The Lotus Elite

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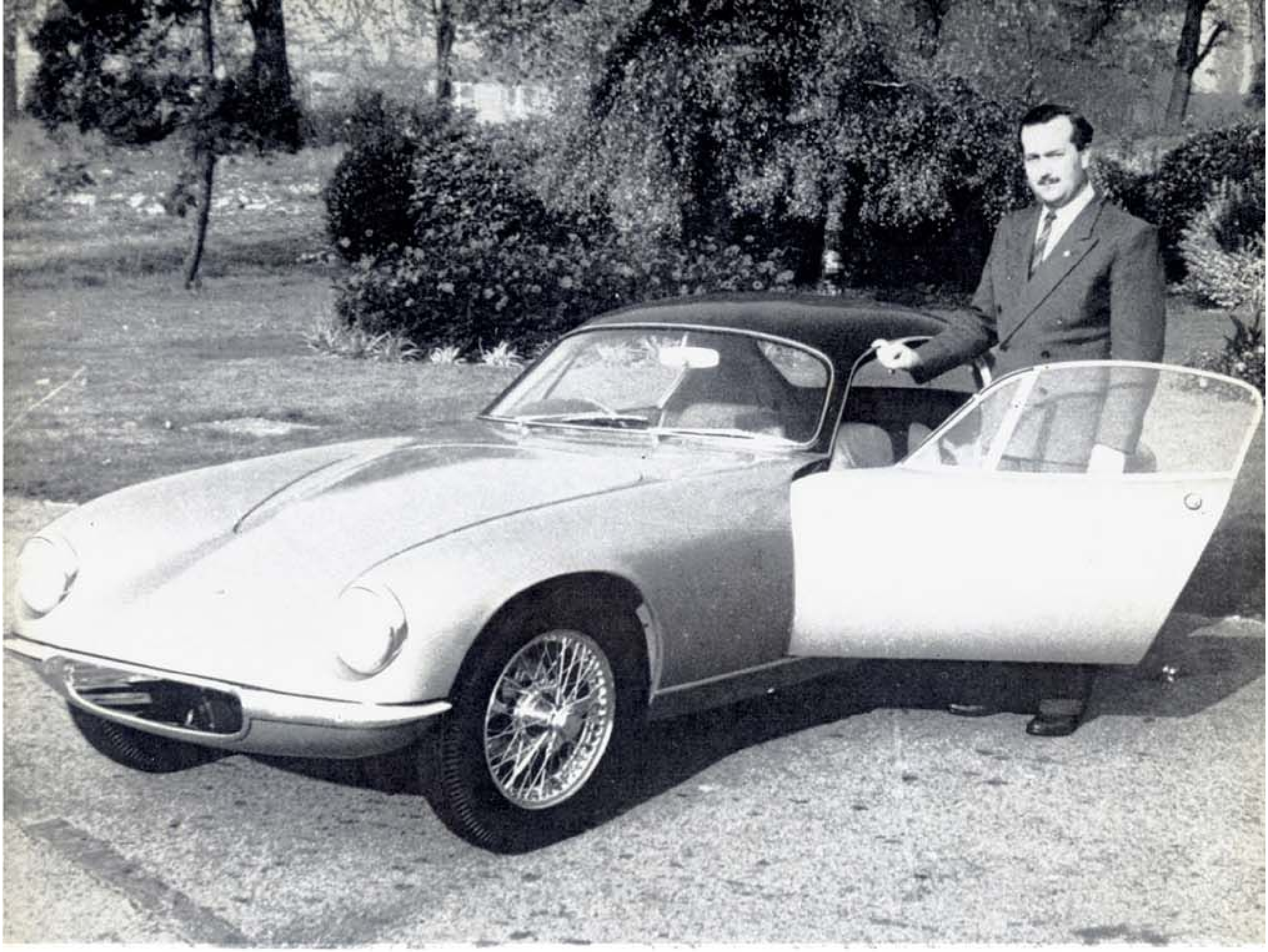


The Lotus Elite

David Phipps

Although only 988 were ever made, the Lotus Elite has a very significant place in the history of automobile engineering. It was the first Lotus designed for series production and intended primarily for road use rather than for racing, and it was the first car ever to use glass-reinforced plastic as a major structural element. It was also, at the time of its introduction, the only small British sports car with an overhead camshaft engine, four-wheel disc brakes and advanced fully independent suspension.

The Elite was conceived in the autumn of 1956, and announced at the 1957 London Motor Show. Almost two years elapsed before it was in full production, but the apparently premature introduction was dictated by the need to obtain adequate financial backing. There was also the question of building and equipping a new factory in which to assemble the car. The small Lotus workshop at Hornsey was clearly not big enough, and as there was no space nearby for expansion it was decided to move into entirely new premises at Cheshunt, Hertfordshire.

After several years of racing in small capacity sports car events, Lotus designer Colin Chapman naturally regarded low weight as a primary factor when designing the Elite. This was one of the chief reasons for the choice of glass-reinforced plastic for the chassis/body structure—and the use of an aluminium alloy Coventry Climax engine. The latter was originally designed as the power unit for a portable fire pump, and thus had to be both light and reliable. The use of a chain-driven overhead camshaft offered considerable development potential, and the general layout of the engine was surprisingly well suited to automotive application.

Prohibitive tooling costs put paid to any thoughts regarding pressed metal structures, and the use of a non-stressed body with a separate tubular chassis

Above: *Colin Chapman with the first Elite prototype, shortly before the 1957 London Motor Show.* (Photo: Geoffrey Goddard)

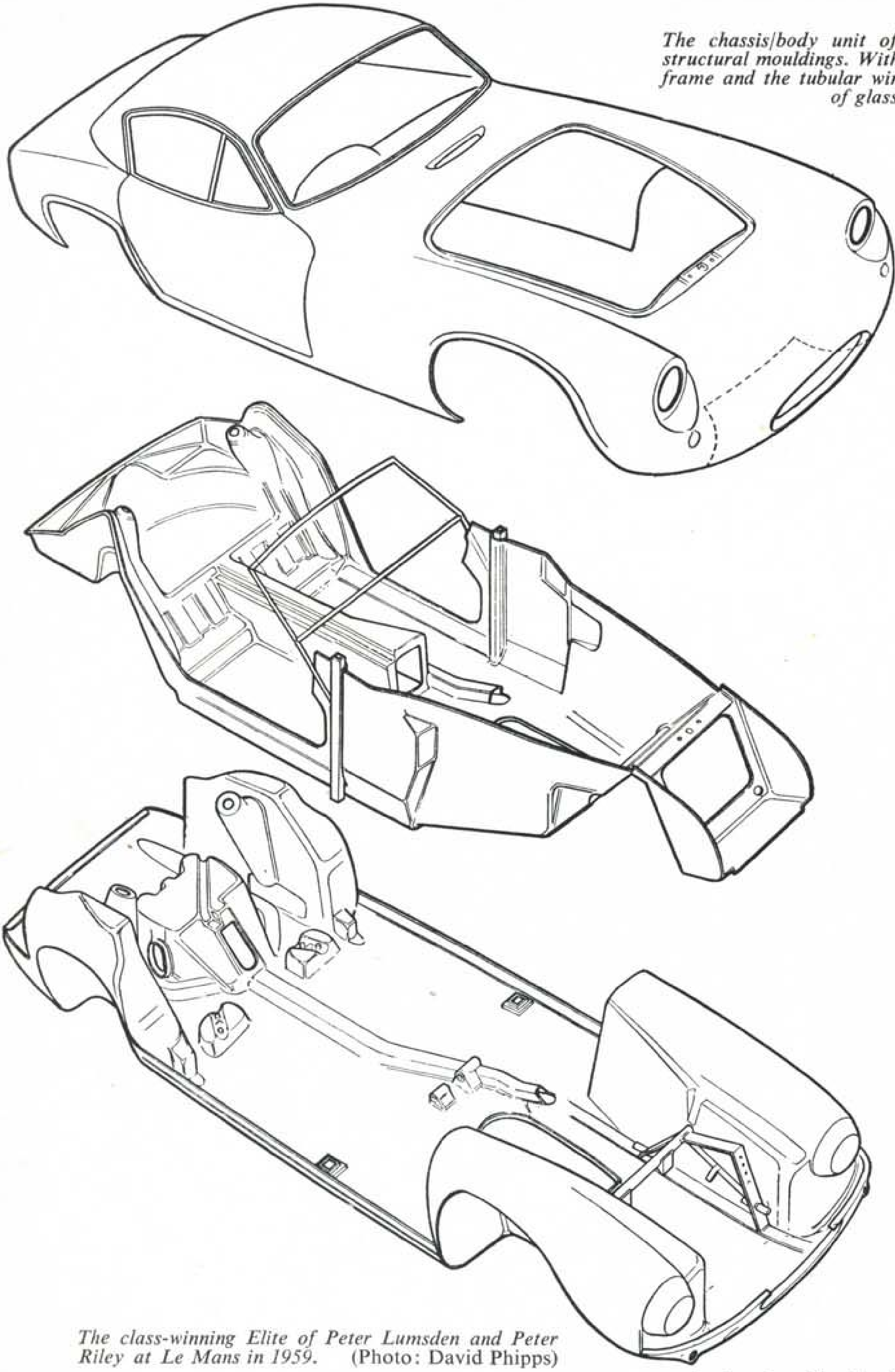
Above: *The Border Reivers Elite at Le Mans in 1959.* Below: *Jim Clark (in helmet) about to take over from John Whitmore, who is in the process of removing his overalls; despite starter motor trouble they finished second in class to the Lumsden/Riley Elite.* (Photos: Louis Klemantaski)

was ruled out on the grounds of both weight and complexity.

THE CHASSIS/BODY UNIT DESCRIBED

The Elite chassis/body unit consists of three major mouldings, and with the exception of the front suspension frame, the windscreen hoop and the bonded-in mountings for engine, suspension, etc., it is entirely composed of glass-reinforced plastic.

The front suspension frame is of sheet steel, and the windscreen hoop consists of 1-in., 10 gauge round section mild steel tube welded into 1½-in. 10 gauge square tube. This member has several functions. At its ends it provides the car's jacking points. The square section tubes, bonded between two skins of glass-reinforced plastic, form supports for the door hinges. The hoop itself strengthens the windscreen pillars and roof and also forms a built-in



The chassis/body unit of the Elite consists of three major structural mouldings. With the exception of the front suspension frame and the tubular windscreen hoop it is entirely composed of glass-reinforced plastic.

crash bar. A further tubular cross member below the level of the windscreen stabilises the hoop laterally and supports the steering column, the instrument panel and the hand brake.

As in all unitary construction cars, some parts of the bodywork are more highly stressed than others. The radiator air intake and headlamp mountings, for instance, have no direct structural function, but the radiator inlet duct plays an important part in stabilising the front suspension frame and is built in the form of a diaphragm. Engine, as well as suspension, loads are taken out into the front suspension frame, and the latter is diagonally braced by being bonded to the inner body moulding. Bending loads in this area are taken out into the vertical sides of the engine bay—and thence into the main side members of the body.

The scuttle bulkhead moulding stabilises the body diagonally and also takes loads from the steering column, the brake and clutch pedals (and master cylinders) and the accelerator pedal. Rearwards the bulkhead contracts into the deep, box section propeller shaft tunnel, which links it to the near-vertical rear diaphragm. The tunnel is extremely rigid and provides bending as well as torsional stiffness, reducing bending loads on the undertray by supporting the seat mountings.

The class-winning Elite of Peter Lumsden and Peter Riley at Le Mans in 1959. (Photo: David Phipps)

The rear diaphragm completes the structure in this area, coupling the body sides and the tunnel by means of a beam. The rear suspension unit pick-ups are located at the top corners of this beam and the final drive is mounted in the centre of it; in this highly loaded area the glass-reinforced plastic is $\frac{3}{8}$ in. thick, tapering to $\frac{3}{16}$ in. and finally $\frac{1}{8}$ in.

At the four mounting points the final drive unit is bolted directly to the chassis via rubber bushes. On some early examples of the Elite, mounting failures were experienced due to heat generated by the exhaust system or the inboard brakes. There were also a few failures due to errors on the part of the body manu-

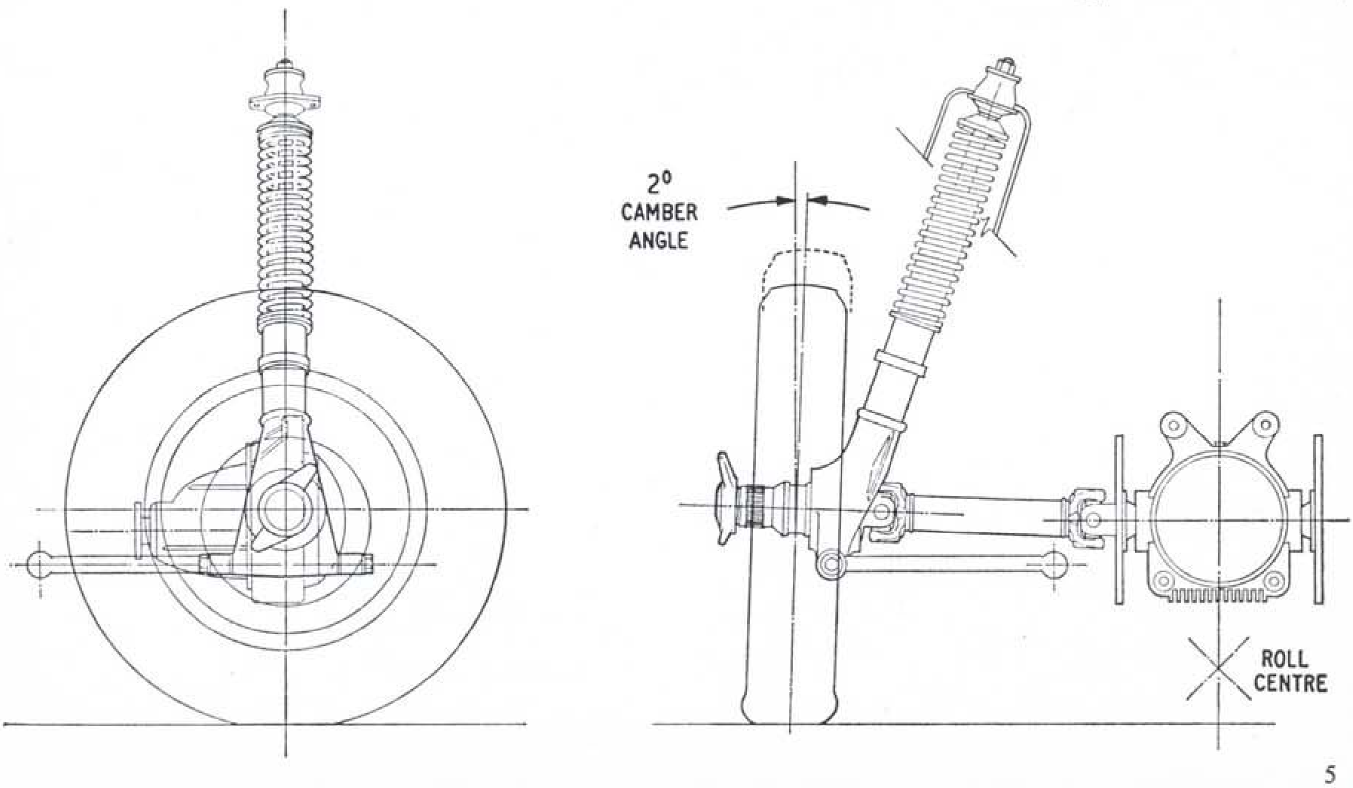
Two of the most successful Elites ever made, Les Leston's DAD 10 and Graham Warner's LOV 1, corner side by side at Brands Hatch. (Photo: Geoffrey Goddard)

facturers, but all these problems were quickly overcome, showing that direct metal-to-glassfibre mounting can be quite practical, even where very high point loads are involved.

On the Series Two Elite the pick-ups for the rear radius arms are formed in the undertray moulding and shaped to accept the rubber bushes for the ball-type mountings. The Series Two radius arm layout is also superior to the original design both structurally and from the point of view of suspension geometry. Most noticeably, the use of two widely separated outboard pick-ups for the two-piece radius arms makes the suspension much stiffer against toe-in loads. The revised geometry also obviates toe-in with vertical movements of the wheel, and this considerably improves the car's straight-running qualities at high speed.

Behind the rear diaphragm the structure consists of the boot floor and two side members, all of which are designed to take the bending loads of the battery and luggage. The roof provides diagonal bracing over the top of the central bay—the one which cannot

The very effective rear suspension of the Series Two Elite, with lateral location provided by the fixed-length drive shaft and fore-and-aft location by a two-piece radius arm. (Drawing: James A. Allington from *Racing and Sports Car Chassis Design* by Michael Costin and David Phipps. B. T. Batsford Ltd.)



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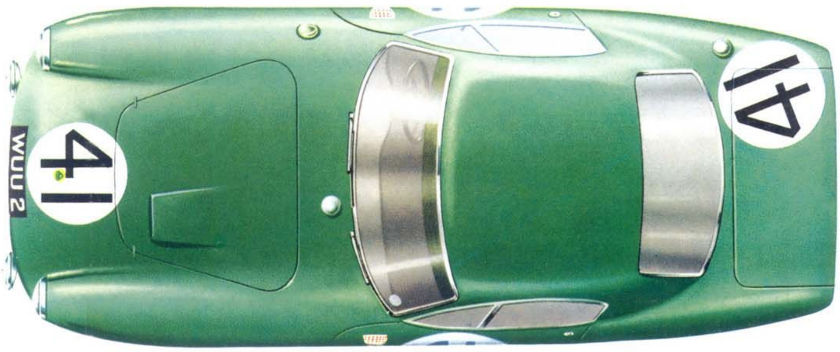


THE LOTUS ELITE which won the 1½-litre Class and was 8th overall in the 1959 Le Mans 24-hour race, driven by Peter Lumsden and Peter Riley. Two weeks earlier the same car and drivers won their Class in the Nürburgring 1,000 Kilometres race.

The Fitzwilliam Team insignia.

normally be triangulated on an open car—and contributes towards the Elite's very considerable torsional stiffness. As an instance of this, when a chassis/body unit was subjected to torsional loading greater than would ever be experienced in normal use, the maximum deflection across the windscreen aperture was 0·050 in. The influence on the structure of holes for doors, engine cover and boot lid is overcome by taking out diagonal loads into the outer moulding round the edges of these apertures; further compensation is provided by the stiffness of the structure at the base of the doors and round the windscreen. The doors themselves are made by a special process which combines torsional rigidity and lightness; they are effectively of box section and the material is locally thickened to take hinge and lock mountings.

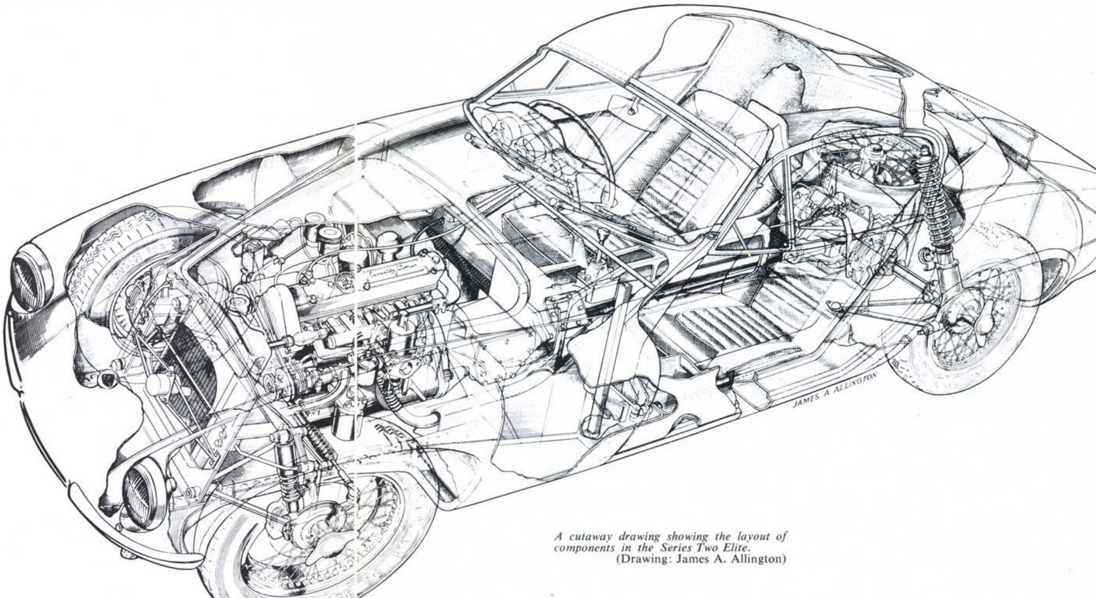
When the Elite was first announced there was considerable scepticism about the use of so much glass-reinforced plastic with so little metal reinforcement, but in fact there was absolutely no cause for concern in this department. As mentioned above, there was some trouble with differential mountings on early models, but this was soon overcome and many of the original chassis/body units are still in regular use, having completed very high mileages.

Suspension, steering and brakes are all basically as on the 1957 Formula 2 Lotus—racing definitely improved the breed in this instance. Front suspension is by double wishbones and co-axial coil spring damper units—the upper wishbone incorporating an anti-roll bar—and rear suspension is of the Lotus strut type, with the drive shaft providing lateral location. As explained above, the single longitudinal radius arm of the original version was replaced by a 'reversed wishbone' on Series Two cars, with beneficial effects on both cornering and directional stability.

Steering is by Lotus-modified Triumph Herald rack-and-pinion, and is beautifully light and precise. Braking is by 9$\frac{1}{2}$-in. Girling discs, the rear ones being mounted inboard, and centre-lock 15-in. wire wheels are used.

ENGINE AND TRANSMISSION

The 1216 c.c. Coventry Climax FWE engine was specially made for the Elite, using the 3·00-in. bore of the 1,460 c.c. FWB and the 2·625-in. stroke of the 1,098 c.c. FWA. With a single 1$\frac{1}{2}$-in. SU carburettor



A cutaway drawing showing the layout of components in the Series Two Elite. (Drawing: James A. Allington)

Peter Riley points out some hazard on the course while mechanics check the oil and tyres; the class-winning Elite at the 1959 Nurburgring 1,000-km. race. (Photo: Henry N. Manney III)

Twin carburettor version of the Coventry Climax FWE engine, which developed 85 b.h.p. and gave the Elite a maximum speed of over 117 m.p.h. (Photo Geoffrey Goddard)

The Elite of Wagstaff and Marsh won the Indice au Rendement Energetique *at Le Mans in 1960.* (Photo: Louis Klemantaski)

Above and below: *Elites at Silverstone and Goodwood: 'Although it was intended primarily for road use it was inevitable . . . that the Elite would be used for racing. . . . Countless victories have been scored in British events at everything from club to international level.'* (Photos: Geoffrey Goddard)

and 8·5 to 1 compression it gave 75 b.h.p. at 6,100 r.p.m. in standard form, but was subsequently developed to give over 100 b.h.p. without any loss of reliability.

Transmission was initially by the BMC 'B' series gearbox, which had the virtues of low cost, reliability and serviceability, but provided a rather stiff shift and had an unsynchronised first gear. Series Two models were fitted with an all-synchromesh ZF gearbox, which overcame both of these disadvantages but added appreciably to the cost of the car!

THE ELITE IN COMPETITION

Although it was intended primarily for road use, it was inevitable—in view of its background and specification—that the Elite would be used for racing. It began its competition career at Silverstone on 10th May 1958, driven by Ian Walker, and won first time out. It won again at Mallory Park the following day, and recorded many further successes during the rest of the season.

No less than five Elites appeared at the 1958 Brands Hatch Boxing Day meeting, and in one of these an unknown Scotsman, Jim Clark, had a race-long battle with Colin Chapman; in the closing stages a slower car spun right in front of Clark, and Chapman slipped through to win.

Elites made their first appearance at Le Mans in 1959, and a privately-entered car driven by Peter Lumsden and Peter Riley finished eighth overall and

first in the 1,500 c.c. class. Two weeks earlier the same car had won its class in the Nurburgring 1,000-km. race.

In 1960 Elites were first and second in the 1,300 c.c. class at Le Mans and first and second in the *Indice au Rendement Energetique*. They were first and second in class again in 1961 and 1962—when they won the Thermal Efficiency award again—and also won their class in both 1963 and 1964. Countless victories have been scored in British events at everything from club to international level, and major successes have also been recorded throughout Europe, in the United States and in Australia, Macao and Japan.

An early Elite pauses outside the Pommery and Greno château at Reims in March 1959. (Photo: David Phipps)

ROAD IMPRESSIONS

I have been fortunate enough to cover a very considerable road mileage in Elites, including two trips from London to Geneva. The first of these was in March 1959, and I completed the 440 miles from Le Touquet to Geneva in a little over 8 hours, cruising at over 100 m.p.h. and yet averaging over 30 m.p.g. I seem to remember that the car was rather noisy, and leapt about somewhat on the frost-ravaged roads of northern France, but the exhilarating performance and ultra-precise handling more than compensated for this.

I did the same trip three years later in a Series Two Elite, which was much quieter and much more refined, and which showed its aerodynamic qualities by running through a snowstorm without letting a single flake fall on the windscreen. It also clambered happily over several feet of snow on the Col de la Faucille, and burbled through the traffic jams of both Paris and Geneva as if built for the job.

THE ELITE SUPERSEDED

Unfortunately the cost of the chassis/body unit went up by leaps and bounds during the Elite's production run, and eventually Lotus were forced to replace it with a car which had a separate chassis, the Elan. (One of the reasons for reverting to a separate chassis was to permit the construction of an open car—something which the Elite could never be—to cater for the increasing demand for such a vehicle in export markets.) Another problem was an engine vibration period at about 4,000 r.p.m., which was accentuated by even the slightest imbalance in the clutch and flywheel.

So in September 1963 Elite production came to an end. But well-maintained ones still fetch a good price on the second-hand market, and are still among the best-looking cars on the road. In a few year's time they will no doubt become collector's pieces, and will be sought as eagerly as the rarer 'vintage' cars are today.

SPECIFICATION: THE LOTUS ELITE

Frame: Integral chassis/body structure of glass-reinforced Epoxide and Polyester resin. This confers the important advantages of exceptional strength, very good impact resistance, first-class sound damping and good thermal insulation. Two-seater, two-door coachwork providing accommodation for two persons with provision for luggage in separate compartment. A wrap-around glass windscreen and side windows with hinged quarter lights for ventilation. Large wrap-around rear window.
Front Suspension: Independent by transverse wishbones incorporating anti-roll bar. Springing by combined coil spring-damper units reacting through a single attachment point at each end.
Rear Suspension: Independent rear suspension by Chapman strut-type system, incorporating combined coil spring damper units and including double articulated drive shaft giving also lateral location. This system was expressly designed to offer a certain amount of camber change with increase in load, to maintain good handling characteristics under all conditions.

The Taylor/Allen Elite, which won its class at Le Mans in 1961. (Photo: Geoffrey Goddard)

The author and a Series Two Elite in snowy surroundings in March 1962. (Photo: Priscilla Phipps)

Brakes: Hydraulically-operated $9\frac{1}{2}$-in. Girling disc brakes, outboard at the front, inboard at the rear. Horizontally mounted hand brake operating the rear calipers through cables.
Steering: Rack and pinion steering gear.
Power unit: Single o.h.c. Coventry Climax 4-cylinder engine. Bore and stroke 76·2×66·6 mm.=1,216 c.c. Maximum power output 75 b.h.p. at 6,100 r.p.m. Compression ratio 8·5:1. The engine is water-cooled and has a steel crankshaft of fully counterweighted design with a large overlap between crankpins and main journals, carried in three $2\frac{1}{8}$ in. diameter and 1 in. wide main bearings of lead-bronze steel backed thin strip type. The aluminium pistons are fitted with plated top rings. Connecting rods are split diagonally. Big end bearings are renewable lead-bronze strip type. High mechanical efficiency is provided by a piston speed of 2,500 ft./min. at 5,750 r.p.m. Cylinder head is heat-treated aluminium. Valves of XB steel are shrunk-in Austenitic cast iron seatings. There is a chain drive from jackshaft to camshaft; the latter operates the valves direct through piston-type cast iron tappets which practically eliminate wear in the valve guides. Tappet clearances are maintained over long periods. A normal spur gear-type oil pump with built-in relief valve is used. Renewable element type full-flow oil filter. The carburettor is a $1\frac{1}{2}$ in. horizontal S.U. unit.
Transmission: Single dry-plate clutch 8 in. diameter, hydraulically operated. Special four-speed close ratio gearbox with following ratios: 1st, 3·35 to 1; 2nd, 2·215 to 1; 3rd, 1·372 to 1; Top, 1 to 1; Reverse, 3·67 to 1.
Final Drive: Hypoid final drive unit. Standard ratio 4·55:1; following axle ratios available at option: 5·125, 4·875, 4·22, 3·73:1. Typical speeds per 1,000 r.p.m. (with 5.00 by 15 rear tyres): 4·22:1 = 18 m.p.h. (28·97 k.p.h.) per 1,000 r.p.m. 4·55:1 = 16·7 m.p.h. (26·87 k.p.h.) per 1,000 r.p.m. 4·89 = 15·55 m.p.h. (25 k.p.h.) per 1,000 r.p.m.
Cooling system: Fully ducted radiator with integral header tank.
Fuel system: Side tank in right hand front wing, total capacity 9 gallons. A.C. fuel pump.
Electrical system: Special heavy duty 12-volt 31-amp-hr. battery, weight 24 lb. located in luggage compartment. Coil and distributor, centrifugal advance and retard. Belt-driven dynamo, automatic voltage control. Fuse box mounted under bonnet. Recessed Lucas Le Mans 7-in. headlamps incorporating side lamps. Separate flasher units. Twin stop-tail lights, rear number plate-stop lamp. High frequency horn. Instrument lighting. Two-speed electric screen wiper.
Instruments: 4-in. tachometer, 0-8,000 r.p.m., 4-in. 0-140 m.p.h. speedometer, oil pressure gauge, fuel contents gauge, water temperature gauge and ammeter.
Wheels and Tyres: Knock-on 15-in. wire wheels with identical rims front and rear are fitted with special high-performance Dunlop or Firestone tyres front and rear. Spare wheel mounted at rear of bodywork (provision for two spare wheels to be carried).
Dimensions: Wheelbase 7 ft. 4 in. Front track 3 ft. 11 in. Rear track 3 ft. 11 in. Overall length 12 ft. Overall width 4 ft. 10 in. Height to roof 3 ft. 10 in. Minimum ground clearance 7 in.
Weight: Standard Elite, less fuel, $10\frac{3}{4}$ cwt.

PERFORMANCE FIGURES

The Motor road tested the Elite in May 1959 and recorded a maximum speed of 111·8 m.p.h. with a best one way speed of 113·2 m.p.h. Acceleration times from a standing start were:—

0—30 m.p.h.	3·8 sec.
0—40 m.p.h.	5·8 sec.
0—50 m.p.h.	8·0 sec.
0—60 m.p.h.	11·4 sec.
0—70 m.p.h.	15·5 sec.
0—80 m.p.h.	20·4 sec.
0—90 m.p.h.	28·3 sec.
0—100 m.p.h.	41.1 sec.
Standing quarter mile	18·4 sec.

Overall fuel consumption was 34·1 m.p.g., and steady speed consumption ranged from 54·0 m.p.g. at 40 m.p.h. to a remarkable 29·5 m.p.g. at 100 m.p.h.
In May 1963 *The Motor* tested a Special Equipment model, with 85 b.h.p. twin carburettor engine and ZF gearbox. Maximum speed was now 117·5 m.p.h., with a one-way best of 119·8 m.p.h., and acceleration figures from a standing start were:—

0—30 m.p.h.	4·5 sec.
0—40 m.p.h.	6·1 sec.
0—50 m.p.h.	8·2 sec.
0—60 m.p.h.	10·7 sec.
0—70 m.p.h.	14·1 sec.
0—80 m.p.h.	19·0 sec.
0—90 m.p.h.	23·5 sec.
0—100 m.p.h.	33·9 sec.
Standing quarter mile	18·5 sec.

Overall fuel consumption was down to 27·5 m.p.g., but the steady speed figures were virtually unchanged; 54·0 m.p.g. at 40 m.p.h. and 29·25 m.p.g. at 100 m.p.h., with a noteworthy 43·75 m.p.g. at 80 m.p.h.
Kerb weights were $13\frac{1}{4}$ cwt. for the standard car and $13\frac{1}{2}$ cwt. for the Special Equipment model; test weights were $16\frac{3}{4}$ cwt. and $17\frac{1}{4}$ cwt respectively, and both cars had 4·2 to 1 final drive gearing.

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