercharger

unveiling ahead of a development programme later this year. Following a piece-by-piece disassembly of the #2 Team Car owned by Bentley (likely the most valuable Bentley in the world) and an exceptionally precise laser scanning of the frame and its components, new parts were ordered from a combination of fully digital CAD data and the original 1920s engineering drawings and drafts.

"After almost a year of highly detailed engineering work, it is extremely rewarding to see the first parts coming together to form the first Bentley Blower in over 90 years," says Bentley Mulliner's Tim Hannig, Head of business unit and business strategy. "The skill of our engineers and technicians in completing hundreds of individual part specifications is equalled only by that of the artisans across the country that have handmade the components that we're now starting to bolt together. As we go, we're refining designs and fixing problems, which is exactly what a prototype build is for. We're all really excited to get this first car finished, and to show it to the world later this year."

From the outset, Bentley Mulliner sought to engage the very best specialists across the country to create componentry for the Blower Continuation Series in a manner befitting such a project – using traditional techniques passed down through generations. With the very latest CAD technology finalising the exact designs to supplement the original engineering blueprints from the 1920s, work began at a multitude of small artisan businesses to bring the new Blower to life.

The chassis has been created in heavy-gauge steel, hand-formed and hot riveted by the specialists at Israel Newton & Sons Ltd. This 200-year old company traditionally makes boilers for steam locomotives and traction engines, and as such has the skills to forge and shape metal in a traditional way. ▶

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The Vintage Car Radiator Company, based at Bicester Heritage, has crafted exact recreations of the some of the Blower's key components – including the mirror-polished, nickel-plated radiator shell and the hand-beaten fuel tank formed in steel and copper. Market leaders in the manufacture and restoration of vintage car radiators and components to the highest possible standards of craftsmanship and authenticity, they were the perfect choice to handcraft these tricky and vital components.

These parts will feed the first Blower's brand new 4½-litre engine, originally designed by WO Bentley himself and now recreated by Bentley Mulliner with the expert support of specialists including NDR Ltd. Featuring many innovations of which a sports car engine of the 1970s would be proud – aluminium pistons, an overhead camshaft, four valves per cylinder and twin spark ignition – the renowned 4½-litre engine will meet a newly machined, exact recreation of an Amherst Villiers roots-type supercharger. Mulliner's experts will then be tuning the engine on a specially prepared testbed at the Bentley factory in Crewe, where together the engine and supercharger should generate around 240 bhp.

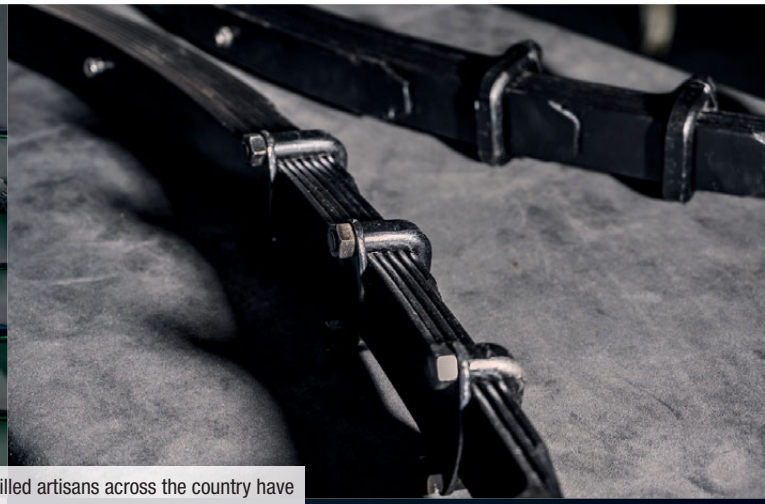
> **"Over the course of the coming weeks, more and more components for Car Zero will be completed and test fit"**

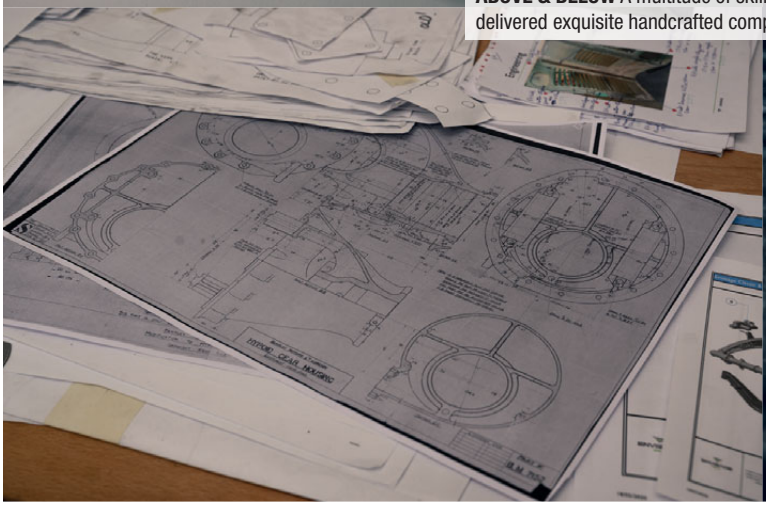
Leaf springs and shackles have been made to original specifications by Jones Springs Ltd, a specialist with nearly 75 years of experience and a history that started in a blacksmith's forge.

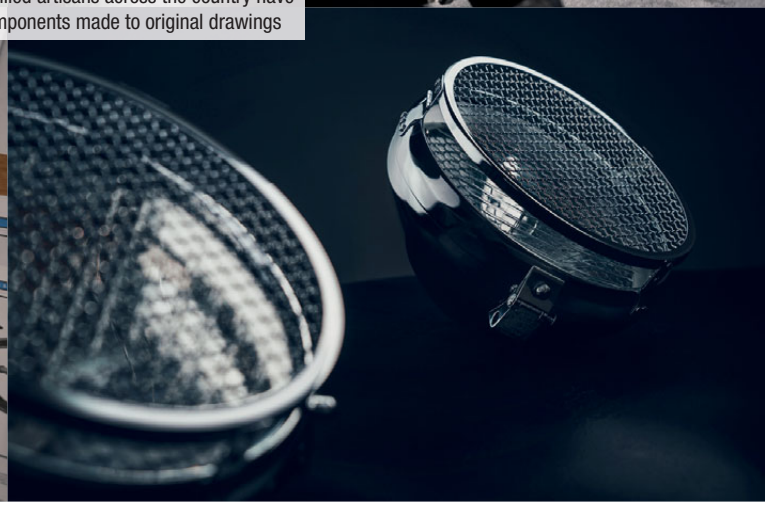
The Blower's iconic headlamps have been reborn by Vintage Headlamp Restoration International Ltd in Sheffield. This father and son team is world-renowned for their silversmithing and ability to create vintage-design headlamps from original specifications.

Meanwhile, in the bespoke Mulliner Trim Shop in Crewe, a new ash frame created by Lomax Coachbuilders is going through the final stages of carpentry by Mulliner's team of experts before hand-trimming starts through Mulliner's master craftsmen.

Over the course of the coming weeks, more and more components for Car Zero will be completed and test fit. The new engine and supercharger will be put through their paces on Bentley's very own engine development test beds in Crewe, while period-specific paint will be applied to the chassis before final assembly begins. HRT







ABOVE & BELOW A multitude of skilled artisans across the country have delivered exquisite handcrafted components made to original drawings

NEWS

AC Cars commemorates 1963 factory Le Mans cars

How AC Cars has recreated the '63 Le Mans coupes - but now powered by electric motors

AC Cars has launched a 'new' limited series of 12 special cars recreated from the 1963 AC factory Le Mans cars. They will be called the AC Cobra Le Mans electric and retain AC's proud heritage of power – the motor maybe electric but it has 460 kw of power and 1000 NM of torque (that's 617 bhp and 738 lb/ft).

The new cars are faithful recreations of the cars conceived and built almost 60 years ago to secure success in the Le Mans 24 Hours.

To ensure maximum visibility and success for the recreated cars, AC has pulled out all the stops to secure the talents employed to design and build them.

Since the late 1990's those AC buyers who fully appreciate the value of the brand and the quality of its products have sought to acquire the most accurate reproductions of the original all-aluminium bodied Cobras. They have been able to enjoy the works of art which feature hand-beaten bodywork by AC Heritage of Brooklands Motor Circuit in Surrey, the site of many a great victory for AC.

The new cars will have bodywork sourced from AC Heritage using some of the original, now decades old, 'technology' employed by AC. This comprises a highly trained pair of human eyes to judge the fineness of the line of the

ABOVE 39 PH pits during the 1963 Le Mans 24 Hour race

ABOVE The two AC Cobra line up prior to the start of the 1963 Le Mans 24 Hours

bodywork, sheets of high-grade aluminium and, not least, the services of a specialist 'planishing' hammer wielded over the curves of an AC body jig.

For these 2021 recreations, new ideas and new skills were also required. Inside the handcrafted bodywork is a power system for a new age. AC has introduced to its talent pool the services of its new Derby-based technical partner Falcon Electric.

THE LE MANS CHALLENGE

In 1963, AC built two bespoke AC Cobras for the 24 Hours of Le Mans. One of those was registration number 39 PH and the other one was registration number 645 CGT. Six of each of the recreated cars, bearing one of the two distinctive liveries are being offered to customers.

The 'new' cars importantly will have chassis numbers each bearing a new and unique prefix as well as their original, in sequence, AC numbers – a vital pre-requisite to their place in the valuation process in the future. The numbers will be listed alongside all other ACs in the company's 'Bible', an important historical listing which underpins the importance and pedigree of the AC Brand.

The Le Mans cars' most distinctive feature was the large, streamlined aluminium hardtop fitted to improve aerodynamics and to increase their speed along the Mulsanne Straight.

These removable tops necessitated the fabrication of long fuel-fillers which terminated just forward of the top of the rear window but they achieved a great result – they produced prodigious speed where it was needed on the infamous Straight.

AC Cars is now going to build six limited editions of each car, constructed just like the original cars from hand-rolled aluminium. They will be electric powered and use hand-crafted bodywork from the AC Heritage workshops on the historic Brooklands Racing Circuit, with mechanical units being added at the Falcon premises in Derby.

The 12 'new' heritage cars will each cost £600,000 plus VAT. ▶

The man behind AC since he acquired the brand in 1996, Alan Lubinsky, commented: "We are determined to make a tremendous success of these recreated AC Cobra Le Mans electrics designs when they are launched first in the UK and later in other markets. We know the external appearance will win the approval of many 'traditional' AC fans. The inclusion of an up to the minute, emissions free powertrain from our new friends, the electric experts at Falcon, will chime well with the excellence of the handmade bodywork built in the historic and important location of Brooklands!.

"This is the start of not just a new chapter but of a whole new era in AC's illustrious history. We will be following up the launch of these new models with other additions to our already expanding range", said Lubinsky.

Allard has also joined the latest craze by building a replica of the JR that participated in the 1953 Le Mans 24 Hour race.

LEFT & BELOW The AC-entered Cobra, '39 PH' driven by Ninian Sanderson and Peter Bolton that finished seventh overall and first in class at the 1963 Le Mans 24 Hours race

The intention is to obtain FIA HTP documentation, which would make the car eligible to compete in the International Classics such as the Le Mans race. Only seven JR sports cars were manufactured between 1953 and 1955. All seven are believed to be in existence. The last JR manufactured in 1955 carried chassis number 3407.

The first JR's being built are authentic Allards, as the cars are being constructed by members of the Allard family, with support from engineers who worked in the original Allard company. This first JR will have continuation chassis number 3408. This could therefore be seen as the restarting of Allard car manufacture after a gap nearly 60 years since the last JR was produced. HRT

Vanwall: renaissance of an historic name

Vanwall has entered the Continuation game with its championship winning F1 from 1958 as **Jonathan Nash** reports

SIXTY-TWO years to the day since Vanwall claimed the world's first Formula One Constructors Championship Trophy, the Vanwall name is reborn. Six continuation cars of the 1958 championship winning Vanwall Formula One car to be painstakingly recreated in partnership with historic racing experts, Hall and Hall.

The 1958 Vanwall is arguably the most important Formula 1 racing car ever built in Britain, with its six victories giving Vanwall the first Formula 1 World Constructors Trophy, and Vanwall remaining the first of only two Formula One teams ever to have recorded a maximum points score in a championship season.

Using the company's heritage in engineering and innovation, Vanwall has commenced investigations to understand how the historic Vanwall brand DNA could translate into a vehicle for the 2020s.

CELEBRATING 1958

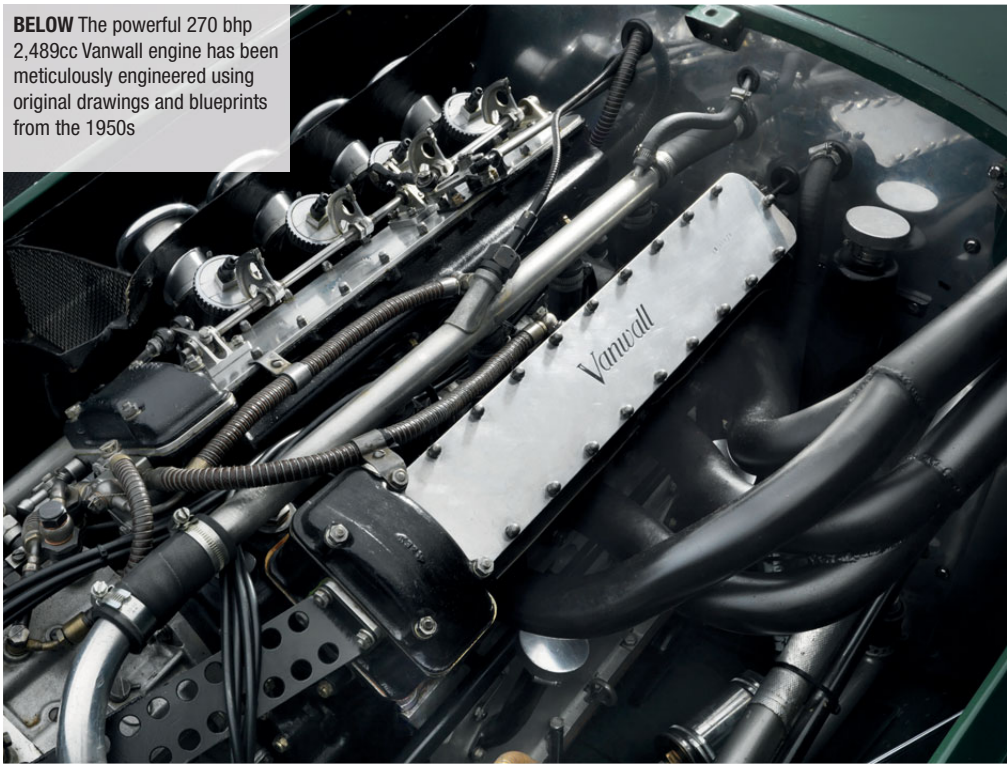
Vanwall Group, the successor to the legendary British Vanwall motor racing team of the 1950s, has announced the renaissance of the historic name with plans to build six new continuation cars to celebrate Vanwall's six Formula 1 wins in 1958. Vanwall had already become the first British-built car to win the British Grand Prix with a British driver, with Sir Stirling Moss and Tony Brooks sharing the honours in 1957. The six victories in 1958 gave Vanwall its eternal position as the first winner of the Formula 1 World Constructors Trophy, and to this day, Vanwall remains the first of only two Formula 1 teams ever to have recorded a maximum points score in a championship season. The 19th October 1958 was the day Vanwall clinched the memorable championship win in Morocco.

Only five of the continuation cars will be offered for private sale, with the sixth car forming the core of a Vanwall Historic Racing Team. Each vehicle will be painstakingly built over thousands of hours by historic racing and vehicle restoration experts, Hall and Hall in Lincolnshire, England. The faithful continuation cars will feature the powerful 270 bhp 2,489cc Vanwall engine, all meticulously engineered using original drawings and blueprints from the 1950s. Each hand-built continuation car will be sold for £1.65 million ex VAT.

In its day, Vanwall was a byword in the paddock for innovative engineering, with the Colin Chapman-designed chassis complementing the aerodynamics by Frank Costin. They pioneered, for example, the use of disc brakes rather than drum brakes in Formula 1 thus giving a small competitive advantage over the Ferraris. Roll the clock forwards 62 years, Vanwall Group has already commenced investigations to understand how the historic Vanwall brand DNA could translate into a vehicle for the 2020s, with studies ongoing into future road and race car programmes.

REVIVING A NAME

Announcing the continuation cars, managing director of Vanwall Group, Iain Sanderson, said; "The Vanwall name is too important to consign to history. The Vanwall story is untold to many, but it is a great British tale



BELOW The powerful 270 bhp 2,489cc Vanwall engine has been meticulously engineered using original drawings and blueprints from the 1950s

ABOVE Each hand-built continuation car will be sold for £1.65 million ex VAT. **BELOW**, Hall and Hall is responsible for building the six Continuation models

of innovation and achievement and shows what happens when the right team come together and push themselves fearlessly to reach a clearly defined goal. On this anniversary, we think the time is right to celebrate this great British story of success. Faithfully recreating the iconic 1958 championship winning car with six 100% accurate and authentic continuation cars is a fitting tribute to their historic success. The DNA that made those cars so successful also serves as an inspiring foundation for the future of the Vanwall marque, which I look forward to sharing in due course."

Sanderson is a former world champion offshore powerboat racer, as well as being an early pioneer in electric vehicles when he commissioned the Lightning GT electric supercar in 2008.

Andrew Garner, chairman of Vanwall Group and a former chairman of the Historic Grand Prix Cars Association, concluded, "I can still remember watching the Vanwalls at Aintree in '57 when I was a boy and had the pleasure of sitting in one at Goodwood. I drove at all the major circuits in a Cooper T51 for many wonderful years but the Vanwall is the car I coveted. These cars will be fully race eligible and in the right hands will be unbeatable, repeating Tony Vandervell's mission to beat the red cars!"

BRM has also announced that it is joining the continuation theme by commissioning Hall & Hall to produce three replicas of its 1½ V16 powered Type 15 Formula 1 car to celebrate the company's 70th birthday. HRT

Keeping Minis, MGs and Austin A40s going

British Motor Heritage is a goldmine for bringing old MGBs, Minis and even Austin A40s not just back to life but also taking some of them to the race track with great success. **Gordon Bruce** talks to BMH MD John Yea about the business

Now in his '60s, John Yea jokes about how he began his career making money out of classic Minis and is on course to end it the same way. The proof hails from the company's Witney-based factory, where some 100 replacement Mini shells as well as about 35 MGB ones are now produced per annum, not to mention literally thousands of individual replacement panels for these and myriad other cherished British models from the same period.

While a good percentage of this hardware is employed in the restoration or repair of road cars, an ever-increasing volume

now finds its way onto the world's racetracks. Always an active supporter of the relevant car clubs and the classic fraternity in general, BMH's own motorsport involvement has evolved to match the trends of the sector. Nowadays, it comprises a team of three highly competitive products of the BMC era — an MGB roadster, Austin A40 and Mini Cooper S.

> **"It is no exaggeration to say that by applying single-seater levels of optimisation to the running gear, and years of experience to everything else, he has completely transformed the car"**

A TENTATIVE START

The daddy of the trio is '516 WDE', a venerable 1964 MGB that was built in-house to FIA regulations back in 2006. The period marked the beginning of BMH's now long-standing association with the Oxford Universities Motorsport Foundation (OUMF), and much of the build was entrusted to undergraduate David Child. A donor car was duly secured, and the racer was created around a brand-new Heritage shell. Even the roll cage was constructed on site.

"We were considering producing them for sale but ultimately found the certification too onerous for the envisaged volumes," says Yea. The engine and gearbox were supplied by marque specialists MG Motorsport, and the liveried product was finished in Yea's chosen colours of white over Mercedes-Benz Jasper blue.

"My previous race experience was confined to a few outings in an MGB RV8 prototype," says Yea, "and our initial preparation skills also left something to be desired — e.g. I inadvertently treated one track to a generous coating of oil after we'd fitted the rear axle seals back-to-front! So, the 2006 season is best described as a steep learning curve.

"The 2007 one terminated abruptly in the barrier at Castle Combe, which I unknowingly attacked while unconscious following a heart attack. Happily, both the car and I lived to race ▶

RIGHT After a shaky start, BMH's A40 is now arguably the one to beat in the HRDC's Touring Greats series

ABOVE With 12 fruitful seasons behind it, BMH's MGB is now a fully sorted machine

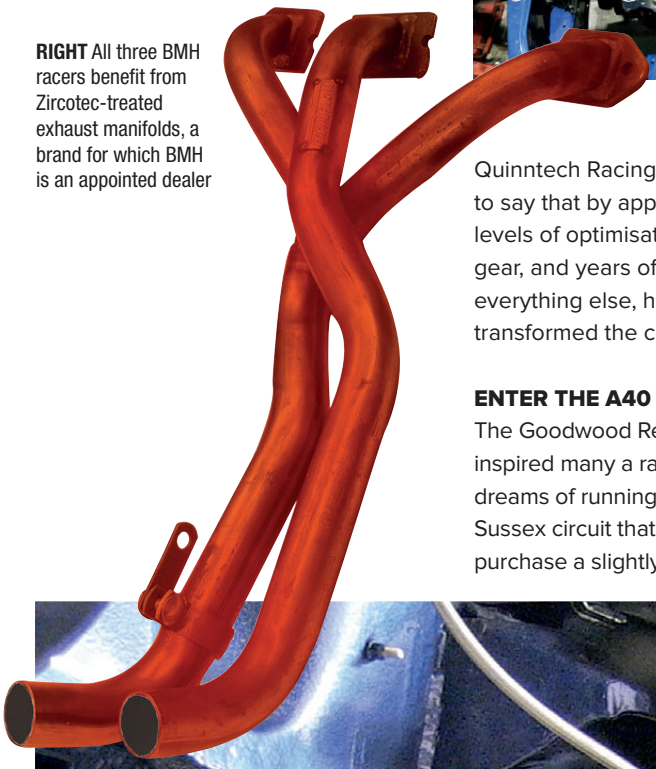
again, and 2008 can be considered the first of 12 truly enjoyable seasons, with hopefully many more to come once the threat of COVID-19 has subsided."

Much has changed over the period of concern. The team's focus for the MGB, the popular Equipe GTS series, has become evermore competitive. The output of the front-running MGB engines has risen from about 145 bhp to 170 bhp, and all the powerplants are now checked and sealed. In many cases, the race cars are now transported, courtesy of articulated trucks rather than trailers. In short, the whole scene has become more professional, all of which has not only affected BMH's MGB but the company's range of products too. For example, when the supply of close-ratio gear sets dried up, BMH commissioned Beard & Fitch for a batch on behalf of the sector, from which it now sells some 25 sets per annum. It also specified the fitment of brass rather than steel baulk rings to lessen the repair costs of the transmissions. A drive to reduce overall weight, the enemy of all racing cars, prompted the company to create alloy boot lids, door skins and FIA-certified front valences, all of which it now offers for sale to other competitors. Deploying heat-dispersant coatings on the MGB led BMH to become a Zircotec dealer and able to offer the full range of that firm's services for any vehicle. ▶

ABOVE Alloy door skins are among a number of components developed for the BMH cars that are now offered for sale to fellow competitors

ABOVE '516 WDE' about to do battle at Donington Park

Commenting on the MGB today, Yea says: "When we started out, all the grafting fell to my colleague Dave Savidge and myself, which he enjoyed, and I didn't! There was no question that to get more competitive, we needed to become more professional in our approach, and have, so '561 WDE' is now a fully sorted machine. The current Classic & Modern engine leaves little to be desired, and responsibility for overall preparation now falls to Rob Quinn of Quinntech Racing. It is no exaggeration to say that by applying single-seater levels of optimisation to the running gear, and years of experience to everything else, he has completely transformed the car."



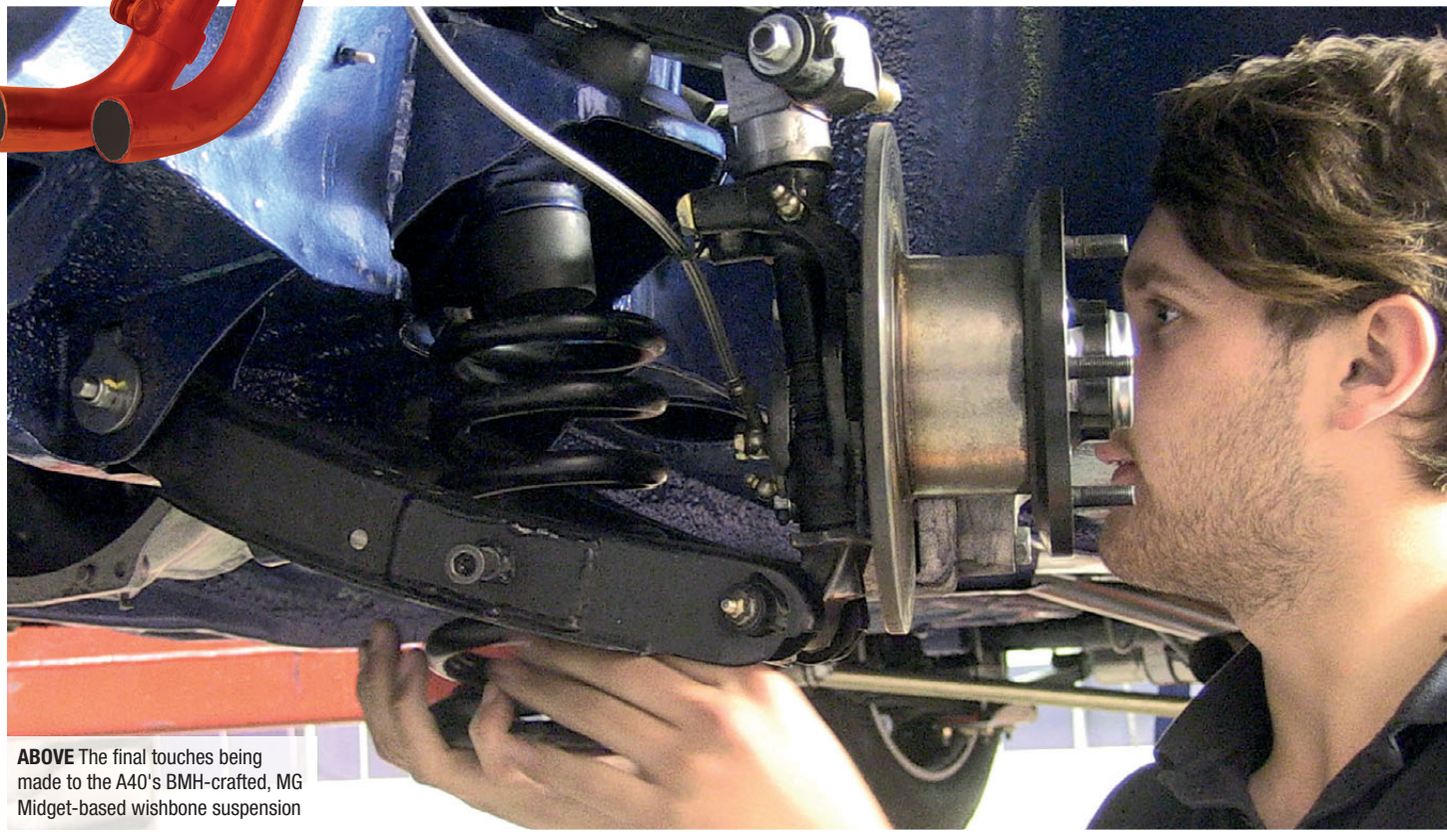
RIGHT All three BMH racers benefit from Zircotec-treated exhaust manifolds, a brand for which BMH is an appointed dealer

ABOVE Four images of the A40 in build, a task that owed much to the input of two undergraduate members of the Oxford Universities Motorsport Foundation

ENTER THE A40

The Goodwood Revival meeting has inspired many a racing project, and it was dreams of running at the incomparable Sussex circuit that prompted Yea to purchase a slightly moth-eaten A40 off eBay in 2014. Though it has yet to line up on the Goodwood grid, it is now arguably the A40 to beat in the HRDC's Touring Greats series.

The first task was to have the 55-year-old shell acid dipped and then repaired as required. As with the MGB, it provided an ideal training opportunity for OUMF, who volunteered the pairing of Jimmy Allen and Dominic Norman for the project. As Touring Greats regulations permit rather more freedom than Appendix K ones, their initial challenge was to visit a ▶



ABOVE The final touches being made to the A40's BMH-crafted, MG Midget-based wishbone suspension

ABOVE The team's Mini is brimming with off-the-shelf BMH parts, including seam-welded Heritage bodyshell, Heritage subframes, and alloy door and boot skins

selection of classic racing gurus, such as Rae Davis, who kindly agreed to share their knowledge with the boys.

Yea admits that the project dragged on somewhat and to being "appalled" by the car during its eventual shakedown at Brands Hatch. "The initial laps were horrendous. I just couldn't get the thing to do what I wanted. However, slowly but surely, the gremlins were ousted, and we had something to build on. Since those days it has been treated to a 1293cc Classic & Modern engine that can be revved to almost 9,000 rpm and produces a mighty 144 bhp — an astonishing leap from the first incarnation of the BMC A Series engine, as found in the Austin A30, that had a modest capacity of 803cc and lowly output of just 28 bhp! Like the MGB, the A40 has benefited greatly from Quinntech's forensic attention to the extent that on most circuits, my hot-shoe co-driver Chris Ryan can not only outpace most other A40s by a country mile but even give the leading Lotus Cortinas the occasional scare."

It is true to say that the A40 owes a lot less to the BMH parts bin than either the MGB or Mini, but its Midget-based suspension wishbones are crafted in-house and, like the MGB, it benefits from a Zircotec-treated exhaust manifold, Samco hoses and Goodridge braided brake lines, all of which and more are available to all from BMH (www.bmh-ltd.com).

Quinntech Racing

Quinntech Racing, founded by race engineer **Rob Quinn**, has extensive experience in preparing race and championship winning cars to the highest level for both circuit and oval racing

JOHN Yea is unequivocal in his praise of Rob Quinn's skills and the positive effect they have had on BMH's trio of race cars. However, he and the many other competitors whose steeds have been equally improved could so easily have been denied his attention as Rob had initially planned to be a vet — and, if not a vet, then a works rally driver. Apparently though "the call from David Richards never came". Instead, he employed his school maths and science qualifications to progress through a BTEC (Business and Technology Education Council) in motorsport engineering and then an HND (Higher National Diploma). He voluntarily majored in suspension for his project work, and while at college, commenced a relationship with the Steve Dance race team that has continued to this day. His comprehensive experience even includes two years in NASCAR, where, as he puts it, "if you are predominantly turning left at 190 mph, the set-up on that side has to be absolutely as good as you can get it."

Whereas optimising the suspension and unsprung weight of a single-seater is standard practice, going to such extremes for a classic saloon racer is still far from de rigueur, and this is how Quinn works his magic. Employing a flat plate to ensure the car in question is on an even keel, he is then free to measure everything from the centre of the tyre contact patches to the ball joints in 3D, which, in turn, allows him to build a computer model. By analysing the dynamic suspension changes, degree of suspension travel, transfer of weight under braking and acceleration, and the unsprung weight, he can optimise the entire set-up. Furthermore, he does not just do this once, or even once a season, but prior to every meeting.

In addition to his NASCAR experience, Quinn's back catalogue includes several successful seasons of pick-up truck racing and building as well as running Steve Dance's highly successful 2600 and 3100 Capris, not to mention the yellow Mark Cole MGB that not only trounced all the regular MG runners in Equipe GTS for two years on the trot, but qualified for the 2016 Spa 6 Hours Classic in the astonishing and, as yet unbeaten, time of 3.03.2. Despite running up to 12 cars at a time, Quinn has so far operated largely on his own. Though, as happens with all successful enterprises, Quinntech (www.quinntechracing.com) has grown to the point of requiring bigger premises and more hands on deck, so changes are currently afoot.

AND SO TO THE MINI

Everybody who witnessed the heart-stopping Mini races at the 2019 Goodwood Members' meeting probably put a Cooper S on their next Christmas list for, as Yea says of the BMH one, "it's so perfect you just want to pick it up and cuddle it". However, cute though they may look, racing them competitively is not for the faint-hearted.

The build of this BMH car yet again involved an OUMF student. On this occasion, it was Vlad Ardeleanu, who will forever be remembered for his "infamous" fuel flow meter and an electrical system "so hi-tech it wouldn't have looked out of place on an LMP1 car". The full FIA roll cage is certainly a work of art, the manufacturing of which was outsourced to Owens Fabrication. The Classic & Modern engine is virtually identical to the A40 one turned through 90°, though a slightly smaller carburettor and friction losses in the drop gears mean the output is reduced by some 14 bhp to around 130 bhp. The car is brimming with off-the-shelf BMH parts, including the complete seam-welded Heritage bodyshell and Heritage subframes, alloy door and boot skins and Zircotec-treated exhaust manifold. In short, it not only looks wonderful but is teaming with potential. However, steering, engine and gearbox woes have meant that it has yet to truly shine, and Yea is the first to admit that the dramatic 'point and squirt' school of driving required is a skill he has yet to fully master.

IN SUMMARY

"Our involvement in racing has been invaluable," says Yea. "By not only mixing with our potential customers but competing against them, we've obtained a far better idea of their needs and done our best to adapt accordingly. Our MGB was one of the very first Heritage-shelled cars to hit the circuits, since when the numbers have escalated year on year. Much as we are obviously delighted to sell individual panels to those restoring MGBs or Minis to race, there comes a point when the purchase of a whole new shell can be a more cost-effective route, and common sense suggests there is a degree of wisdom in putting a new body through the rigours of racing, rather than one that's been used and abused for 50-odd years.

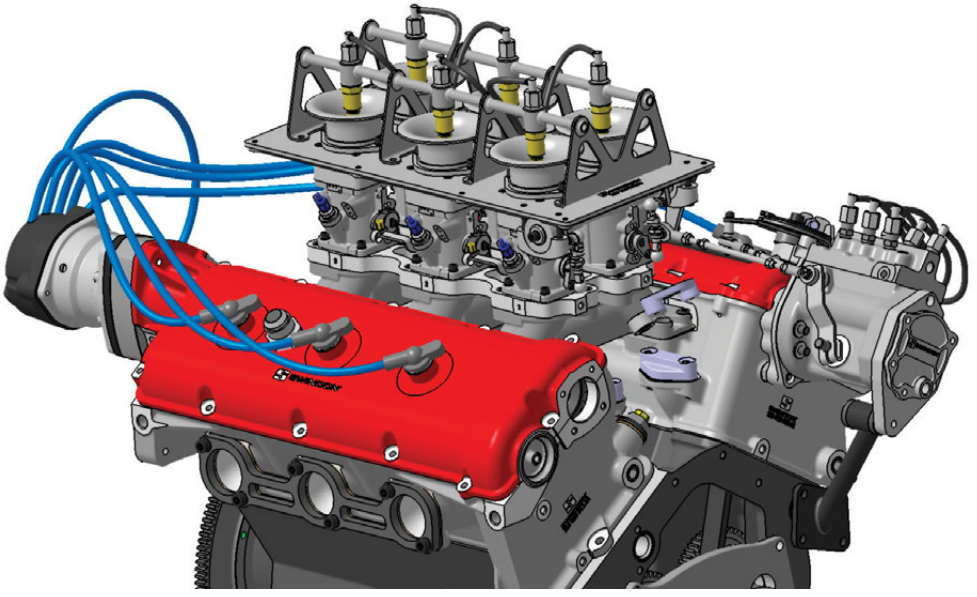
"These days we can supply a whole raft of carefully sourced items, from seam-welded racing shells to FIA-certified Piloti driving shoes, close-ratio gear sets to Tex period wiper and mirror items, and brake upgrades to such invaluable accessories as Revotec electric cooling fan kits — a far cry from when I first took to the circuits in our own MGB. So, as soon as the historic scene is back to normal, we plan to return to the thick of things with both the MGB and the A40, looking, like everybody else, to shave a few more tenths from those laps times. The jury's out over the future of the Mini, but even if we elect not to race it, we can always pick it up and cuddle it!" HRT

> **"As soon as the historic scene is back to normal, we plan to return to the thick of things with both the MGB and the A40. The jury's out over the future of the Mini, but even if we elect not to race it, we can always pick it up and cuddle it!"**

ABOVE & BELOW Here we see the production of the Mini's seam-welded Heritage bodyshell in progress. Common sense suggests new metal is preferable to old when it comes to racing

Recreating a classic engine

Chris Pickering talks to Swindon Powertrain on how it has recreated the 24-valve Lancia Stratos engine



ABOVE Swindon Powertrain has recreated the iconic Lancia Stratos 24-valve layout

THE chances are you'll hear it before you see it. A magnificent multi-cylinder howl that sounds more like a seventies Formula 1 car than a typical stage rally contender. And yet there never was anything remotely typical about the Lancia Stratos – a baby supercar with a mid-mounted Ferrari V6 designed to crush the four-cylinder Ford Escorts and Fiat 124s in the newly-formed World Rally Championship.

The works cars first appeared in 1973 with 12-valve engines, but within a matter of months they switched to a 24-valve layout, thanks to a new competition cylinder head design. These are the engines that captured the Stratos's most memorable victories, but less than 30 were made at the time. Now, Swindon Powertrain has recreated this iconic engine for a private customer.

"Our brief was to recreate that 24-valve version of the engine and see if there was anything we could do to improve it within the scope of the regulations," explains Sylvain Rubio, technical director of Swindon Powertrain. "There had been a few reliability issues with this version of the engine in-period, for instance, so we wanted to see if there was a way we could address those."

> "Our brief was to recreate that 24-valve version of the engine and see if there was anything we could do to improve it"

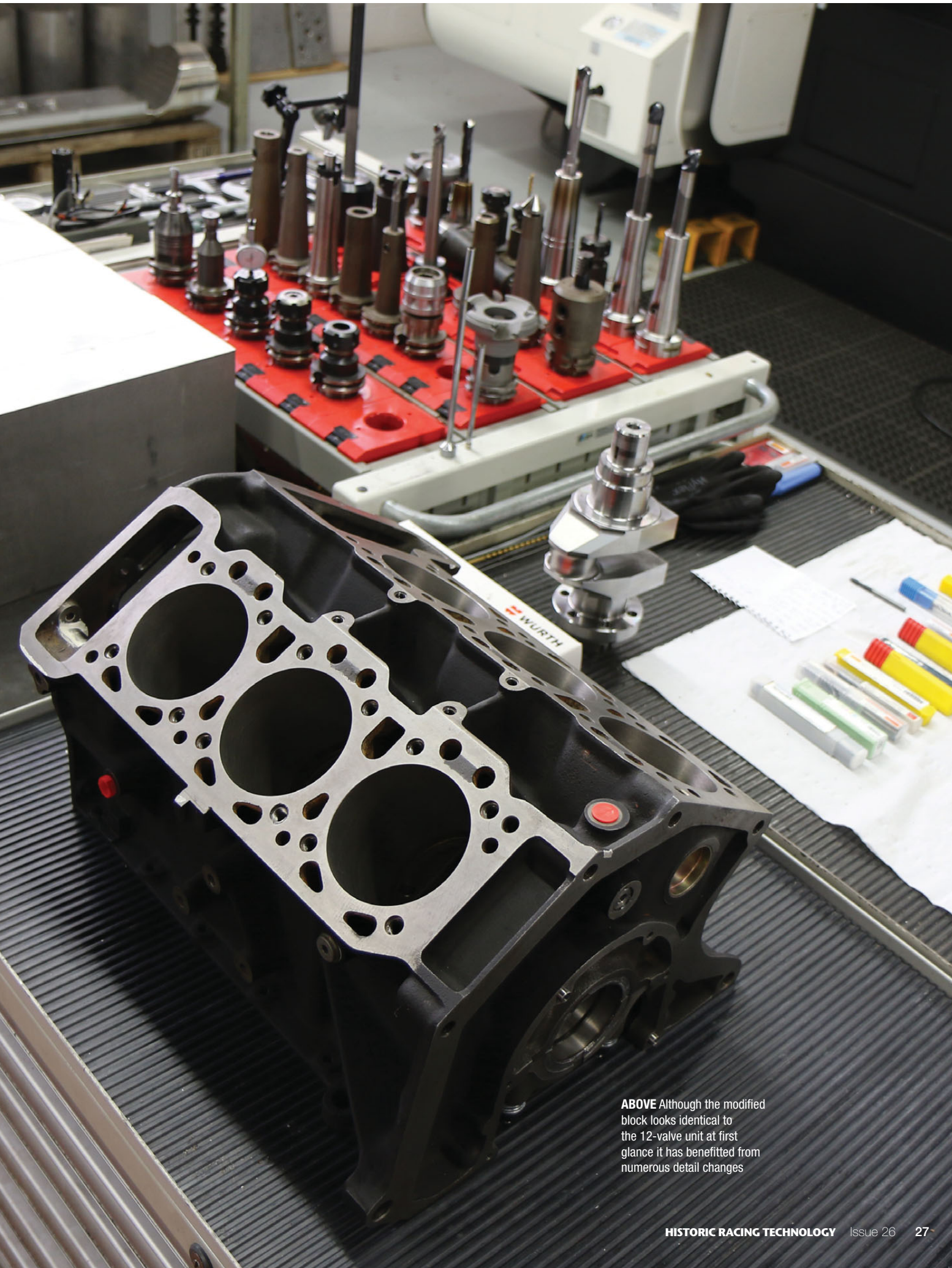
Rubio and his colleagues had little to go on when they started the project – an engine with a standard 12-valve head and a handful of photographs from the original 1970s homologation documents. There were no drawings or detailed technical specifications available to them.

"The block and the auxiliary components had to remain as close as possible to the 12-valve, as did the manifold design," he comments. "A lot of the initial work was based on the photos we had of the period engine, trying to get the external design of the cylinder heads as close as possible."

HIGHLY ACOUSTIC ENGINE

The valvetrain was believed to be a weak point on the original 24-valve engine. With this in mind, Swindon set about redesigning it from scratch using the company's own valvetrain simulation software. This has allowed the current engine to reliably deliver high lift at speeds of up to 10,500rpm (for comparison, a contemporary report in *Autocar* said that the original revved to 9,000rpm).

"This engine is highly acoustic," comments Rubio. "That's to say, you have a significant difference in breathing efficiency from one engine speed to the next. This leads to corresponding change in fuel demand. When you are trying different hardware on the dyno – for instance different camshaft profiles, different exhaust lengths and different ▶

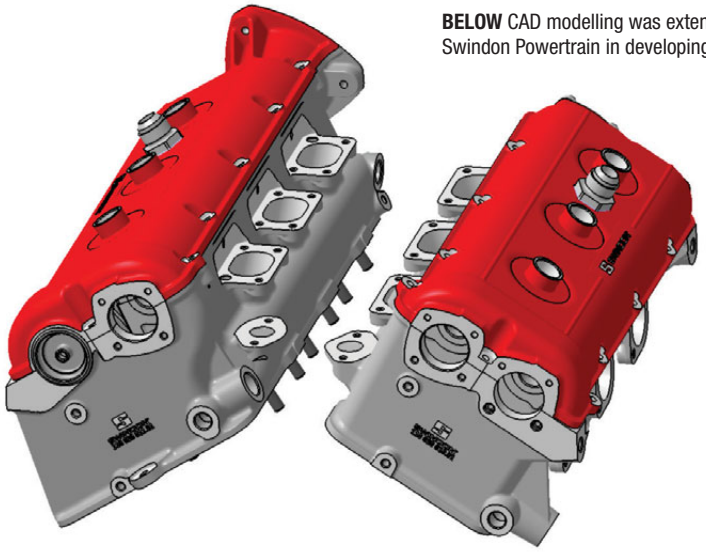


ABOVE Although the modified block looks identical to the 12-valve unit at first glance it has benefitted from numerous detail changes

ABOVE The aluminium cylinder heads are new

inlet lengths – you would normally re-engineer the cam for the mechanical fuel injection system each time.

"Instead, what we did was to fit an electronic injection system and electronic ignition on the engine for the development process. That allowed us to go through all the hardware very quickly without having to worry about the fuelling and ignition – that was all done automatically in closed loop. It wasn't until the very end that we replicated those settings on the original mechanical injection and ignition system.



BELOW CAD modelling was extensively used by Swindon Powertrain in developing the Stratos engine

There's no reason why the works team couldn't have reached the same end result in the 1970s, but it would have been extremely time consuming in terms of mechanical testing."

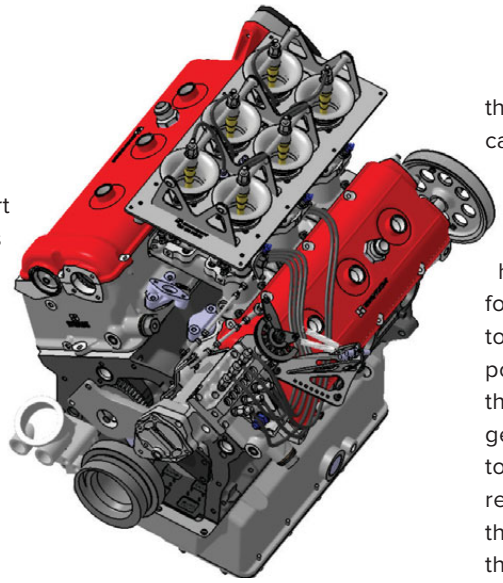
The original fuel pump cam was modified to increase its flow capacity, while the fuelling map was painstakingly reverse engineered. Rubio and his colleagues began by recording the cam displacement versus output and then used a CAD model of the pump's internal geometry to work back to the corresponding cam profile. This also needed to be adjusted for engine speed, so the Swindon engineers came up with an elegantly simple solution; they produced a transparent backplate that allowed them to run the pump at a known speed and measure the rotation of the cam. These observations combined allowed them to map the original fuel injection system across the engine's full speed and load range.

REVERSE ENGINEERING

"I would say developing that theoretical model of the mechanical injection system was the hardest part of the project, mainly because it was new to us," comments Rubio. "The reciprocating assembly and the valvetrain was just another day at the office for us and we expected it to work first time, which it did, but that's the first time we've had to reverse engineer a mechanical fuel injection setup."

The aluminium cylinder heads are new. The owner of the car was already in touch with a company that had begun developing the castings. The Swindon engineers worked with this external supplier to oversee production of the base castings and then applied their own machining processes to complete the build.

Most of the work was carried out with five-axis CNC machines, but this was out of convenience rather than necessity, Rubio notes: "Modern machining methods give us the accuracy and the consistency that they didn't have in the seventies, but there's nothing about the geometry that couldn't have been produced in-period."



ABOVE Swindon set about redesigning the valvetrain from scratch using the company's own valvetrain simulation software

BREATHING

No real information was available on the original combustion chamber design, so the Swindon engineers essentially started off with the biggest valves that they could fit and the highest lift. As on the original engine, a straightforward camshaft layout is used with direct tappet actuation.

The design of the piston crown was then dictated by the cylinder head and valvetrain. In 24-valve form, the compression ratio rises to 12.5:1, despite the use of deep pockets to provide clearance for the high-lift valves. Once the piston geometry had started to come together, the connecting rods were re-engineered for the revised loads on the pistons, which are slightly lighter than those on the 12-valve.

"It's fairly typical of the competition engines of the times. There are lots of good ideas next to a few that aren't as clever," comments Rubio. "The basics are good, with the 24-valve configuration and a nice straight intake layout with beautiful porting within the head itself. However, then a lot of that benefit was lost with the original intake manifold that has some very sharp bends that I think were put in to accommodate the original carburettors. Even once they switched to fuel injection they carried over that design. ▶

BELOW A Lancia Stratos at Goodwood

Jeff Bloxham

You see that sort of thing in quite a few places – the concept is great, but the detail is sometimes compromised."

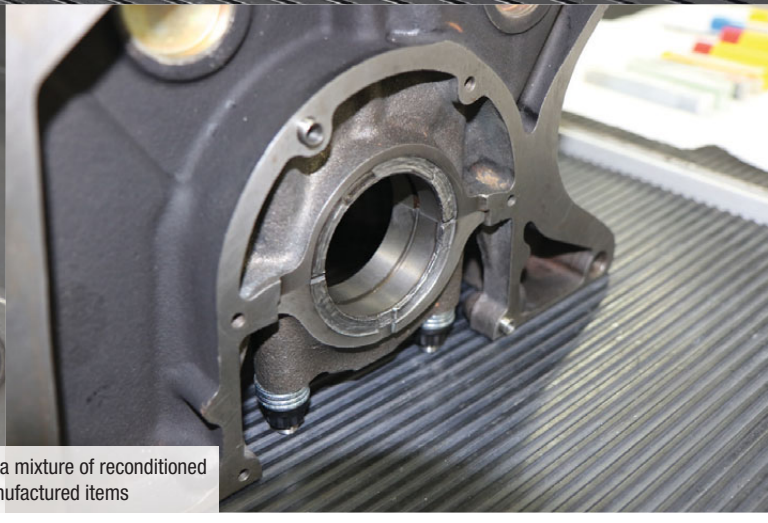
Another example is the oil drain from the cylinder head on each side back to the sump. The standard design was reaching the edge of its capabilities on the 12-valve competition engine. Swindon believed it could create a weak spot on the 24-valve engine with its higher rpm potential, so it was supplemented with external pipes direct to the sump.

The primary drive for the valvetrain follows the same basic layout as that on the 12-valve head. Starting at the crank, two gears split the drive between the opposing cylinder heads; from there, a pair of chains drive the two overhead camshafts on each bank.

> **"The original block casting was visually inspected and crack tested to guarantee its integrity before work began"**

Although the modified block looks identical to the 12-valve unit at first glance it has benefitted from numerous detail changes. The cooling galleries, for instance, have been moved slightly in places. "We machined off the original water channels and replaced them with fabricated parts. For instance, there were places at the front of the engine where the original water galleries now clashed with the position of the chain, so we machined those off. There were ▶

ABOVE Swindon Powertrain had to reverse engineer a mechanical fuel injection setup



ABOVE The engine uses a mixture of reconditioned original parts and re-manufactured items

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also a few bits of clearance machining here and there."

The original block casting was visually inspected and crack tested to guarantee its integrity before work began. A couple of areas were laser welded and then re-machined to ensure perfect condition, but it was fundamentally carried over from the 12-valve engine. The crankshaft is a bespoke design by Swindon, but it was developed previously for use with this engine in original 12-valve form. In contrast, the connecting rods and pistons are all-new for the 24-valve unit.

One of the questions that came up during the build process was how to approach the engine balancing. Lancia originally used bob weights on the crank, along with the flywheel and the nose pulley to balance the engines.

Swindon has followed the same practice, although the option was there to balance the engine perfectly on the crank alone. "Looking back, that's something we maybe should perhaps have changed for the sake of simplicity," notes Rubio. "If you balanced on the crank you could get a slightly lower rotating mass and a bit less deflection. The bob weights on the end of the crank cause it to flex slightly."

A clean sheet crankshaft design for a modern engine would typically involve torsional analysis in FEA, but Swindon elected to go for a more traditional approach in this instance. There wasn't particularly large scope to change either the mass or the packaging constraints, so the torsional characteristics were always going to be similar to the

> **"The connecting rods and pistons are all-new for the 24-valve unit"**

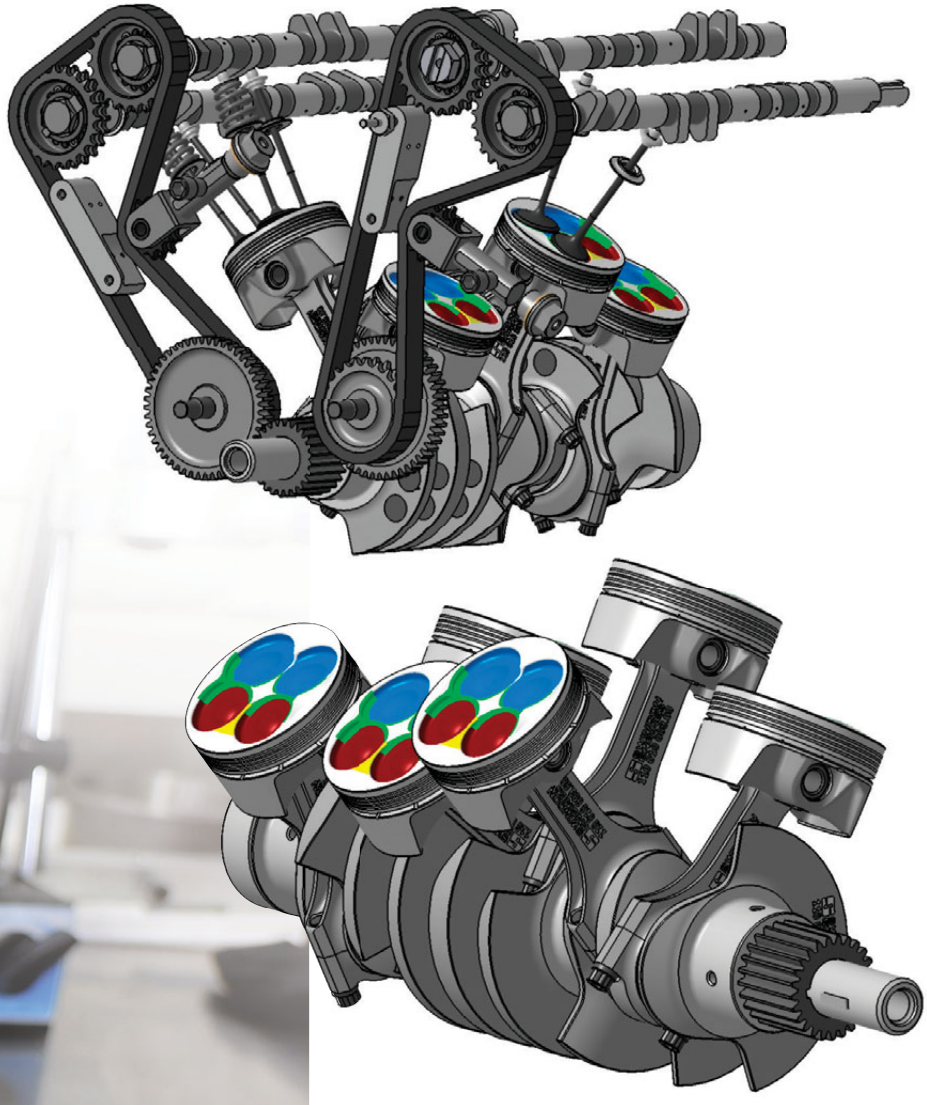
ABOVE Swindon used a mild evolution of the original crankshaft in EN40B and gas nitrided to a depth of 0.5 mm

existing competition-proven design.

"The situation would have been different if we'd removed the external balance weights," notes Rubio. "Instead, we used a mild evolution of the original crankshaft in EN40B and gas nitrided to a depth of 0.5 mm."

POWER BOOST

Autocar's period review of the Stratos claims that the 24-valve rally cars were producing 294 bhp. Depending on the camshaft configuration, Swindon says that up to around 330 bhp is possible with the current engine, although the best combination of torque and driveability equates to around 300 bhp.



ABOVE Starting at the crank, two gears split the drive between the opposing cylinder heads

"We could have pushed things a lot further, but we wanted to maintain the authenticity of the engine. We still use the original inlet manifold design, for instance, which probably costs us 30 or 40 bhp on its own. It's very much the sort of thing they could have done in-period with more development time," Rubio concludes.

Ironically, the development time on the original works engines was cut short. With the Stratos at the height of its powers, the Group 4 regulations were changed and the 24-valve engines were effectively banned from competition. The 12-valve engines remained competitive for another few years, but the unique sound of the high revving 24-valve engines was gone from the WRC. A handful still compete in private hands, however – and thanks to Swindon there's now one more. HRT

More than just hot air

For years, perfecting an engine's airflow has been as much art as science. This, discovers **Alan Stoddart**, is changing thanks to one student's particularly ambitious project

ABOVE A Mk VIII Cooper-Norton car, driven here by Nigel Challis, is similar to that which Les Leston used to take the British F3 Championship in 1954

IT was a distinctly modern approach that Ollie Leston decided upon during his degree studies at the University of Brighton, when he sought to apply a science-based route to understanding the flow of air through an historic racing engine. But there is a bit more to it than that. The project work also offered a rather personal incentive, in that the engine tested was a Ford 'Pre-Crossflow', the same type of engine as commonly used in Formula 3, a category in which his grandfather, former Formula One Grand Prix driver Les Leston ('godfather' of the motoring bolt on accessories business and inventor of flame proof overalls), won the British championship in 1954.

The Advanced Engineering Centre at the University of Brighton forms the internal combustion engine thermal efficiency spoke to the UK's Advanced Propulsion Centre hub. Air motion and fuel sprays are the focus of the high-resolution optical engine research work carried out at Brighton, providing opportunities for ambitious student project work. As such, Leston was well placed to buff up on the subject of fluid mechanics as applied to inlet port flows, and in-cylinder air motion and its influence on combustion efficiency. This would pave the way to a series of experiments using existing cylinder heads, and lead ultimately to a 3D printed cylinder head test piece of a new design.

To get some baseline measurements, ▶

> **"Of particular note here is that the improvements are greatest at lower valve lifts, allowing engine performance gains to be found without necessitating high valve lifts and ramp rates"**

Leston tested the airflow through an absolutely stock head, then, by way of comparison he tested a race head that had been donated to the university by TN Engineering, who have acted as an industrial partner for this project. This head had been carefully fettled by the firm's founder, Joe Allenby-Byrne, a few years ago for use in his own racing Cortina GT, and by his own assessment, it was a good one.

BESPOKE TEST RIG

"I had just kept it for reference because it had been so good," notes Allenby-Byrne. "It had already been on my flow bench, obviously, because I developed it, and it had already been in my engine in my car when I'd raced it and it got me round Spa in 3:14 and Goodwood in 1:38 so I knew it worked."

"But eventually I gave it, along with the valves and everything else, and a standard Cortina head with standard valves on to the University so they had two benchmarks and sort of left them to it. The valve size is homologated, so that's a fixed parameter meaning that improvements would have to be made elsewhere."

To investigate this thoroughly, and have confidence that the findings would lead to real-world improvements whilst remaining FIA rule compliant, a bespoke test rig was required. This would feature specialist instrumentation, allowing accurate measurements to be made and a number of performance parameters to be calculated, in particular, flow rate and also in cylinder air motion. This rig was developed by Leston and his project supervisor at university, Dr Daniel Coren, who has extensive experience in automotive and aeronautical propulsion systems research and development.

A STEPPING STONE

"One intention of the test rig approach used for this student project work is to provide a stepping stone between relatively simple air motion investigations, and the advanced research behind the emissions performance of the internal combustion engines in modern road vehicles. In-cylinder swirl and tumble motion have a direct impact on the uniformity of air-fuel mixture uniformity in homogeneous charge engines, which in turn, has a direct impact on combustion efficiency, and therefore the ability of the engine to produce torque and power. Conducting student project work in this environment has allowed students to gain insight into cylinder head design which would be relevant for any historic motor racing, or indeed future road vehicles using synthetic fuels".

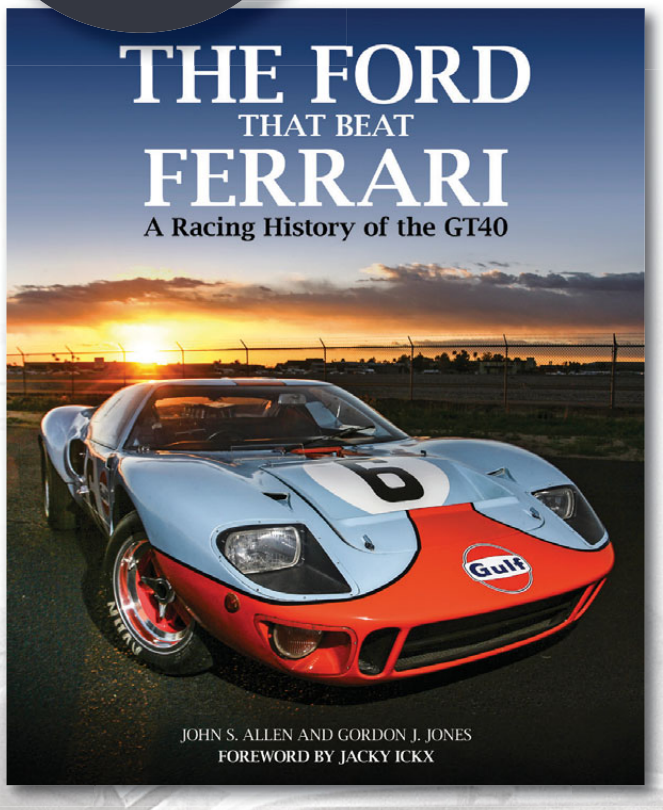
The rig itself is comprised of a metal frame and CNC machined mounting plate which supports the cylinder head, and a plastic tube representing the cylinder liner attached below. This in turn was connected to a variable speed fan which draws air through the test ring in a steady state fashion, representative of a snapshot of the inlet part of an engine's cycle. The head's inlet valve is positioned by a micrometer lead screw, while pressure and flow meters allow the rate of air flowing through the cylinder head to be set at a pressure drop representative of an engine's inlet process in the real-world environment of the car.

The rig allowed flow discharge ▶

ABOVE To make quantifiable improvements, thorough testing must first be conducted

BELOW Silicone mouldings were made of the heads' internals to allow Leston to much more thoroughly investigate their shape

The Ford That Beat Ferrari



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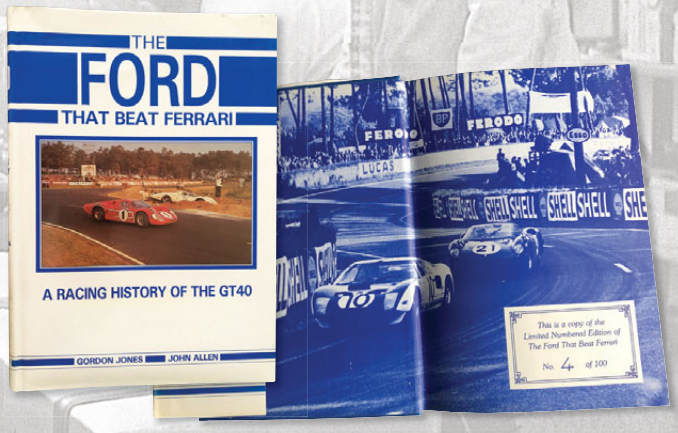

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> **“All this analysis has helped Leston develop a thorough understanding of the way the air moves into the cylinder, he is confident there is more to be done”**

coefficients to be measured, which is a term that quantifies the efficiency of flow through an orifice. This is one of the things that set the study apart from traditional methods, because it quantified the actual flowrate for the given area of the port as compared to the ideal calculated flowrate. This allowed Leston to demonstrate how efficiently the charge was flowing thought the port, rather than just the flow magnitude, as more typically measured. Importantly, airflow within the cylinder itself could also be measured, by means of lightweight paddle-type tachometers. Combined, this let Leston look at the flow in detail, making it possible for him to find ways to reduce ‘unwanted’ air motion through the port in the form of flow separation, and put that energy into ‘useful’ air motion in the form of swirl and tumble in the cylinder.

“What we did to make the experiments more scientific and in order to gain a better understanding of the air motion in the cylinder, was to measure swirl and tumble. This was carried out at different distances away from the gas face of the head, representative of the engine stroke. We were analysing flow patterns within the cylinder, in order to better correlate the influence of port shape on in-cylinder air motion during the induction stroke,” Leston explains.

ENHANCING COMBUSTION

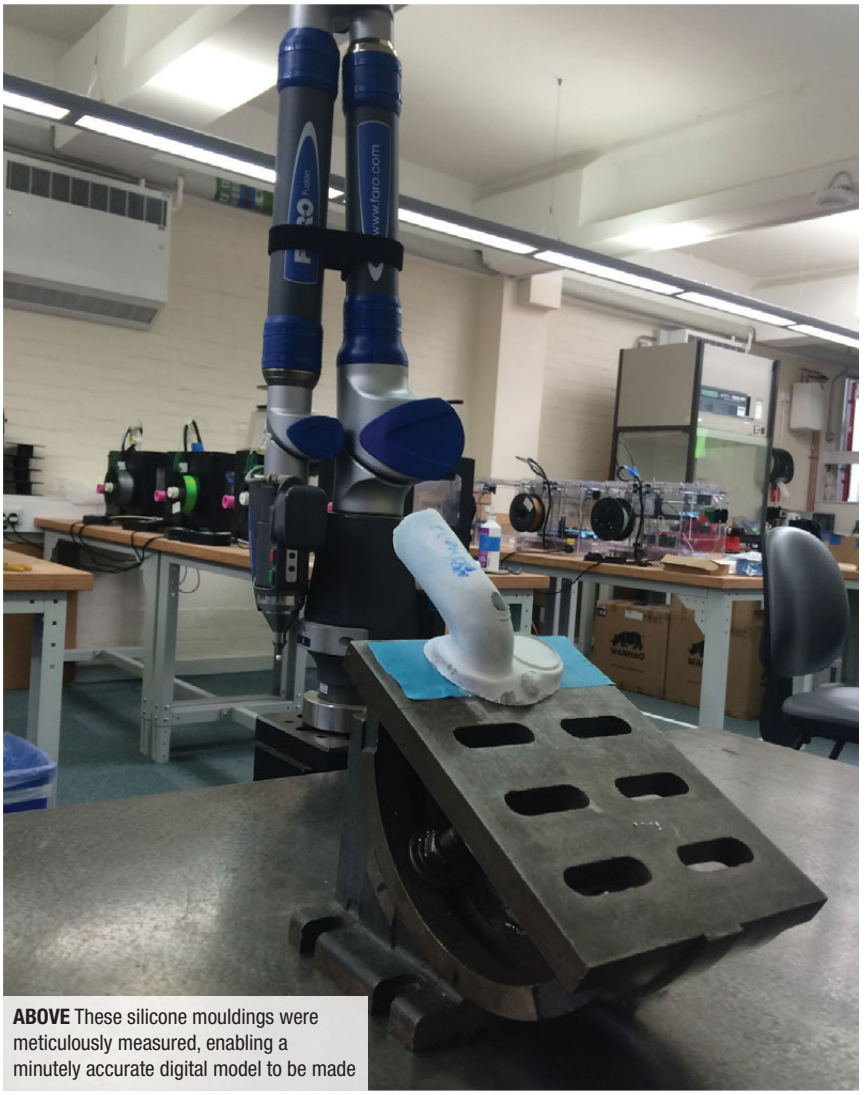
“We were looking to enhance combustion through increased fuel and air mixing, and with better fuel and air mixing you get more uniform flame propagation, and with that you get better performance.

“Anyway, the results of the test were actually very interesting because the TN Engineering modified head produced significantly more tumble than the original, which is based around the fact that the inlet port curvature and surface blending was so much smoother. By minimising sudden changes in shape, which leads to separation and momentum loss, more energy is transferred into tumbling motion into the cylinder.”

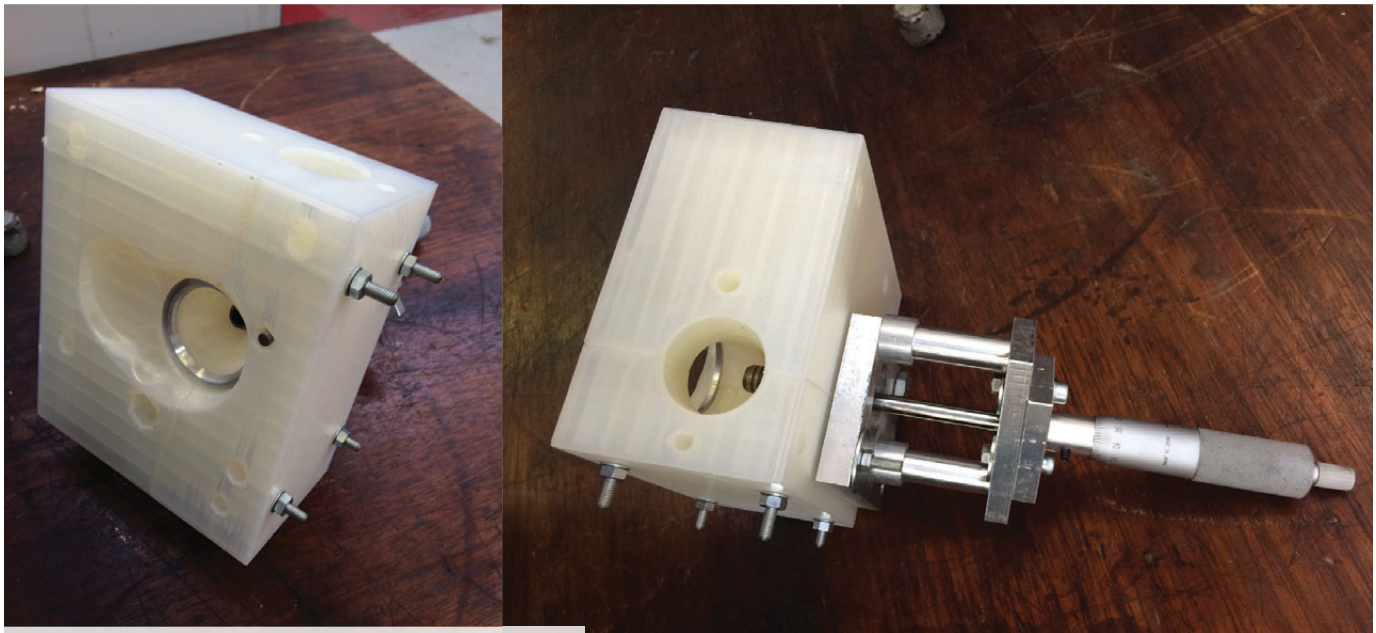
The results allowed the performance improvements associated with the modified head to be understood more clearly. The head’s discharge coefficient increased by a factor of 1.3 at 25 per cent valve lift, 1.2 up to 50 per cent and 1.1 up to 100 per cent lift. Of particular note here is that the improvements are greatest at lower valve lifts, allowing engine performance gains to be found without necessitating high valve lifts and ramp rates, which can over stress vintage valvetrain components and sap power from the crank.

In terms of air motion, which was measured at 5, 20, 40 and 60 mm away from the gas face of the cylinder head, tumble increased by a factor of 1.5 at 50 per cent valve lift, and 2.0 at 75 per cent valve lift and upwards. It is interesting to note that this peaked at 20 and 40 mm away from the head, which ties up well with the piston position during the inlet stroke of the running engine.

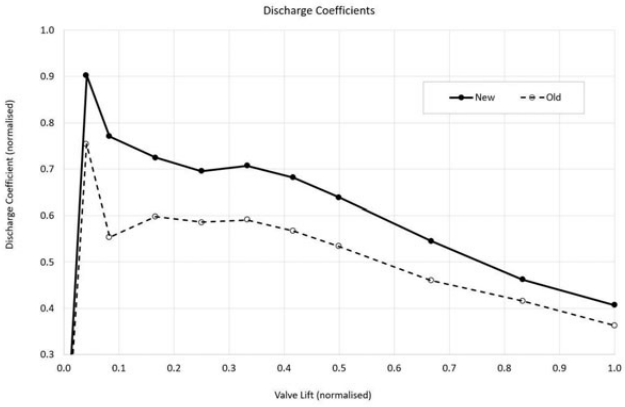
This increased level of tumble, which is the head over heel rolling of the air and fuel mixture around a horizontal axis within the cylinder (originally termed ‘barrel swirl’ by Keith Duckworth), is very desirable because it much more thoroughly mixes the air and fuel before ignition and is one of the reasons the race head performed so well on track. Tumble is also preferable to swirl in a homogeneous charge petrol engine because when the piston rises on the

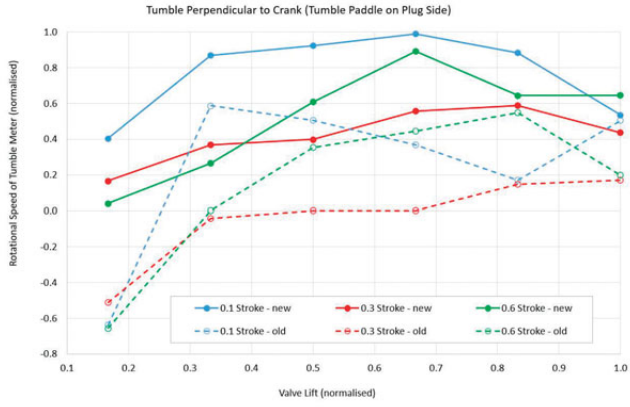


ABOVE These silicone mouldings were meticulously measured, enabling a minutely accurate digital model to be made



ABOVE A 3D printed port enabled Leston to put his theories to the test





compression stroke, the volume at the top of the cylinder in which the mixture can tumble is reduced and the effective radius of the tumbling mixture reduces correspondingly, and in accordance with the conservation of angular momentum, the rate of the tumble increases, mixing the air and fuel mixture even more. In short, tumble leads to better dispersed fuel, a bigger bang, and more power.

Leston wasn't satisfied though, and sought to improve the tumble even further. To do so, he first took silicone mouldings of the standard and race heads, allowing the ports and the chamber geometry to be accurately measured with a 3D laser scanner. This allowed him to build up a 3D digital CAD model of the head, which he could modify with the aim of promoting tumble motion. This model was then 3D printed allowing Leston to put his research to the test.

Preliminary results indicated an even more consistent tumble air motion. With the bench being able to measure not only the amount of swirl and tumble but also its direction, Leston was able to see that in the unmodified head the direction of the swirl and tumble was reversing at various locations in the cylinder, meaning that energy that could have gone towards mixing air and fuel was being lost. In the new 3D printed head though, Leston's changes were able to further reduce this switching of direction to make the mixing of fuel and therefore the engine itself, even more efficient.

PHYSICAL LIMITATIONS

Even with the advantage of 3D scanning and computer models, achieving these results wasn't easy given the limitations faced by Leston. You are limited by the cylinder head itself because once you start trying to machine ideal port shapes, you risk breaking through to the water jacket, oil passages or stud cavities. That means there is only so far you can move things around.

"In the end we took the inlet port entry up and across, and blended the port shape to suit, but that small change was enough to make a useful difference. There is always the risk when making changes like that that you can make things go the other way, but it actually enhanced the old TN Engineering race head.

"It was also important to think about the payoff between flow rate and swirl and tumble," he continues. "You know if you were to create loads of tumble but decreasing the flow-rate by half you'd make things worse. So, from the start we were trying to develop both."

Allenby-Byrne is himself a proponent of this way of thinking, he says that many of the old cylinder heads already flow very well at high levels of valve lift, with improvements to the flow being negligible past about 10 mm. To him this meant there's no point "chasing a couple of extra ▶

CFM [cubic feet per minute] once you get past half an inch valve lift, because they are never going to open that much anyway". Instead he looks to make improvements that would benefit a racer in the real world.

"The cylinder head flow mirrors the torque curve, in that you're getting as much airflow through the cylinder head as quickly as you can. The sooner it starts flowing the better, and if you lose CFM at the top end it doesn't really matter because you've got it lower down.

"And if you think about it the valve's only fully open for about 20 degrees [of the camshaft] but in total the cam is going to open the valve for 300 degrees, or perhaps even more. This means that on average the valve is only open about four or five millimetres.

"So when I start a head, any head, I'll always look for the flow at a quarter inch lift, because I figure that's where the valve spends most of its time. So, I might not have 135 CFM to boast about down the pub, but I still have 130, and, what's more my average flow is still three or four CFM higher over say 0 – 10 mm valve lift. My average flow is three – four per cent better."

ABOVE Leston, and investigations like his, are sure to see historic racers getting faster for years to come

SOFTWARE ANALYSIS

"I've recently gone down the same route but a little bit more extremely," he adds. "I've kept the ports and the throat tighter to get higher gas speed, with the engine producing the same numbers but at a broader spread, running with smaller chokes and burning less petrol; I've effectively made it more efficient."

One of the other tools that has helped Allenby-Byrne get to this point, alongside his oily books, is Performance Trends Engine Analyzer, which as the name suggest is an engine analysis tool, but one that is most valuable when working on weird and wonderful engines where parts might not be readily available; the Isuzu Bellett that Throbnozzle has in at the moment, for example. The tool means that the heads can be flow benched, then all the data such as port size, valve size, the basic engine geometry, details about the carburettors and other specificities about things like the type of fuel being used can be inputted. Then, with all this information Engine Analyzer can help understand what kind of camshaft would work well. "It helps you pick a cam that best suits the head. Does it flow well at low lift, does it flow well at high lift, and does it do both, or neither, and it can calculate all that in relation to the valve size and the port size."

Using software to predict whole engine performance is also part of the work being carried out in the university labs, in this case using GT Suite software, which Dr Coren points out, makes further use of the experimental data collected.

"This aspect of the historic engine work is just beginning here, but already the usefulness of accurate test rig data to better predict the influence of increased air flow, or increased tumble, as well as bespoke valve lift profiles, is looking promising in terms of methodical engine development. Combined, this work has allowed us to target cylinder head airflow performance improvements in terms of valve lift: low lift (valve seat geometry), medium lift (valve shrouding and chamber shape), high lift (port shape and size). By calculating the flow under valve lift profile curves, the overall effect of local percentage gains can be predicted and targeted. The air motion data, in the form of tumble or swirl, is a key feature of this work and allows us to better model the combustion efficiency; a highly complex field. One way to think about this is; increased airflow leads to improved volumetric efficiency, whereas improved air motion leads to improved combustion efficiency. If you can achieve both, you will be able to produce more torque and power."

All this analysis has helped Leston develop a thorough understanding of the way the air moves into the cylinder, he is confident there is more to be done, and, given the chance would like to apply his scientific approach to other areas, or even go into even greater levels of detail in terms of airflow.

"In the combustion chamber, it would be good to look at shrouding and see what could be removed, or potentially make it so there was even more meat in the combustion chamber itself to see if we could direct the flow where we wanted it to go...It would have been nice to play around with the combustion chamber itself and see if we could make a design that was even better at enhancing tumble."

It is ideas like these that ensure historic cars keep getting faster; pushing for a bit more is always going to be in the nature of racers. With this being the case, it seems certain that scientific approaches, and delving deep into the minutiae of an engine's operation, will be how the next improvements which triumph at future historic meetings will be found. HRT

ABOVE Leston, and investigations like his, are sure to see historic racers getting faster for years to come

A new lease of life

How ZF has given Walter Röhrl's championship winning transmission fresh legs

THE Ascona A with which Walter Röhrl and Jochen Berger won the European Rally Championship in 1974 – paving the way for the German driver to become a rally-driving legend – was unforgettable. With this title and many other international overall victories, the Ascona should have become a rally icon. After being used endlessly, the ZF transmission was worn out and Röhrl's championship-winning car was until recently left to gather dust for a great many years in the hallowed halls of Opel in Rüsselsheim.

The champion transmission has now been overhauled at ZF Tradition on Lake Constance, providing double the delight for the rally scene – this is because the Ascona is celebrating its 50th birthday this year and ZF has recently also started offering spare parts for the S5-18/3 once again.

SPORTS TRANSMISSION

In the 1970s, most passenger cars were equipped with a four-speed transmission as standard. The five-speed version was, in most cases, offered as an option, of which ZF's S5-18/3 was one. This sports transmission is now more popular than ever and is used very regularly in historic rallying across Europe, including the UK. ▶

> "In hard rally runs, it is inevitable that wear will occur"

ABOVE Rebuilding: In ZF's historic workshop, S5-18/3 transmissions are being overhauled by Christian Restau

BELOW Legendary success: Walter Röhrl and Jochen Berger in the Ascona plant on their way to winning the European Rally Championship

ABOVE A legendary winner: Walter Röhrl

The five-gear Synchroma transmission (S5) was also installed in numerous designs in vehicles from almost every manufacturer. With a maximum input torque of 180 Nm in the third version (18/3), the sports transmission was installed in many Opel models, including the Commodore, Ascona, Manta, and Kadett, as well as in the Alfa Romeo Montreal, Fiat Abarth 131 and 130, Ford Escort, Capri 2600 RS, 3.0 Essex and Escort, and the BMW 2500, 2800, and 2002 models.

THE IMPORTANCE OF SEALS

The most common reasons for a transmission being overhauled are worn synchroniser rings and bearings or defective seals. After hundreds of thousands of gear changes, the gearing of the gears can be ground down or even broken off, which means that the gears can no longer engage and emit strange noises.

It is more dangerous if a seal is no longer intact, as oil can leak out and block up the transmission. Here, the oil used is also very important – for the S5-18/3, Christian Restau from ZF Tradition recommends changing the oil once a year and to use the SAE 30 engine oil. SAE 80 transmission oil can also be used as an alternative.

In hard rally runs, it is inevitable that wear will occur and specific spare parts will be needed as a result, which is why ZF has started to reproduce gear sets and synchroniser parts for the 2.3 to 1.0 transmission ratio used extremely frequently in rally cars. These are ▶


ABOVE Manual work: smaller tip chamfers on the tooth tip can be smoothed using the turbo grinder

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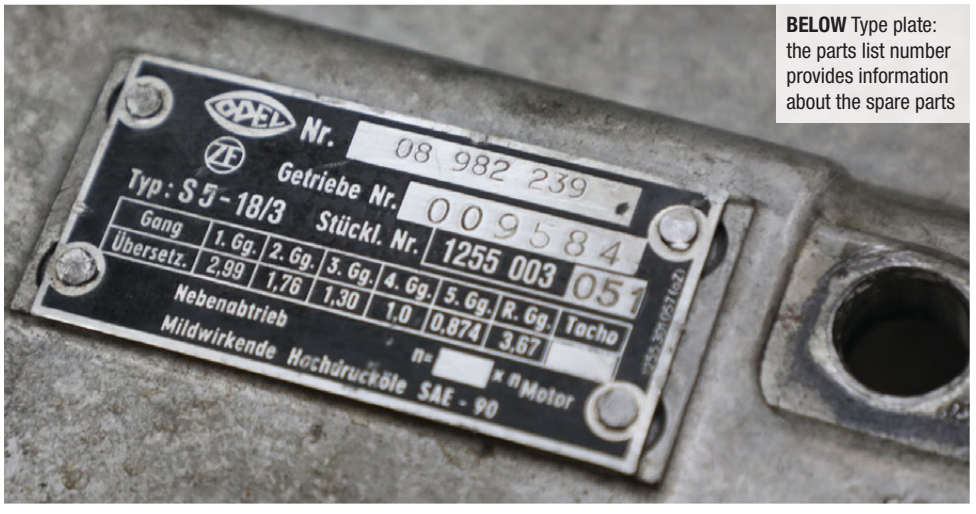
ABOVE A legendary car: The Ascona rally car by Walter Röhrl

offered by ZF as a complete repair kit for both Ford and Opel that includes shafts, wheels, synchroniser packages with sliding sleeves, bearings and variants of sealing rings. Kits for both makes are currently available and have been used successfully at rally meetings. Other transmission ratios will be added to the inventory as demand dictates. Additional bespoke transmission ratio applications and parts are available on request.

At first glance, the different transmission designs can be distinguished by the clutch bell housing and the length of the gearshift arm. If you would like to know exactly which ZF transmission you have, simply look for the parts list number on the type plate and then contact ZF Tradition and provide them with this number.

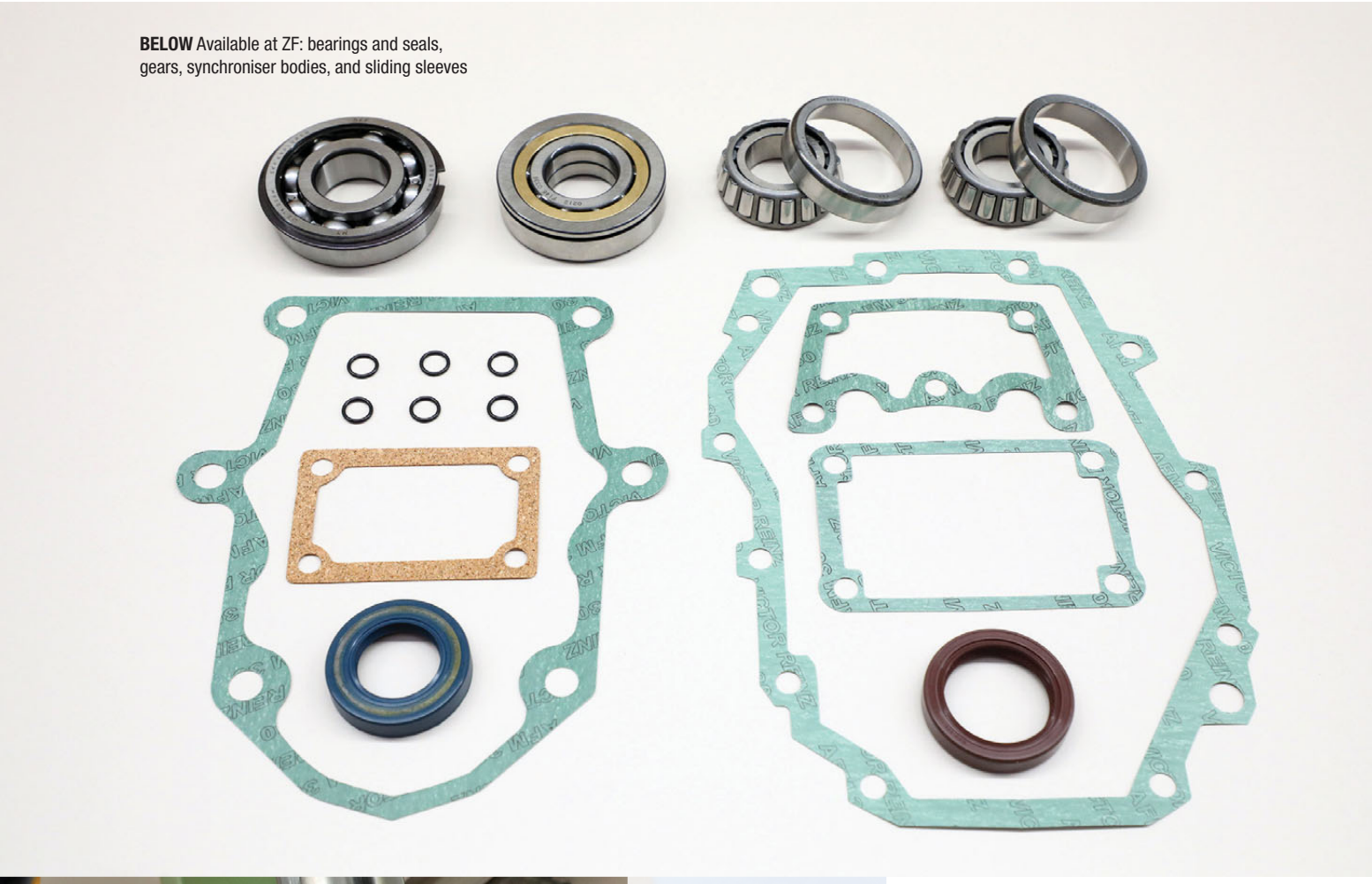
ZF TRADITION

At ZF Tradition, the transmission can be completely overhauled or just the wear parts restored. An overhauling of the wear parts



BELOW Type plate: the parts list number provides information about the spare parts

BELOW Available at ZF: bearings and seals, gears, synchroniser bodies, and sliding sleeves



BELOW The heated tapered roller bearing is pressed onto the countershaft using the hand press

with bearings, seals, and synchroniser rings costs approximately €1,800 at ZF and includes a subsequent test run on the test bench. A complete gear wheel set is available for around €3,800. During the installation of these gear wheels, the transmission ratio can also be changed, as the replacement of the appropriate countershaft is included in this service. The exact costs can, however, only be calculated if the transmission has been dismantled and tested.

GUARANTEED PERFORMANCE

Incidentally, the maximum input torque stated in the model name refers to the worst-case gear wheel configuration – it should therefore be seen more as a guaranteed performance value. In total, there are more than 250 different parts lists for the S5-18/3, each containing descriptions of the individual parts used for each vehicle type. The gearset used in Röhrl's Ascona can deliver up to 300 Nm in order to put the 206 hp generated by the 2.0-litre cross-flow four-cylinder engine on the track. HRT

Refabricating a modern F1 car

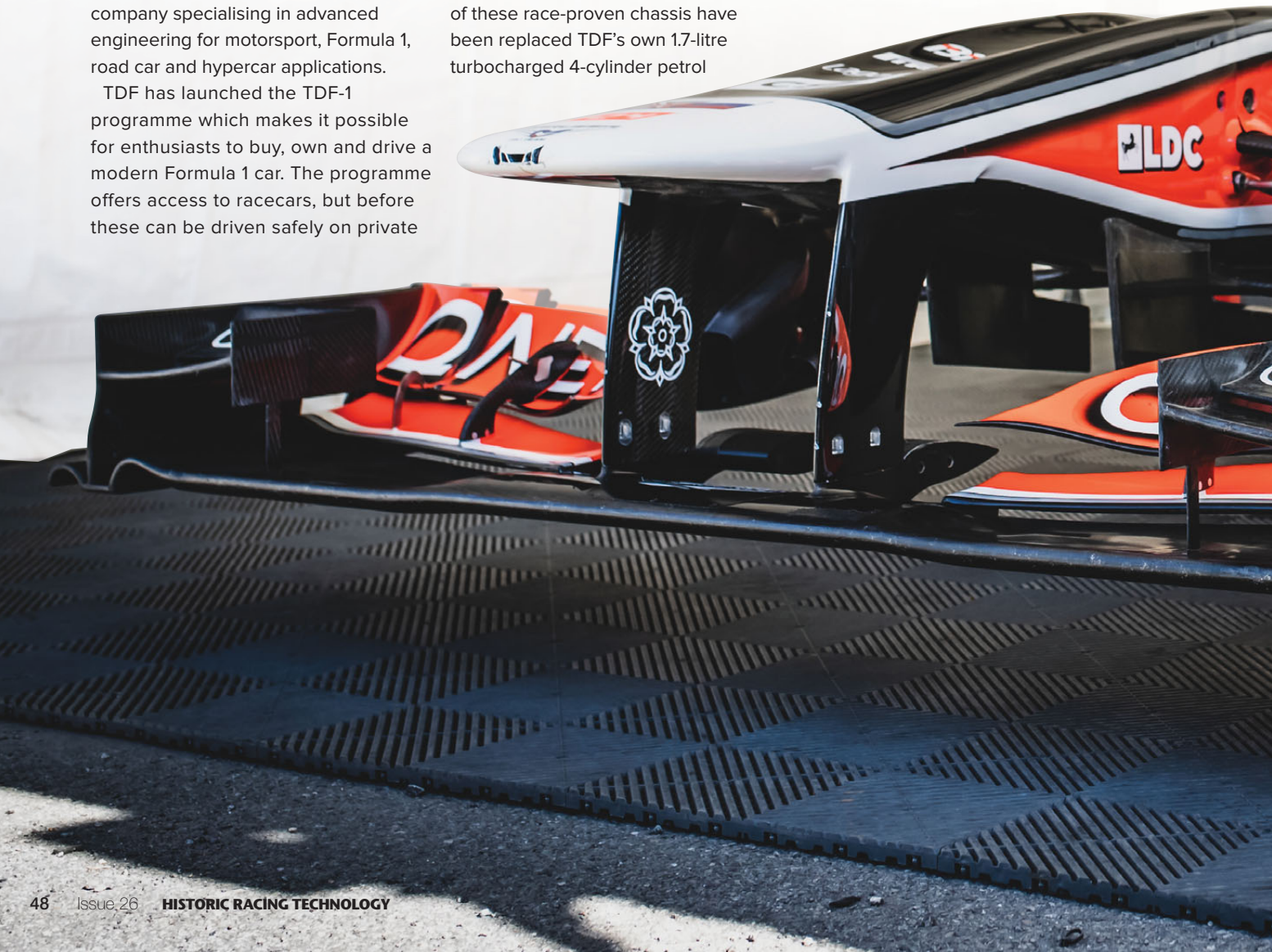
William Kimberley investigates how a programme makes it possible for enthusiasts to buy, own and drive a modern F1 car

FORMULA 1 motor racing has millions of fans across the world, and most would give almost anything to step into the cockpit of one of the sport's high-performance cars and experience the thrill of driving it. For a lucky few, this has now been made possible by Tour-de-Force Power Engineering (TDF), a Bedfordshire-based company specialising in advanced engineering for motorsport, Formula 1, road car and hypercar applications.

TDF has launched the TDF-1 programme which makes it possible for enthusiasts to buy, own and drive a modern Formula 1 car. The programme offers access to racecars, but before these can be driven safely on private circuits, numerous modifications are needed. Every car produced as part of the TDF-1 programme is built at TDF by former F1 engineers and mechanics who have previously worked for teams such as Williams, Mercedes, Marussia and Renault.

The original 2.4-litre V8s that were once found under the skin of these race-proven chassis have been replaced TDF's own 1.7-litre turbocharged 4-cylinder petrol engine in the back. TDF says the new powerplant is aimed at making the package easy to run independently rather than with a team of mechanics. Better still, it develops 600 bhp so it's no slouch. However, engine power and throttle mapping are completely adjustable to driver requirements.

Each TDF-1 weighs just 600 kilograms



too, resulting in a power-to-weight ratio of 1,000 bhp-per-tonne — more than 250 bhp-per-tonne than that of a Bugatti Veyron Super Sport.

All aerodynamic surfaces are retained from the F1 season the chassis originally raced in, including Drag Reduction System(DRS). This could be used in a Formula One race at the time on-demand for improved lap times by opening a flap in the rear wing to reduce drag. TDF has re-engineered the system slightly, still allowing the driver to use it on command though the system will automatically close if it senses a sudden steering input, throttle lift or application of the brakes to ensure the car is not unsettled.

Optional onboard starter and radiator fans allow for single person operation of the car in all environments whilst the advanced electronics package removes the need for preheating the car or any external "packs" usually associated with running a Formula One car. In addition, a complete set of pit equipment, circuit spares/consumables and flight cases for movement of the car are included.

F1 supplier OZ Racing have produced wheels exclusively for the TDF-1 programme which coupled with the choice of Pirelli P-Zero Formula One tyres in hard, medium, soft and wet compounds allow the driver to experience true Formula 1 levels of downforce and grip.

> **"The choice of Pirelli P-Zero Formula 1 tyres in hard, medium, soft and wet compounds allow the driver to experience true F1 levels of downforce and grip"**

REVERSE ENGINEERING

In many cases the original design documentation for these unique vehicles is simply not available. The first step then is to generate accurate dimensional data for reverse engineering the vehicles and key components. This is essential not only to facilitate the design and implementation of the modifications needed to make the vehicles safer to drive, but also to support on-going maintenance and repairs that might be needed should a vehicle be damaged in a race.

Design engineering company ES Products and Design Ltd was tasked ▶

ABOVE The re-purposed and improved 2011 Marussia MVR02 that has been constructed by Tour-de-Force Power Engineering

ABOVE Whether it is the Marussia or the 2012 F1 Sauber, both are powered by TDF's own 1.7-litre turbocharged four-cylinder petrol engine in the back

TDF-1 Specifications

Chassis:	2011 Marussia MVR02 or 2012 Sauber C31 – carbon fibre monocoque and nose box
Suspension:	Double carbon fibre/carbon shrouded wishbone suspension front and rear. Titanium flexures/spherical links. Ohlins dampers, torsion bar front spring, coil rear spring
Engine:	TDFM600T 1730CC turbocharged, limited to 9000 rpm, producing circa 600bhp. Installed as a stressed member
Transmission:	Six speed semi- automatic gearbox with reverse gear, hybrid magnesium and carbon fibre construction, electronically controlled, installed as a stressed member
Electronics:	Cosworth/Pi/Pectel/ GEMS/TDF Electronics package including onboard data logging system
Brakes:	AP Racing 4-piston callipers.
Brake Discs/Pads:	Hitco carbon/carbon.
Clutch:	AP Racing multi-plate with fly-by-wire clutch control from steering wheel paddles
Steering Wheel:	TDF constructed bespoke wheel with OLED display, driver controls, gearshift and clutch paddles
Seat/Belts:	Anatomically formed composite with 6-point HANS compatible harness
Fuel System:	130L FIA FT3 homologated fuel cell with triple lift pumps and pressurised collector
Fuel Type:	Sunoco 260GT Plus
Tyres:	Pirelli P Zero
Wheels:	OZ Racing
AERODYNAMICS:	As per relevant season with DRS system

with project managing the design work for virtual assembly of the vehicles and with the reverse engineering of key components. To produce the dimensional data needed to underpin this work, the company chose T3DMC, a leading specialist in 3D scanning and data acquisition, to perform precision 3D scans on the vehicles. Data from these scans, augmented as necessary by manual measurements made on components, is transferred to a Siemens NX CAD system which is used for modelling and design.

DIGITAL TWIN

"We were asked to scan the Formula 1 cars for reverse-engineering purposes and also to create a digital twin of the vehicles," says Scott Robinson, product sales manager at T3DMC. "The digital twin means that design engineers can 'virtually assemble' the modified vehicles so that they can easily see and correct problems before work starts on the real vehicles.

"By using our handheld KSCAN 3D scanner we were able to make extremely accurate scans of the

panels and of the tub that houses the cockpit. We scanned the whole of the exterior (surface A) of the vehicles, then took the panels off and repeated the process to provide a surface B scan. The whole job took just a few hours, compared with the days of tedious work it would have needed to make manual measurements."

BLUE LASER TECHNOLOGY

Portable and easy to use, KSCAN quickly captures accurate 3D data and is ideal for use in reverse engineering projects as well as in quality and inspection applications. KSCAN's exceptional capabilities result from its use of blue laser technology, which easily captures extreme details with 10 µm resolution, complemented by a red laser mode that provides an incredible 600 mm scanning window.

With its Intelligent Edge Detection feature, KSCAN can operate in confined spaces, such as aircraft cockpits and vehicle interiors and, thanks to its portable probe with a capability of 0.03 mm, it is well suited to demanding inspection applications such as determining the dimensional accuracy of drilled holes, trim, edges and cylindrical components. With built-in photogrammetry features, this portable scanner boasts volumetric accuracy of up to 0.035 mm/m and makes easy work of scanning large objects such as car panels or dashboards.

> "The first step then is to generate accurate dimensional data for reverse engineering"

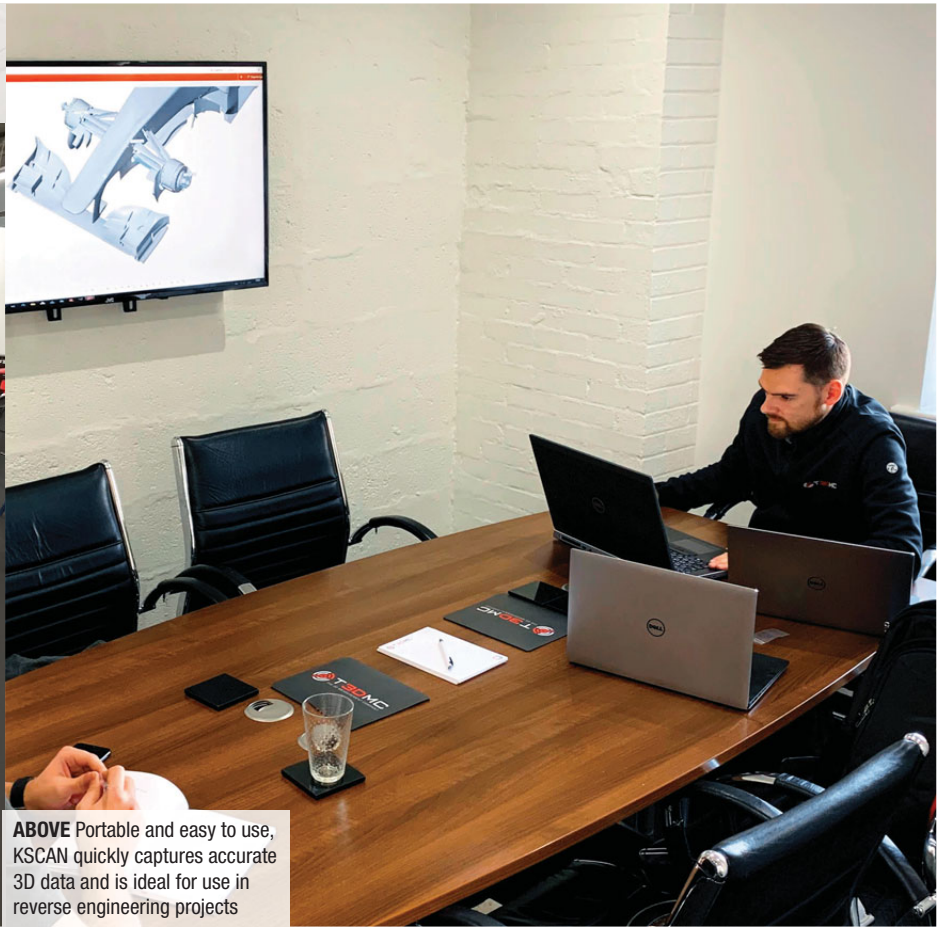
"We were very impressed with how quickly and easily we were able to carry out the many scans required using KSCAN," says Edward Smith, director at ES Products and Designs. "The CAD drawings we produce from the scan data will be used for manufacturing components and spares so even if a car is badly damaged on the track it can be rebuilt to exactly the same specification, which gives extra peace of mind to the owners of these spectacular vehicles."

"Working with T3DMC and seeing the capabilities of KSCAN up close was an excellent experience from beginning to finish", explains James Densley, chief technical director at TDF. "Capturing the data for our circuit cars was a really fast and straightforward process that was easily carried out in our own workshop. I would thoroughly recommend T3DMC's measurement capabilities, modern scanners and expertise in unique and complex automotive projects. They get the job done!"

Buyers of a TDF-1 will also be offered a comprehensive driver training course to allow them to learn the insides and out of the car before heading out on track. Coaching will be provided by Jessica Hawkins, who currently competes in the W Series.

No pricing has been confirmed, though expect the TDF-1 to cost many, many pounds. HRT

BELOW Great effort goes into generating accurate dimensional data for reverse engineering the vehicles and key components



ABOVE Portable and easy to use, KSCAN quickly captures accurate 3D data and is ideal for use in reverse engineering projects

Silent Roar

Indy 500 champion **Parnelli Jones** discusses with David Linden driving the first turbine-powered car in the Indy 500

WHEN Parnelli Jones, Indianapolis 500 champion, was given the opportunity to drive the turbine-powered STP sponsored car owned by Andy Granatelli in the 1967 Indianapolis 500, he had a difficult decision to make. The Granatelli chassis was constructed around a Canadian-built Pratt and Whitney, 550 horsepower, ST6 helicopter turbine engine. The vehicle featured the driver seated on the right side of the car beside the power plant, which was housed on the left. Rather than emitting the roar of its piston-powered rivals, the turbine, as one racing journalist described it at the time, gave off a sound that was something of a cross between "a vacuum cleaner and a street sweeper."

Unhappy with the early season testing performance of his own Shrike chassis, and with Granatelli eager for the use of his services, the 1963 Indianapolis 500 winner had to decide on a course of action when the month of May arrived.

MONEY AND PUBLICITY

"Money was the decider," says Jones. "Well, would you do it for $25,000? Would you drive (the car) at Indy?" Jones asked himself. "No was the reply. I then asked myself would you do it for 50,000? Again, I said no. I then asked if I would do it for $100,000 and I said, yeah, for $100,000 I would probably do it. So I told Andy I wanted $100,000 to drive the car. He balked a little bit at this, but he paid me."

Jones then tested the car at Phoenix. "I didn't run all that quick, but it seemed to be stable and I felt that one thing about going to Indy with it would be the fact that I knew I was going to get a lot of publicity as it was so different. I felt that if I could make the race, I'd just go from there. I had no idea it was going to be as good as it was."

TURBINE CHALLENGES

Jones, the first man to officially break the 150 mph barrier at the Speedway in winning the pole in 1962, discusses both the strengths and the challenges of driving the STP-sponsored turbocar.

"I started running the car at the Brickyard and while it didn't have a lot of horsepower, it had tremendous torque and it would really come off the corners hard. That made it good across the short straight-a-ways, and made it good going out onto the long ones except that about halfway down them, and the straight-a-ways were five eighths of a mile long, it had reached its maximum speed. So guys like AJ Foyt, Mario Andretti and Al Unser and all the others who were all running 10-15% nitro in their methanol and running light fuel loads, would start passing me.

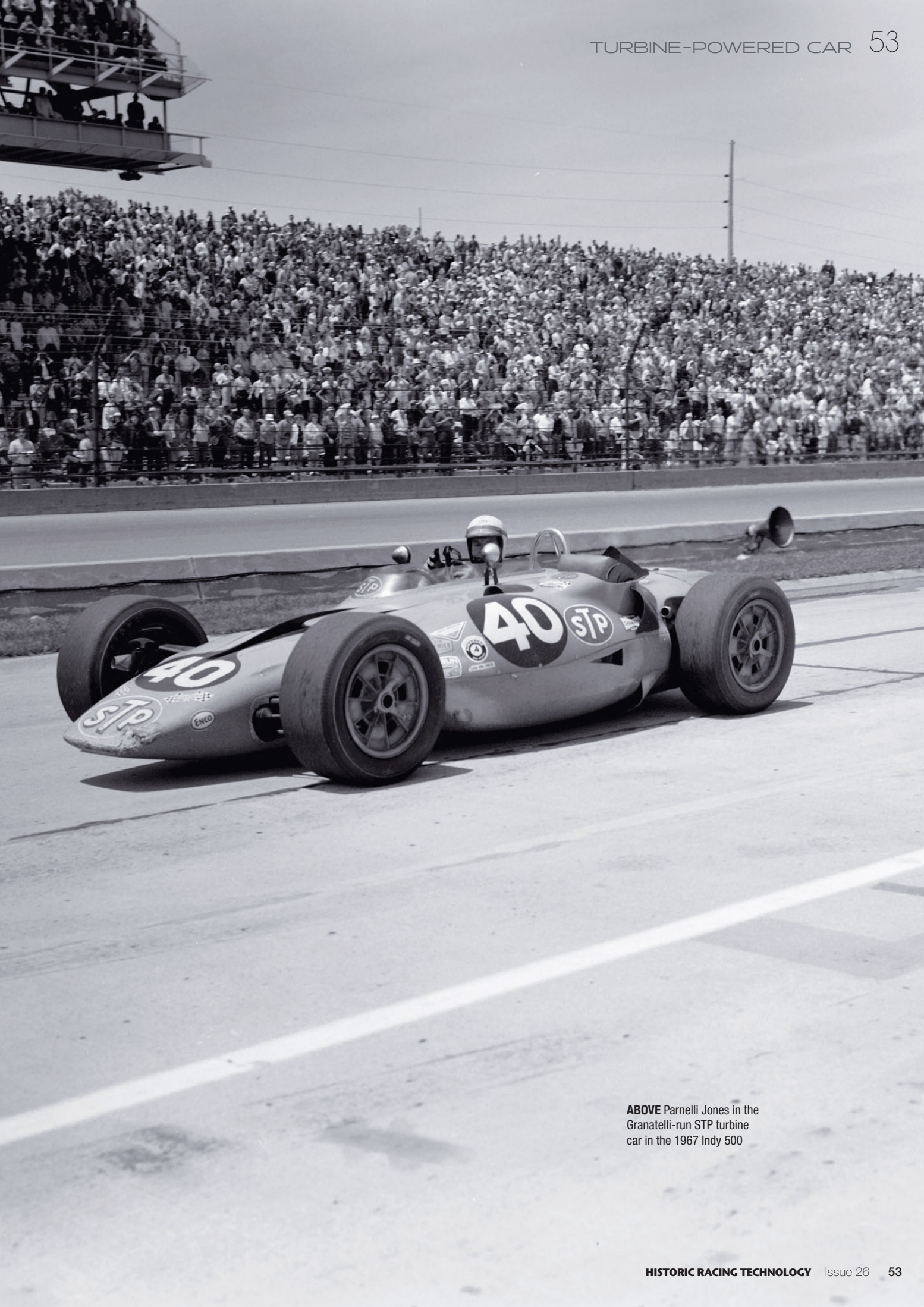
> "First of all, it had a three second delay throttle time – it would go one, two, three, before it really took off"

"And, a bit like a model airplane, when you wind up the rubber band and you first release it, it has a tremendous amount of thrust and torque. It takes off real hard, but then peters out as it goes along. Well, that's kind of the way the turbine did.

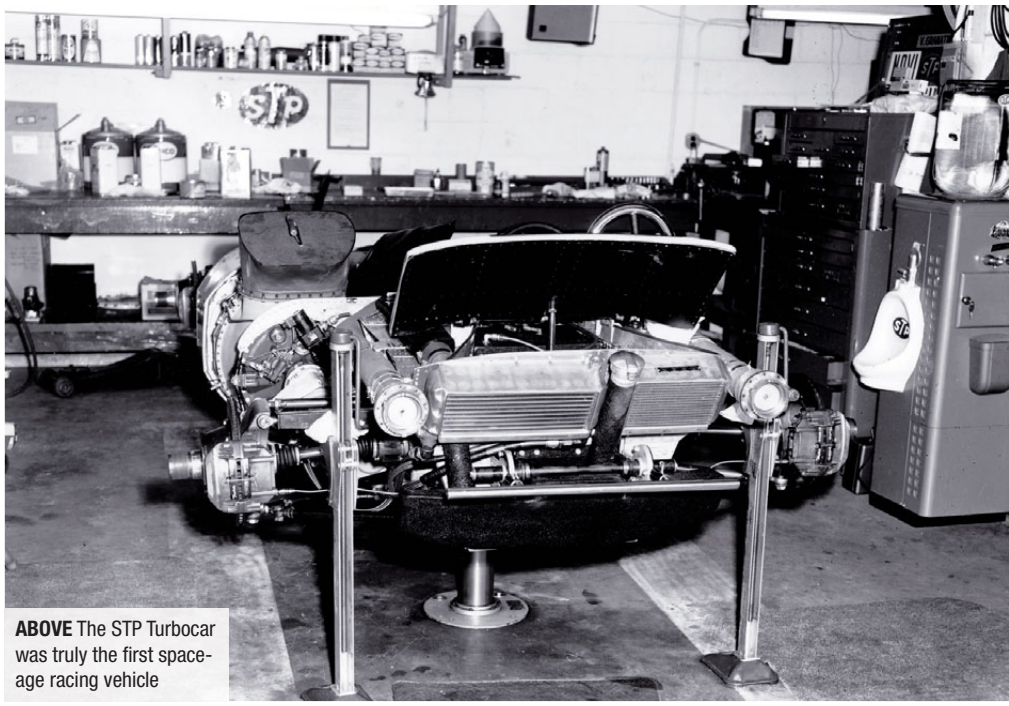
"You could put a taller gear ratio in there, and make it accelerate a little bit farther down the straight-a-way, however, you couldn't run as quick in lap time."

DRIVING STYLE TO SUIT THE TURBINE

The 1963 winner describes how the turbine engine altered his driving style at the Speedway. "First of all, it had a three second ▶



ABOVE Parnelli Jones in the Granatelli-run STP turbine car in the 1967 Indy 500



ABOVE The STP Turbocar was truly the first space-age racing vehicle

delay throttle time – it would go one, two, three, before it really took off – same way when you backed off of the throttle. It was as if the throttle was stuck. I mean, it was still running. When you backed off the throttle there, it was still running hard. You had to use the brakes to make it slow down. You had to do a little guessing. It wasn't all that easy to drive."

Jones felt that with high-powered nitro-enhanced fuel mixtures generally not used during race competition and with the added burden of carrying a full load of 75 gallons of fuel, the opposition would come back to him at the drop of the green flag. However, running with a full load of the jet fuel used to power the turbine did not seem to bother the Granatelli chassis.

"We'd put on a full load of fuel," says Jones, "and it didn't seem to make a lot of difference – and we ran just as fast during the race as I qualified. My qualifying speed (166.075 mph) was a couple miles an hour off, I guess, to Mario's who was on the pole at 168.982 mph, but when he took his fuel (mixture) out, his speed would come down past where I would run.

"I thought, that on race day that they probably weren't going be able to drive back and overtake me, and basically that's what happened.

"The car did handle great...it was a four-wheel drive car. The competition accused me of sandbagging because when we were running in practice, they were driving by me at the end of the straight-away and they thought that I was lifting the throttle, which I wasn't. I had no reason to sandbag or anything like that."

However, there were those who were sceptical as to whether the STP turbine was showing its full potential in practice.

"These people started sending me

BELOW The revolutionary turbine car led the 1967 Indy 500 for 171 of the 200 laps

ABOVE The cockpit and engine were located side by side in the chassis, the result of three years of design and construction and over half a million dollars, a huge amount at the time

sandbags in the mail," says Jones. "Of course, I was having a lot of fun with it myself. I was joking with them and before the race, I said, 'tell me how fast you guys are going to run during the race so I know where to set the screw'."

CONSERVATIVE POWER SETTING

The STP team was careful with the amount of engine power based on the recommendations made by a representative from the turbine engine manufacturer.

"We were very conservative on the power setting. If you turned 'em up too high, then you would melt the blades out of 'em," says Jones, "and with this engine alongside you, you certainly don't want to do that. We had a guy there from Pratt and Whitney that was making the decisions on the engine.

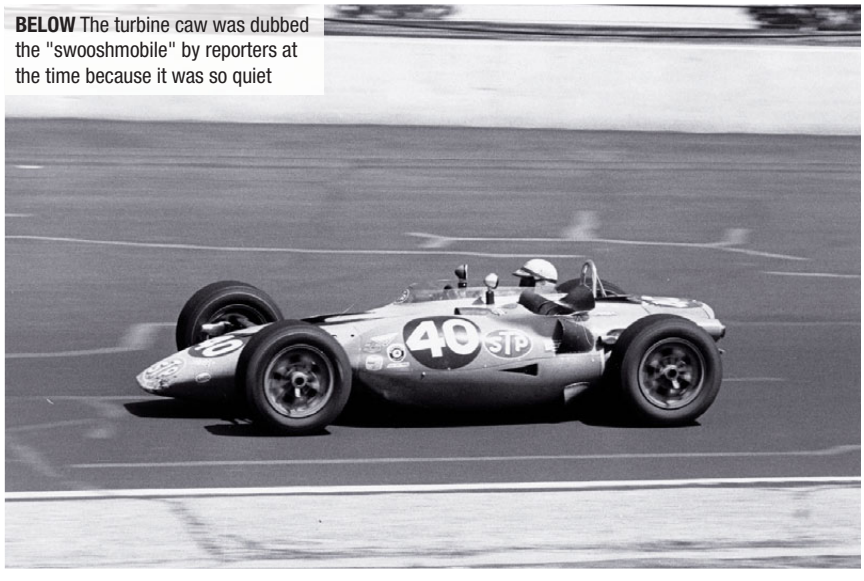
"If I'd have known what I learnt from that race, we could have run the car the following year and we could have turned up the power even more."

TURBINE DOMINANCE

Starting in sixth position on race day, Jones' # 40 STP turbine-powered machine passed all but one car ahead of him by Turn 2 of the opening lap, and then overhauled polesitter Andretti for the lead on the backstretch. From there, Jones began undisputed dominance of the 51st Indianapolis 500 which would see him lead 171 of the 200 laps.

"When the race started, the car's handling was great. I started on the outside of the second row, which was my worst starting position in the seven ▶

BELOW The turbine caw was dubbed the "swooshmobile" by reporters at the time because it was so quiet



BELOW Engineers tend the turbine car during practice

years that I ran at Indianapolis, but when the race started, I drove around Gordon Johncock, and everybody on the outside in the first turn, and, in perfect timing, I caught Mario, coming out of turn 2. I went underneath him, and passed him, and (in) half a lap I had the lead.

"All the cars I passed, except for Mario, were all in the corner. And, really, passing Mario was in the corner—ya' know, comin' off."

Jones credits the car's excellent handling not only to chassis setup, but also to the car's four-wheel drive system and to running all rear tyres on the car as well.

"First of all, you had a little more rubber on the ground because now you're running four rear tyres. Although I'm not an educated engineer, I was kind of a practical engineer. I had built my own cars and knew how to set them up, and so I worked with the car and got it handling really well."

Although the race was stopped after 19 laps due to rain, at the restart the following day, the STP turbine continued to be the class of the field. While leading on lap 52, though, Jones ran into trouble when he got caught in a spinning tangle with rookie Lee Roy Yarbrough and both cars ended up in the infield grass.

Jones felt at the time that the quietness of the turbine engine might have been a factor in the incident. "This car was so quiet, and when I pulled up alongside him across the short strait-a-way, it was as if he never

knew I was there. He just turned down into me, so I just turned down into the infield and we both spun."

Two laps after the mishap, though, Jones regained the lead and continued his drive to apparent victory.

WITH A WHIMPER

However, on lap 197, some seven and one-half miles from the chequered flag, a six-dollar bearing failed in the gearbox and left the STP machine coasting toward the pits.

"You, know, I never was a very smart race driver," says Jones. "In fact, I was very stupid now that I look back on it. Because the car was so good, I could have taken it a lot easier," he says, "especially going in and out of the pits. Having so much torque leaving the pits, it probably damaged the bearing in the rear end, and that's what put the pressure on the bearing.

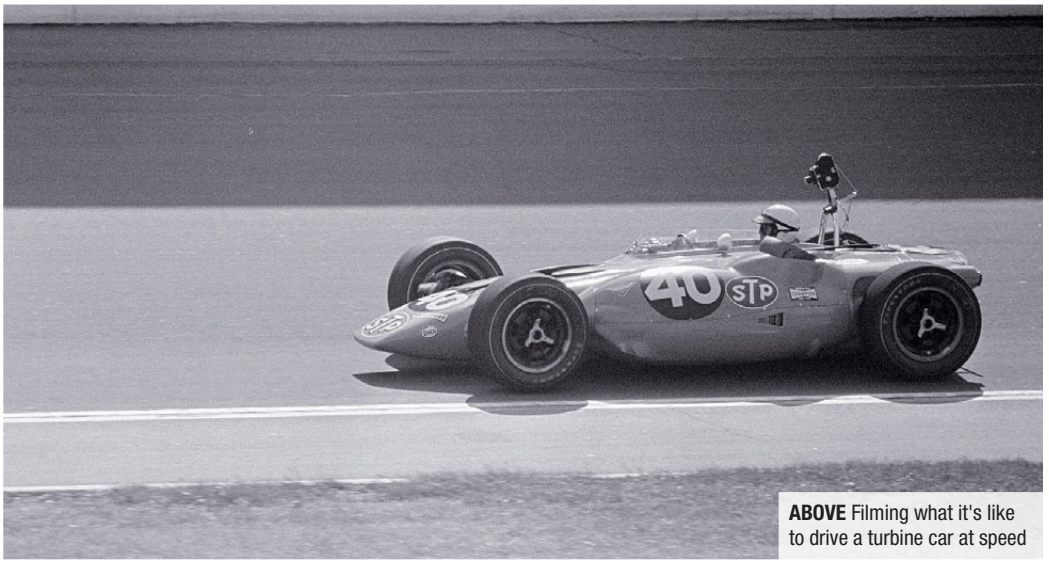
> **"The engine was still running but it just wouldn't connect up to the tyres"**

"In fact, it was so close to the end of the race that I was really taking it easy at that point. I was really soft-pedaling it, when all of a sudden it was just like it was in neutral. The engine was still running but it just wouldn't connect up to the tyres."

Foyt inherited the lead and took the chequered flag to join the exclusive group of three-time winners of the Indianapolis 500 Mile Race, which included drivers Louie Meyer, Wilbur Shaw, and Mauri Rose.

Recalling his feelings back in the STP pit, Jones says, "I was in total shock, myself, being that close to the end, and I had almost a lap lead. Foyt was right in front of me and... I could have passed him anytime I wanted to, but I should have taken it easier earlier in the race and that's all."

The turbine-powered car was credited with a sixth-place finish. ▸



ABOVE Filming what it's like to drive a turbine car at speed

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DECISION TO RETIRE

Jones admitted that his decision to retire from competing in the Indy 500 was made as he was leading that day. “When I was leading the race in ’67, I was thinking, winning again wasn’t going to be as great as the first time. Sad to say, when the car quit, I really felt bad, while Andy (Granatelli) cried like a baby.

“It helped me make a decision, because I was thinking that if winning wasn’t as great as it was the first time—what the hell was I doing it for?

“Because I’d won everything – the Indy 500, sprint car, stock car and sports car races – not that I was going to stop racing, but I would quit running open-cockpit cars.

“That’s when I started doing Baja, and the Trans-Am – I’m the kinda guy who likes to see what’s on the other side of the hill. Which may explain a lot of why I’ve driven all different kinds of cars. You kinda get on top of one and then you want to go try something else – and that’s probably why I drove the turbine.”

> “Having so much torque leaving the pits, it probably damaged the bearing in the rear end”

TURBINE RESTRICTIONS

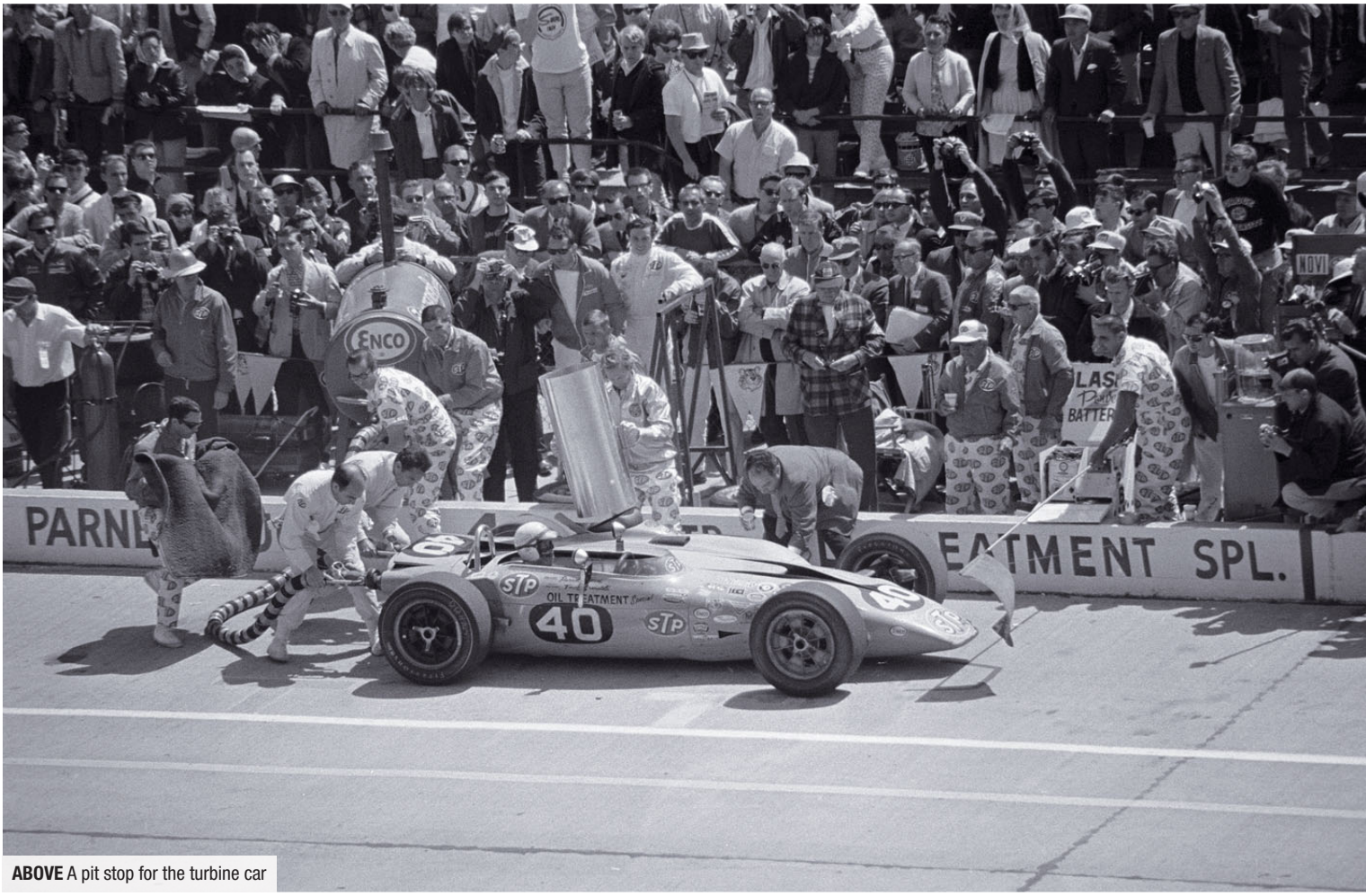
For 1968, the United States Auto Club restricted the air inlet of the turbine engine, from approximately 24 inches to around 16 inches, thereby reducing its horsepower in head-to-head competition with its piston engine rivals. One source declared the engine’s power had fallen from 550 hp to a base of 430 hp.

Granatelli was back at the Brickyard in 1968 with the restricted turbine in combination with an aerodynamically advanced Lotus chassis. STP driver, 1966 World Champion Graham Hill set one and four-lap qualification marks, only to be bested by turbine teammate Joe Leonard, who erased Hill’s times and captured the pole with new record clockings of 171.953 mph and 171.559 mph respectively.

However, as in 1967, the turbine would be deprived of a trip to victory lane in the final miles as a fuel pump shaft broke on Leonard’s leading machine with less than 10 laps to go.

USAC would further cut the turbine’s air intake to approximately 12 inches for 1969. With the corresponding drop in horsepower, the engine was rendered uncompetitive—effectively putting an end to the brief but memorable STP turbine era at the Speedway.

As to Jones’ opinion of the unique engine’s place in motor racing history, the 500 champion says simply, “It showed the public, or the racing world, that there are other means of power.” HRT



ABOVE A pit stop for the turbine car

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