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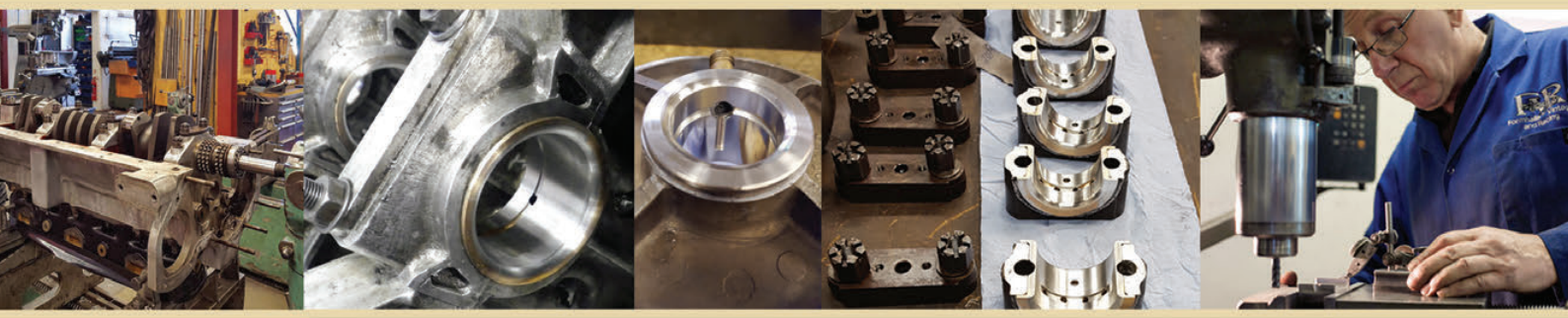
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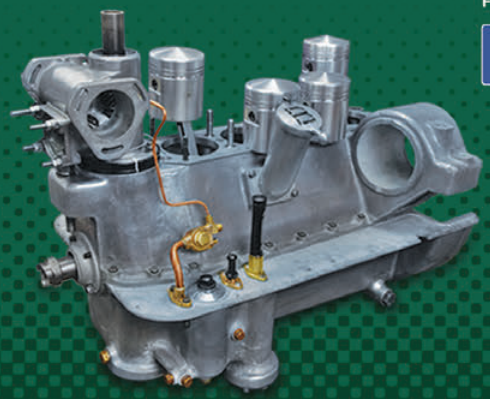
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THE WILDEST ESCORT EVER

How the Wild West of rallying in the US led to the creation of a spectacular Ford Escort



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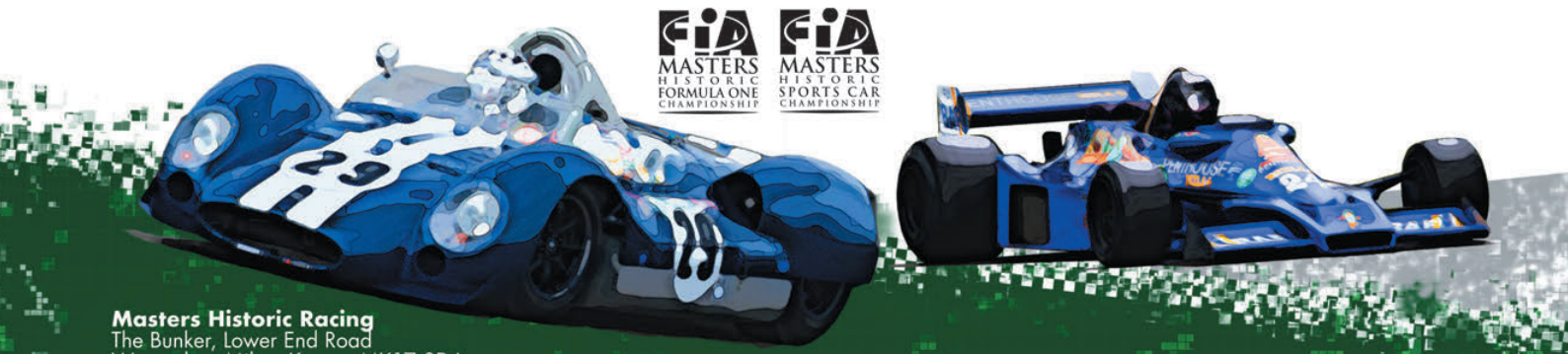
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2017 EVENT CALENDAR

APRIL	08 – 09	Barcelona, Spain	Espiritu de Montjuic
MAY	19 – 21	Mazda Raceway Laguna Seca, USA	The Spring Classic
	27 – 28	Brands Hatch GP Circuit, UK	Masters Historic Festival
JUNE	09 – 11	Montreal, Canada	Formula 1 Grand Prix du Canada*
	16 – 18	Mosport, Toronto, Canada	VARAC Vintage Grand Prix
	18	Silverstone GP Circuit, UK	MGLive!
JUNE/JULY	30 – 02	Magny Cours, France	Grand Prix de France Historique
JULY	21 – 23	Road America, USA	The WeatherTech® International Challenge presented by HAWK
	28 – 30	Silverstone GP Circuit, UK	Silverstone Classic
AUGUST	11 – 13	Nürburgring, Germany	Oldtimer Grand Prix
SEPTEMBER	01 – 03	Zandvoort, Holland	Historic Grand Prix
	15 – 17	Spa-Francorchamps, Belgium	Spa Six Hours
OCTOBER	20 – 22	Austin, Texas, USA	Formula 1 United States Grand Prix*
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	27 – 29	Mexico City, Mexico	Formula 1 Gran Premio de Mexico*

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Safety First

The Vintage Sports-Car Club has come up with a very clever initiative that's aimed at improving safety standards for competitors at its events. Called Safety First, the intention is to balance the need for modern safety measures with the desire to retain the period authenticity of cars competed in by VSCC members.

I haven't raced for years but things have changed since I last competed over 30 years ago. Back then, and I'm not advocating it was better then, we just didn't know any better, all you needed was a helmet with the desired sticker and a pair of goggles – and that was it.

I used to race in my tee-shirt, sometimes mechanics overalls – not even a driver's one – and stupidly without shoes as I convinced myself I could "feel" the car better. Forget safety belts and anything namby-pamby like that. When I look back, I was stupid and thankfully never was involved in an accident, but it could have been so different.

I know there will be some who oppose the over regulation of everything, including vintage motorsport, but it is necessary. The VSCC is absolutely correct wanting to promote this initiative and I hope it is accepted.

One of the challenges is how to ensure that a car built up to 100 years ago can be made safe without ruining its authenticity. The best way is to protect the driver as much as possible but in many cases a HANS device, let alone a full race harness, is utterly impractical.

Taking into account the number of events the VSCC organises a year, it can boast a pretty good record. But it needs only one person to kill themselves or seriously hurt themselves to attract critical media attention.

Perhaps a safety foundation should be set up along these lines whereby the VSCC works with the MSA and other organisations and car clubs to establish guidelines at the very least for historic and pre-war cars that race, bearing in mind that they may also be road cars and not out-and-out race cars.

At a time when cars are under scrutiny like no time before, we have to do all we can to ensure that we do not attract negative publicity and while the general public still loves the older cars and flocks to historic racing events, we cannot take it for granted.

Take the recent announcement from Barcelona whereby motorists will be prohibited from driving private cars registered before January 1997 and vans registered before October 1994 on working days. Although the ban does not come into force for two years, those vehicles will already be banned from the roads during periods of high pollution from December 1 this year. It follows a similar ban on older vehicles announced by Paris at the start of the year. It will not be too long before this becomes a Europe-wide policy. Just what it means if you are touring in your classic car and want to enter a city on a weekday I'm not sure, but as far as I'm concerned, it's waving an amber flag at the historic car world, one that we need to heed.

With safety uppermost and the sensitivity to the general population at large, historic motoring and motorsport needs to be very circumspect. HRT

William Kimberley
Editor



NEWS

Masters launches Endurance Legends series

Andrew Charman and William Kimberley

LE MANS sports and GT cars dating from 1995 to 2011 are eligible for a new series currently under development by Masters Historic Racing, dubbed Masters Endurance Legends. The initial championship is set to be held at six Masters meetings in Europe in 2018 with a pilot race at the Spa-Francorchamps 6-hour meeting on 15-17 September. Eligible cars will be those that have previously competed in the International Sports Racing Series, the FIA Sports Car Championship, European Le Mans Series, American Le Mans Series, Intercontinental Le Mans Cup and Le Mans Endurance Series.

Organisers expect a wide range of chassis to be available to the series, which will include cars to SR1 and SR2 regulations and their LMP1 and LMP2 successors, plus specific classes for IMSA sports cars and GT1 and GT2 cars. All will run to the same technical regulations used in their period championships. Three classes are planned – 1995-1999, 2000-2005 and 2006-2011, each further divided into LMP1, LMP2, GT1 and GT2 categories. Onroak Automotive quickly announced that it wanted to be involved and has been putting the finishing touches to the preparation of a Pescarolo LM P1 and is pursuing the restoration of several LM P2s, which raced between 2008 and 2011.

Each round is expected to consist of two 30-minute qualifying sessions and a 45-minute race with mandatory pit stops. Penalties will be applied to professional drivers entering to equalise the field.

Leading sports car racer Nicolas Minassian has taken on the role of series director with responsibility for overseeing technical stability and promoting grid sizes. “These are superb cars which captured the hearts of the fans and the drivers and with them being recent cars, they are fresh in people’s minds,” he said.

“This is the ultimate historic racing category and one I believe that has enormous potential with so many cars built from major motor manufacturers and low-volume race car constructors.”

“This is the next step in building the Masters Historic Racing series,” said events director Rachel Bailey. “The era between 1995 to 2011 saw some of the greatest cars ever racing in different endurance events around the world, and it will be great to see them compete once again in our series. The response to this initiative has been overwhelming and so I think we are set for brilliant new championship in 2018.” HRT



Photo: Peugeot

ABOVE Peugeot and Audi entrants from recent top-level sportscar racing, here in the 2010 International Sports Racing Series, are eligible for the Endurance Legends category

Photos: Andy Swift



ABOVE Unraced in its day, a Mercedes C292 has appeared this year at historic events

Mystery Mercedes C292 appears

Andy Swift

ONE of two Mercedes-Benz C292 chassis surprised spectators at the Goodwood Festival of Speed in June. Neither car has ever been seen in public before but chassis 1 was a static exhibit at Goodwood – and the Silverstone Classic a month later.

The C292 was the stillborn successor to the C291 sports prototype which won a single World Sports Car Championship race in the hands of Michael Schumacher and Karl Wendlinger at the end of 1991. Neither of the known chassis competed in period and Mercedes-Benz pulled out of top-line sports car racing ahead of the 1992 season when Le Mans ceased to be a round of the world championship. It's not clear whether a C292 ever ran in anger during its development.

The C292 was to be powered by a revised version of the M-291 engine from the C291, a bespoke 3.5 flat-12 unit developed in-house by the works. Producing 680 bhp at a dizzying 13,000 rpm in final form, the motor never had chance to publicly correct the problems of 1991 when it suffered repeated reliability woes. The M-291 was notable in period for its hugely advanced TAG Electronics telemetry systems, at a time when the technology was in its infancy.

The C292 shows signs of aerodynamic influence from TWR's game-changing Jaguar XJR-14 which introduced the twin rear wing concept, in conjunction with deep endplates effectively to increase the length of the single, full-width underbody diffuser. Side-mounted radiators fed by deep scallops either side of the cockpit were the result of tiny doors – a regulatory loophole first exploited by the Peugeot 905.

The car's previous whereabouts remain a mystery, though a sister chassis is believed to be in the possession of Mercedes-Benz. Chassis 1 was displayed at Goodwood complete, except for its dashboard and sophisticated TAG Electronics ECU. The current owner intends to install a MoTeC system in its place, should he decide to commission the car for use. MoTeC supplies 'plug and play' ECU solutions for many teams running Group C cars in historic racing. This raises the tantalising prospect that the C292 might finally run on track in public; over 25 years later than intended. HRT

FIA expands historic resource

THE FIA is consistently adding more information to its online Historic Database, which is rapidly becoming a highly useful resource for historic motorsport competitors. Already included is a searchable vehicle homologation database, which includes FIA homologation papers for individual vehicles, while the site also includes many period regulations for a host of formulae and championships, and appendix J to K regulations from the period in question. HRT





RIGHT Still a staple in national events, the Ford Escort will be able to compete in Britain's World Rally Championship round in October

Historic rally cars to take on WRC stars

Andrew Charman

OWNERS of historic rally cars will be permitted to pit them against the leading contenders in the World Rally Championship at Britain's round of the series in October.

New FIA regulations have enabled organisers of Wales Rally GB on 26-29 October to open up the field to entrants with national MSA regulations. This encompasses cars that were familiar during the event's past years, such as the Mitsubishi Evo and the Ford Escort RS1800 – many of which are still campaigned on national events.

Such cars must comply with the FIA's safety requirements detailed in Appendix J Art 253, and the final list of entrants will require approval by the FIA before the rally. British crews will need an international competition licence and a car with an MSA Log Book.

Crews will be offered entries to the full four-day international event at a discounted British privateer entry fee of £1995 (£1662.50 + VAT). They can register their interest in entering at the walesrallygb.com website.

As a result of the rule change, the WRGB National Rally that supports the WRC event has been reduced to a two-day format that will be less demanding of both finances and time.

Organisers insist that the National runners will still be an important part of the event, based in the WRC Rally Village in Deeside and competing on the same special stages as their WRC counterparts.

The National event will have its own dedicated start in Chester city centre on Friday afternoon (27 October), going on to eight timed stages totalling more than 60 miles. These include the Cholmondeley Castle RallyFest on Saturday morning, ahead of four speed tests in the Dyfi, Gartheiniog, Dyfnant and Aberhirnant forests of mid-Wales. Sunday's schedule is set in north Wales featuring three more stages – Gwydyr, Alwen and Brenig and onto the finish on Mostyn Street in Llandudno.

The WRGB National Rally will be priced at £625 + VAT, and entries will open on 30 August, through the official walesrallygb.com website. Organisers expect the national event to be sold out as in previous years.

Dayinsure Wales Rally GB managing director Ben Taylor believes the new formats will offer something for everyone. "Britain's WRC round is now genuinely open to those who want to take on the full challenge – that's the stuff of personal legends," he said. "Secondly, the shorter National event should appeal to those who want to have the amazing experience of competing on a huge event, but who will also appreciate the smaller time and money commitment required." HRT

Rally 2WD bids to revive gravel entries

THREE Shropshire-based rallying enthusiasts are launching an initiative to try and reverse a decline in gravel events for two-wheel drive and historic rally cars. Dubbed Rally 2WD, the concept sees each event effectively becoming two rallies run back to back – the first for 2WD cars, including historics, and the second for 4WD cars.

Regulations for stage rallying which seed cars based on their performance have had the result of pushing 2WD and historic entries further down the running order at rallies. Drivers of these cars have to cope with poorer surfaces as the result of the 4WD cars running first, and often suffer damage to their cars.

With many 2WD/historic runners on limited budgets, the result has been to decimate the entries to UK rallies. According to Simon Wallis, one of those behind Rally 2WD, average historic entries have dropped from 67 to 37 cars and for the pre-1968 category 1 cars from 13 to just two. As a result, many rallies are running at a loss.

"It has become very clear that gravel rallying is in a perilous state and a significant number of 2017 events have lost money," Wallis said. "That is an unsustainable situation and the organising clubs cannot be expected to keep on losing money. At the very least they should be running at break even and preferably making a modest profit for the huge amount of work put in by the organising teams.

"If we don't get some of the disaffected crews back into the forests next year, they could be lost from the sport forever. Some rallies are on the brink of collapse and once events are lost, they are unlikely to return." HRT



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ABOVE Owners of BTC-T specification Vauxhall Astra Coupe, Honda Integra or MG ZS cars, here seen competing in the BTCC at Donington in September 2004, can now race them in the Historic Super Touring Challenge

Super Touring Series opens up to later cars

Andrew Charman

THE Historic Super Touring Car Challenge has moved to counter a recent reduction in entries by extending the entry criteria to allow owners of pre-2006 British Touring Car Championship machinery to compete in the series. The ST4 class, previously an invitation category for cars built before the Super Touring era of 1990-2000, has this season been open to all naturally-aspirated 2.0-litre Touring Cars built before 2006.

This mainly permits entries for cars from the cost-cutting BTC-T class, introduced by BTCC organisers TOCA in 2001 after the expense of Super Touring became unviable. However, it also includes cars built to the FIA's Super 2000 regulations, introduced in 2002 to the European Touring Car Championship and evolving into the World Touring Car Championship three years later.

According to organisers of the Historic Sports Car Club administered series, interest had been shown by owners of BTC-T and S2000 cars who have had limited opportunities to race them. Meanwhile the Super Touring Challenge has seen a decline in entries to its pre-1990 class.

Having researched lap times officials are confident that the newer cars can compete on equal terms with the Super Touring machinery, but the option of adding ballast to any car that becomes dominant is also available.

So far, the change appears to have made little difference to numbers, with the only regular new entrant Jason Hughes in his BTC-T specification MG ZS. Hughes had previously raced the car in the BTCC between 2004 and 2009, before putting it in a showroom for eight years.

Numbers in the Super Touring series slumped to just nine cars at the Legends of Brands Hatch Superprix event on 1-2 July. However, the entry for the series' showpiece race at the Silverstone Classic on 28-30 July attracted a 43-car grid. While 23 of these were in the pre Super Touring GA classes, the entry also included five ST4 runners, among them a 2005 BTCC Vauxhall Astra entered by Roger and Jack Stanford, and from the same year the Halfords Honda Integra of Bernie Hogarth, the youngest car racing at the event. HRT



ABOVE This BTC-T specification Honda Integra was the youngest car to race at the Silverstone Classic at the end of July

VSCC promotes safety agenda

THE Vintage Sports Car Club is pushing forward with a campaign to improve safety standards for competitors in its events. Dubbed Safety First, the campaign aims to balance the need for modern safety measures with the desire to retain the period authenticity of cars competed in by VSCC members.

The VSCC is aiming to foster a culture amongst its members, encouraging them to understand and accept their personal responsibilities for their safety. A safety working group set up by the club is promoting mentoring of novice drivers, and addressing areas of concern.

One of these is standards of car preparation – VSCC members have been advised on what is expected and the likely penalties for not meeting the standards, and these will be supported by posters visible when drivers sign on, information during driver briefings and random car inspections in paddocks.

Standards of competitor fitness are also a concern. A confidential medical declaration form, random alcohol testing but also education of competitors to the likely dangers all form elements of the Safety First initiative.

Britain's motorsport governing body the MSA has praised the VSCC initiative, safety director Kate Adamson saying that "Self-policing our sport and safeguarding its future viability while helping to reduce accidents is a welcome approach that should be applauded."

Separately, UK motorsport governing body the MSA has warned those competing with older vehicles to check that their structural integrity has not been compromised by corrosion. Pictures in the *MSA Extra* newsletter showed a non-UK vehicle with so much rust in the A-pillar and sill it would have been very unlikely to have withstood a heavy impact. HRT

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Ford GT40 Godfather passes away



ROY LUNN, the "Godfather of the Ford GT40", passed away in early August after suffering a catastrophic stroke at the age of 92.

He was born in Richmond, England in 1925. One of three children, he was a 14-year-old student at London's Kingston Technical School when World War II broke out in 1939. He took a job during the week as an apprentice tool maker at a local shop while attending school on weekends, eventually becoming a tool designer and engineering representative.

Turning 18 in 1944, he joined the Royal Air Force to become a pilot. However, because of his level of education he was transferred to the RAE (Royal Aircraft Establishment) at Farnborough where he worked on the development of gas generators for the first turbo-jet aircraft. He also studied enemy vehicles captured as the Germans were forced back across Europe.

He started his automotive career at AC Cars as an engineer in 1946. From 1947 to 1949 he became the assistant chief designer at Aston Martin and built two DB2s that competed at Le Mans. He joined Jowett Cars in 1949 where he continued engineering work on the recently introduced Javelin 1.5-litrs saloon while also working on a new sports car which became the famed Jowett Jupiter. He then joined Ford of England where his first project was to design an all-new Anglia 105E, the iconic Anglia, to replace the ancient 100E.

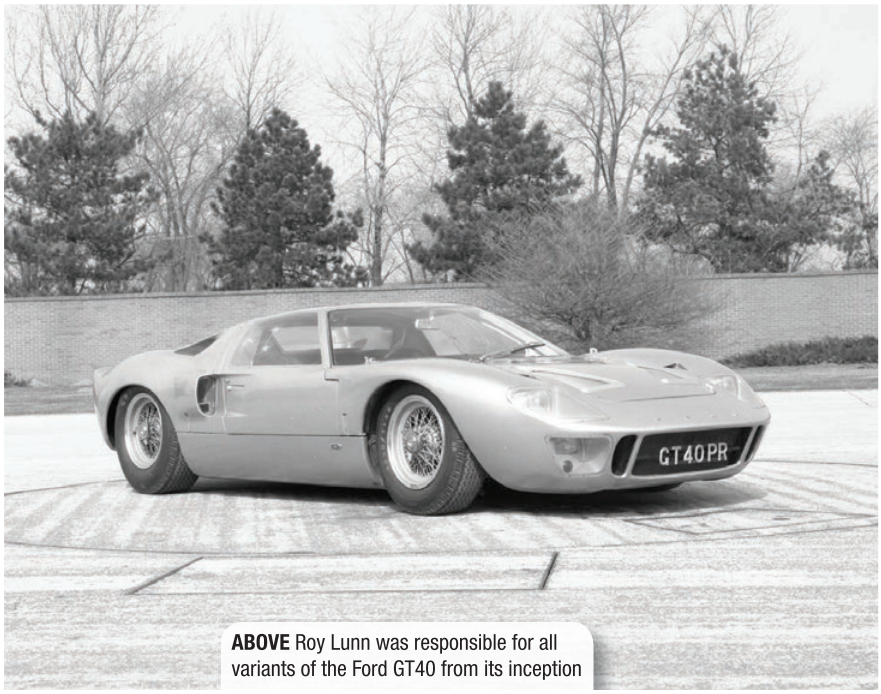
He gave it a modern overhead-valve four-cylinder engine, four-speed transmission and a longer wheelbase for improved comfort. However, it was the "Z-line" reverse-angle rear window that stood out the most.

In 1958, he moved to the US, taking a position at Ford Central Advanced Engineering. Between 1958-1969, his titles included head of the Advanced Vehicle Department and Advanced Concepts Group. Some of the projects he was responsible for included the Mustang I, Big Red, the Superhighway truck, Flying Car Concept, the mid-engineered Mustang and all the GT40 variants.

He left Ford in 1969 to become vice-president of engineering at Kar-Kraft where he oversaw production of the Boss 429 Mustang and development of Mustang concepts with mid-mounted 429 engines. In 1971, he was recruited by American Motors Corporation to become the technical director of engineering for Jeep.

A dozen years later, he was responsible for the vehicle that would change the automotive landscape in the US and beyond with the '83 Jeep Cherokee XJ. It is considered to be the first modern, lightweight four-wheel drive unibody SUV. The Cherokee was the first American-branded vehicle to be manufactured in China and a huge success for AMC and then Chrysler. Over three million units were sold by 2001.

He is also credited with the AMC Eagle, the first production four-wheel drive car. He was elevated to chief engineer of AMC and president of Renault Jeep Sport and centralised all



ABOVE Roy Lunn was responsible for all variants of the Ford GT40 from its inception



ABOVE While Roy Lunn was behind several iconic and groundbreaking cars, it is the Ford GT40 and all its variants that he will be remembered that inspired the current Ford GT programme

AMC-Renault competition programmes in the US. He also developed the first SCCA Spec-racing car in 1983, the SCCA Sports Renault.

He served as chairman of the technical board of the Society of Automotive Engineers (SAE) in 1982-1983 and elected a Fellow of the Society in 1983.

After retiring from AMC in 1985 he joined AM general as vice-president engineering to head the HUMVEE military compliance programme for the Pentagon.

He retired in 1987 to Florida but continued to work on automotive projects. Aside from sailing his monohull "Cat" boat built to his specifications, building two houses and playing golf, he authored three books: *The Oil Crisis: Sooner Than You Think!*, 2004, *Globalization- A Worldwide Quest For A Sustainable Future*, 2008, and *The World Crisis- It All Started With 9/11*, 2009. His story about the history of Jeep is still on the drawing board, as are his tireless efforts towards designing a new 'People's Car' out of entirely sustainable materials.

After relocating to Santa Barbara, California in 2015 he again set up a working home office and continued development of his new concepts that drew the attention of the local college - University of California, Santa Barbara. Within six months he was a mentor to their mechanical engineering programme and met with students weekly to advise and teach them. He was rewarded with an in-depth research project focusing on his plans for the 'Peoples Car' and a 3-D model of the concept.

Roy Lunn was one of the industry's original disrupters, the product of an enquiring mind and relentless ability to utilise it. He was inducted into the Automotive Hall of Fame in 2016 for overseeing the development of the legendary Ford GT40 that ended Ferrari's domination of endurance sports car racing. GT40s won the 24 Hours of Le Mans four consecutive years -1966-1969. He felt it was the proudest moment of his life when his peers in the industry recognised his work. His goals throughout his career were visionary, with a clear eye to the future. Roy was especially proud of the 1967-winning Mark IV, the first GT40 designed, engineered, powered, developed and built in the US.

"All of us at Ford are saddened to hear of the passing of Roy Lunn," said Raj Nair, Ford executive vice president and president of North America. "His legacy as the godfather of the original Ford GT40 was well known throughout the company, and he helped bring Ford a performance car that is just as legendary today as it was in the 1960s. The team that put together the Ford GT of today was inspired by the work of Roy and his team and we will be forever grateful for the work they started. We like to think that his GT40, and our GT of today, are both cars that showcased the best of what Ford Motor Company can do." HRT

THE WILDEST FORD ESCORT EVER BUILT

Johan Ragnarsson talks to **William Kimberley** about how the Wild West of rallying in the US has led to the creation of a spectacular Ford Escort

THINK of Sweden in motorsport terms and you tend to conjure images of rallying, rallycross and the late and great Ronnie Peterson.

Over the decades the country has nurtured a strong group of motorsport engineering companies that support a loyal customer base. However, that wasn't enough for longstanding friends and newly graduated engineers Johan Ragnarsson and Niclas Jancic, who had spent every free hour building rally cars out of Johan's father's sheet metal shop in the late 1980s and early '90s. By 1993 the two friends had decided that there was business to be had in the US and consequently moved to Florida to set up JRD, Johan Ragnarsson Design.

Instead of preparing rally cars, though, the new business found a burgeoning market in developing custom cars for wealthy clients. This brought them to the attention of Dan Panoz, who at the time was developing the Panoz Esperante road car. A deal was done and JRD Tuning relocated to Hoschton in Georgia so that they were more on hand to work on the new model, ultimately becoming the in-house R&D and custom car builder following Panoz buying an interest in the company. In 2003 it released the JRD Panoz Esperante RSr that was fitted with a supercharged and enlarged 32-valve 5.2-litre Ford V8 developing a claimed 600 horsepower.

While customising this and other cars was the mainstay of the business, rallying was never too far beneath the surface for Ragnarsson. While the US doesn't have a strong rallying culture, there were enough enthusiasts out there to make it viable, which led to the ▶

> **"With free rein, our idea was to make a car that was modern from a technical standpoint but true to the heritage of the Escort"**



Photos: Bobby Brunelle

ABOVE Beneath the skin lurks a blend of NASCAR, circle track, rallycross and V8 Supercar expertise

Technical Specifications: JRD Ford Escort Mk2

Engine	3.7-litre Ford V6 with stock internals. Dailey Engineering/Ginetta dry sump system, BBK throttle body, Griffin aluminium radiator, Setrab oil cooler, and stainless exhaust with dual JRD full flow racing catalytic converters 350 hp @ 6500 rpm, 320 lb/ft @ 4300 rpm Tuned by Ed Senf of Engine Management Sales
Control System	MoTeC M130 ECU, MoTeC PDM 30, MoTeC C127, Race Grade switch panel, JRD steering wheel control panel, MoTeC LTCD 4.9, Jay F. Yue Motorsports wiring harness
Fuel	VP109e
Drive Line	Saenz TT3-D6S 6-speed sequential gearbox, JRD shifter and linkage, Quartermaster flywheel and clutch with reverse-mounted starter, JRD custom aluminium bellhousing, steel driveshaft, Strange Engineering 9-inch lightweight aluminium casing with 3.89 final drive ratio, Holinger LSD ramp diff (from V8 Supercar), Speedway Engineering bespoke Ford 9-inch rear axle with floating and crowned NASCAR axle shafts (to make camber and toe-in possible), Speedway Engineering Mod Lite aluminium rear hubs
Suspension	Suspension geometry has been calculated and designed using Performance Trends suspension analysis and SolidWorks 3D CAD software Front: Tubular subframe with JRD billet lower control arms and steel compression struts, modified Mustang uprights, Mustang hubs with APR studs, short Escort motorsport rack, EPAS from Opel Corsa B with controller from Simtek, in-line steering quickener that can be altered between 1:1, 1.5:1 and 2:1, 45-degree steering angle and 1.5 turns lock to lock (w 1.5:1 quickener), JRD/Öhlins 3-way TPX with PDS and 198 mm stroke, Öhlins springs, JRD top mounts Rear: 4-link suspension system with Watt's linkage, Öhlins 3-way TTX 210 mm stroke, JRD/PAC Racing sway bar, JRD top mounts
Brakes	Front: AP Racing CP8350 callipers and CP3862 discs with JRD aluminium hats Rear: AP Racing CP8241 callipers and CP3928 discs JRD carbon handbrake with CP7855 cylinder, Tilton pedal box
Chassis	Original shell was scanned and turned into a SolidWorks 3D CAD model to serve as a base for the new purpose-designed rally chassis 8-point roll cage, front-mid engine layout, enlarged wheel houses and shock towers, raised tunnel, JRD strut brace, quick disconnect front nose section, seam welded and powder coated, 10-gallon ATL fuel cell with JRD aluminium enclosure
Interior	Carbon dash, floors and door cards, Sparco steering wheel, Schroth 6-pt seat belts, JRD Recaro seats, Stilo intercom, SPA fire system, Coralba trip
Body	GRP4 carbon bonnet, boot lid and bumpers, modified alloy wheel flares
Wheels and Tyres	Pirelli 205/65-15 on Enkei 7x15 rims for gravel
Light System	Lazer Lamps Carbon-20 and Carbon-2 with quick release
Kerb Weight	2600 lb/1180 kg
Track	Front 1460 mm; Rear 1500 mm

JRD would like to thank: Seamus and Joseph Burke, Niclas Jancic, Jay F Yue, Auston and Andrew Cain, Ingvar Gunnarsson and Martin Claesson of IGMAB, Christer Lööw of Öhlins, Lazer Lamps, Ed Senf and James Whisler, Allen Lopez of TheWrapDepartment.com, Keith Merritt, Tyler Crawford, Ben Paddick of Raceparts USA Ltd, Perfect Edge and our sister companies within the Panoz organisation.

creation of JRD Rallysport USA.

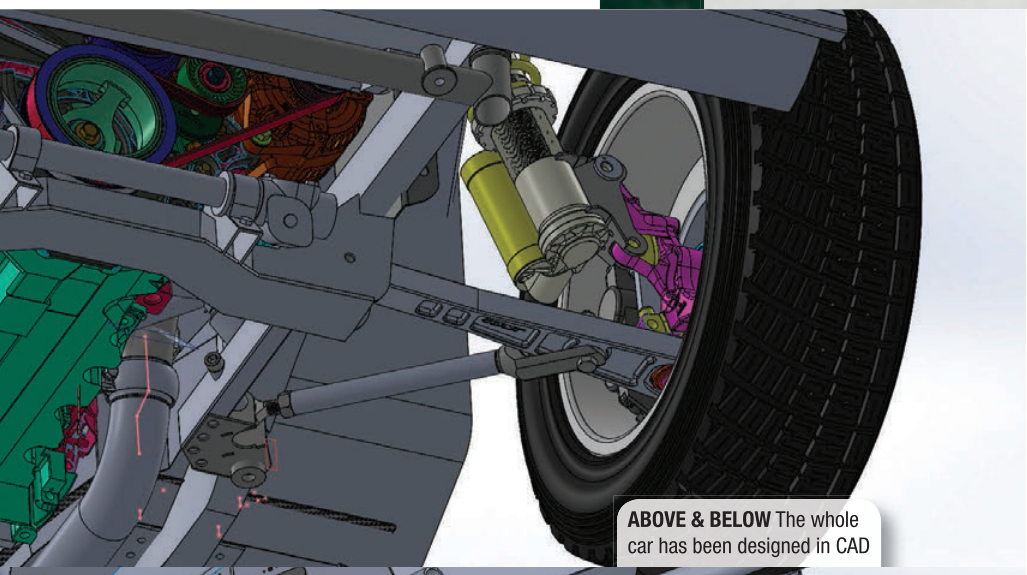
One such was Seamus Burke, who had enjoyed success back in the day with Escorts in his native Ireland. On his return to rallying in the US, after having built up his construction business in that country, he had taken to competing in JRD-developed Mitsubishi Evos. However, his love for the Escort was never far away and a scheme was devised whereby JRD Rallysport would build such a car for him.

Nothing is conventional in the US, though. The enterprising Swedes decided to take full advantage of the fairly lax American rally regulations to come up with a car that might loosely be called a Mk2 Escort.

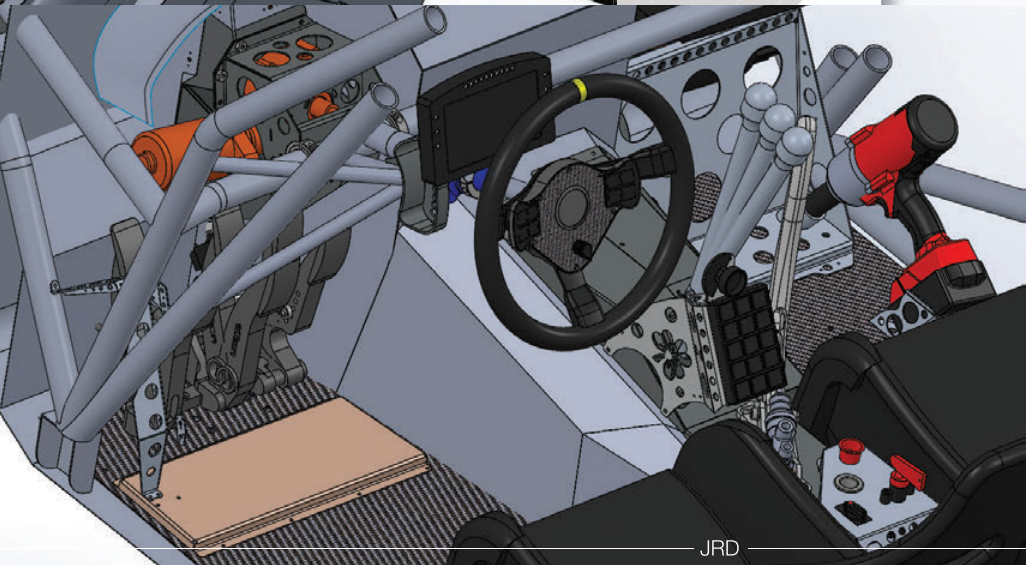
"The Ford Escort project started with running a Mitsubishi Evo for Seamus and while he drove the Evos, his first love was the Escort," says Ragnarsson,



ABOVE The Escort is wider than the original in order to be able to run in the ruts of the US cars ahead of it on the stages



ABOVE & BELOW The whole car has been designed in CAD



JRD

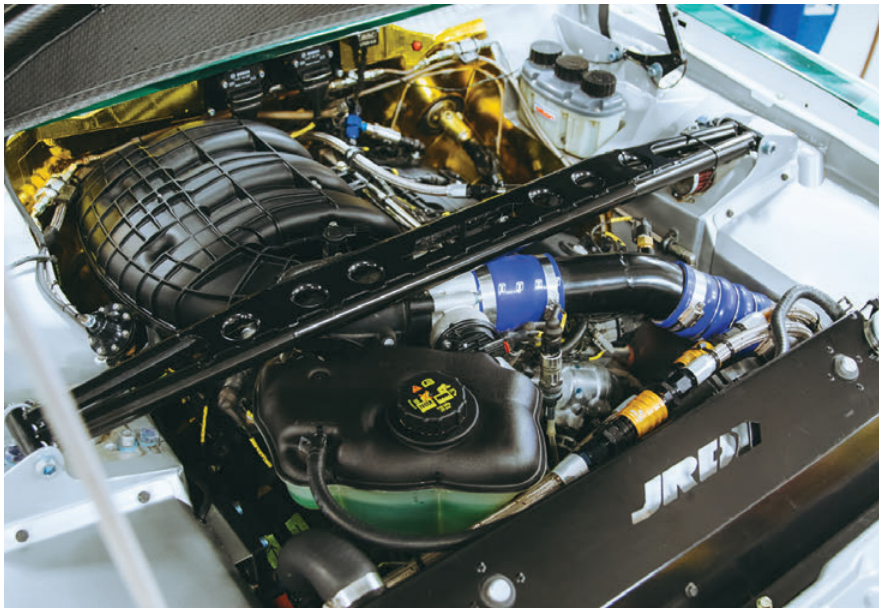
"so he went and bought one that was already undergoing a conversion into a rally car. It already had a cage that we decided to leave in the car as it was already homologated for America. In hindsight, it was probably a mistake because if we had used an FIA cage, we would lose around 100 lb."

STARTED FROM A SCAN

Working on the car with the cage in place was also a challenge, says Ragnarsson, as it limited moving the seats back and it was very tight to make it all work. "What we had already done, though, which helped, was to scan the car from the start," he says. "So we knew where we were, while I also got a CAD file from Ford of the motor, so the whole car was designed in CAD.

"With Seamus giving us free rein, our idea was to make a car that was modern from a technical standpoint. It used mainly Ford components, but from newer and more powerful cars, both racing and OE parts that are designed for heavier cars and so would be more than adequate right out the box. That was our concept, but we wanted to be true to the heritage of the car and it had to look like the old Escort."

Even before JRD Rallysport became ▶



involved in the project, Burke had already decided that it was going to be powered by the Ford Mustang 3.7-litre Cyclone V6 developing 305 hp and 280 lb/ft of torque. However, as Ragnarsson says, in the magic hands of MoTeC tuner Ed Senf at Engine Management Sales, it reached 350 hp and 310 lb/ft of torque. The engine is heavy, but even with that, the car has a perfect 50-50 weight ratio and exactly the same weight in each corner, which makes it easier to drive.

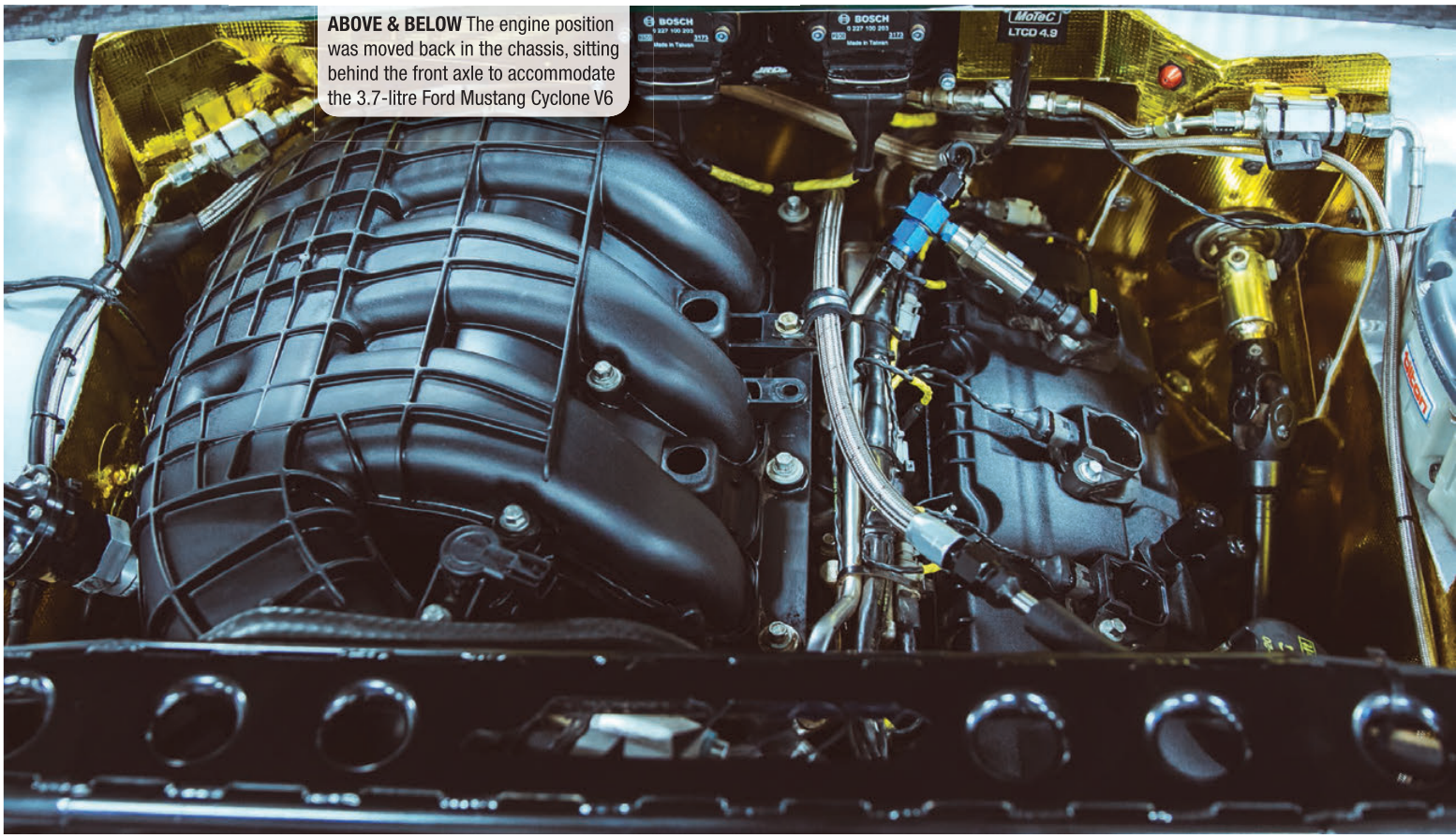
"To make the engine fit under the bonnet we had to convert it to dry sump so I went to LNT in the UK that was using the same engine in one of its spec racing Ginettas. To get it to fit, though, we had to move the entire engine back about a foot so that it's sitting behind the front axle. This meant the firewall had to be modified to accommodate it and that led to the gearbox being pushed back with a custom bellhousing to mate it to the engine and a custom Quartermaster clutch.

"We also needed a rear axle and picked a Ford 9-inch, a semi-floating, drop-out axle, the same one used in all the NASCAR Cup cars and had one built up by Speedway Engineering, which refer to the axles as 'crowned' to our specification. It has a degree of negative camber and around an eighth of an inch toe-in at the back. As it's a floating axle it means that it can be pulled out without taking the wheels off."

V8 SUPERCAR INFLUENCE

Ragnarsson had to go to Australia to get a Holinger diff from a V8 Supercar. "There are plenty of inexpensive diffs available for the 9-inch axle, but unfortunately they don't have the ramp height and are more like a generic disc-type limited diff where you put a lot of pre-load on it," he explains. "However, we wanted one that increased the pre-load on the diff on acceleration and opened the diff on deceleration to make the car turn in better. It's also got a rear gear from a NASCAR Cup car, which is very strong with aluminium housing.

"Originally the car was going to have a regular H-pattern dog box but it was decided to switch to a sequential gearbox so we got one from Saenz ▶



ABOVE & BELOW The engine position was moved back in the chassis, sitting behind the front axle to accommodate the 3.7-litre Ford Mustang Cyclone V6

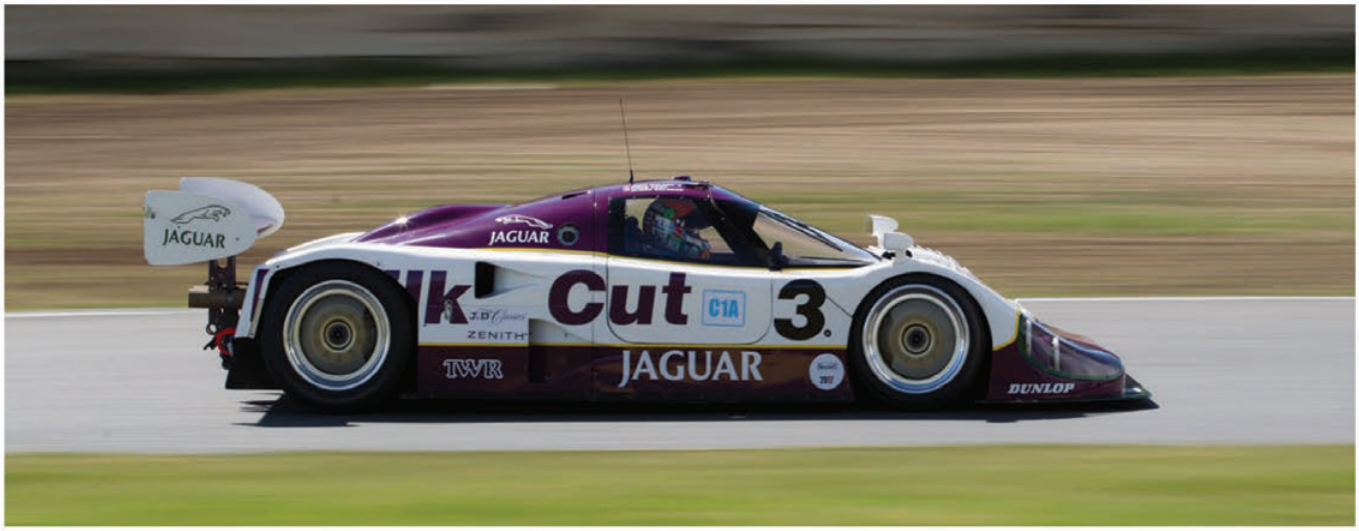


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ABOVE WRC expert M-Sport recommended auxiliary lights from Lazer Lamps

in Argentina that's used in a lot of Escorts in Europe."

When it came to the suspension, Ragnarsson knew what he wanted with things like the roll centre and the anti-squat and anti-dive characteristics and called upon the help of Ingvar Gunnarsson Motorsport in Sweden. "Not only does it prepare rallycross cars, it also converts front-wheel drive cars like Volkswagen Golfs and Ford Fiestas into rear-wheel drive ones and it has developed a really good geometry setup," he notes. "We got some advice based on that but we also have our own suspension analysis software. We knew what we wanted and built up our geometry based on that."

The off-the-shelf Ford Mustang spindles that were used on the front had to be slightly modified but all the pick-up points still ended up precisely where the Performance Trends suspension analysis software used by JRD Rallysport indicated they should be located. "We also designed our own control arm, used the original Ford Escort tubular subframe, but we added on to it to triangulate it so the front suspension has a JRD billet lower control arm made out of 7075 aluminium alloy," he says. "It has the compression structure like a WRC (World Rally Car) except it isn't four-wheel drive.

"We buy blank struts from Öhlins and make our own brackets that fit onto our upright spindle and we make our own top mounts that we put in place. In the rear, we've used Evo X R4 shocks that work well with the packaging. It has a 4-link suspension geometry with Watt linkage."

Circle track racing AP Racing discs are fitted to the car, which also uses 15" wheels. "It means we can buy discs for $100 and we make our own hats and our own calliper mounts to make it work with the Ford spindles. It uses the same pads, callipers and discs as the four-wheel drive cars we prepare."

The whole nose on the car is removable from the shock towers forward so that it's easier to replace after crashes and to take the engine in and out. ▶



BELOW The front suspension has a JRD billet lower control arm

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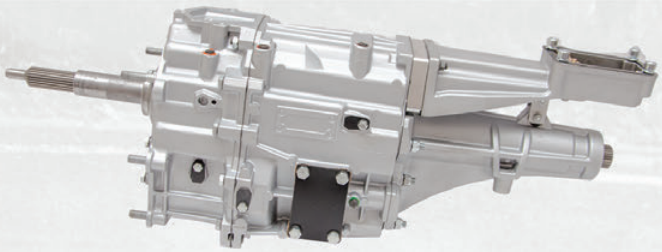
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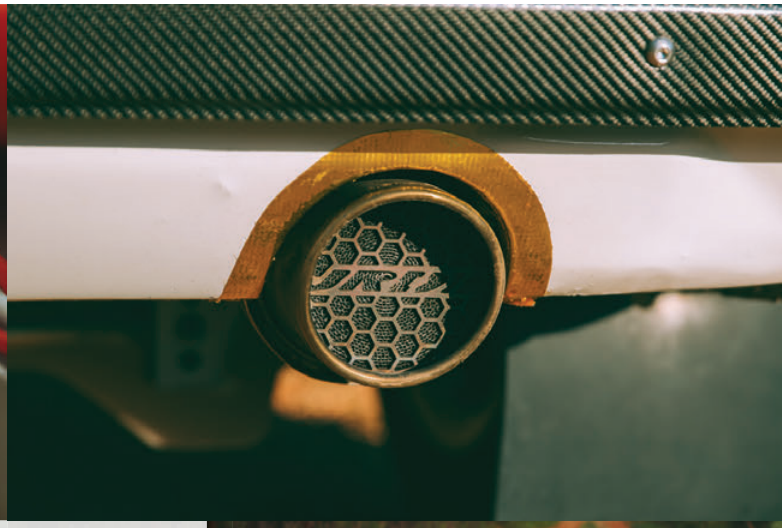
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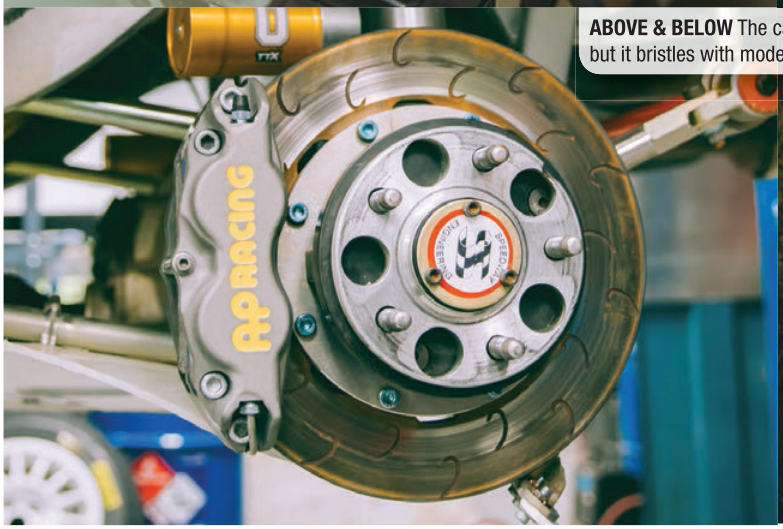




New cylinder heads for Opel Manta and Ascona 400









ABOVE & BELOW The car might look standard but it bristles with modern technology

Look at the car from the front and the rear and you realise that something's different. It looks like a Mk2 Escort, but with different proportions. It's then that Ragnarsson owns up that the car's wider than the original: "We wanted to go wide because the cars it would be running behind here in the US are wider and we needed to make sure that it would fit into the ruts they made. It meant we had to get extra wide flares from Ralloy, but even then we still had to modify them to make them wider."

MINIMISING BUMP STEER

The car is shod with Pirelli 205/65-15s on Enkei 7 x 15 rims for gravel. "They're the same rims as on the Evo, along with the same bolt pattern so they are a lot larger than the original 13" wheels. It meant we had to open up the wheel openings and housings to make room for them," says Ragnarsson. "There's an 8" wheel travel front and rear but in our suspension analysis we were trying to get as little bump steer as possible."

JRD Tuning made a new motorsport harness for the car. MoTeC being the electronics of choice, it features a MoTeC M130 computer to run the engine, a MoTeC PDM 30 to run all the electrics and a MoTeC C127 dash and a 15-button keypad. The steering wheel buttons are the same as on the R5 Fiesta.

The Escort originally featured electric power steering from an Opel Corsa, but it turned out to be too weak and JRD Rallysport is in the process of changing to a proper motorsport unit

> **"Reaction to the car has been amazing"**

courtesy of EPAS Performance. The wheel can turn 45 degrees with one and a half turns from lock to lock. "At first we thought it would be too much and when testing it on tarmac we found it was a little bit twitchy, but it's perfect on gravel," says Ragnarsson. "It uses a stock motorsport rack from an Escort but we've made our own tie rod ends to fit with the Mustang uprights."

A circle track V8 Mustang all-aluminium radiator, made by specialist Griffin Thermal Products, is fitted in line with using Ford components that are built for more powerful engines and applications and it's also cheap, says Ragnarsson. Other non-standard features on the car include an ATL fuel cell, SPA fire suppression system, a Braille lithium-ion battery, Recaro seats but with JRD covers, a carbon dashboard and carbon bonnet and boot lid from GRP4 Fabrication, the company in Galway that specialises in the manufacture of competition components for the Mk1 and Mk2 Escort. The auxiliary lights have come from British company Lazer Lamps on the recommendation of M-Sport with JRD Rallysport now selling them in the US.

Despite the engine being down on power as the team didn't have the time to put it on the dyno before it was in action, the car won its first event. "We were quite nervous as everyone was talking about it coming so there was a bit of pressure there, but Seamus loved the car and said it was the best he had ever

driven," says Ragnarsson. "It was very predictable and very easy to drive. He didn't even use the handbrake! We were racing against Ford Fiesta R2s which are in the same class and beat them. Two Fords at different ends of the spectrum!

"Reaction to the car has been amazing. The funny thing is that we take it to a race and people who don't even know the Escort tell us it's their favourite car.

"We now have another shell ready to go if needed. The idea with the whole thing is that it's a platform and we can do the same thing with any two-wheel drive car. We are looking at doing the same thing with a Talbot Sunbeam Ti and Opel Ascona A rally cars.

"I love America for the Wild West rules where you can build cars like this without all the politics of homologation and so on." HRT



ABOVE MoTeC electronics help run the car

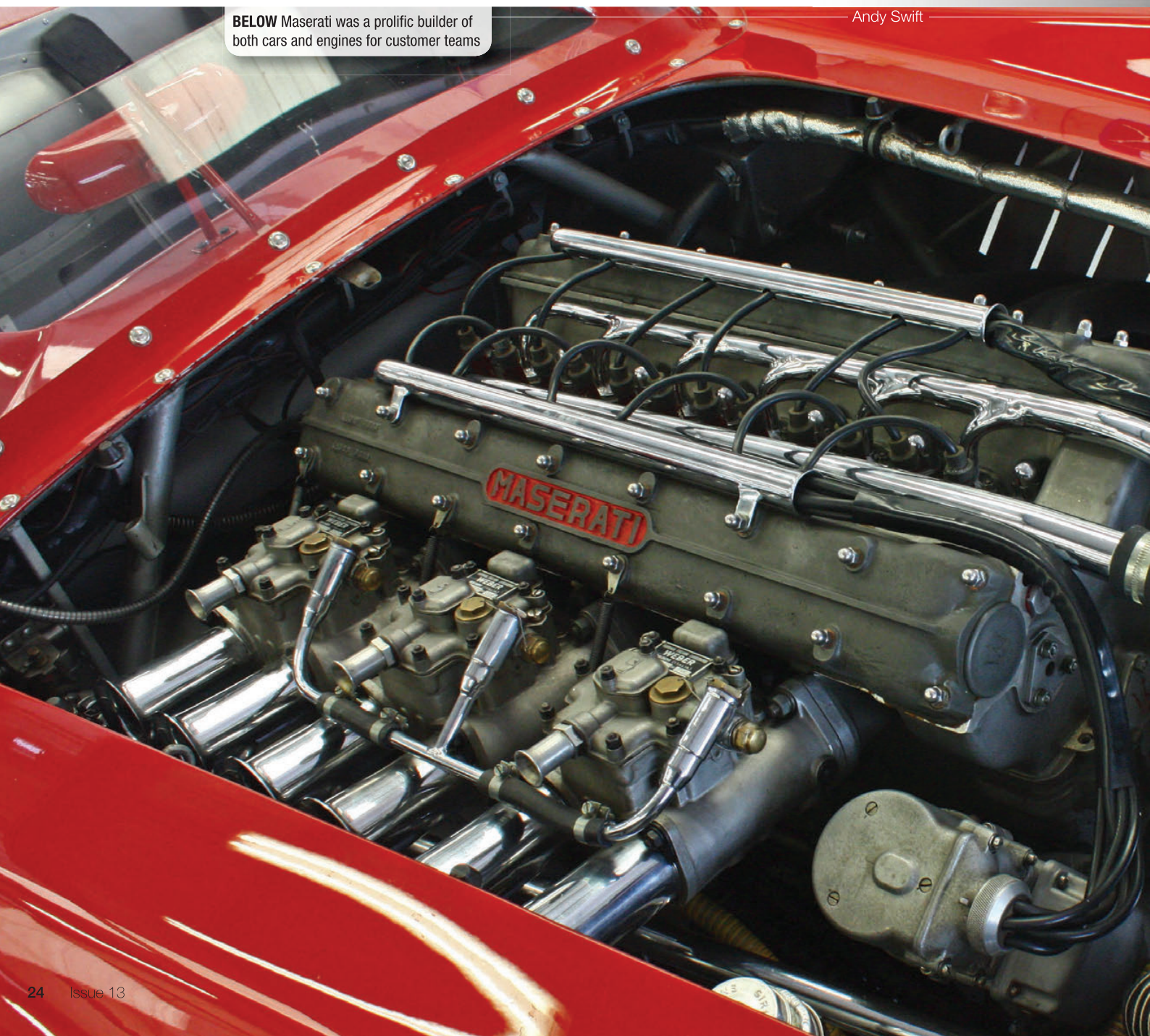


David Cosseboom

ABOVE Sideways to victory: typical Escort action maybe, but this is anything but a typical Mk2

TRIDENT MISSILES

Maserati's trident emblem still inspires a mystique in historic racing. But, as **Chris Pickering** finds out, the idiosyncrasies of the Italian marque's engines do present challenges



Andy Swift

BELOW Maserati was a prolific builder of both cars and engines for customer teams



ABOVE Few cars can match the visual drama of the Maserati Birdcage.

Andy Swift



FEW cars capture the glamour of motor racing quite as elegantly as the Italian machines of the 1950s. And while the prancing horse of Maranello may be more widely recognised, it's the Maserati trident that you're more likely to see on the front of a 1950s grand prix car or sports racer competing today.

The Maserati back catalogue is deceptively complex. Most of the company's racing engines from this era can be divided into two families: four-cylinders, and six-cylinders (with a smattering of later V8s and V12s). The two groups follow a distinct process of evolution – both getting bigger, more powerful and more sophisticated as time goes on. Beyond that, though, there's relatively little commonality.

> **"Contrary to popular belief, these Italian thoroughbreds are generally reliable if handled correctly"**

"Maserati never did anything simply," says Steve Hart, owner of Steve Hart Racing, which specialises in these engines. "Even with the four-cylinder engines, which look similar on paper, they're actually quite different under the skin. The Birdcage engine, for instance, is a different design to the 200S that preceded it; the block assembly is similar, but the sump and the cylinder head are all completely different."

The six-cylinder A6-series started in 1947 with a 1,448 cc engine, which featured a cast iron block and a single overhead camshaft operating two valves per cylinder. Loosely based on the pre-war 6CM powerplant, it produced just 65 bhp in its original form. However, the introduction of the A6GCS in 1947 saw a 2-litre variant, with a substantial increase in compression ratio – 11:1 up from 7.5:1 – and three Weber 36D04 carburettors in place of the single item on its predecessor. This is good for upwards of 120 bhp, making the featherweight A6GCS a potent performer.

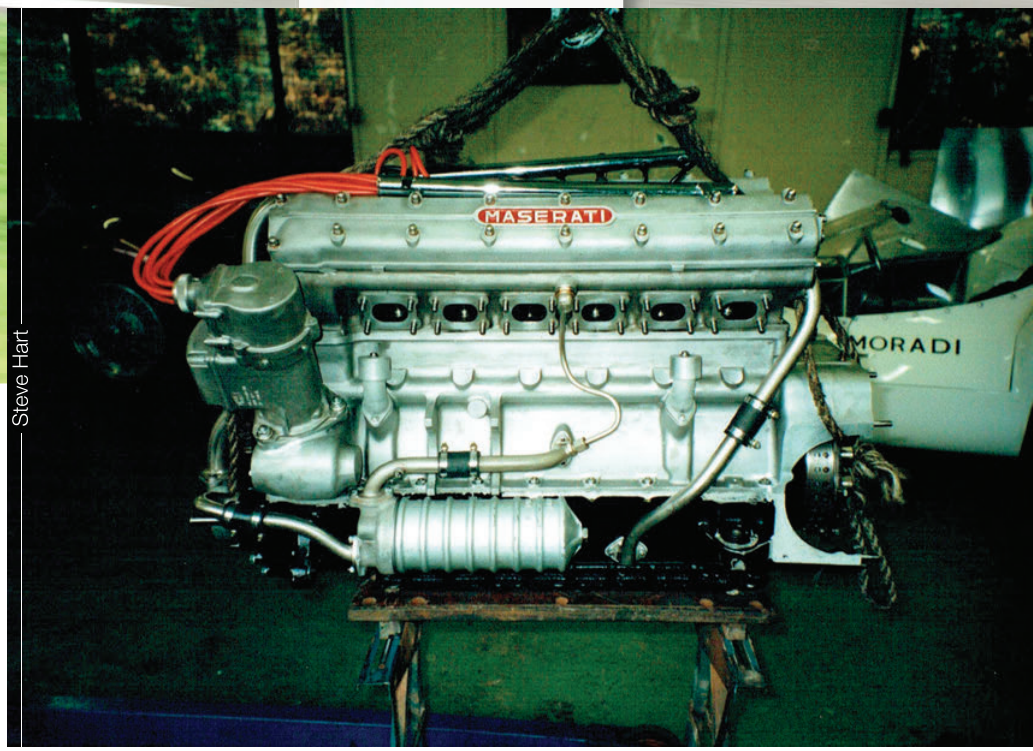
The last few examples of the A6GCS were fitted with a heavily revised engine, featuring a double overhead cam cylinder head. Somewhat confusingly, these retain the G notation, despite switching to a lightweight aluminium alloy block. A development of this engine is also used in the A6GCM Formula 2 'monoposto', which is good for nearly 200 bhp at a screaming 8,000 rpm.

The A6GCM engine was to inspire perhaps the most famous racing Maserati of them all, the 2.5-litre 250F. Designed primarily for customer teams, it was built in comparatively large numbers and remains one of the most popular front-engined post-war grand ▶



Andy Swift

ABOVE & BELOW The A6GCM engine inspired the iconic 2.5-litre 250F



Steve Hart

prix cars in historic competitions. It uses a 2,490 cc straight-six with two spark plugs per cylinder (as per the A6GCM) initially producing around 240 bhp in-period. A mechanical SU fuel injection system was later trialled by the factory, but the 250Fs racing today all use a conventional setup with triple Weber 45 DCO3 carburettors.

The final evolution of Maserati's straight-six racing engines was a long stroke version of the 250F engine, stretched to three litres for the 300S sports car.

"The cylinder heads are identical on the 250F and the 300S," notes Hart. "The block is very similar, but it's machined differently to accommodate the longer stroke; the bore size is the same."

The four-cylinder engines follow a similarly convoluted path. When the time came to replace the six-cylinder A6GCS sports car, Maserati drew inspiration from an abandoned Formula 2 engine project to create the four-cylinder 150S. Like the A6GCS, it uses an aluminium block with cast iron liners and a double overhead cam, twin spark head. Even in its most basic form, this engine produces over 140 bhp from just 1,484 cc.

The 2-litre engines in the 200S and the 2.5-litre in the 250S are relatively similar – again it's primarily the bore and stroke that change, with differences to the crankshaft design to accommodate these. However, the engine in the Type 60 'Birdcage' that followed is a very different beast. Although the block is loosely based on the 200S, the cylinder head and the sump are bespoke items that allow the engine to be canted over by some 45 degrees, lowering both the bonnet line and the centre of gravity. Despite sharing the 200S's 2-litre capacity it also uses a shorter stroke with a larger bore.

"Again, it's a very different engine to its predecessor," notes Hart. "The cylinder head is a completely different design, with the inlet and the exhaust sides swapped round. Likewise, the cam follower arrangement actually bears more resemblance to the sixes than the earlier fours."

The ultimate evolution of the front-engined Birdcage was the Type 61, which followed in 1959. This saw the engine stretched to 2,860 cc, with a power output of 250 bhp. ▶

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Larry Bolander

ABOVE One of the very last 2.9-litre Type 61 Birdcages

HANDLE WITH CARE

Contrary to popular belief, these Italian thoroughbreds are generally reliable if handled correctly, Hart explains: "The sixes are quite robust, certainly in 2.5-litre form. You have to be a bit more careful with the revs on the 3-litre because the crankshafts can crack, but the top ends don't tend to give any issues."

The fours can be somewhat more fragile in the larger sizes, he explains, because the successive increases in capacity don't leave much material between the bores. Nonetheless, major issues are relatively rare. Unfortunately, though, they can be expensive to fix.

"Everything on these engines was purpose-built for racing," says Hart. "They very rarely carried anything over from the road cars, and the engines are not especially simple. Most of them use gear-driven valvegear with ground gears, which makes them very expensive to reproduce. Likewise, the crankshafts are fully counterweighted and everything was made in the best materials available at the time. Even by modern standards, they were made to very high tolerances, so your manufacturing has to be very good to reproduce that."

One consequence of this attention to detail is that they're relatively difficult to tune within the Appendix K regulations, he explains: "It's not like a Jaguar straight-six or an American V8, where you can release upwards of 100 bhp beyond where they were in period. You could never do that with a Maserati engine."

Instead, it tends to be a process of blueprinting. Modern casting techniques mean that the material quality and dimensions more consistently follow those specified by the original design. Wall thicknesses in the cylinder head, for instance, can now be controlled far more accurately, while CNC porting allows a highly repeatable finish.

One area that a lot of owners choose to upgrade is the clutch. The original Maserati designs have a reputation for burning pressure plate fingers and



Andy Swift

ABOVE These thoroughbreds are fundamentally reliable, but they do require careful attention

wearing out release bearings if they're allowed to slip, but a modern racing clutch will cure this issue.

The gear-driven engines also have their quirks when it comes to the valvegear. It's fundamentally a very good system – even at well over 8,000 rpm in some applications, the Maserati engines do without any kind of torsional damper. The four-cylinders use rubber mountings for the carburettors (as is common practice, to isolate vibration that could cause fuel cavitation) but the sixes don't even require those. Again, however, the setup is critical.

"You have to be very careful to maintain the backlash if you skim the cylinder head or anything along those lines," notes Hart. "That generally means moving the centres or re-grinding the teeth, neither of which is a simple exercise."

Another idiosyncrasy of the six-cylinders and the later fours is their unusual cam profiles. They're markedly asymmetrical, with a gentle radius on the opening ramp and then an abrupt closure, made possible by the use of finger followers. Maserati later attempted to take this a step further with desmodromic valves, but they lacked development.



Andy Swift

There's also the question of fuel. The grand prix cars were designed to run on a part-methanol mixture in-period, but modern high-octane race fuel can now be used instead. Modern fuels burn faster and cleaner than their 1950s counterparts, but the Maserati engines still benefit from the twin spark cylinder head arrangement used on all but the earliest designs. These days the 2.5-litre 250F engine generally produces around 275 bhp, while the 3-litre in the 300S is good for a shade over 300 bhp.

ULTRASONIC MACHINE

Paul Adams at Classic & Modern Engine Services (CMES) also works on the six-cylinder Maserati engines. His workshop in Bracknell is a hive of activity, packed to bursting point with all manner of historic road and race engines.

Rebuild work always begins with a thorough clean, he reveals. The blocks are given a hot wash and then usually placed into an ultrasonic machine with a specialist cleaning solution. They're then wire brushed and the threads are all checked.

Next, the engine is crack tested with a Flawfinder spray and pressure tested. "One of the areas we look at during pressure testing is the oil galleries," he says. "You can end up with porosities ▶

ABOVE & BELOW The A6GCM uses a 2-litre straight six that bridges the gap between the A6GCS and the legendary 250F



Andy Swift

in old aluminium blocks, particularly if they're coming off something like a 250F where they will have been stressed. It's things like that we need to find before it's too late – you don't want to finish the rebuild and then go back to correct a fundamental issue."

For ferrous parts, CMES uses a Magnaflux testing machine. This passes an electric current through the part to create a magnetic field, while a dye is applied, loaded with magnetic particles. When an ultraviolet light is passed over the part, it highlights any cracks.

If new liners are required they're shrunk into the block, Adams explains: "Depending on the engine we either make them in-house or outsource them to someone like Westwood Cylinder Liners. We use ductile iron liners, which are harder and stronger than cast iron." The liners are then refaced in-house using a diamond cutting machine.

Next, attention turns to the bottom end. "When an engine comes in, we tend to measure and machine the main bearing housings. They're almost always distorted, so they need correcting before you do any work," notes Adams.

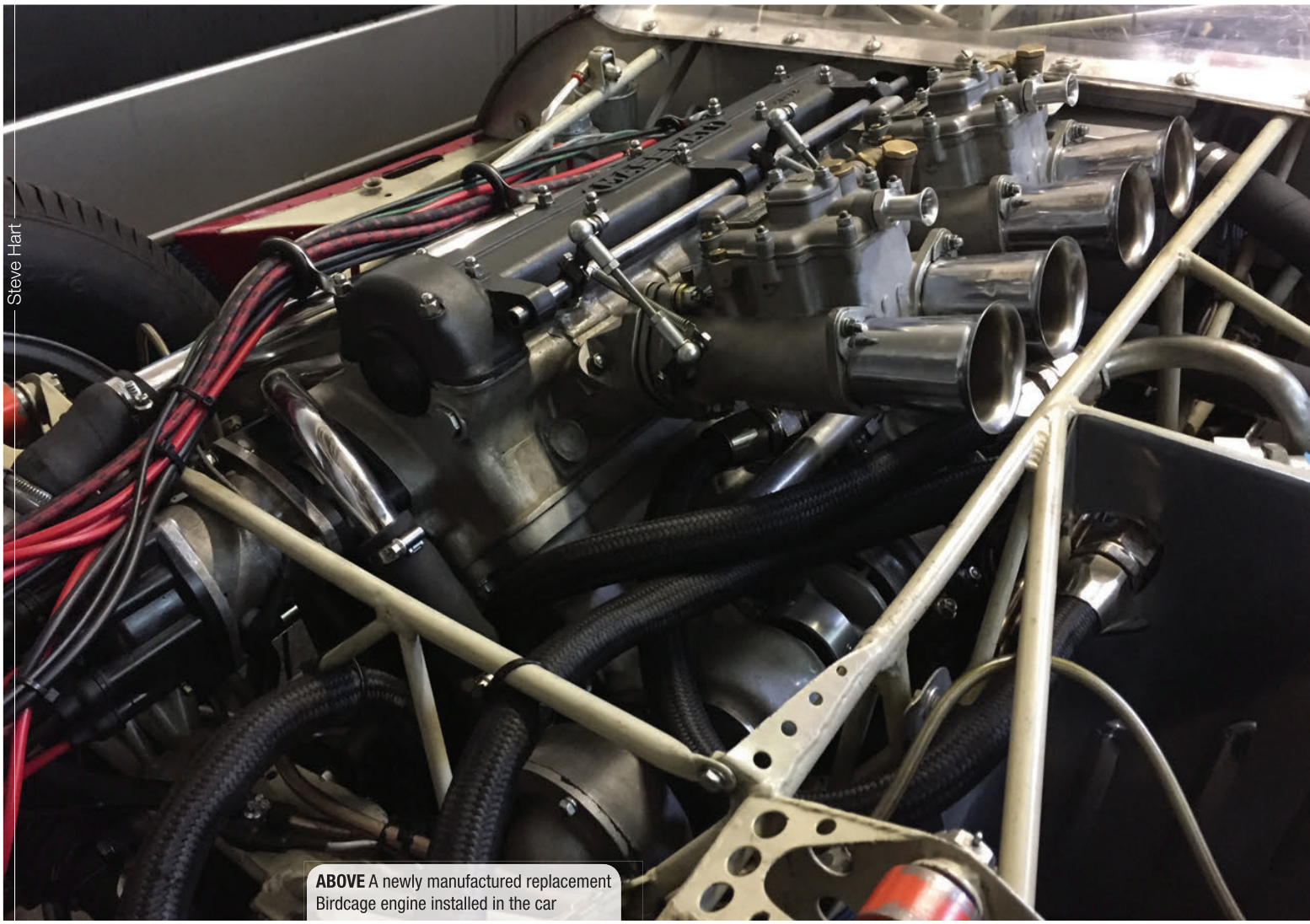
The main bearing housings are repaired by bolting the caps down, line honing them to a good tolerance and then fitting the shells. After that, the individual bearings are measured and the crankshaft is ground to suit. "You will inevitably have some variation," comments Adams. "You don't want a loose crankshaft in an aluminium engine like a 250F, because when it gets warm the block will grow, the bearings will pull away and you'll end up with no oil pressure."

It's common to replace the other reciprocating components during major rebuilds too, and here there are potentially gains to be had.

"We can put in shorter pistons, made to our own specifications from someone like JE Pistons in the US, with longer conrods. This reduces the weight of the rotating components and it alters the conrod angle, which can help the engine to pick up better," says Adams. "Modern materials with lower expansion rates also allow you to run tighter clearances in the bore so there's less blow-by. And thinner piston rings incur less drag."

CMES has also looked at the top end of the engines. "There are bits and pieces you can do to the breathing," he continues. "We can re-flow the heads to help them breathe a little better and we work with Piper Cams to re-time the camshafts. We have the camshafts made and superfinished, then we DLC coat the followers to cut down on friction."

Armed with this technology, the engines that Maserati conceived in Modena in the 1950s are now fitter and stronger than ever before. HRT



Steve Hart

ABOVE A newly manufactured replacement Birdcage engine installed in the car

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BACK TO SCHOOL

Racecar manufacturers come and go, but one that has withstood the test of time is Crosslé. Now celebrating its 60th anniversary, it is entering a new phase of its life thanks to a couple of entrepreneurial Frenchmen, as **William Kimberley** reports

EVERYONE knows Hollywood with the two 'l's while hardly anyone knows the same name with the single 'l', but those who do are very familiar with a racecar company that claims it is the world's longest established constructor of just racecars, having been in business for 60 years. Still operating from its original factory at Rory's Wood in Holywood, County Down in Northern Ireland, the Crosslé Car Company has built close to 1,000 cars over this period with a good many being exported around the world.

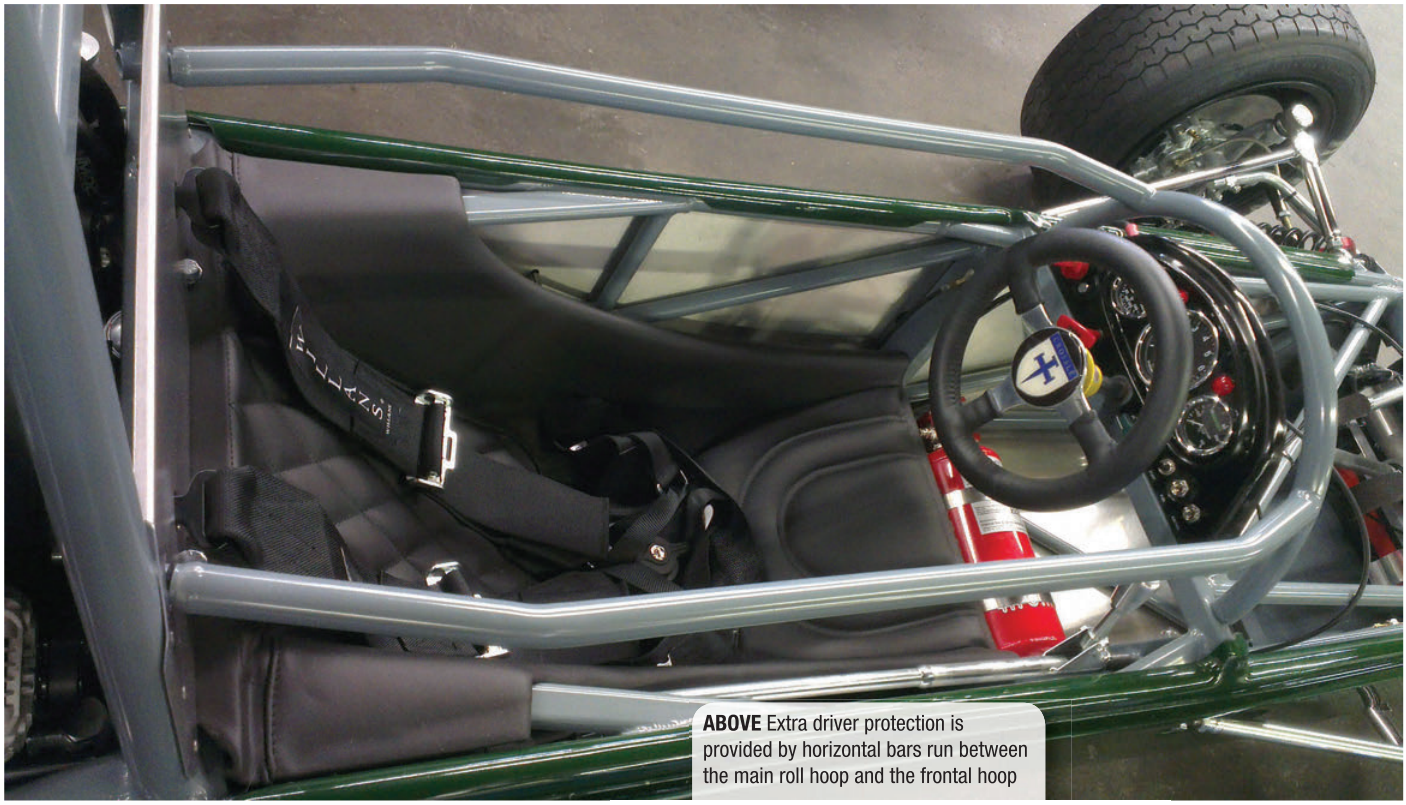
Its heyday in terms of success came in 1969 when Gerry Birrell became the European Formula Ford champion driving a Crosslé-Hart 16F in the championship's inaugural year. This was a time when there was a plethora of Formula Ford manufacturers, including Alexis, Merlyn, Lotus and Titan among others.

The 16F was the basis for the 17F Formula 3 car and the 18F and 19F Formula 2 cars. With well over 200 bhp as well as slicks and wings, the F2 cars proved the effectiveness of the original design in top level international competition. They were also a popular choice with race schools in both Europe and the US where the robust design, reliability and factory support were key attributes. In recent decades, these cars have competed with success in historic racing worldwide.

The company today offers a range of services to owners, including restoration and repair, spare parts and technical support, as well as new cars of its own design and manufacture.



ABOVE Robust design, reliability and factory support have always made the Crosslé designs a popular choice of race schools, but this is a school car with a difference



ABOVE Extra driver protection is provided by horizontal bars run between the main roll hoop and the frontal hoop

> **“The original bodywork was central to the car’s appeal, echoing grand prix cars of the period”**



However, thanks to the efforts of two entrepreneurial Frenchmen, it is entering a new phase in its life.

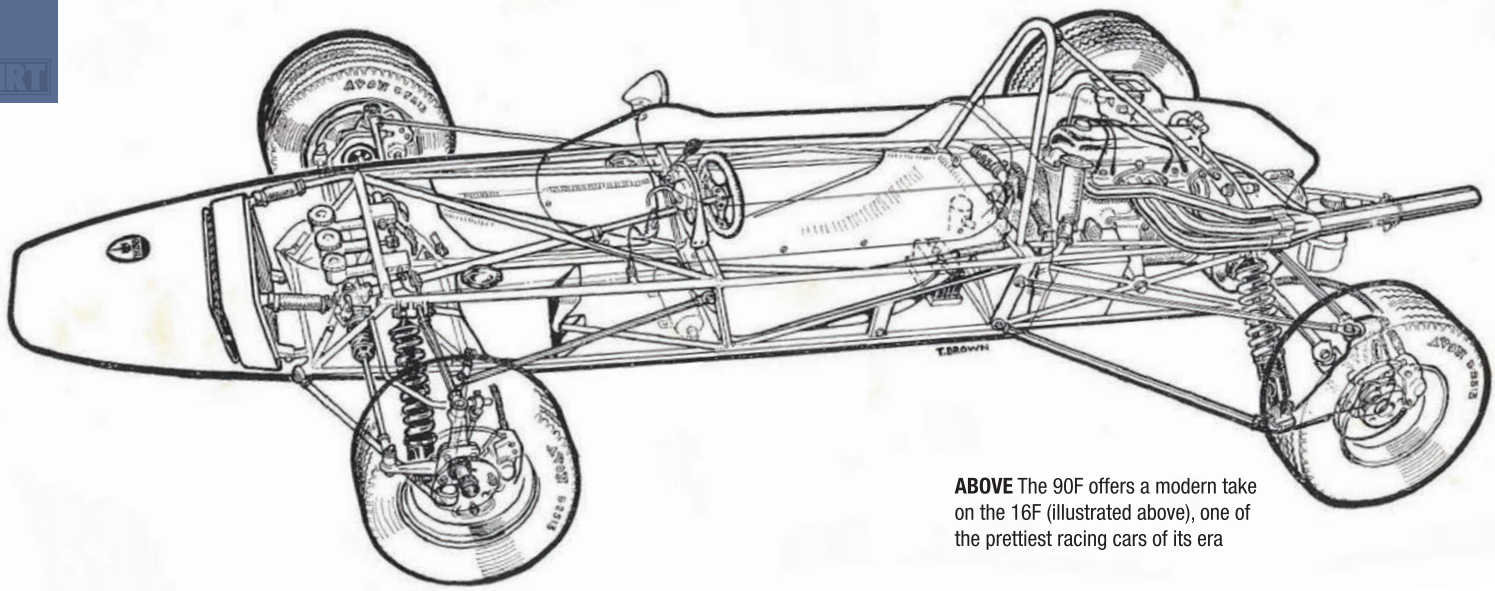
Julien Chaffard and Morgan Pezzo have recently opened the Classic Racing School as an innovative ‘historic racing academy’ at the Circuit de Charade in France. Rather than have de-powered modern racecars, though, it has opted for a car from a bygone era inspired in its own words by a ‘golden age’ of motor racing. That car is the Crosslé 16F, or rather, the 90F as it now is, that aims to conserve the charm and simplicity of single-seaters from another era, hand-built by perfectionist craftsmen in the traditional way, but with significantly enhanced safety and reliability.

DESIGN BRIEF

As far as practical, the new car had to visually and in terms of track behaviour resemble the 16F, one of the prettiest racing cars of its era. But it had to combine the iconic late ‘60s appeal with enhanced safety, economy, and environmental impact.

Other requisites included meeting the 90 dB noise limitations of the Circuit de Charade as per the FIA static test. It needed to operate reliably and economically in a race school environment with a focus on ease of use by multiple drivers, simple maintenance, ▶

CROSSLÉ 90F RACE SCHOOL SINGLE-SEATER



ABOVE The 90F offers a modern take on the 16F (illustrated above), one of the prettiest racing cars of its era

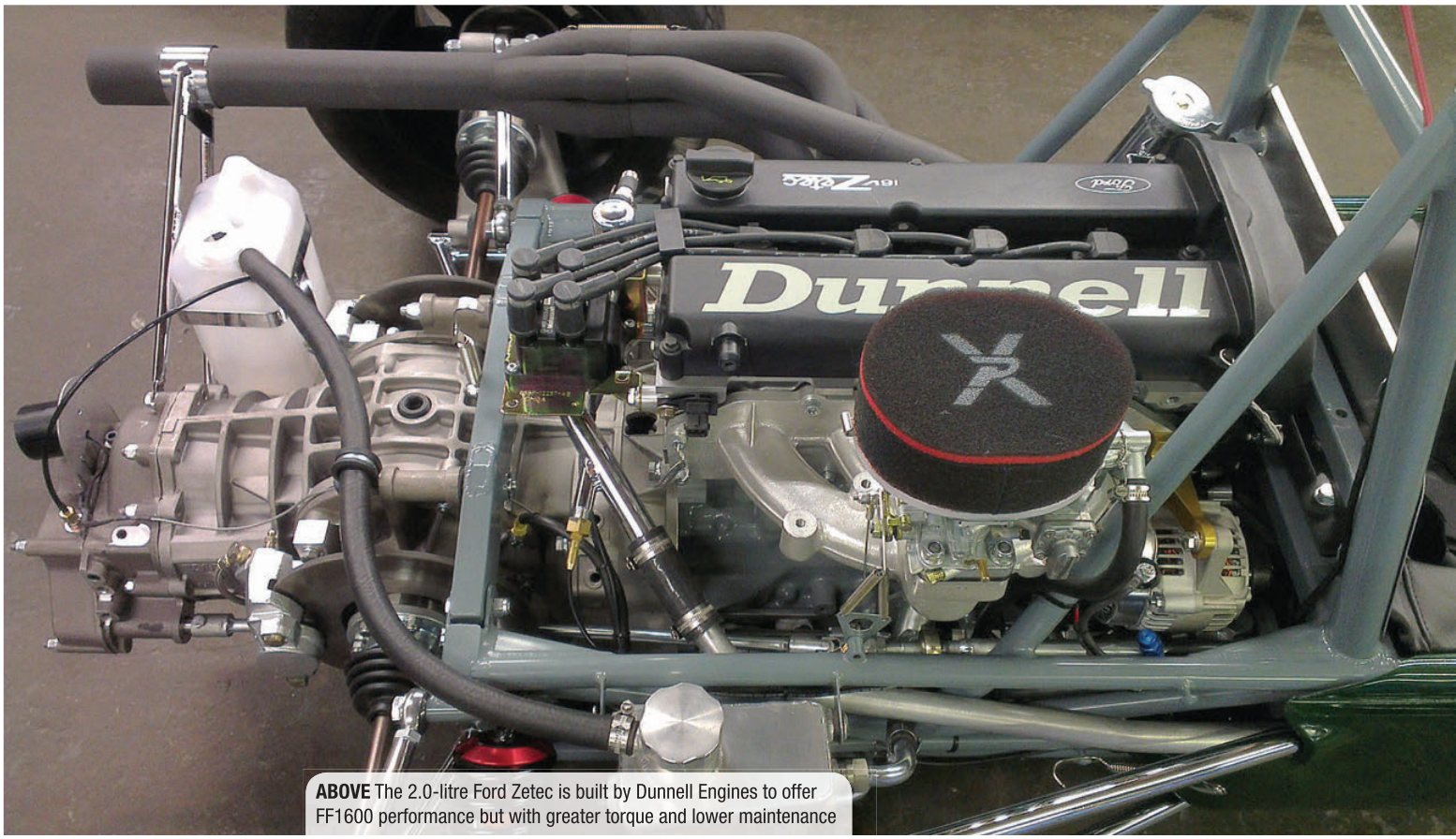
and typically 12 months between major overhauls. It also had to lend itself to further development, both for the Classic Racing School as well as potentially in less restricted versions for private owners and others.

While superficially resembling the 16F, though, the new design could not be confused with original 1969/70 cars or facilitate 'reconversion' to period 16F specification. It is not a historic car and isn't built to comply with any FIA, ASN or single-seater technical regulations. As it is not intended to compete in any existing historic race series, an Historic Technical Passport is irrelevant and not required.

The original bodywork was central to the car's appeal, though, echoing grand prix cars of the period and remains unchanged as far as possible. The complete body comprises the combined nose and main body section, with windscreen and mirrors, the engine cover and left and right side panels.

Crosslé used the existing 16F jigs, moulds and components as far as practical to conserve the spirit of the original car while also minimising the development costs. The bodywork is moulded at the factory using a gel coat pigmented in a single colour from the Llewellyn-Ryland standard range. The radiator cowl and radiator duct, as well as dashboard and seat, are moulded in black GRP.

Bodywork graphics can be added via a gel coat inlay, vinyl decals or paint. Gel inlay has the advantages of deep lustre and durability, whereas vinyl graphics are inexpensive, easily replaced, and almost indistinguishable from paint. Any of these can be added as optional extras ▶



ABOVE The 2.0-litre Ford Zetec is built by Dunnell Engines to offer FF1600 performance but with greater torque and lower maintenance

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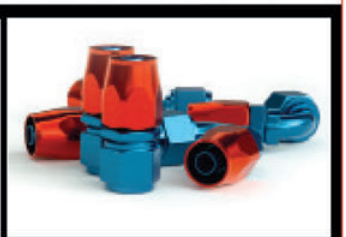
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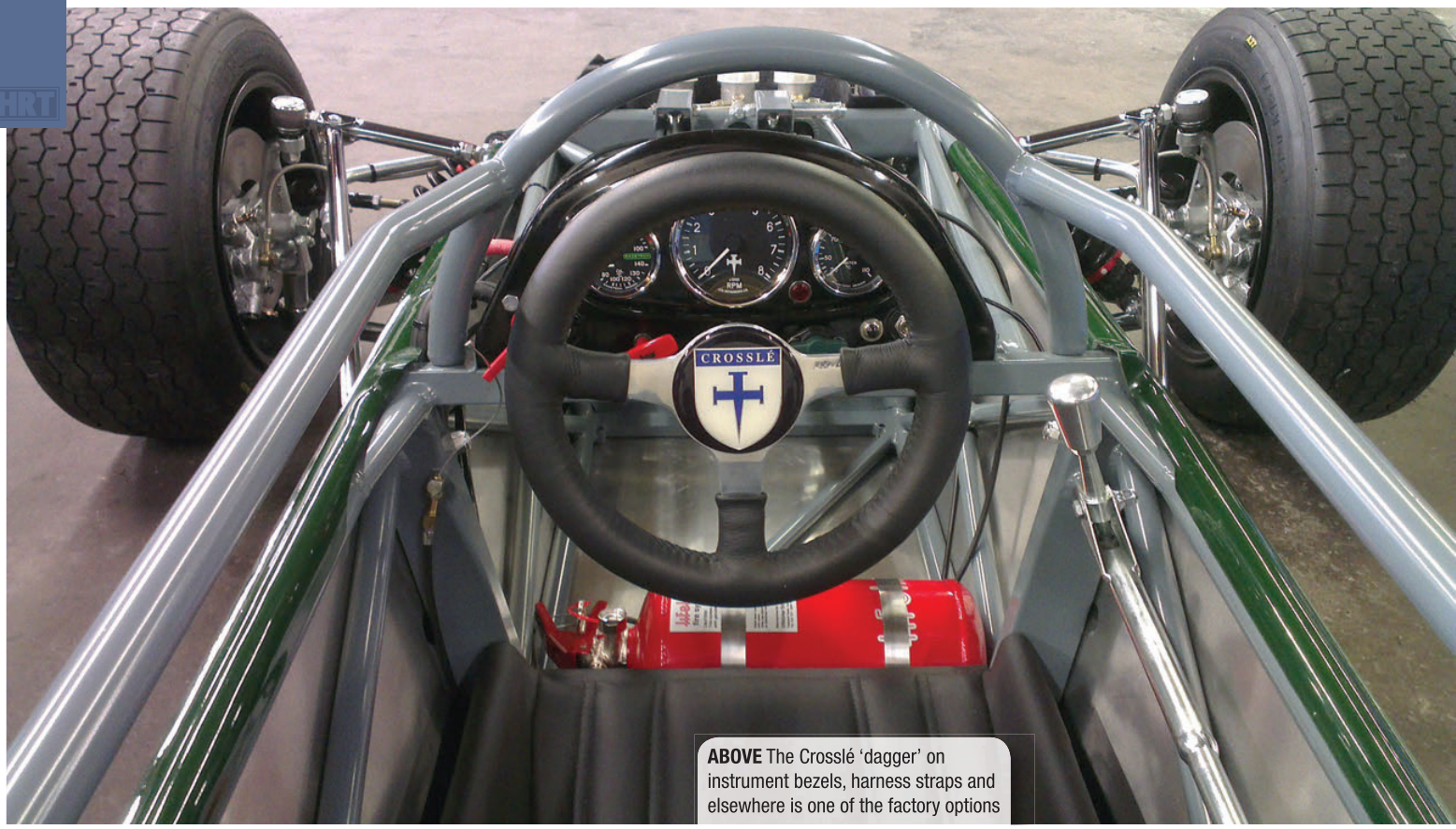
SIZE	OFFSET RANGE	C DIMENSION (BACKSPACE)	APPROX WEIGHT KGS
13 X 10.0	-38 TO -08	97 TO 127	5.3 TO 5.9

SIZE	OFFSET RANGE	C DIMENSION (BACKSPACE)	APPROX WEIGHT KGS
13 X 5.5	-17 TO 13	60 TO 90	4.0 TO 4.6
13 X 6.0	-13 TO 17	73 TO 103	4.1 TO 4.7
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CROSSLÉ 90F RACE SCHOOL SINGLE-SEATER



ABOVE The Crosslé 'dagger' on instrument bezels, harness straps and elsewhere is one of the factory options

to customer requirements.

The chassis has been strengthened using additional members and heavier gauge round tube, and the engine bay adapted for the new powerplant and ancillaries so that changing a gearbox, for example, has been greatly simplified. The original design routed cooling water from the engine to the radiator and back through the chassis rails, a common practice at the time. However, this exposed the driver to scalding in the event of a serious accident, and the chassis to internal corrosion. In recent times, water piping has been routed outside the chassis while aluminium panels have been added on each side of the cockpit for driver protection.

These updates are included in the 90F design, and water outlets to the chassis rails, a feature of the original, have been deleted. Existing parts have also been used from other Crosslé models, as well as proprietary parts from external suppliers to help reduce build costs. Where external components have been used, they will continue to be available for the foreseeable future to avoid shortages while also minimising maintenance costs.

Most of the original 16F suspension such as the traditional front lower wishbone, upper transverse link and leading link, adjustable coil spring damper units and spring platforms are used. The 90F also features a traditional lower rear wishbone with Silentblock bushes, trailing links and upper transverse link, with adjustable coil spring damper units and spring platforms. Crosslé 30-series cast alloy rear uprights are used with inboard rear brakes, custom driveshafts and rear wishbones specific to this car. Spherical rod-end bearings provide for extensive set-up adjustment.

With the benefit of hindsight, though, Crosslé has addressed the drawbacks of the original chassis. The original roll-over protective structure consisted of a roll hoop behind the driver with a single, removable tubular stay facing rearwards over the engine bay. There were no forward-facing stays and no roll hoop ahead of the driver, although later FF1600 designs included both. An upper aperture for the removable rollover protection system stay is no longer needed.

The 90F has an additional removable upper cockpit assembly that required minor modification to the main body section. It comprises an additional integrated roll hoop fabricated from T45/4130 steel that's located close to the ▶



ABOVE Over the years the Crosslé Car Company has built close to 1,000 cars

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dashboard for improved driver protection.

Additional horizontal bars run between the main roll hoop and the frontal hoop, following the upper contour of the windscreen. Together these provide extra driver protection in the event of a frontal or side impact and protect the windscreen by supporting the weight of the driver while entering or leaving the cockpit. This is particularly useful in a school environment with inexperienced drivers.

Some drivers found the 16F cockpit cramped due to a horizontal beam above the driver's knees. This has been modified in the 90F to improve cockpit access and increase legroom. The pedals can be adjusted forward or back between six fixed positions. The seat is deeper than before, while most drivers use an individually customised foam pad to fill the space between this and their back. Together it allows a comfortable seating position to be achieved and along with a taller roll hoop, the new car can accommodate drivers at least 1.85m tall.

The car is fitted with a Willans 6-point racing harness with mounting points for traditional and HANS shoulder belts and a Lifeline fire extinguisher bottle is mounted below the driver's knees, with a pin and indicator gauge. Nozzles direct the extinguisher contents to the cockpit and engine bay.

Instrumentation is pretty standard with items such as ▶



ABOVE In recent decades the brand has competed with success in historic racing worldwide

Standard specification includes:

Spaceframe chassis in round tube, hand-brazed in mild steel and powder-coated grey, with T6 fully-hardened aluminium floor. Based on the 16F original but simplified where possible, significantly strengthened using 16-gauge tube (18-gauge originally), and adapted to accommodate a relatively modern engine, the chassis includes an integrated roll hoop fabricated from T45/4130 steel with rear-facing braces.

Provision for an additional (optional and removable) upper cockpit assembly with front roll hoop over dashboard, and horizontal bars following top edge of the windscreen from dash to main roll hoop.

Ford Zetec 2.0-litre engine with Weber 32/36DGV carburettor, built by Dunnell Engines to develop 110 bhp. Dry sump.

Aluminium panelling for driver safety to cockpit front, sides and rear, with water piping external to the chassis and contained within GRP side panels.

Engine-mounted alternator to maintain battery charge and condition.

Custom-made exhaust manifold and silencer, developed for the 90 dB requirements of Circuit de Charade, France.

Mk9 4-speed gearbox by Elite Racing Transmissions with VW 'Rhino' main casing, 10:31 CWP and easily interchangeable final ratios.

Crosslé 30-series cast alloy rear uprights with custom driveshafts.

Front suspension: Traditional lower wishbone, upper transverse link and leading link, with rod-end bearings. Adjustable coil spring damper units and spring platforms.

Rear suspension: Lower wishbone with Silentblock bushes and rod-end bearings, trailing links and upper transverse link, with adjustable coil spring damper units and spring platforms.

Front anti-roll bar, adjustable.

Solid disc brakes with single-piston callipers, outboard front, inboard rear.

Rack and pinion steering, with 30-series rack.

GRP body in four sections. Based closely on period bodywork, the engine cover accommodates the Zetec engine and additional roll hoop structure.

Foam-filled 13-litre alloy fuel tank, housed behind the seat. Electric fuel pump.

Weller steel wheels, 13" x 5-1/2" front and rear, powder-coated silver/grey and fitted with Avon ACB9 racing tyres (as fitted to Historic FF1600) for school use.

GRP seat with Willans six-point driver harness in black. Chassis mounting points for traditional and FHR/HANS shoulder belts. Padded headrest.

Leather-look 265 mm steering wheel with Crosslé emblem.

Rain light, activated via dash-mounted master switch.

Aluminium radiator with GRP ducting.

Instrumentation: tachometer, oil pressure, water temperature.

Clear acrylic windscreen with period rear-view 'bullet' mirrors either side.

Lifeline 2.25-litre fire safety system, mechanically-activated from dashboard.

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CROSSLÉ 90F RACE SCHOOL SINGLE-SEATER



ABOVE As much of the original car has been kept as possible, but many of its drawbacks addressed

a tachometer, oil pressure gauge and master cut-out switch. The rain light remains permanently 'on' when the master switch is activated as a reminder to school drivers and staff to turn this off when the car is not in use. A dashboard-mounted brake balance knob is optional, as is a wired-in transponder system for lap timing and display to the driver and pit crew. The ECU allows run hours, maximum rpm and other key parameters to be logged electronically to assist maintenance and record any incidents of misuse.

ENGINE AND GEARBOX

Formula Fords of the late 1960s were powered by the 1600 cc Ford Kent engine with a cross-flow cylinder head that was first seen in 1959. Race-prepared with a dry sump and other specialist features, it produces some 105 bhp and typically requires a rebuild after each season of approximately 20 running hours. Although most parts can be obtained without difficulty, the cost of a complete 'new' FF1600 engine exceeds £6,000 while season-end rebuilds can cost £2,000.

More modern engines offer greater power, reliability and economy. After considering options for the 90F, including the Ford Sigma regularly used by Caterham 7s at the Circuit de Charade, the 2.0-litre Ford Zetec engine was selected as it's still relatively plentiful and is well known to Crosslé and its partner Dunnell Engines. The engine itself and the component costs are therefore relatively modest with parts available for the foreseeable future and it also delivers excellent performance over many years.

Tuned to 230 bhp for the Crosslé 9S sports car and raced hard, it has run flawlessly for over 100 hours between rebuilds. It also neatly fits into the 16F engine bay, requiring just a modified engine cover for the single carburettor and exhaust although its overall height and shape are little changed.

Adapted for a single Weber 32/36DGV carburettor as per the original Kent engine, the 2.0 Zetec produces over 150 bhp without any form of tuning. With the power output restricted to 110 bhp to achieve 90 dB, the 90F's performance is equivalent to a Kent-powered Formula Ford 1600 with its heavier and stronger chassis. The Zetec also produces greater torque with less vibration and noise, using a standard pump fuel without the Kent's need for lead substitute or octane booster. The internal components are uprated to resist accidental damage in the hands of novice drivers, while a dry sump system facilitates installation into the 90F chassis and protects the engine from cornering and braking loads during sustained track use.

Kent Formula Ford 1600 engines have to use a regulation silencer from Ford measuring 322 mm long x 127 mm diameter. While this satisfies the needs of many circuits, others require more efficient silencing as sensitivity to the environment grows and noise restrictions become ever more stringent. A longer, wider silencer is used for the 90F at Charade that has more extensive internal baffling but which still retains the appearance and sound quality of the original. However, a more compact silencer with louder and more aggressive engine note is an option for unsilenced events.

The engine rpm is electronically monitored and restricted with 'soft' and 'hard' cut-out thresholds, reducing the likelihood of over-revving under acceleration, and recording incidents of missed or incorrect gearchanges by novice drivers.



ABOVE The 90F is an integral part of the historic racing academy at the Circuit de Charade

An engine-mounted alternator maintains battery charge and condition. Kent-powered FF1600 cars typically require their battery to be recharged from an external source between outings, which is inconvenient and impractical in a race school environment.

In period, the 16F used a Hewland Mk5 gearbox with elastomeric 'donut' transmission couplings from the gearbox, universal couplings outboard, and outboard rear brakes. Later FF1600s used the 4-speed Mk9 gearbox with safer and more efficient CV joints, together with inboard brakes.

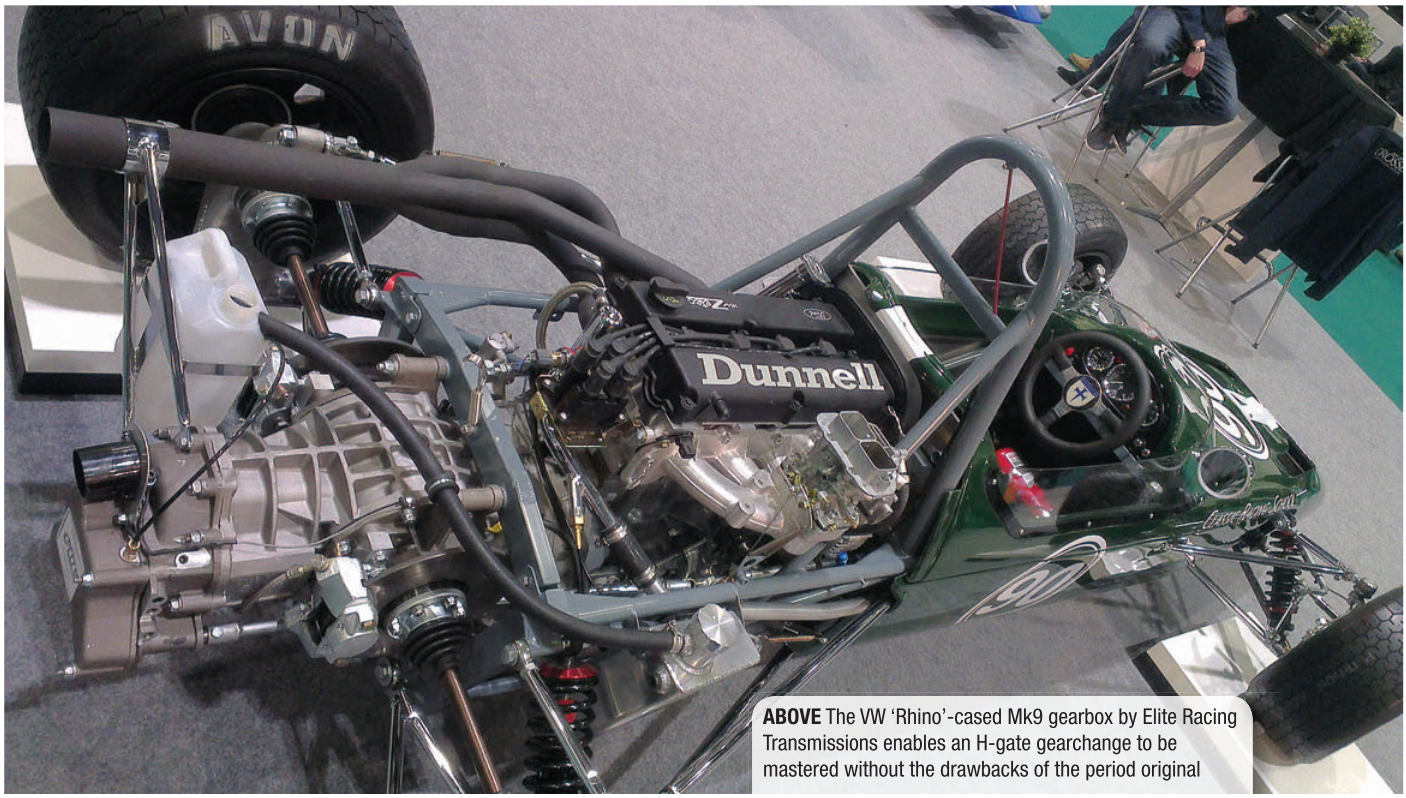
For design simplicity as well as cost and parts availability, the 90F uses an externally similar, but stronger VW 'Rhino'-cased Mk9 by Elite Racing Transmissions, with CV joints and inboard rear brakes. As with the period original, this offers the satisfaction enthusiasts derive from mastering a traditional H-gate gearchange with fewer drawbacks. The gearbox features a 10:31 crown wheel and pinion, with four final ratios selected to deliver track performance at Charade similar to an FF1600, at lower rpm than the original Kent motor using a 9:31 CWP. Ratios are interchangeable for other circuits and driver preferences. The Elite gearchange is positive and smooth, making it easy to pull away in first gear, engage reverse, and shift across the gate in ways that novice drivers sometimes find tricky at first.

WHEELS AND TYRES

The 16F and other Historic Formula Fords racing today use 13" x 5.5" pressed steel wheels front and rear, with Avon ACB9 tyres. For school purposes, Weller steel wheels with ACB9 tyres are used as they provide excellent grip in most weather conditions, work well with the chassis and suspension, and can be used for up to a full season of racing.

However, the 90F is not restricted by eligibility rules or the compromises of Formula Ford. Using wider wheels and racing tyres enhances the new car's visual appeal at relatively little extra cost. For this reason, 6" front and 8" rear ML alloy wheels, together with Avon ACB10 tyres, are included in the specification, the car riding lower with a more aggressive stance. They will also be required if and when the 90F is allowed to run unsilenced, with substantially more than 110 bhp.

The 90F is offered at a cost of £34,950 ex-works, exclusive of delivery and any applicable taxes. At the time of writing, new orders can be delivered to customer specifications within six months of receipt of a 50% deposit. Each car comes with a Certificate of Origin, detailing the identity of each car as it left the Crosslé factory, including chassis, engine and gearbox serial numbers and a photograph of the completed car. HRT



ABOVE The VW 'Rhino'-cased Mk9 gearbox by Elite Racing Transmissions enables an H-gate gearchange to be mastered without the drawbacks of the period original

A fresh mint

The Porsche 956 and 962C were the most successful sports racers of all time. **Glen Smale** traces the story of one of the later models

IN February 1984, Porsche ran its freshly modified 962 for the first time in the Daytona 24 Hours race, the opening round of the endurance racing series that season. With hindsight, and despite setting the fastest qualifying time, it wasn't the debut that Porsche had hoped for, as it retired the car with 127 laps on the board due to gearbox failure.

While the 956 had proved immensely successful in its first two years of competition, IMSA ruled that it would not be legal for racing in the US as the driver's feet sat ahead of the centre axle line. This was a red line for the US motorsport body, and so Porsche set about extending the wheelbase by moving the front axle forward by 120 mm, while retaining the same overall body dimensions.

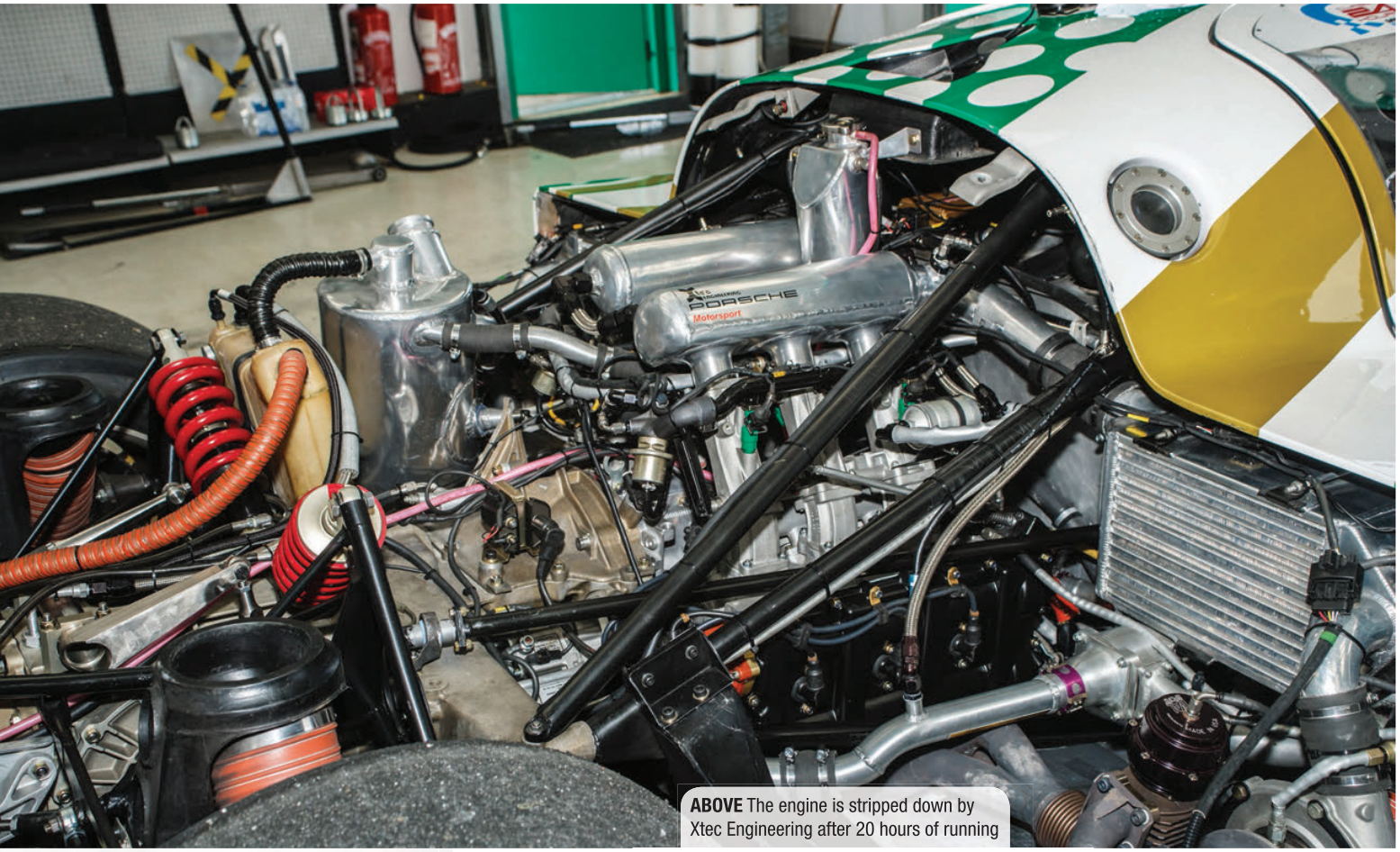
The Porsche 956 and other racecars manufactured before the 1st January 1985 cut-off were allowed to continue racing without modification until the end of the 1986 WEC campaign. For the 1985 season, and in the face of increasing competition, the works team replaced its 956s with 962C models which helped Porsche to notch up wins in the Le Mans 24 Hours in both 1985 and 1986.

The correct name for the new Porsche model was in fact the 962C, where 'C' referred to Group C in the World Endurance Championship (WEC). The 'C' was dropped for the IMSA cars as they had a slightly different spec compared to their European cousins, so the American cars were referred to as just the 962. As a result of the 956's massive success, the road to the top for the 962 was not the long and winding one usually associated with new racecar developments; it was instead a rather rapid and direct route.

> **"Porsche captured nine of the top 10 places at Le Mans. 'Nobody's perfect' suggested its promotional poster"**



ABOVE The Tic Tac 962C made forays into the World Sports-Prototype Championship and IMSA long after the factory had ceased development of the car. It is seen here in action at the Silverstone Classic



ABOVE The engine is stripped down by Xtec Engineering after 20 hours of running



All photos: Virtual Motorpix

ENGINE

Although it was introduced with the reliable 2649 cc unit, the 962C would in time be powered by a 2.8-litre, 3.0-litre and a 3.2-litre engine. Pushing the capacity from 2.65 litres to 2.8 litres required an increase in bore and stroke to 93.0 x 70.4 mm, giving a capacity of 2869 cc. The increase from 2.8-litre to 3.0-litre saw just the bore increase to 95.0 mm, and with the same stroke, the capacity was 2994 cc for the Type 935/83 engine. With the 962C weighing just 850 kg, this engine capacity increase boosted output to 720 bhp at 8200 rpm and gave the car a top speed in excess of 220 mph (350 km/h).

Instead of producing a new model, each year the 962C was further developed through component upgrades and incremental improvements. In 1985, the 2.8-litre and 3.2-litre engines were introduced, but it was only in 1987 that the 3.0-litre engine was seen in the 962C.

The 3.0-litre engine was fitted with twin KKK turbochargers, and the car ran with the relatively high compression ratio of 9.0:1 which was made possible by welding the individual heads to their respective cylinders. This dispensed with the need for a head gasket, which had been a source of some trouble in the Porsche 935, the base engine of the 956 and 962C. In 1989, the 962C received the advanced Bosch Motronic 1.7 engine management system that controlled the injection, ignition and wastegate on the turbos, offering more accurate control.

The weight of the engine was 192 kg with the turbochargers, and 167 kg without. Shell TMO SR oil was used to lubricate the engine, which had a total capacity of 18 litres. The Type 956 gearbox, with five forward gears plus reverse, weighed just 50 kg dry, but required 4.2 litres of Shell S 6909. The 962C is fitted with rack and pinion steering which is not power assisted, and the 120-litre fuel bladder is an ATL FT3 unit. Fuel was delivered to the engine by way of a pre-pump, two main pumps and two reserve pumps.

Suspension improvements for the 1985 season saw the 962C receive 19-inch rear wheels, replacing the 16-inch wheels of the earlier car. This required a redesign of the rear suspension, and the rear shock absorbers and driveshafts had to be re-aligned accordingly. The larger diameter wheels necessitated rear body modifications to accommodate them. Although the front and rear suspensions were borrowed from the 956, spring and shock absorber attributes were revised to suit the ▶

extended wheelbase and aerodynamic characteristics. The differential housing was cast in aluminium, further increasing torsional rigidity.

CHASSIS AND BODY

The brakes fitted to the 962C were supplied by Brembo. Disc diameter of the ventilated front and rear brakes was the same at 354 mm, and the thickness of 32 mm was the same for both the front and rear. Four-pot alloy callipers were fitted all round.

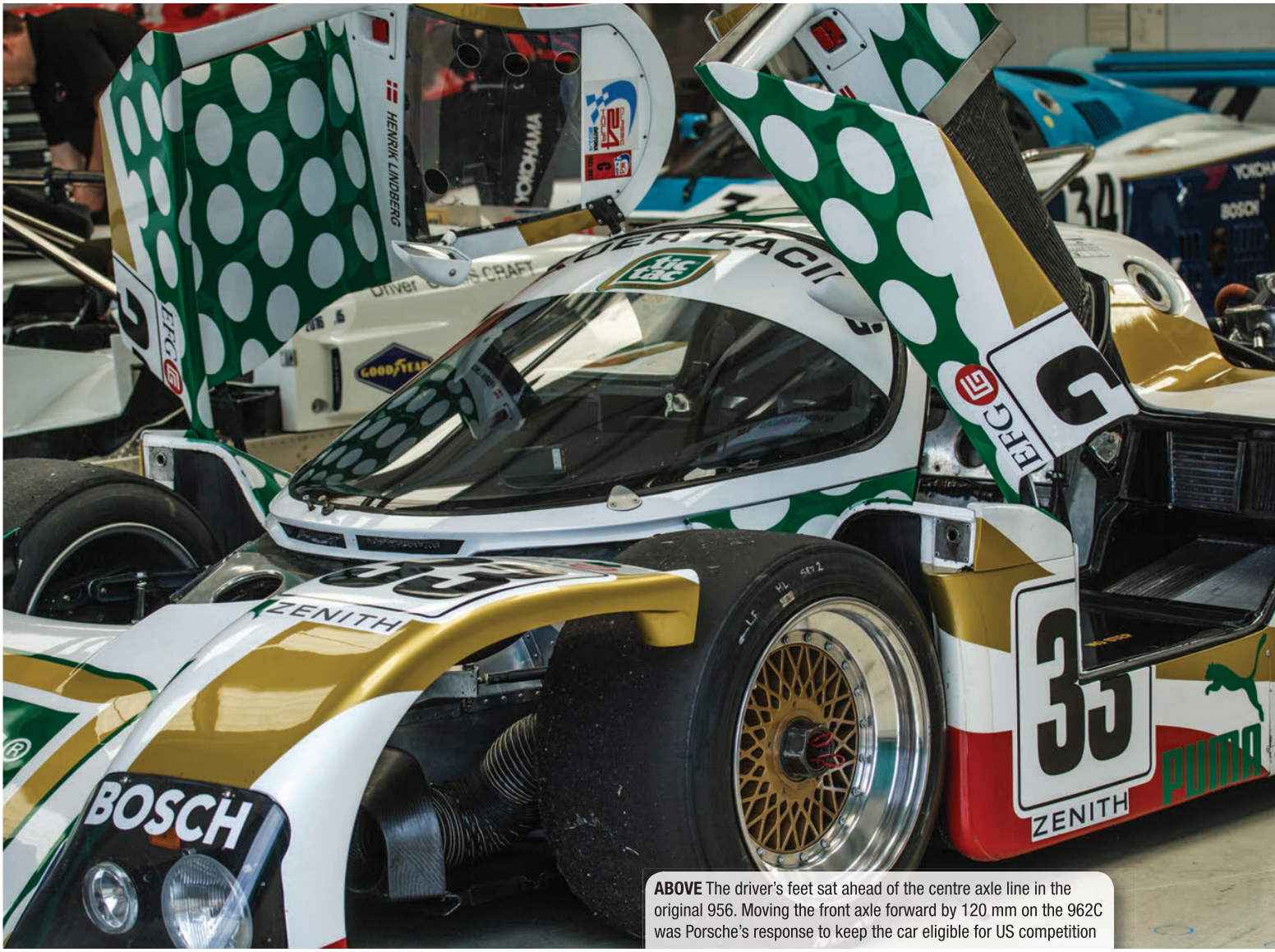
The rear section of the 962C was dominated by a large wing, and was responsible for keeping the race car well and truly glued to the tarmac at speed. The rear wing was supported by the endplates which were an integral part of the rear bodywork and measured 1100 mm from the point the upright began to rise from the horizontal deck, to its trailing edge, and was 500 mm from where it joined the body, to its top edge. The rear wing itself was a substantial component, and measured 1800 mm from left to right with a 570 mm chord, and was just 1000 mm from the track surface. The wing was 55 mm thick and it was fitted with a 40 mm gurney flap on its trailing edge.

The roll cage fitted to the 962C was made from the standard approved CDS steel tubing with a diameter of 45 mm (main lateral bar, front bar, diagonals and other struts) and a wall thickness of 2 mm. The roll cage was fixed to the body by way of four mounting points.

CUSTOMER RACING

Where Porsche made a great deal of money, was through its customer racing department. This was run by Jürgen Barth, and being a highly successful racing driver himself, he knew what customers needed and how to sell it to them. Well-known privateer teams included Joest Racing, Fitzpatrick Racing, Kremer Brothers, George Loos (Gelo Racing), as well as many others in Europe and the USA. At the end of 1983, John Fitzpatrick hung up his helmet and took on the role of managing his racing team. This he did admirably until the end of 1986 when he decided to retire from ▶

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ABOVE The driver’s feet sat ahead of the centre axle line in the original 956. Moving the front axle forward by 120 mm on the 962C was Porsche’s response to keep the car eligible for US competition

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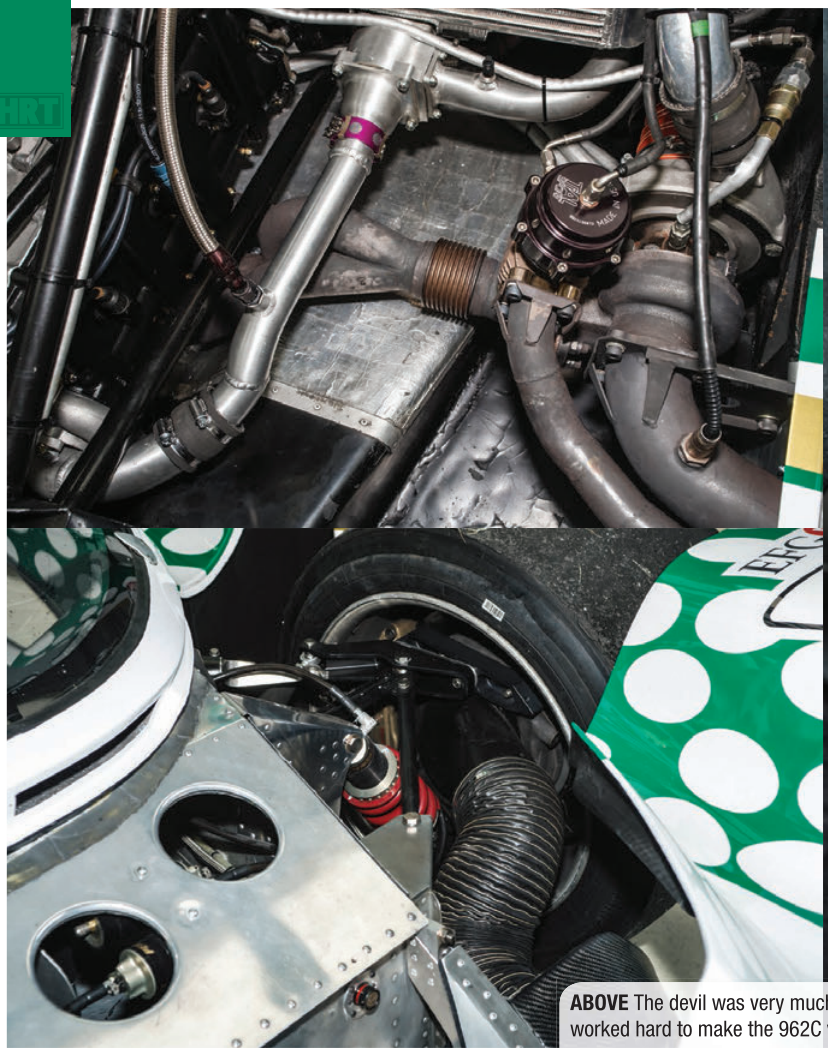
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ABOVE The devil was very much in the detail as the factory worked hard to make the 962C viable for an army of privateers

motorsport, and he duly sold his entire outfit to Jochen Dauer, an accomplished German racer.

In 1987, Jochen Dauer Racing was formed, and Dauer enjoyed several years of racing with the Porsche 962C in the German Supercup and European Interserie championships, with occasional entries in the World Sports-Prototype Championship and Camel GT Championships. Dauer was himself fairly successful, winning the 1988 Interserie Teams' and Drivers' Championships. Victor Computer had been the team's primary sponsor but in 1989 the well-known brand, Tic Tac, took on this role.

The records show that Porsche 962C chassis #141 was sold to Jochen Dauer on 23 January 1989. Dauer raced chassis #141 in 1989 and 1990, where it was a popular and striking entrant, with its colourful livery. In the longer races, Dauer enlisted the help of co-drivers. Two of these were the Englishman Will Hoy (he sadly died of a brain tumour in December 2002), and the very talented Brazilian Raul Boesel.

The first recorded race for chassis #141 was the Nürnberg 200-mile event on 25 June 1989 in which owner/driver Dauer recorded a DNF, as he ran out of fuel. On 6 August, he once again scored a DNF at the ADAC Diepholz Airfield race. But at the Most Interserie, Dauer finished first in the opening heat and runner-up in the second, scoring an overall second place for the event. He then notched up two further DNFs at the Nürburgring and Spa-Francorchamps races that followed.

REPLACEMENT CHASSIS

Dauer's last race of the 1989 season was Round 8 of the Sports-Prototype World Championship in Mexico City on 29 October. For this race he partnered with local driver Juan Carlos Bolanos, but an accident in practice put paid to their chances. An urgent call was made to Porsche for a replacement chassis, and Dauer duly built up a new racer with the chassis plate from the damaged car, and so #141 breathed again.

At the first race of the 1990 season, the Brazilian driver Raul Boesel teamed up with Al and Bobby Unser for the Daytona 24 Hours on 4 February. Having qualified seventh, the Porsche retired after 360 laps with engine trouble. At the Miami GP later in the month, Boesel was teamed with Bob Wollek. They led the race initially but unfortunately retired again with mechanical issues.

In the second round of the 1990 Endurance Triple Crown in March at Sebring, the result was also disappointing when #141 driven by Boesel/Hans Stuck/René Herzog recorded a NRF following an accident. Boesel's final race in chassis #141 was in the sixth round of the World Sports-Prototype Championship at the Nürburgring on 19 August 1990. The car was not running well, but driving solo, the Brazilian managed to improve his 22nd position on the grid, to finish in 11th place.

A winner of the Sportscar World Championship with Jaguar in 1987, when the XJR-8 won eight races to Porsche's two, Boesel's reflections on the two cars are interesting. "The ▶



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Porsche was much softer. I mean it is not that it was easy to drive, but to go faster in the Jaguar was very tricky," he said. "The Porsche was smoother through the corners and it didn't bounce as much, it was a much better ride. The other thing was it didn't have much lag and when you changed gears you would hear the spin of the turbo, which was a nice feeling for the driver."

PREPARING A 962 FOR RACING

Paul Knapton of Xtec Engineering got to know about this 962 while it was still in the hands of a previous owner, the company working its magic on the car's engine. "The engine has been apart two or three times and it has had a new crankshaft and pistons in that time," Knapton shared.

The car is fitted with Omega pistons and Arrow conrods, while the new crank also came from Arrow. Recently new cylinder barrels, which are specialised Xtec components, were fitted. Nimonic exhaust valves are used for their increased operating temperature characteristics, ideal for turbo engine applications. The spark plugs employed are NGK DR9. Motul 15-50 engine oil is used while the gearbox takes Motul 75-140 oil. The original Brembo brake callipers are today fitted with Pagid RSL 1 pads.

Preparing the 962 for a race meeting would begin with the removal of the rear underbody floor, a large lightweight panel covering the mechanicals. The brakes would be stripped down, checked and reassembled ready for action. The engine oil would be drained and the engine oil filter, which comes apart, would be removed and stripped to check for any tell-tale signs of wear or broken parts. The fuel tank too would be drained, and the spark plugs taken out.

Pre-race inspection and preparation would also necessitate the strip down of the gearbox and removal of all the gears, as this step could reveal damage or wear that could lead to a failure. During the course of a race meeting, riding the kerbs can induce wheel



BELOW The car will forever be rooted in time at a special period in endurance racing history – but fire suppression standards have moved on!

bearing play. If that is the case, that particular hub will be stripped down. But, in general, if there is no play, then this would only get checked every four or five races.

Depending on where the car is raced, the brake pads should last a minimum of two meetings. The 962 will use two sets of tyres per race meeting, and the best of those would then go on to do the first stint at the next event, or they could be used for testing.

Normally the engine would get stripped down once a year. In period, Porsche advised teams to inspect the engine after every 24 hours of running. Today people question when a 962 engine is stripped down after just 12 hours, but Porsche's original advice was based on a new block and heads, new carriers, new cams. It is a little bit unfair when you have got a block that might already have done 80 hours for example, to then question why an engine is being inspected after just 12 hours or at some interval less than the recommended 24 hours. With this in mind, Xtec Engineering will usually carry out this task after 20 hours of running. The engine strip down and reassembly would take – on average and assuming there are no major problems – around 120 hours.

In more recent times, this car finished second, just feet ahead of a similar third-placed 962, in the inaugural Motor Racing Legends Group C/GTP race, a support race to the 2004 Le Mans 24 Hours. The 962 also had wins at Monza and the Nürburgring in 2004 and 2005, and has also raced in the Silverstone Classic on several occasions, as well as in the United States. The car is now being prepared for another tour across the Atlantic to compete in the Classic 24 Hours at Daytona in November.

962 TWILIGHT

The last season in which Porsche entered an official works team was for the 1988 Le Mans 24 Hours. Three 962Cs were run, and they finished second and sixth, with the third car ▶



Technical specifications – Porsche 962C 1989 model

Engine	Type 935/83 – 6-cylinder boxer engine
Displacement	2994 cc
Turbochargers	2x KKK turbochargers with intercooler
Bore x stroke	95.0 x 70.4 mm
Output	720 bhp @ 8200 rpm
Torque	463 lbs.ft. @ 5400 rpm
Compression	9.0:1
Camshafts	4 overhead camshafts
Valves	4-valves per cylinder
Cooling	Mixed cooling – cylinders by air, cylinder heads by water
Lubrication	Dry sump

Transmission

Gearbox	Type 956, with five forward gears plus reverse
Gears	1st–16/30; 2nd–20/33; 3rd–23/30; 4th–26/27; 5th–29/29
Clutch	Fichtel & Sachs
Final drive	8/37; also 9/36 & 9/38

Suspension

Front/rear independent suspension by dual wishbones

Springs	Titanium coil springs
Shock absorbers	Bilstein gas-pressure shocks

Dimensions

Length	4770 mm
Width	2000 mm
Height	1030 mm
Wheelbase	2770 mm
Front track	1634 mm
Rear track	1548 mm
Weight	850 kg



ABOVE Supported by the endplates, the rear wing is a substantial component

posting a DNF due to engine maladies. At the conclusion of the 1988 season, Porsche realised that the end of the 962C was nigh as new chassis construction methods and electronics technology was being built into its competitors' racecars. The 962C had competed at the top of the sport for an unbelievable seven years, with just some upgrades and improvements keeping the Porsche competitive.

The two models, the 956 and 962C, earned the company the World Championship of Makes for four consecutive years, from 1982 to 1985. In its first year at Le Mans, 1982, the three works 956s finished 1-2-3, but in 1983 the 956 captured nine of the top ten places at Le Mans. The only non-Porsche car was a Sauber-BMW in ninth place, which prompted Porsche to issue a promotional poster to this effect with the words: 'Nobody's perfect'. This pattern continued through 1984 and 1985, but it was only in 1986 that the 962C made itself felt at Le Mans.

During the mid to late '80s, Porsche's customer teams bought and raced the 962C in relatively large numbers. Although the factory stopped the development of the 962C at the end of 1988, its customer teams continued to develop the car to the extent that they could, and several privateer outfits such as Joest Racing, Kremer Brothers and others did extremely well with it.

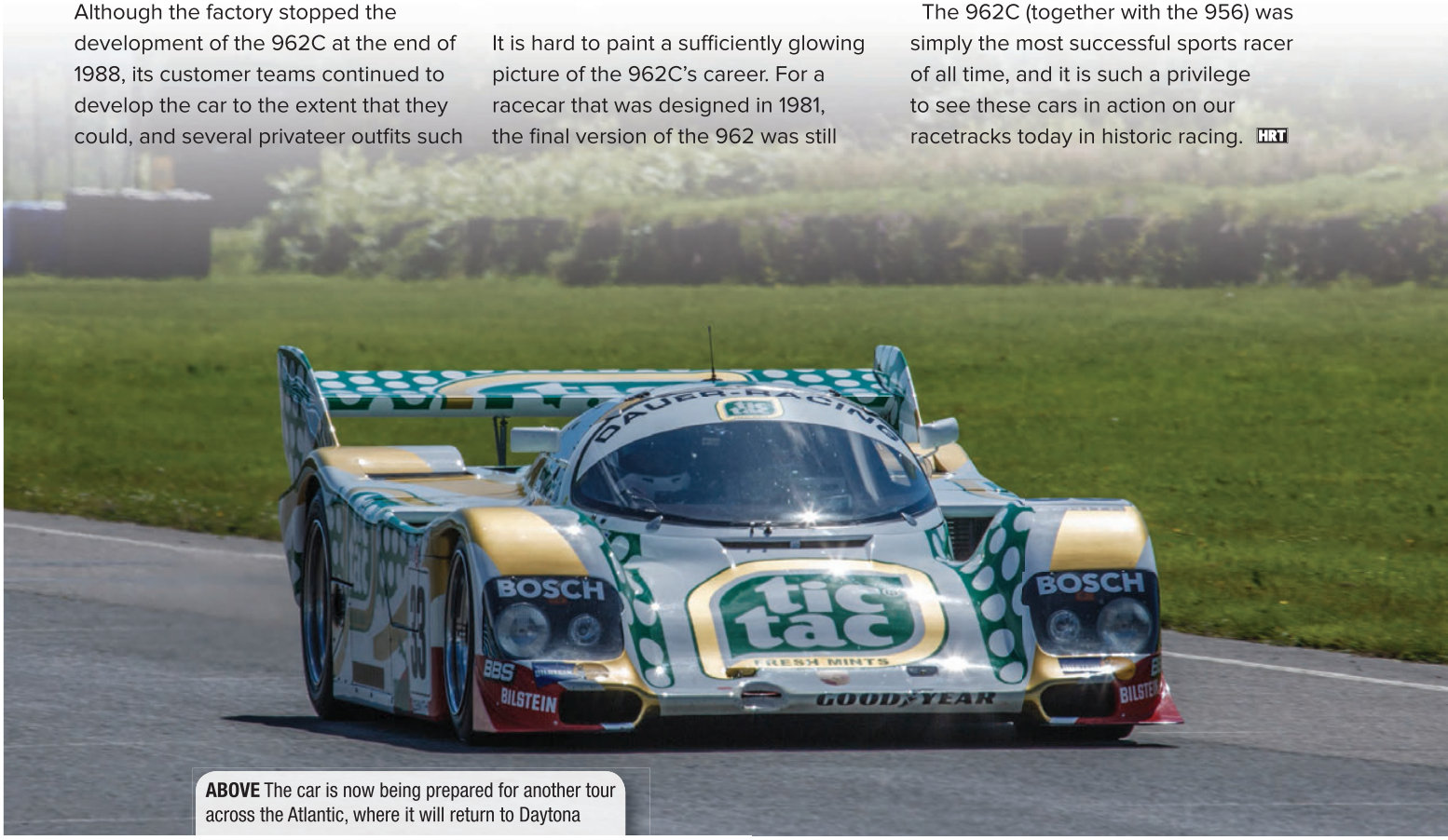
Significant factory development was at an end, but it seemed that the Porsche engineers could not keep their hands off the 962C, helping to improve the car in some small way and benefiting the customer teams in the process. The company went so far as to help set up attractive lines of supply for their favoured teams, as Porsche would still enjoy the benefit of the 962C's successes in the hands of its customers.

END OF THE ROAD

It is hard to paint a sufficiently glowing picture of the 962C's career. For a racecar that was designed in 1981, the final version of the 962 was still doing proud duty in America as late as 1994. But unquestionably, the 962C's proudest days were in the mid-80s when it dominated the World Sportscar Championships so comprehensively.

While the factory ceased official development of the car at the end of 1988, the 962C package was such that the privateer teams could still fettle and improve the car in some areas to extend its competitive life. Between 1982 and 1994, the 956/962 in all of its different guises, amassed 232 major international victories around the globe, in all kinds of weather.

The 962C (together with the 956) was simply the most successful sports racer of all time, and it is such a privilege to see these cars in action on our racetracks today in historic racing. HRT



ABOVE The car is now being prepared for another tour across the Atlantic, where it will return to Daytona

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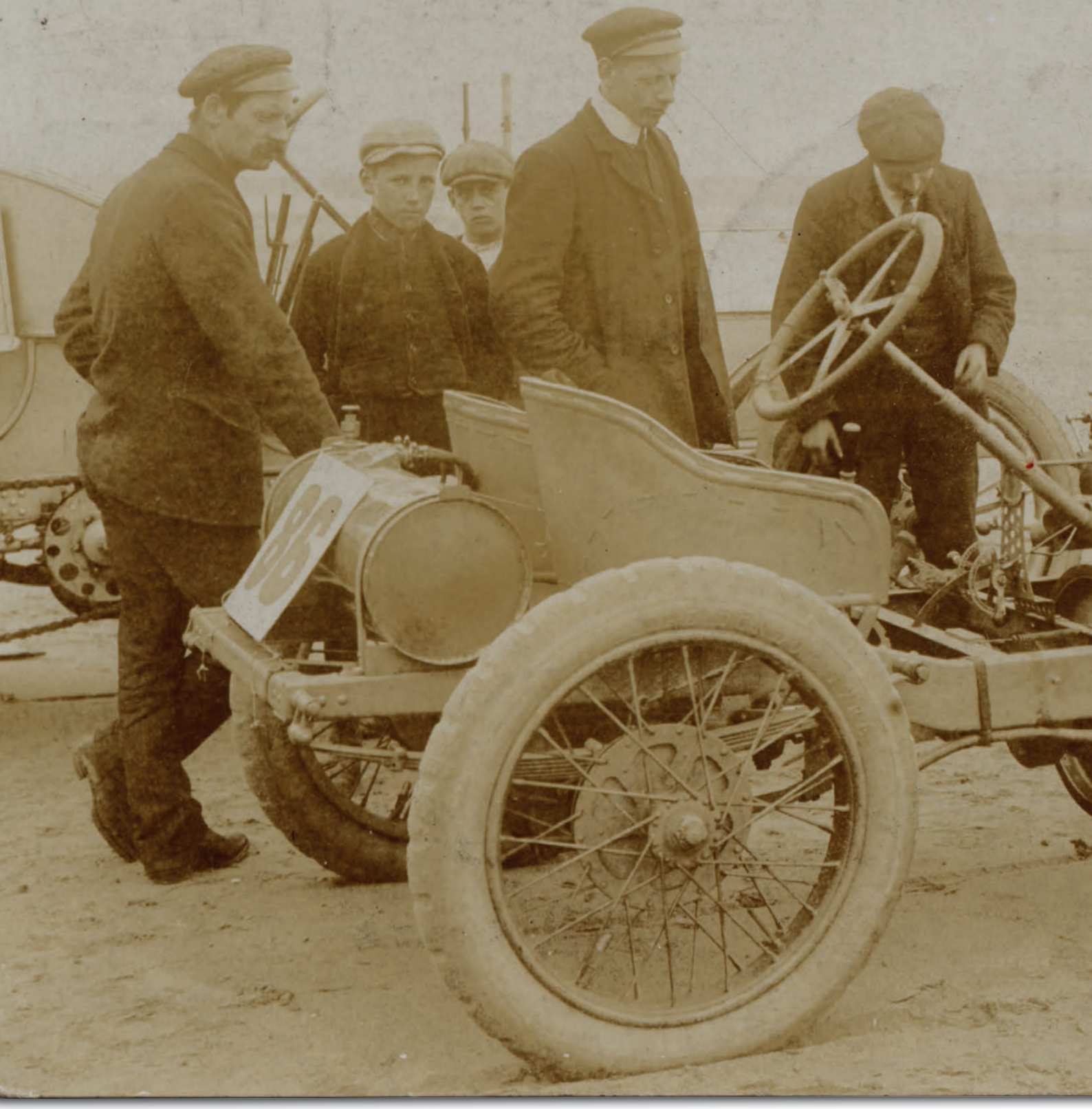
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This is Edwardian motoring? *Really?*



Chris Pickering discovers how modern manufacturing techniques have added a 21st century tinge to the sepia-tinted myths surrounding a beast from a bygone era

SIX months. That's all that separates the 1905 Darracq 200 HP that you see here from the cut-off date for cars eligible for the London to Brighton run. And yet, to watch it in action – owner Mark Walker sawing at the wheel as its improbably large powerplant unleashes another barrage of torque – will obliterate any preconceptions you might have about sedate Edwardian motoring.

This spectacular machine was built to break speed records; something that it did rather well, taking the outright Land Speed Record at 109.65 mph in 1905. A few weeks later it was clocked at 122.5 mph at Florida Speed Week.

Soon afterwards, the car was sold to Algernon Lee Guinness, early motor racing pioneer and heir to the Guinness brewery fortune, who raced it with his brother Kenelm. He continued its record breaking exploits until 1909, but after that the car disappeared.

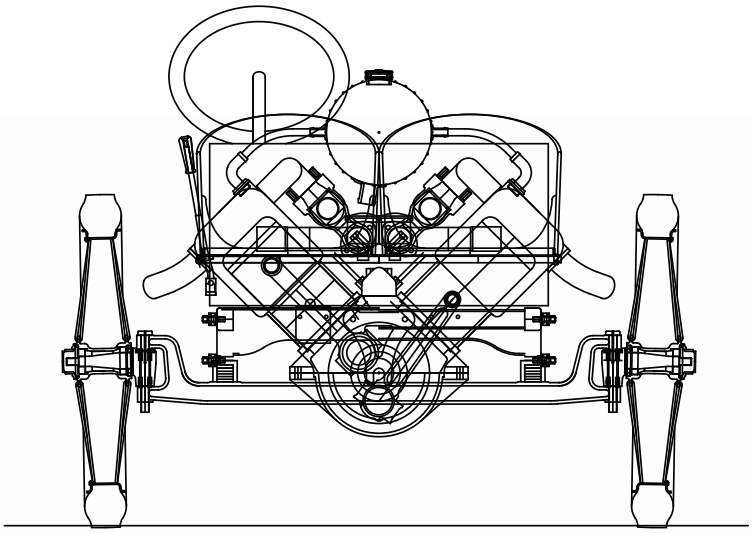
"It was a car I'd always wanted, even before I knew it had survived," comments Walker. "If you go through 'The Boys Book of Early Racing Cars' you'll probably find the Fiat S76, perhaps the Lion Peugeot with the exhaust over the top and this... the Darracq 200 HP."

Walker is no stranger to the world of Edwardian racing cars, having owned and raced several, including a 1908 Grand Prix Panhard. In 1985, while on a trip to America, he came across a First World War era Curtiss OX-5 aero engine and bought it on the spot with the intention of creating his own special. The car he sketched out, he recalls, resembled a miniature version of the Darracq that he'd long coveted. It was this project that later morphed into the 1913 Monarch now owned and raced by Duncan Pittaway.

A few years later Walker discovered that the original car still survived. Algernon had been its custodian until his death in 1954. Two years later it was bought by Darracq enthusiast Gerald Firkins. In 2006, well into his eighties, Firkins decided to sell the car and it was then that Walker's dream of owning this pioneering machine became a reality. ▶



ABOVE The Darracq captured in 1908 on Saltburn Sands in Yorkshire, where it was one of the star performers. Believe it or not, this car once held the Yorkshire Speed Record



The car had been put together as a museum piece, presumably on the assumption that nobody would actually be crazy enough to want to race a 25.4-litre Edwardian record breaker. Walker, however, had other ideas.

"It was never built for circuit racing, but amazingly that's something it does rather well," he says. "The only real rule for Land Speed Record cars at the time was that they had to weigh under 1,000 kg, so it's deceptively light."

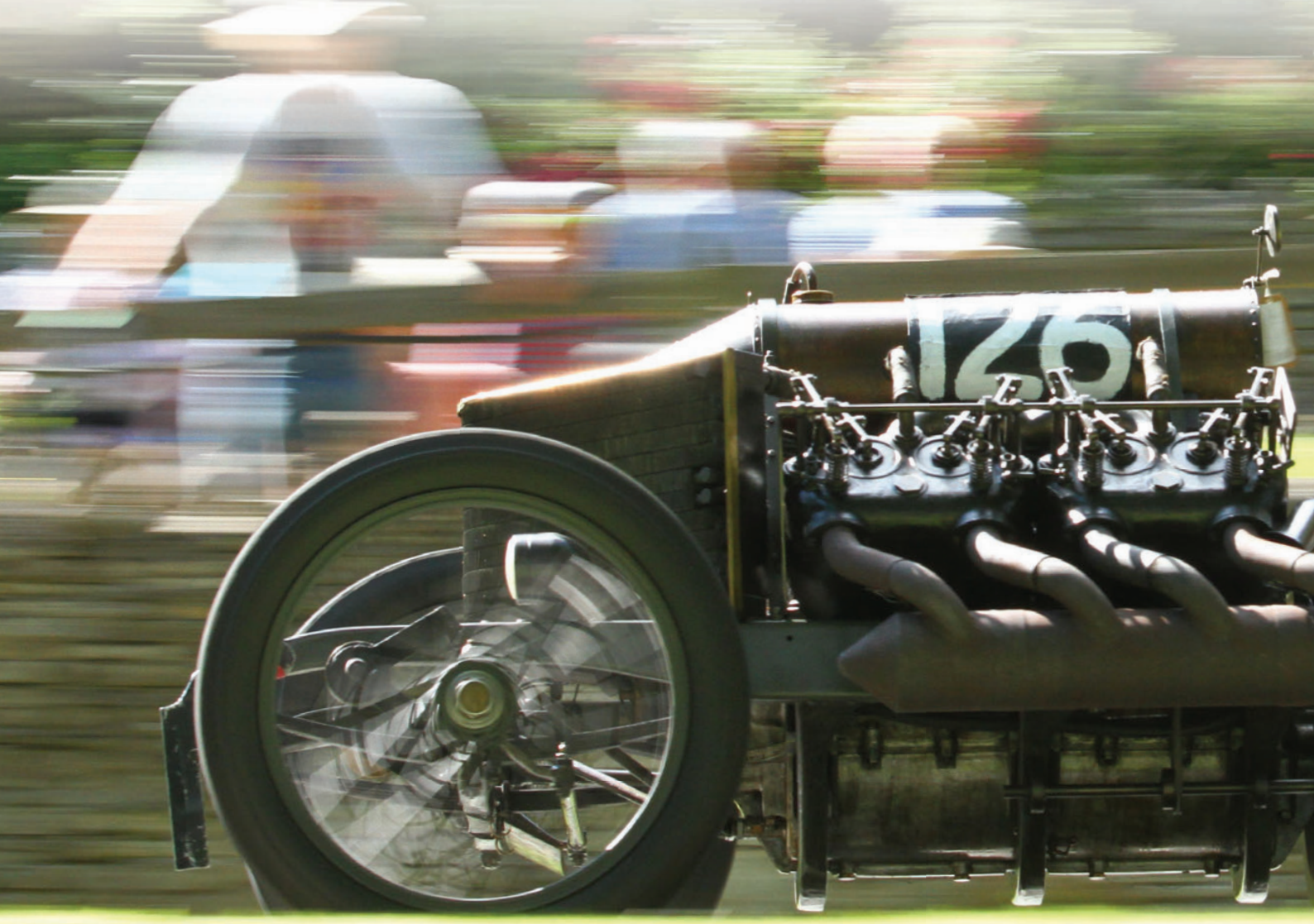
RESTORING AN ICON

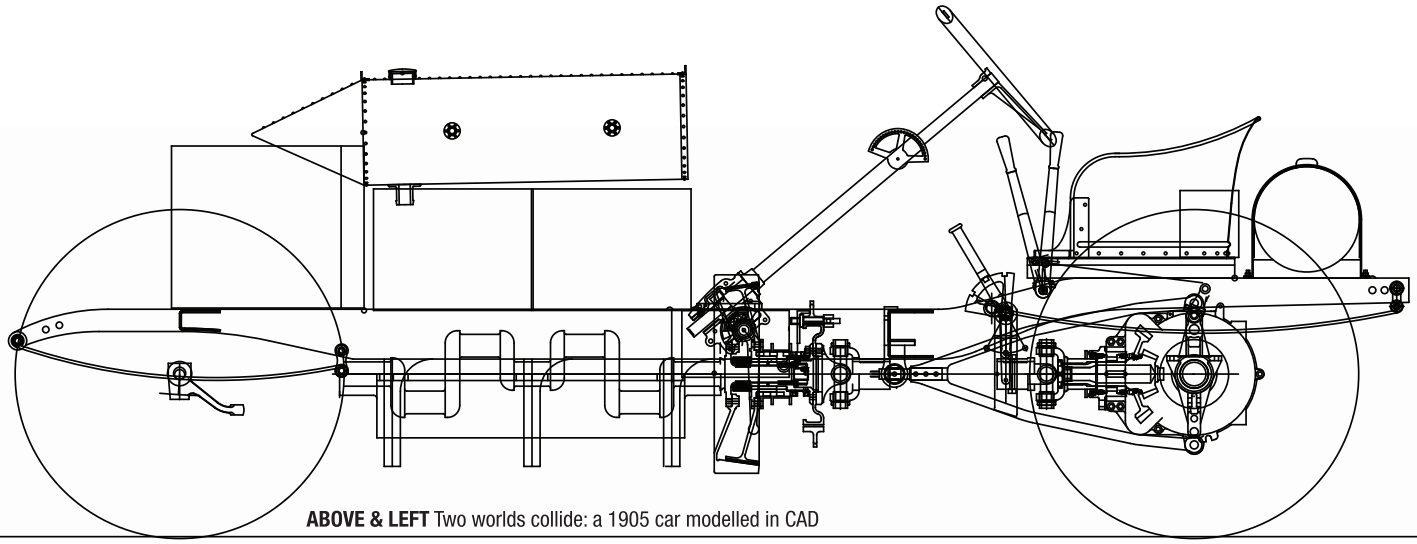
The engine and the centre section of the chassis (as far as the spring mounts in either direction) had survived intact. But the remainder of the package that Walker purchased in 2006 had been recreated from the scant records available before the days of internet research and digital photo archives. The decision was taken to strip it back to the original components and start again – an exercise that would eventually take Walker around 12,000 hours to complete.

"It was a completely fascinating and absorbing piece of automotive archaeology," he says. "One of the things that made it feasible was the lack of bodywork. You can see almost everything in the photos."

Fortunately, dozens of original photographs had survived, along with several detailed written accounts. Nonetheless, there was still a mountain of work involved in creating proper engineering drawings.

To tackle this problem, Walker imported high resolution digital copies of the photos into Adobe Illustrator, which allowed him to measure key dimensions





ABOVE & LEFT Two worlds collide: a 1905 car modelled in CAD

from the images. Using some basic geometry, he was able to correct for the perspective in the images and work out the relative dimensions of the components. He then scaled these relative to the known diameter of the flywheel – mounted on the centreline, which negates the perspective issues – to calculate the outright dimensions.

"The wheelbase was relatively straightforward to calculate, but the perspective changes within a photograph, so some parts of the car were far trickier to work out," he notes. "Generally, though, it's fair to assume the original design would have worked to a round number. So if something initially came out as 49 mm, I knew there was a good chance it was actually 50 mm."

He then taught himself to use AutoCAD and set about creating a series of engineering drawings. In total, he produced over 160, with numerous projected details and notes. This alone took several thousand hours, but it meant that for the first time in a century or so the design of the Darracq 200 HP was fully mapped out.

The first, and arguably most critical, job was to reconstruct the back axle. From ▶



Mark Ballard

ABOVE In action at Prescott, the Darracq dispels myths of sedate Edwardian motoring



ABOVE The main section of the chassis is original, but the ends come from a period Darracq touring car

contemporary articles, Walker knew the car had a two-speed transaxle with no differential and no reverse. Fortunately, one of the sources stated that the Darracq was geared for 45 mph per thousand rpm in first and 90 mph per thousand rpm in top. Having read the tyre size off one of the photos, Walker was then able to calculate the gear ratios.

Initially, he contemplated adding an extra ratio and a reverse gear, but the idea was swiftly abandoned, he explains: "It rapidly became clear that the only way to do it was as close as I possibly could. There are a couple of things I couldn't quite bring myself to retain – I'm not doing 120 mph on beaded-edge tyres, for instance – but almost everywhere else I decided to follow the original design as closely as possible."

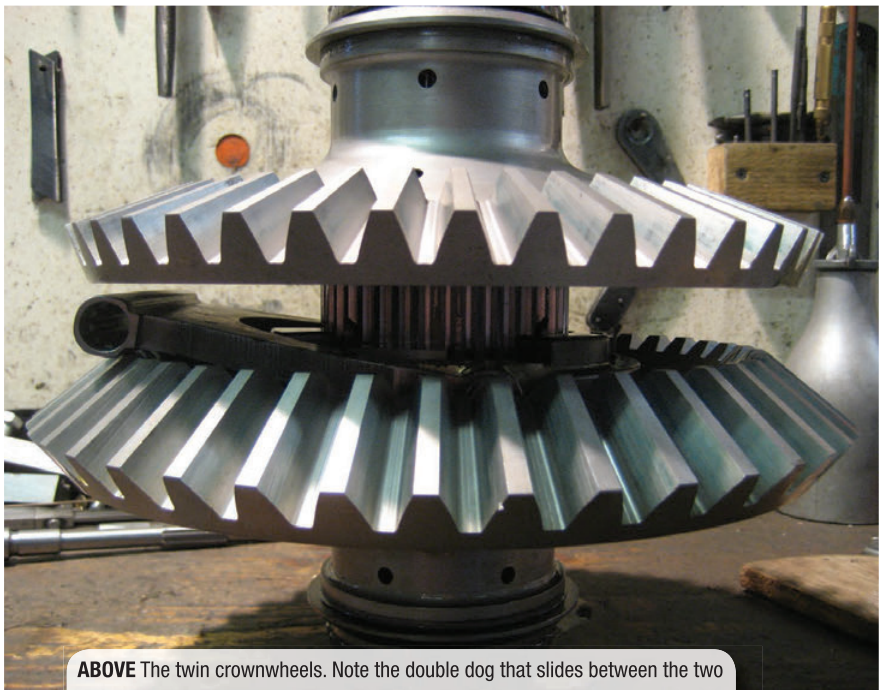
Of course, there are literally dozens of ways to create a two-speed axle. One option would have been to lock the crown wheel to the axle for top, and use a pair of gears with a layshaft for second. This is perhaps the most obvious solution, and it's similar to that employed on a number of other Darracqs, but there was a snag. Most transaxles of this type have a very obvious lump in the casing that conceals the layshaft and the photos clearly showed that the 200 HP did not.

So how had it been done? Eventually the clue came from a conversation with motoring author David Thurlby, who had interviewed GN and Frazer Nash creator Ronald Godfrey.

"David had asked Ron [Godfrey] what gave him the idea for the double dog transmission used on the GN," Walker explains. "He said that Ron and Archie [Frazer-Nash] had seen the Darracq at Brooklands before the First World War and managed to get a look at the transmission with the lid off and that had given them the idea for the GN transmission."

Armed with this information, plus the external shape of the axle, Walker was able to piece together the internal layout: it has two pinions, one nested within the other. These are in constant mesh with two crown wheels. One is the same size as its pinion to provide a 1:1 ratio; the other twice the size to provide a 2:1 reduction. Between the two crown wheels sits a double dog, which can be slid into contact with either gearset to lock it to the axle. The end result is hardly any heavier than a normal back axle, but it functions as a gearbox too.

Once the design of the axle was drawn up, Walker went to Apple Gears in Wellingborough to create the internals. The main part of the casing is an aluminium casting, produced by Carvell ▶



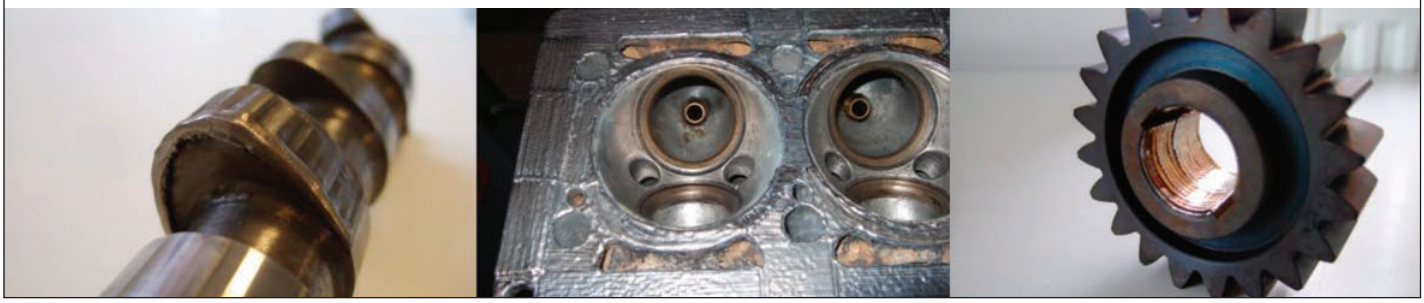
ABOVE The twin crownwheels. Note the double dog that slides between the two

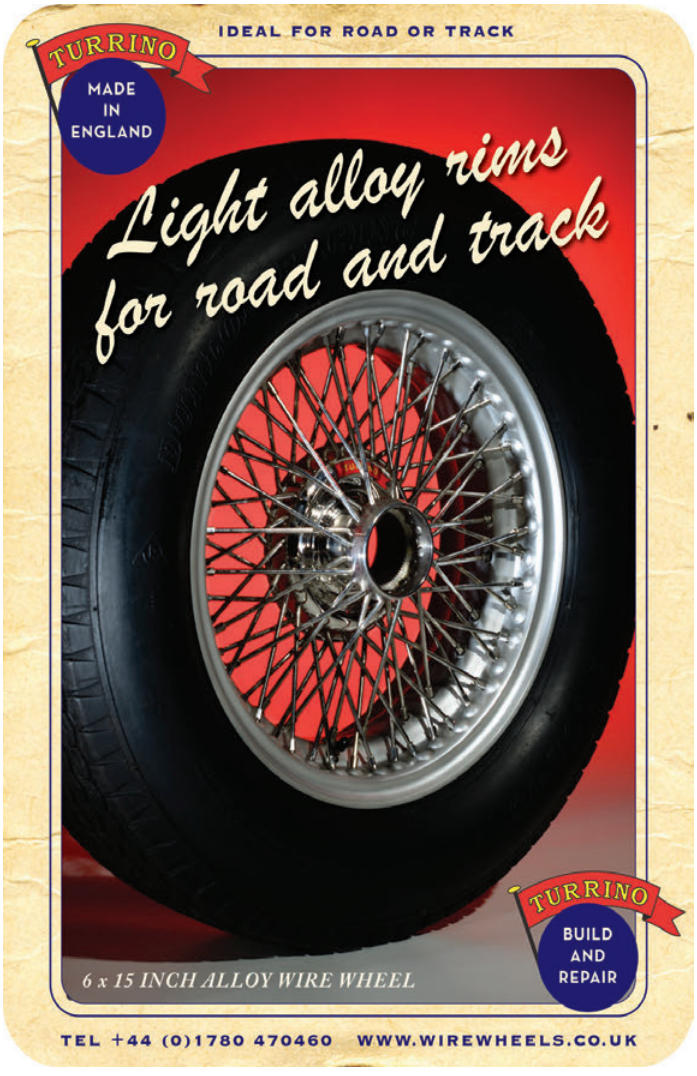


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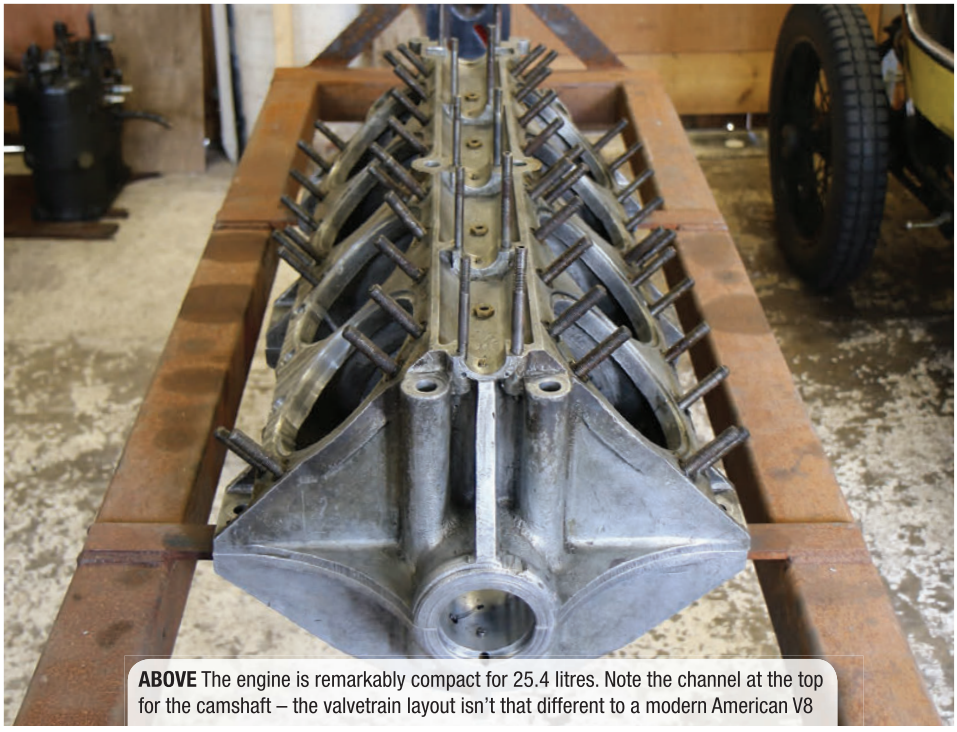
ABOVE The 'moment' at Mallory last year: the left hand blocks fail in spectacular fashion

Castings, which is combined with two lengths of steel tube and a pair of cast ends to create the axle. It's possible that the original axle used a single driveshaft, but Walker has split it into two EN24T steel halfshafts that spline into a solid spool in the middle.

"Sizing the shafts was tricky," he recalls. "With an open differential the most that one halfshaft will ever have to transmit is half the axle torque. If you've got no differential you have to assume that all the torque can go through one halfshaft (if the inside wheel comes off the ground) plus you have the bending loads in the axle."

At the other end of the drivetrain, the engine-speed propshaft meets the flywheel via a cone clutch. This is fairly standard in design, and even had what was thought to be the original lining (identified by a distinctive rivet pattern in one of the period photographs).

At the time, a lot of cars used leather clutch linings. In an effort to transmit the 200 HP's huge torque, though, Darracq used bronze. This quickly wore out once the car was rebuilt, and after a bit of experimentation Walker has switched to a Kevlar lining. While this distinctly 21st century solution appears to dramatically improve the life of the lining, it hasn't changed the friction characteristics greatly and the clutch still slips under full load.



ABOVE The engine is remarkably compact for 25.4 litres. Note the channel at the top for the camshaft – the valvetrain layout isn't that different to a modern American V8

CHASSIS

Walker still possessed the chassis from a long-dead Darracq touring car that he had planned to turn into a replica of the 200 HP. With the arrival of the real thing, he sent both chassis to Julian Ghosh at Green Farm Racing who re-shaped the extremities of the touring car frame and grafted them on to the racer's frame. The resulting join is absolutely seamless, and with a bit of artistic licence the whole structure can now be said to be period Darracq.

The front axle also comes from the Darracq tourer. Although different to the 200 HP's original design, it's identical to the axle fitted to the company's 1906 grand prix cars. Incredibly, the Guinness brothers actually switched to this pattern shortly after they acquired the car, so it too is a correct period part.

The springs are a mixture of period leafs and modern replacements by Jones Springs. They're governed by a set of Truffault friction dampers – the forerunners of the Hartford dampers found on a lot of subsequent vintage racers.

Not for the last time in the project, fate appeared to be smiling on Walker when he came across these. "I was starting to make a replacement set when I went to stay with a friend of mine," he recalls. "I was moaning about the amount of work involved in the dampers. By this point it was about 3am and he said, 'Let's go into the shed and have a look'. To my amazement, he had a pair of Truffault dampers, taken from a Darracq racing car. He'd swapped them for an old carburettor that somebody wanted and they were now surplus to requirements."

Virtually everything else you see

on the car has been made by Walker himself. That includes the steering box, which is identical to the original pattern, and even the ignition cut out button. To most people this is the sort of thing you'd buy off the shelf from an electrical company. Not so for Walker, who crafted his own to perfectly replicate the period item. Elsewhere, even the thread pitch on the cap for the characteristic torpedo-shaped water tank is just as it was in period.

"It would have been far easier to design the bits from scratch, but that just wasn't an option," comments Walker. "It's an important car, so it's worth doing properly."

Another example of this obsessive attention to detail is the oilers for the front axle. They have an ornate design that fascinated Walker, but he couldn't work out where they'd come from. Two years after he'd bought the car he attended the centenary of the very first grand prix, and there to his amazement was the same type of oiler on a 1908 grand prix Mercedes.

"Unbelievably, the Mercedes had the same oilers on its camshaft. I spoke to the guy who'd made the replacement engine for this car. He'd found a box of them in a shop in Stuttgart. It turned out he had more than he needed so he said, 'I'll stick a pair in the post for you'."

The brakes, on the other hand, are relatively conventional for the time. They're cable-operated drums, controlled by a hand lever and fitted to the rear wheels only (a poster in Walker's garage reads 'front brakes are for girlies'). The drums have been scaled up slightly, but they are otherwise standard with linings from Bonding & Reline Services in Leicester. There's also a transmission brake, somewhat confusingly operated by a foot pedal, but Walker says he rarely uses it.

"The brakes are very good for an Edwardian," he comments. "Normally on a racing car of this age you have a ratchet. You'd put the brakes on full on the ratchet, double de-clutch down the gearbox and then release the handbrake as you entered the corner. On the Darracq you have no ratchet, so you have to stop braking and take your hand off the brakes to change gear."





ABOVE & BELOW The family oven was 'hot-rodded' to help provide a novel solution to the broken block

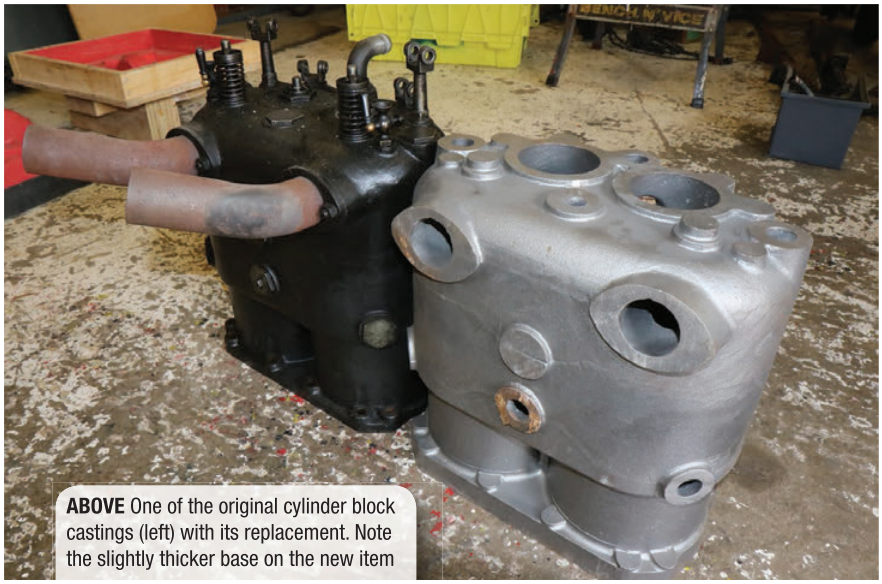
25.4-LITRE V8 ENGINE

The heart of the Darracq is its mighty 25.4-litre V8. Despite this mammoth capacity, it's actually reasonably compact, with each pair of pistons directly opposite each other, in place of the staggered layout employed on most modern vee engines. This is made possible by an elaborate set of fork and blade connecting rods, where the twin big end bearings for the piston on the right hand bank sandwich a single bearing for that on the left.

As with most engines of the period, the crank case is a separate item. The cylinder blocks – in this case cast in four pairs – are bolted on, including an integral cylinder head for each pair. A single camshaft runs in the centre of the vee, much like a modern Chevy, with pushrods going up to conventional overhead valves.

The engine was complete, with all the major castings intact. Unfortunately, when it was stripped down, the crankshaft turned out to be cracked. Walker set about sketching out a replacement, carefully incorporating a number of features into the original design to protect it during future use.

He considered counterbalancing the crank and submitted his drawings to Arrow Precision's senior design engineer Dave Whitbread, who put them into CAD and ran a finite element analysis. This revealed some rather unexpected results, Walker recalls: "It turned out that counterbalancing would have been a complete waste of time. ▶



ABOVE One of the original cylinder block castings (left) with its replacement. Note the slightly thicker base on the new item

It's quite a low-revving engine – it's only doing about 1,500 rpm – and the highest loading actually turned out to come from the gas pressure."

Instead, they tried increasing the fillet radius where the crank webs meet the journals. Ordinarily, this would eat significantly into the length of the journals, but the Darracq's gargantuan bearings meant there was still plenty of room left to accommodate the modification. What's more, the FEA simulations confirmed it would substantially increase the strength of the crank.

As part of the process, Arrow used a CMM machine to check the position of the flywheel mounting bolts. It turned out these had been marked out by hand and weren't in fact on a fixed spacing. As such, the new crank has been built to fit the drillings carried out by a French craftsman more than 100 years ago.

It seems almost unthinkable these days, but the Darracq engine relies totally on splash lubrication, with only two litres of castor oil to lubricate almost 10 times that capacity. There were signs that its owners in-period had been attempting to improve the lubrication, and evidence that the engine had once run a bearing. With this in mind, Walker considered converting it to pressurised lubrication, but he concluded that the lack of a sump would have made this difficult to engineer. Instead, he set about improving the splash lubrication system.

> **"Almost unthinkable these days, the Darracq engine relies totally on splash lubrication"**

As designed, the engine has a scupper above each main bearing. This collects oil and channels it into a drilling that lubricates the bearing. At least, that's the theory. Walker wasn't convinced that gravity alone would suffice.

"Inside an engine that's doing 1,500 rpm you have a tornado of oily air flying around," he comments. "What I've done is to add a tin scoop to catch the oil and guide it into the scupper for each main bearing."

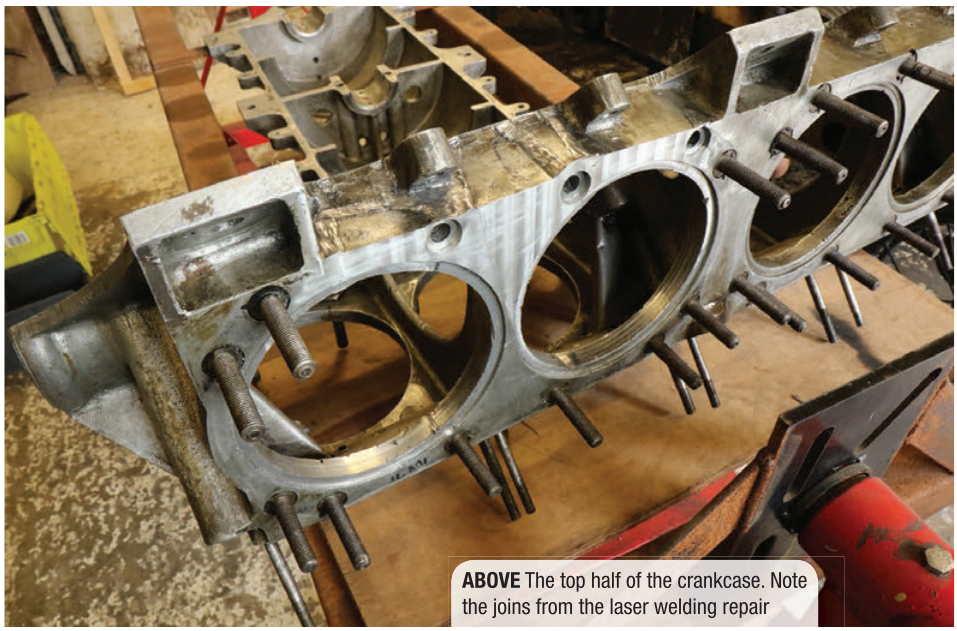
A small scoop was also added to each of the crank webs, with a series of internal drillings to channel oil down into journals. Here, it's forced outwards by centrifugal force to oil the surface of the big end bearings. "I know that works, because the car has now done more mileage than it ever did in period and the bearings are still in great condition," notes Walker.

During the initial rebuild it was discovered that pistons had also cracked, so these were remanufactured by FJ Engineering. They are carbon copies of the originals, with the exception that they have been cast in aluminium instead of iron. Geoff Harris's firm Stemax produced the new rods to Walker's drawings, which followed the original design with a bit more material thickness around the head of the big end bolts, along with a slightly larger gudgeon pin diameter.

Unusually for an Edwardian, the original carburettors had survived with the engine. Originally they had each used a single jet with no automatic mixture compensation. Instead, there was a manually adjustable window that allowed the mixture to be controlled by the driver. If that strikes you as a bit labour intensive, you're not the only one.

"I thought I'd have enough on my plate without constantly fiddling with the mixture," says Walker. "What I've done is to make an adaptor plate that features a Zenith compensator jet. It's completely removable and you can hardly see it's there, but it works brilliantly."

Another unusual feature in the car's original incarnation was its low tension ignition system. This used an additional set of lobes on the camshaft to complete the circuit to a terminal (analogous to a spark plug) in the appropriate cylinder. In 1908 the Guinness brothers ▶



ABOVE The top half of the crankcase. Note the joins from the laser welding repair

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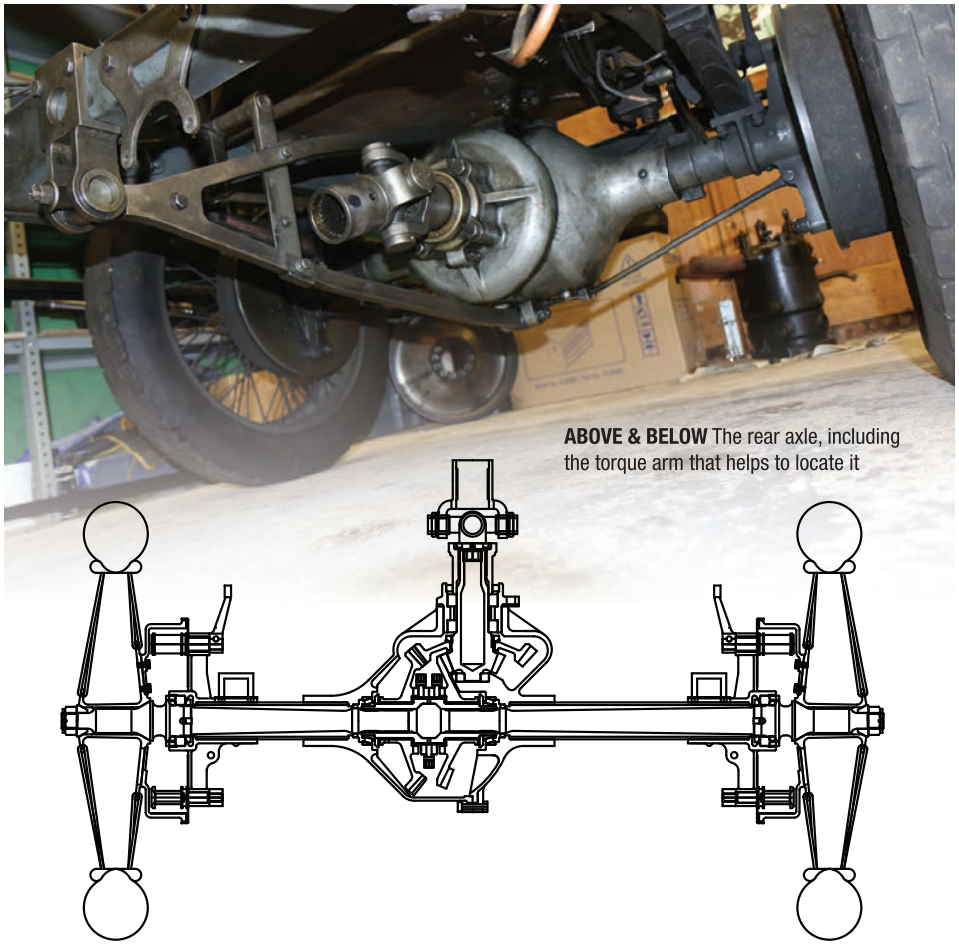
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converted the car to high tension with a conventional magneto and spark plugs, so Walker has elected to keep this modification. The only addition is a small generator and a Varley Red Top battery to power the lights.

There's no real bodywork to speak of. The car's distinctive vee-shaped radiator was remanufactured by the Vintage Car Radiator Company at Bicester Heritage, along with the magnificent polished-metal fuel and water tanks. The bucket seats, meanwhile, come from Mick Sharpe of Western Coachworks.

While the results are absolutely authentic, there is a 21st century tinge to the manufacturing techniques in a lot of instances. Most of the sheet aluminium parts were drawn in CAD and then laser cut by Coventry firm MicroStep UK (formerly known as Matrix Laser) for instance.



ABOVE & BELOW The rear axle, including the torque arm that helps to locate it

DRIVING IMPRESSIONS

The 200 HP name comes from the Darracq's so-called RAC rating. Walker says he's not yet plucked up the courage to take it to a rolling road, but he believes the true figure to be closer to 300 bhp. It's worth contemplating that figure for a second – it gives the Darracq, with its 1905 chassis technology, around the same power-to-weight ratio as a 1990s TVR Griffith.

In road use that vast engine returns a surprisingly-credible 10 mpg. It's helped by the car's light weight (fractionally over a tonne in current trim) and the fact that it does 50 mph at tickover in top gear.

"Bottom gear in this is taller than top gear on a lot of Edwardian racing cars," notes Walker. "That means you never get any issues with wheelspin, but it makes launching it off the line very tricky. As soon as the clutch begins to grip, it tends to grab."

Since its rebirth, the car has covered over 6,000 miles, including racing, sprinting and a good deal of road touring.

"Every drive is an adventure – it's so bonkers, I'm not sure I've ever actually given it full throttle," he confesses.

"Although for such an extreme car it's also weirdly usable once you get your head around it. I've done over 1,000 miles in one trip before down to the South of France with a group of other Edwardians."

He's resisted the urge to fit a starter motor. Period photos show Algernon Guinness starting the car with a hand crank. That's no mean feat when you consider that each cylinder displaces more than three litres, but Walker was determined to follow suit.

One of the few modifications that has been carried out since the car's return was the fitment of a larger steering wheel, as Algernon had done in period. "The steering was very heavy initially. That was fine, but it was very difficult to get opposite lock on quickly," comments Walker. A quick search for the video of him ascending the hill at the 2015 Goodwood Festival of Speed will make it abundantly clear why this was a priority.



ABOVE The exquisite tanks are a notable feature

BACK FROM THE BRINK

Generally, the Darracq has been remarkably well behaved for such an extreme machine. There have been a

> **“The Darracq, with its 1905 chassis technology, has around the same power-to-weight ratio as a 1990s TVR Griffith”**

couple of notable exceptions, though. In 2011, while on the way to Prescott, one pair of cylinders almost blew themselves clean off the crank case.

“There was a loud bang and I looked down to see the right-hand rear cylinder block was moving around,” he recalls. “I turned the engine off immediately and saw that the flange at the base of the block had broken off with only two of the 12 studs still holding it on.”

Luckily, there was no internal damage, but Walker was left pondering a solution. The idea for the fix eventually came from his son and fellow vintage racer Hughie Walker. They sawed the block off just above the break and cast a new base section, which also acts as a sleeve for the joint. The cavity between the two was then filled with Loctite heat-curing metal-loaded epoxy using a grease gun and placed in the family oven, which had been hot rodded (as Walker puts it) to maintain the right temperature. Afterwards, the repaired part was sent off for machining and then put back on the car.

“Lots of people were surprised at the decision to use glue, but it’s actually worked really well,” notes Walker. “Cast iron is not an ideal material to glue, because of the graphite, but we used an etching material to prepare the surface and we had no problems. I worked out that the shear strength of the joint is something like 10 times the maximum gas pressure load, so it should be a permanent repair.”

Normal service was then resumed until the final VSCC race meeting of last year at Mallory Park. “Coming out of Gerard’s there was a bang followed by what sounded like a load of maniacs with sledgehammers smashing up cast iron,” comments Walker. “In fact, that was more or less what was happening as the pistons were smashing the bottom of the block off.”

This time it was one of the left-hand blocks that had failed, blowing the flange clean off. Only the decompressor rail that connects the two blocks prevented it from parting company. The failure mode appeared to be the same, but in this case there was too little material left to salvage the block casting.

At that point the decision was taken to put the two remaining original blocks on the shelf and cast a whole new set. The damaged block was cut into sections and sent to Walker’s pattern maker, along with one of the complete blocks, with the instruction that the new set should be identical, barring a slightly increased thickness around the base.

Unfortunately, during the course of the failure, the flailing rods had bent themselves and destroyed two of the pistons. They’d also taken substantial chunks out of the crankcase. Since then, a rather miraculous repair has been performed by EMP Tooling, using laser welding to stitch the shattered areas of the crankcase back together. Look carefully inside, and you can just about see the scars left behind, but structurally everything is back to normal. “It’s an insanely clever technique,” says Walker. “I’m very impressed indeed with the results.”

As we’re talking in his workshop a van pulls up from the foundry. In the back is the first of the new cylinder blocks sent over for inspection. It represents the next chapter in the history of this remarkable car. One which will hopefully be back in action, thrilling spectators again, very soon. HRT

• With thanks to Mark Walker and the Vintage Sports Car Club for their help with this article.

BELOW Bottom gear in the Darracq is taller than top gear on a lot of Edwardian racing cars



Mark Ballard

Restoring a jewel

How Formhalls is restoring a precious Ferrari 250 GTO Boano engine



As its first volume production car, the 250 was a vitally important car for Ferrari. However, as it was unable to accommodate the volume it was outsourced to specialist companies. Pininfarina, its preferred partner, was also unable to handle the numbers, so Ferrari turned to Mario-Felice Boano of Carrozzeria Boano for production of the bodies and interiors based on the Pininfarina design.

Initially 75 cars were built at the Boano facility in Brescia but then Boano himself left the company to join Fiat, and sold his business to Luciano Pollo and his son-in-law Ezio Ellena who renamed the company "Carrozzeria Ellena". The Ferrari 250 GTs produced by Ellena are instantly recognisable thanks to the slightly higher roofline and the lack of vent windows in the doors. The styling of the Ellena is considered by many Ferrari purists to be one of the cleanest of the 250s with the best ergonomics.

Records indicate that a total of 143 cars were produced – 19 by Pininfarina, 75 by Boano and 49 by Ellena.

Formhalls is a company that relishes the challenge of these Ferrari engines. Their tight tolerances, demanding quality requirements and racing pedigree means that an engine such as this must be assembled to the highest possible standard. First come the strip and inspection of the engine. Pooling decades of experience, we determine the work required. Then begins the process of machining and building this iconic racing engine.

From this assessment came the following 'to-do' list.

- Re-profile camshafts
- Polish cam journals
- Repair cracked sections in block
- Grind and polish crankshaft
- Re-cut valves and seats + vacuum test
- Bore liners
- Adjust liner nip
- Skim all heads, blocks and flywheel
- Replace small ends
- Balance all
- Rebuild engine

Parts required (initial)

- New pistons
- New main and big-end bearings
- New roller bearings, O-rings, gaskets, precision studs ▶



ABOVE The Ferrari 250 GT Boano like many racing engines has a 'dry' sump resulting in a lower centre of gravity and therefore better handling. The smaller sump also contributes to a lighter engine. This is the engine at the very first stages of strip and assessment



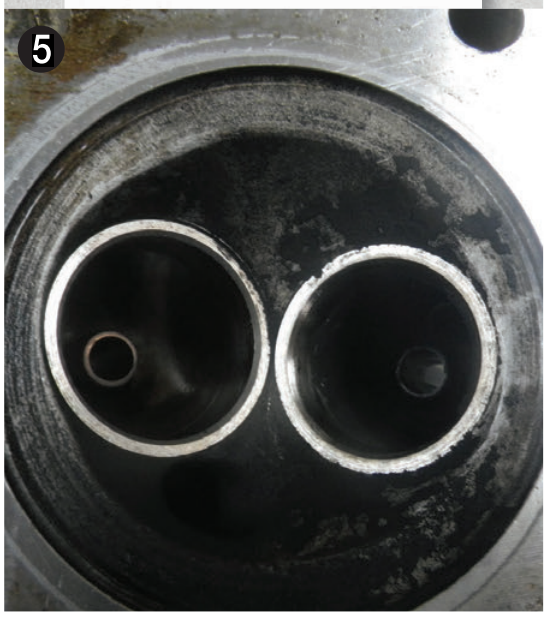
ABOVE Short stroke conrods



ABOVE Removing the liners. These were found to be in need of re-boring, a regular in-house service

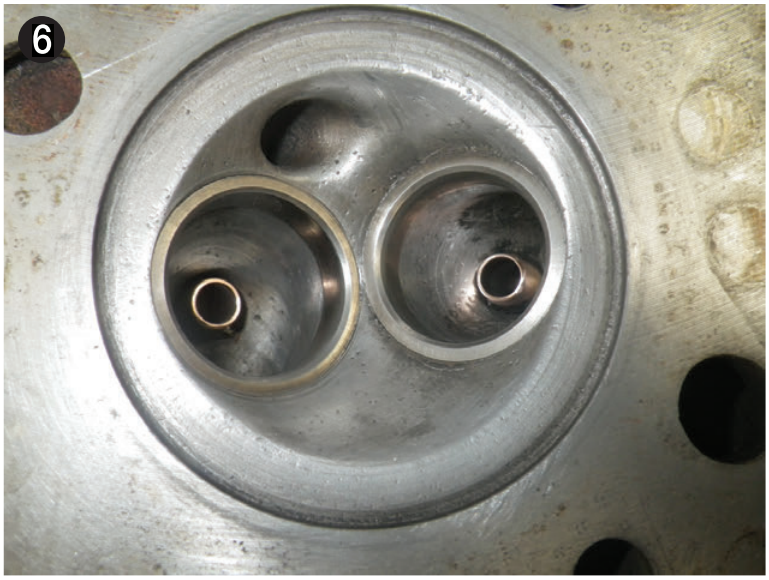


ABOVE Example of a worn piston found in need of replacement with a precision-machined fully forged, lightened and balanced custom-made piston, which is currently in production



Ferrari 250 GTO Boano engine spec

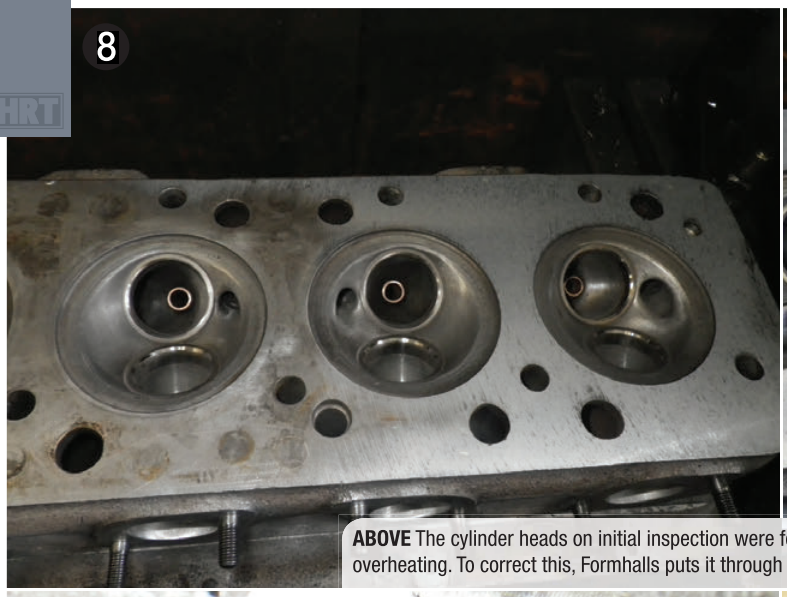
Type	Limited production car
Released at	1956 Geneva Motor Show
Built at	Brescia, Italy
Body stylist	Pininfarina
Coachbuilder	Carrozzeria Boano
Production	118
Predecessor	1953 Ferrari 250 Europa
Successor	1958 Ferrari 250 GT Coupé
Engine	Type 128B/C 60° V12
Position	Front, longitudinal
Block material	Siluminium
Valvetrain	SOHC, 2 valves / cyl
Fuel feed	3 Weber 36 DCL/3 carburettors
Displacement	2953 cc / 180.20 in³
Bore	73 mm / 2.9 in
Stroke	58.8 mm / 2.3 in
Power	179.0 kW / 240 bhp @ 7000 rpm
Specific output	81.27 bhp per litre
Bhp/weight	183.77 bhp per tonne
Torque	261.7 Nm / 193 ft lbs @ 5000 rpm
Body/frame	Steel or aluminium body over Tipo 508 steel tube chassis
Transmission	Type 508B 4-speed manual
Clutch	Twin plate dry
Top speed	201.13 kph/125 mph
0–60 mph	5.9 seconds
Fuel capacity	100 litres or 26.40 gal



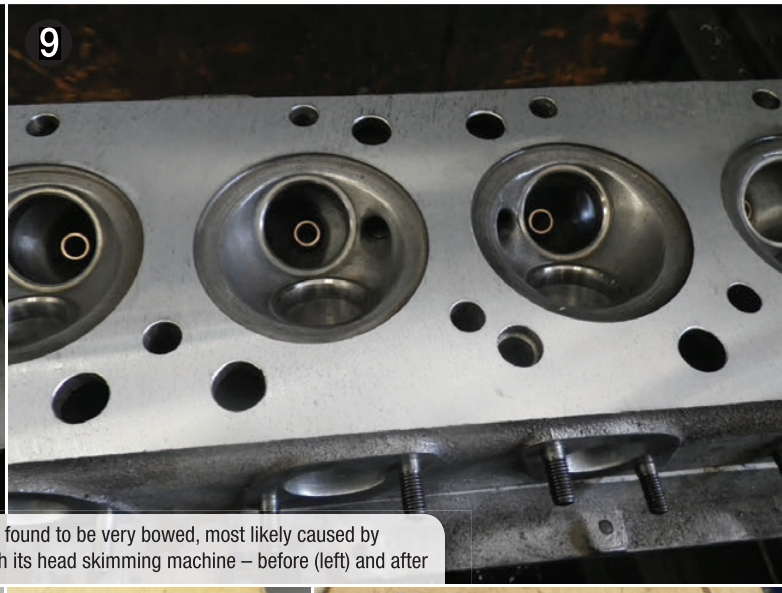
LEFT & ABOVE Valve seats before and after decoking and cutting. Formhalls offers a very wide range of in-house traditional manual machining. Cutting valve seats is standard procedure in its shop. The valves of this particular engine are cut to 45 degrees

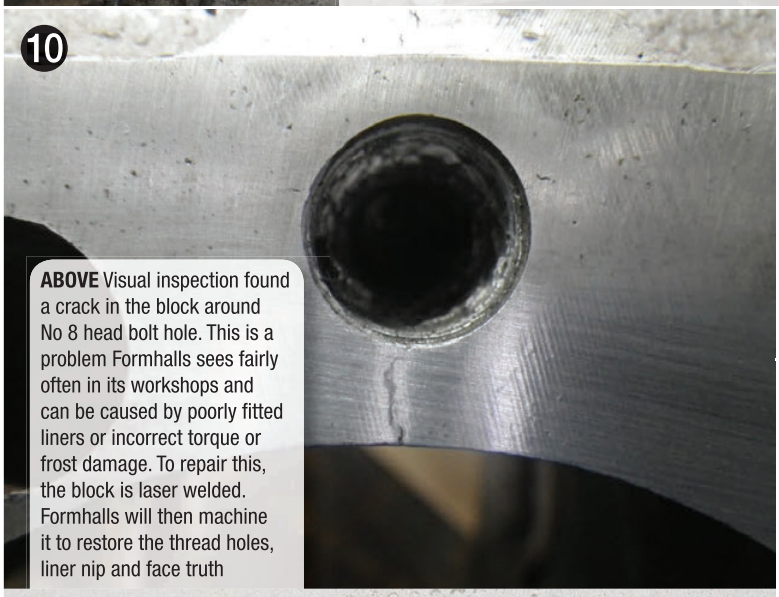


LEFT Valves decoked – before and after

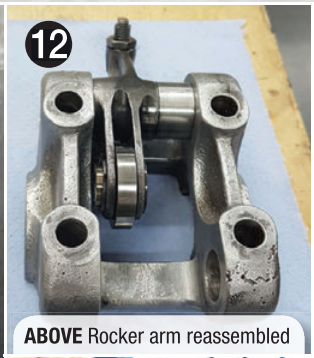


ABOVE The cylinder heads on initial inspection were found to be very bowed, most likely caused by overheating. To correct this, Formhalls puts it through its head skimming machine – before (left) and after

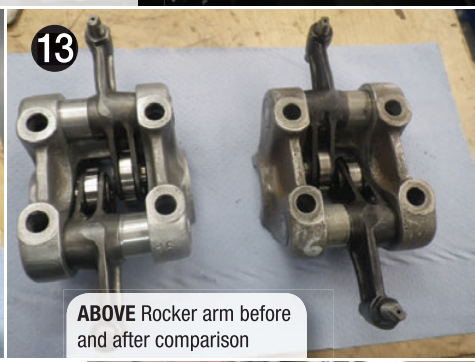




ABOVE Visual inspection found a crack in the block around No 8 head bolt hole. This is a problem Formhalls sees fairly often in its workshops and can be caused by poorly fitted liners or incorrect torque or frost damage. To repair this, the block is laser welded. Formhalls will then machine it to restore the thread holes, liner nip and face truth



ABOVE Rocker arm reassembled



ABOVE Rocker arm before and after comparison



ABOVE Rocker arms fitted to cylinder head



ABOVE Complete cylinder head rebuilt



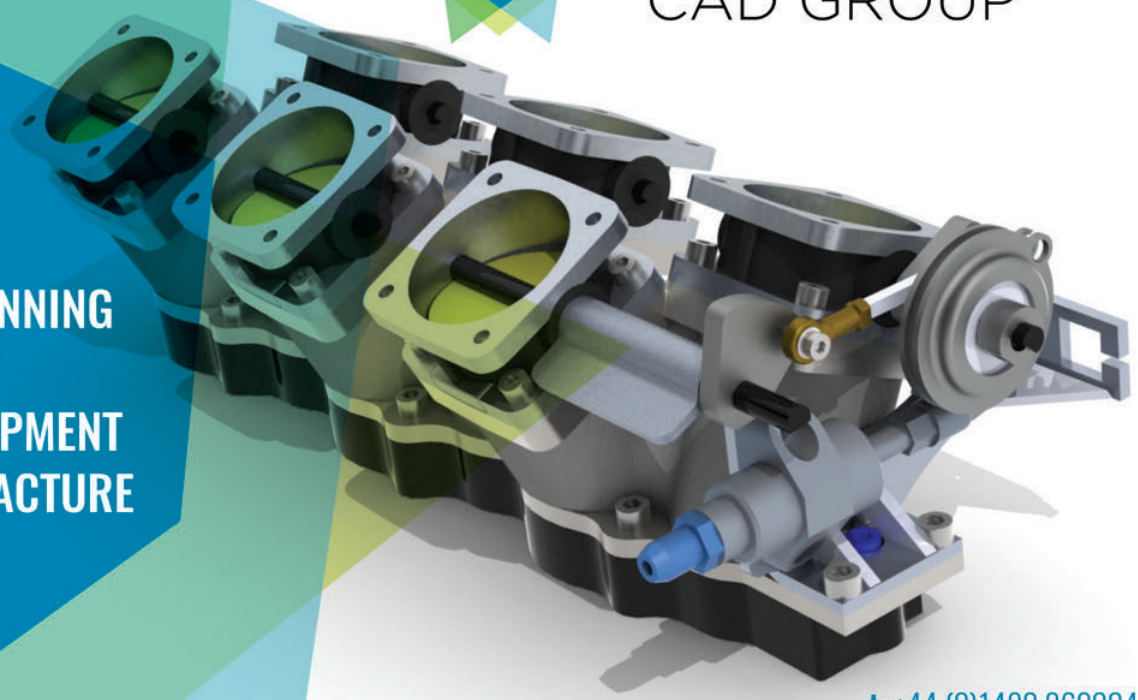
ABOVE Disassembled rocker arm after cleaning



ABOVE 'Nitrided' crank re-ground. Formhalls noted this particular crank had been ground before, resulting in poor radiuses and big-end pins at different over-sizes to one another. It has now ground this crank and all journals are within 0.0005" tolerance across the whole shaft.

Some crankshafts can suffer ovality issues on the journals and therefore care must be taken with grinding to eliminate this. Formhalls always uses a 'steady' on the centre main and sets the wheel to slower revs. Once the centre main is correct, the rest usually follows suit! Diamond dressing the wheel to ensure it is 'sharp' is also key to achieving the best possible finish HRT

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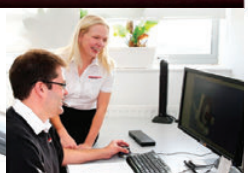
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PERFORMANCE PROJECTS

The problem solvers

William Kimberley meets Chris Horton, one half of a duo that consider themselves 'the problem solvers'



ABOVE Horton and Goad will turn their hands to anything, as long as it's innovative

SPECIALISING in engineering design for motorsport and niche vehicle programmes, Performance Projects has quickly made a name for itself in both the motorsport world as well as in historic road and race and in other industries. Located at Silverstone, and a recent recruit to the Silverstone Technology Cluster, it could not be better located for the services it offers.

While founders Chris Horton and Terence Goad have a background in motorsport and a passion for classic cars, they are prepared to turn their hand to anything, as long as it's innovative. For example, who would have thought that a child's car seat is something to get excited about? Well, according to Horton, that's just what shivers their timbers. The pair set about re-designing one to slide sideways to create more room on the back seat.

"The seat allows three passengers to use the rear seat of a car which hasn't been possible before with normal ISOFIX child seats," says Horton. "Our design enables the seat to slide sideways and lock securely into position, thereby creating more space in the middle."

Having crash-tested it and gone through all the pre-production phases, it is now production intent. However, both Horton and Goad learnt a valuable lesson on the way: to repeat due diligence on any patents whilst committing to such a venture.

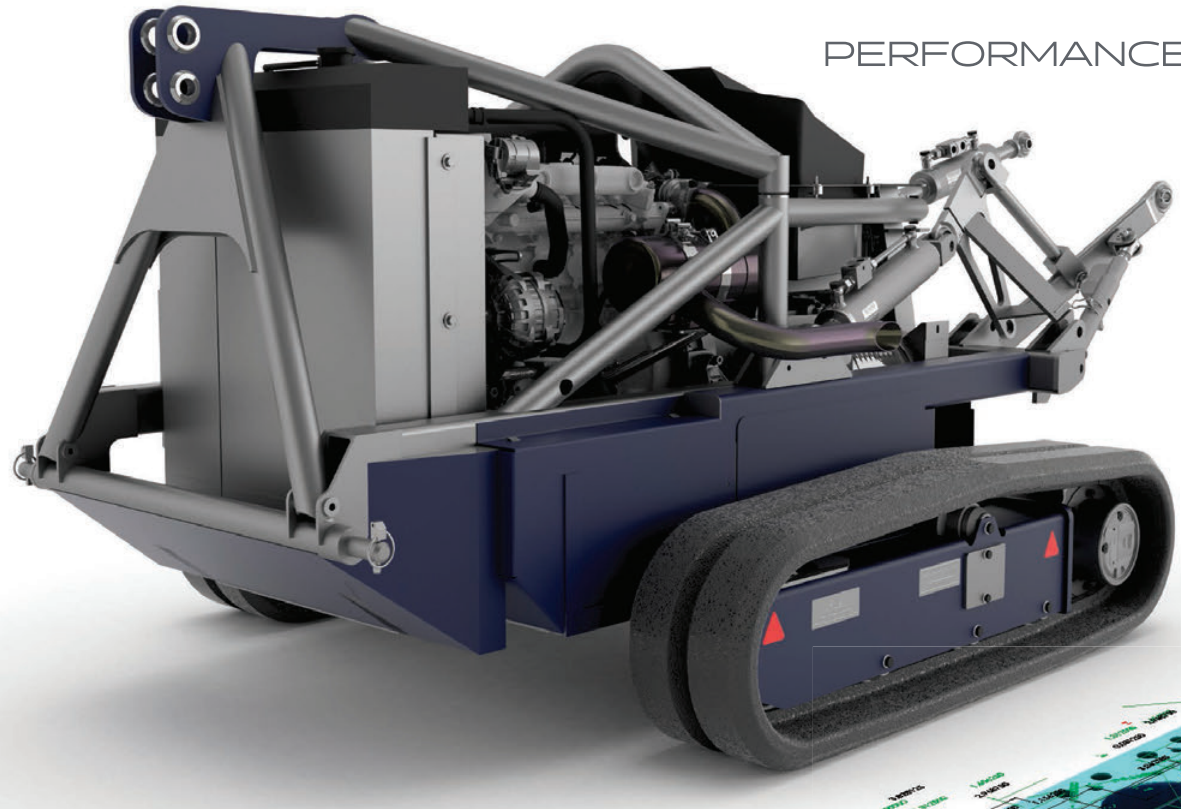
"Unfortunately, after all this investment, and although we had searched before going ahead with it, a manufacturer had taken out a patent which hadn't been published in the database as it was still relatively new," says Horton. "However, on the upside, we've been granted a licence in the key territories so the offering has changed from being one of IP to that of limited manufacture, if we want to go ahead with that."

Their portfolio ranges from the design of an autonomous farm vehicle to a slightly wacky design concept for a major manufacturer, in which the pair were given free rein to come up with an innovative answer to a novel problem. "Sometimes we are given a very broad brief, such as when a particular carmaker was collaborating with the London club 'The Ministry of Sound' to produce a set of promotional vehicles of one its new models to publicise the relationship," explains Horton.

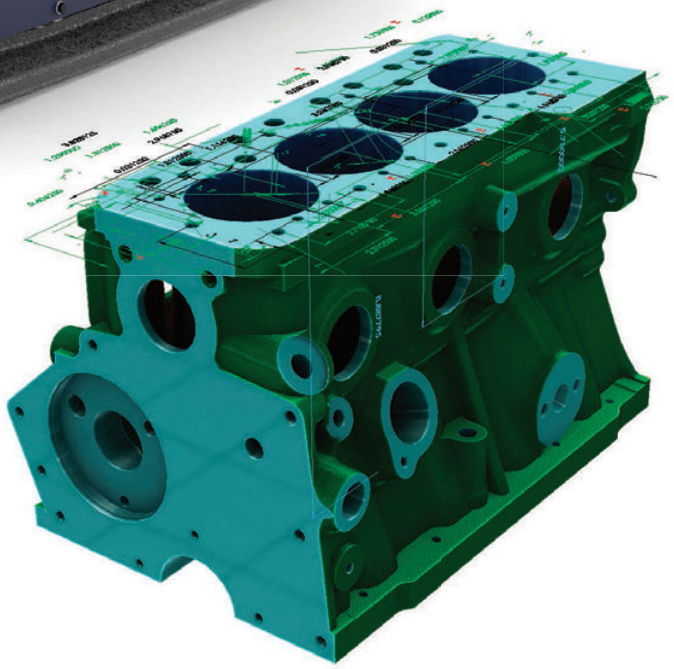
"Without going into too much detail, we had to engineer the enclosures and a boot lid which could come right up and over itself, almost unfurling itself, and the mechanism to allow the rapid deployment of the stadium-quality speakers, which was a key part of linking this car to the event at which the speakers were being used. We also had to engineer feeding the speaker with 240 volts, and so doing the engine generator side of it. It was a really challenging task but it was great to work on, and successfully promoted the vehicle to a whole new audience."

This project illustrates how Horton likes to describe both himself and Goad, and that is problem solvers: "In a nutshell we take a look at customers' problems or ideas for new products and design the solution. This can range from something for a low volume run to producing a fully functioning item for technical or market appraisal."

Horton and Goad met at RML, the motorsport engineering company that has turned its hand to many projects, the former coming in as a graduate and Goad from the aerospace industry where he was a stress analysis engineer. Both then went on different paths to pursue Formula 1. Horton wound up at Cosworth, very much involved in the extensive Formula 1 programme at the time as a senior trackside engineer, but also acquiring his MBA along the way. Meanwhile Goad went to the Renault F1 operation and then on to Toyota before it closed its F1 activities. While he had the option of staying on, he decided to take a package and as Horton was deciding on his future at Cosworth,







LEFT & BELOW Performance Projects' portfolio ranges from challenges as diverse as an autonomous farm vehicle, to crash-testing a child seat and reverse engineering a BMC "A-Series" engine block

decided to collaborate and set up Performance Projects in 2010.

It's not just problem solving but also sourcing and producing component pieces, whether they be one-offs or limited production runs. Whether reverse engineering existing worn components, designing from existing drawings or working from scratch via pictures or less, Horton and Goad believe they can reproduce any part on a car. "It can be any part from a broken bit to a full historic item that's long out of production," says Horton.

"We can implement current technologies to address reliability issues sympathetically, giving the owner lower maintenance and improved durability," he says. "As historic car enthusiasts, we know that any deviations from original designs should be kept to a minimum to achieve the required results, and that the original, period look has to be maintained where possible."

He cites examples of work on Lagonda fuel pumps, Aston Martin engine front covers for the DB range and reverse engineering a specific variant of BMC "A-Series" engine block, providing all the necessary CAD models and detail drawings to enable remanufacture.

"Three old blocks were used to derive the CAD model of the A-Series engine block, so as to ensure any anomalies of one block were not carried over to the reproduced parts," says Horton. "Research was undertaken to understand the original design fully; for example, which features were used as datums on the original production line, and which features were machined for each variant.

"Modifications that would have been made by engine tuners in the 1960s were incorporated, with slight adjustments to the casting made to allow those modifications to be made reliably. Close liaison with foundries and machine shops ensured that the features desired for cost-effective modern manufacturing methods were included.

"In the historic car market our typical customer is a marque specialist who has a large portfolio of products and parts, and a known client base. They can pick through their list, identify critical parts for remanufacture and consolidate to an appropriate volume, such that parts can be made available at a sensible price. We then undertake the design work to make remanufacture possible. Where necessary, we can collaborate to do a mini production run if one or more specialists ask for a specific part. We can share the risk and return between groups if desired, rather than them taking the risk on it individually." HRT

Respect the old, seek the new

With the development of new data capture technology bringing added value to the automotive industry, **William Kimberley** reports on one company that is already using it effectively to apply modern engineering to historic vehicles

THE Cambridge CAD group was born from a collaboration of three passionate engineering designers, Thom Attewell, Simon Farmer and Jack Shaw, with backgrounds in the automotive design and manufacturing industry and an aim to provide an engineering design consultancy and reverse engineering service.

As avid followers of the historic racing world, they understand that there is fierce competition between owners who all strive to be on the top step of the podium. With this insight grew a passion to provide a means of improving a car's performance. Through their method to provide a means of capturing individual components, if not the whole car, in a virtual world, this becomes a worthwhile exercise if original drawings no longer exist, as well as giving legacy data to be called upon come the day when the vehicle might unfortunately meet the tyre wall or worse.

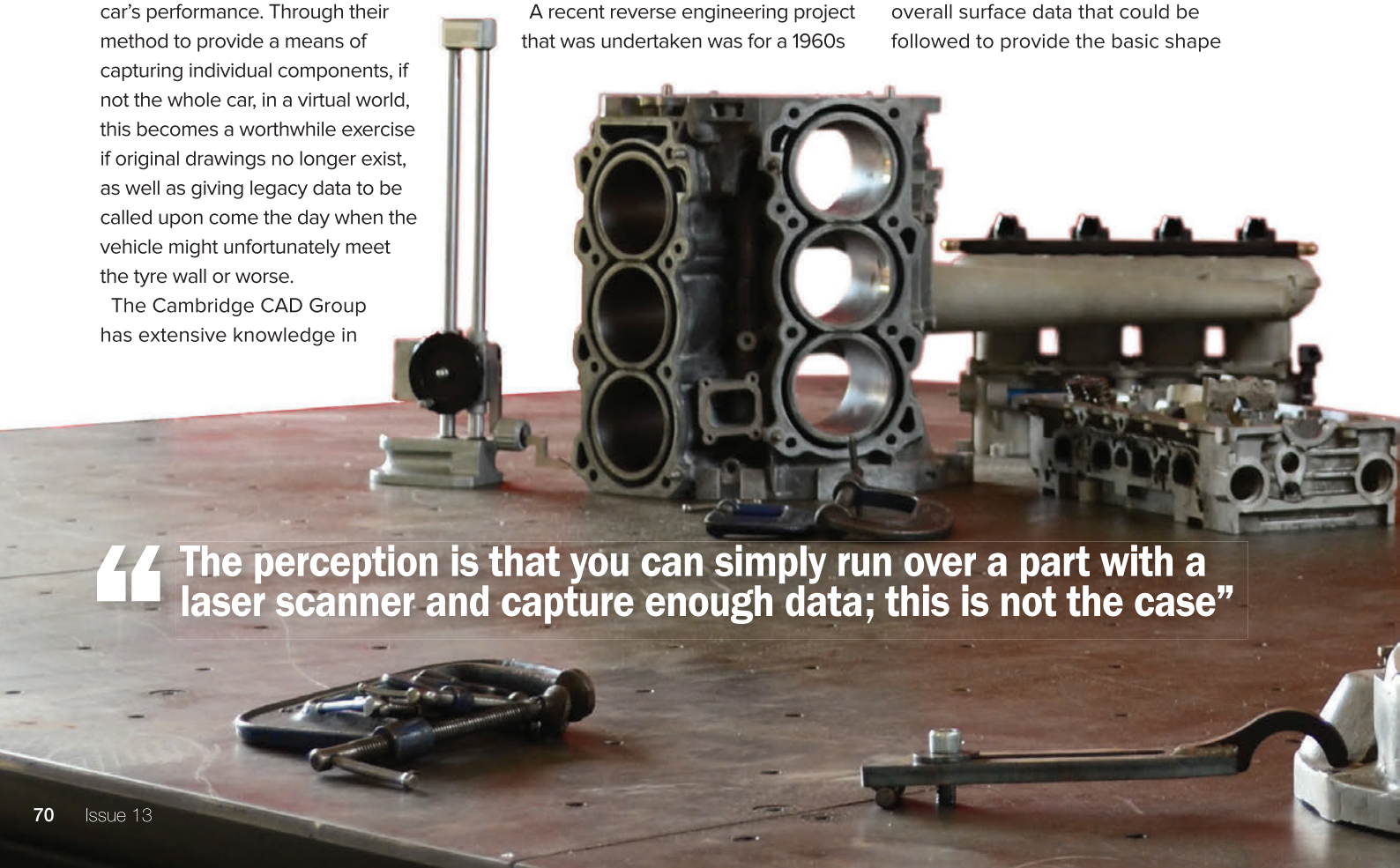
The Cambridge CAD Group has extensive knowledge in reverse engineering and the technology available to perform the task effectively. Not to mention, being able to draw on the experience of previous projects, be it the 3D modelling and drawing of a 1980s Formula 1 chassis, suspension components and bodywork, or a 1930s Bugatti rolling chassis, including full suspension and steering system. This combined with a vast array of various one-off components from bodywork to bracketry, to gearbox and engine casings and mechanisms gives a truly unique service and insight into adding value to historic vehicles.

A recent reverse engineering project that was undertaken was for a 1960s Italian sports car. The trio were tasked with creating a full CAD model and a pack of drawings for remanufacture of its six-speed gearbox. The original bellhousing had obviously had a difficult life, visibly having been in several pieces in its past and welded back together with additional blocks of aluminium roughly welded on, acting as stiffening, but it was only really fit for the scrap bin.

The brief was to capture the 3D data of the bellhousing, and remodel the part in a computer aided package CAD file. Following the geometrical changes applied to strengthen the part, more subtly then had been previously attempted, and new mounting features created for a new internal clutch release bearing set-up, the 3D data and a full machining drawing would then be supplied to a local casting company and machine shop.

To capture the housing's 3D data, a combination of laser scanning and portable coordinate measuring machine (CMM) technology was used. This enabled remodelling of the part in CAD to be carried out as accurately and as authentically as possible.

The laser scanning provided good overall surface data that could be followed to provide the basic shape

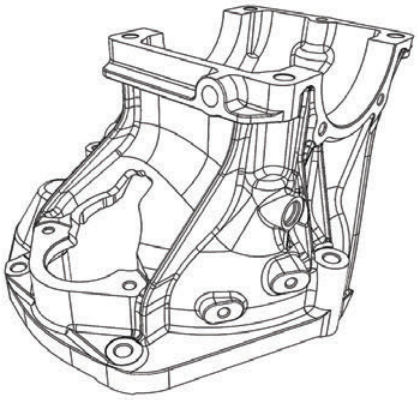


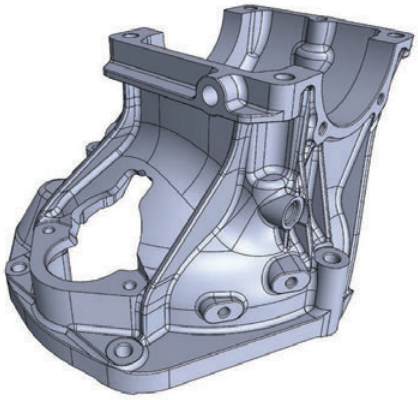
"The perception is that you can simply run over a part with a laser scanner and capture enough data; this is not the case"





ABOVE LEFT & RIGHT The laser scan data of the original part





ABOVE LEFT & RIGHT A full parametric CAD model was created

of the part, but use of the in-house portable CMM measuring arm provided accurate numerical xyz data for all the critical features, such as the mounting holes, the input shaft centre, starter motor position and its mountings. To ensure correct interfacing with the engine and gearbox main case, the CMM measuring arm was used again to capture the mounting faces and holes, as well as the flywheel position and envelope for reference when modelling the bellhousing.

The work took a number of weeks to undertake, to both capture and create a full parametric CAD model and produce manufacturing drawings of the housing. The perception is that you can simply run over a part with a laser scanner and capture enough data to provide a fully engineered solution, but this is not the case. Although laser scanning reduces time in the data capturing process and provides more data to work with, there is still significant time taken in creating the 3D model feature by feature, fully dimensioned and constrained. This creates a robust model, which is a complete engineered solution, whereby performance gains can be made at each iterative stage of modelling.

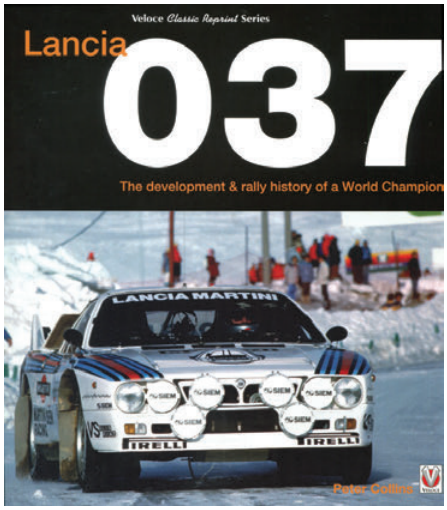
To date, the Cambridge CAD group has been working closely with historic racing companies that compete in a range of racing series, including Masters Historic Racing, pre-66 Touring Cars, Historic Can-Am, SuperTCC and HSCC Super Touring Cars. HRT



ABOVE The combination of portable coordinate measuring machine (CMM) technology and laser scanning was used for accuracy and authenticity

Lancia 037

The development & rally history of a World Champion
Peter Collins
Published by Veloce Publishing
ISBN 978-1-787111-28-8
224 pages
£45.00/$70.00



THIS is a welcome reprint of Peter Collins' book that was first published in 2008 and for those who might have missed it, it is a fascinating insight into the Lancia 037. With a Foreword by World Rally Champion Walter Röhrl who says that the 037 is his favourite rally car, the book then goes into the story of how it came to be developed.

It is full of some amazing pictures from the moment the car was little more than a shell to some early prototype images. As the story unfolds, you appreciate just what went into it in terms of resource, not just initially – as it fought against Audi's Quattros – but to keep the car competitive as it became the one to beat. There is also a shot of the Evo 3 037 that was developed due to the 038 being delayed. In the event, it was never needed.

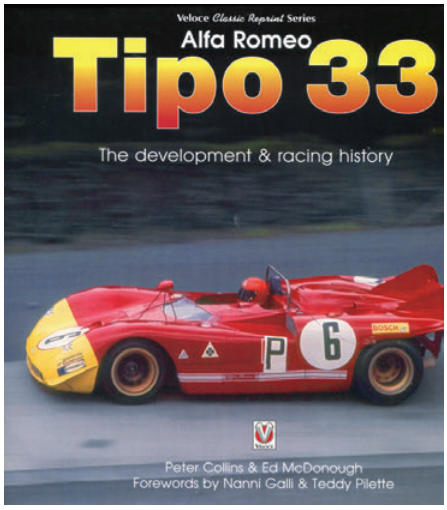
It was in 1984 that the competition was taken to a new level with the arrival of the Peugeot 205 turbo 16 with its mid-mounted power unit and four-wheel drive. As Collins notes, it represented something of a quantum leap in the way the Group B rules were interpreted. At the same time Audi had evolved the 'short' Quattro specifically with the intention of challenging the Lancias on tight tarmac roads where the Italian cars were at their strongest.

In Corsica, the first event where the Peugeot appeared, its speed and setting fastest stage times out of the box shook everyone at Lancia and they knew they had a fight on their hands. Although the 037 was still a quick rally car in its own right, the French machine was unbeatable by the end of the season.

The book has a comprehensive list of results and also the chassis numbers. A beautifully produced work, it will sit well on the book shelf of everyone who loves Lancias and also rallying when it was going through one of its heydays. HRT

Alfa Romeo Tipo 33

The development & racing history
Peter Collins & Ed McDonough
Published by Veloce Publishing
ISBC 978-1-787111-31-8
224 pages
£45.00/$70.00



ALMOST a sister book to the Lancia 037 that is also reviewed in these pages, the Alfa Romeo Tipo 33 is a reprint of a book that was first published in 2005. However, that does not detract from it in any way.

As with the Lancia 037, the authors start the story with the launch of the T33 in early 1967, but it was not universally acclaimed. Italian driver Nino Galli, who has written one of the Forewords, described the car's chassis as being "a disaster". Little did anyone know at the time that this was the start of a journey that was to last 10 years.

Over the decade, the T33 evolved from being the wayward car it was into one that went on to win the Manufacturers' Championship in both 1975 and 1977. In the first part of its life, as a model it was really put in the shade by the Porsche 917 and Ferrari 512, which were admittedly in a different class with bigger engines, until they were outlawed by the governing body. By this time, though, Ferrari had developed the 312PB and Lola had the new T280 with a 3.0-litre Cosworth engine.

By the end of the 1972 season – which should have been the Alfa Romeo's year – the results said it all. Ferrari finished on 208 points and Alfa Romeo was second on 85 points, not that far ahead of Porsche which was not officially entered as a manufacturer. So this is a story of a car that evolved over its 10 years from being an also-ran to becoming a championship winner twice over and then gently fading away.

There is an interesting chapter on some concept cars that evolved from the Tipo 33. There was the Bertone Carabo, the Pinifarina P33 Roadster and 33 Prototipo Speciale, the wedge-shaped Cuneo and the Navajo. To be honest, some were absolutely dreadful but do deserve some space in a book devoted to the Tipo 33.

Lavishly illustrated, a list of results and of existing cars make this a worthwhile addition to the library. HRT



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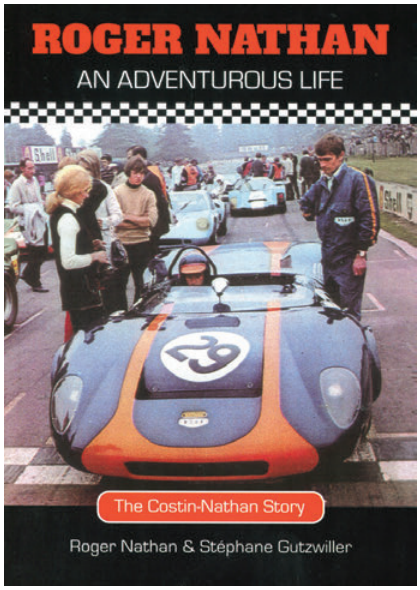
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Image: Jakob Ebrey Photography

Roger Nathan

An Adventurous Life, The Costin-Nathan Story
Roger Nathan & Stéphane Gutzwiller
Published by Stéphane Gutzwiller
ISBN 978-0-09553934-0-2, 184 pages, £20.00



IT is perhaps Bernie Ecclestone who sums this book up best in his Foreword. As someone who knew Roger Nathan's parents and watched the early part of his career, even selling him an Elva FJ, the only single-seater he drove, when Ecclestone writes that racing drivers in the 1960s were exploring the 20th century's last frontier, speed with style, fair play and an almost total disregard for money and safety, he sums up what this very readable book is all about.

Through the author, we live in an era that was exciting, but daunting, exhilarating but tinged with sorrow as drivers were seriously injured and died. However, Roger Nathan was more than just a racing driver as he also made a name for himself as the tuner par excellence of the Hillman Imp engine. In 1966 he also created the Costin-Nathan sports-racing car powered by a Nathan Imp engine, as seen on the front cover that won its class five times and also set five new class records.

The following year he took a closed Costin-Nathan GT to Le Mans. It wasn't a resounding success but the story that Nathan tells makes for compelling reading. While the practice and qualifying were daunting enough, at the start of the race, back when the drivers had to sprint across the track and get into their cars, Nathan found that his car simply wouldn't start. It did eventually, by which time most of the grid had gone, but it was the precursor of what was going to be a challenging race. It may not have gone the way he hoped but how many of us can claim that they raced their own car at the Le Mans 24 Hours?

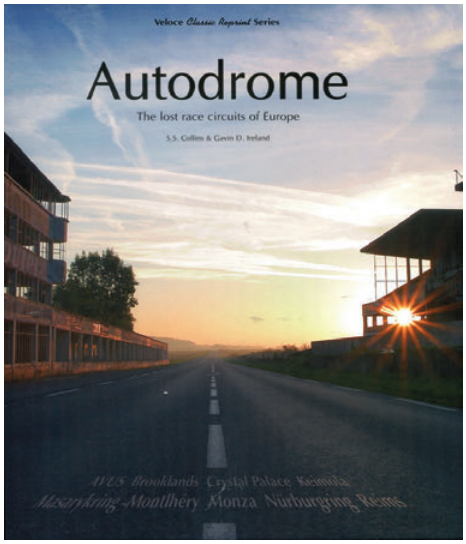
The following year was much more successful, winning the *Motoring News* GT Championship and the Total National GT championship in his Nathan Hillman GT. It also saw the arrival of his first GT powered by a 2.0-litre Alpina BMW engine. On its maiden race at Brands Hatch, Nathan won by some margin, beating a BMW-powered Chevron B8 and another B8 with a Schnitzer-prepared engine.

The following year saw the arrival of the 2.0-litre Coventry Climax-powered Astra RNR1 Group 6 car that also immediately proved to be a race winner and then swansong Ford Cosworth FVC-powered Astra RNR2 that actually had a short life. The common factor in all Nathan's cars? They were all wooden monocoque with tubular spaceframes.

This is an important book written by someone who really did make it in motorsport as both a driver and constructor, and hopefully will bring some recognition of just what he achieved with the minimum of resources. At £20 it really is tremendous value and a great read. HRT

Autodrome

The lost race circuits of Europe
SS Collins & Gavin D Ireland
Published by Veloce Publishing
ISBN 978-1-787111-29-5
170 pages
£45.00/$70.00



AS with the Lancia 037 and Tipo 33 books, this is one of Veloce's Classic Reprint Series. At first glance, it might seem to be a bit of a hotpotch, but take time and delve into the book, and it is an Aladdin's cave of little jewels. In fact, I found myself going back to it time and again.

Sam Collins is an accomplished journalist and writer, while his words have been amplified by the beautiful photographs taken by Gavin Ireland. At the same time there are plenty of period photographs of when the circuits – or autodromes – were being used.

It's a book that makes you want to visit all the venues covered – Brooklands, Monza, Reims, Nürburgring Südschleiffe, Crystal Palace, Keimola, Masarykring. Avus and Linas Montlhery – with this book in hand. While it is a little pricey, it's worth it for those who want to know more about the history of motor racing than just the cars and drivers. HRT

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