

The History of Another Dimension

50 Years of Bentley's V8 Engine

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BENTLEY

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The History of Another Dimension

50 Years of Bentley's V8 Engine

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Bentley and Rolls-Royce Timeline



Founded by **W.O. Bentley**
 Later owned by **Woolf Barnato**
 Factory in **Cricklewood**



Owned by **Rolls Royce**
 Move to **Derby**



Move to aero engine factory in **Crewe**



Owned by **Vickers**



Owned by **VW Group**



BENTLEY

ROLLS ROYCE



Founded by **Charles Rolls & Henry Royce**
 Factory in **Derby**



Move to aero engine factory in **Crewe**



Owned by **Vickers**



Owned by **BMW**
 Move to **Goodwood**

1959

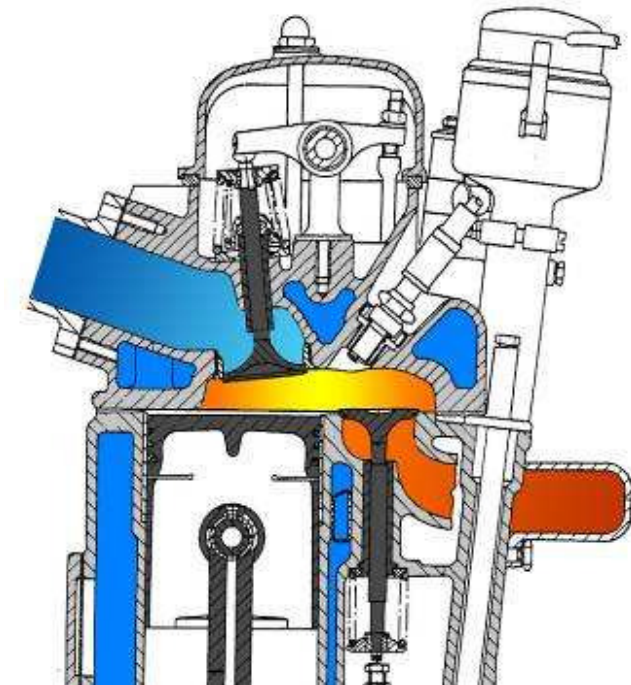
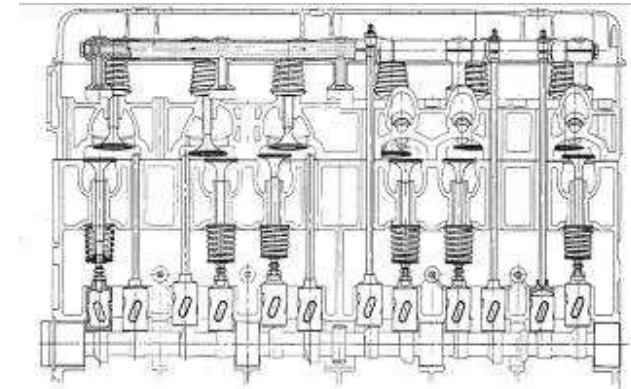
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2009

Background Information



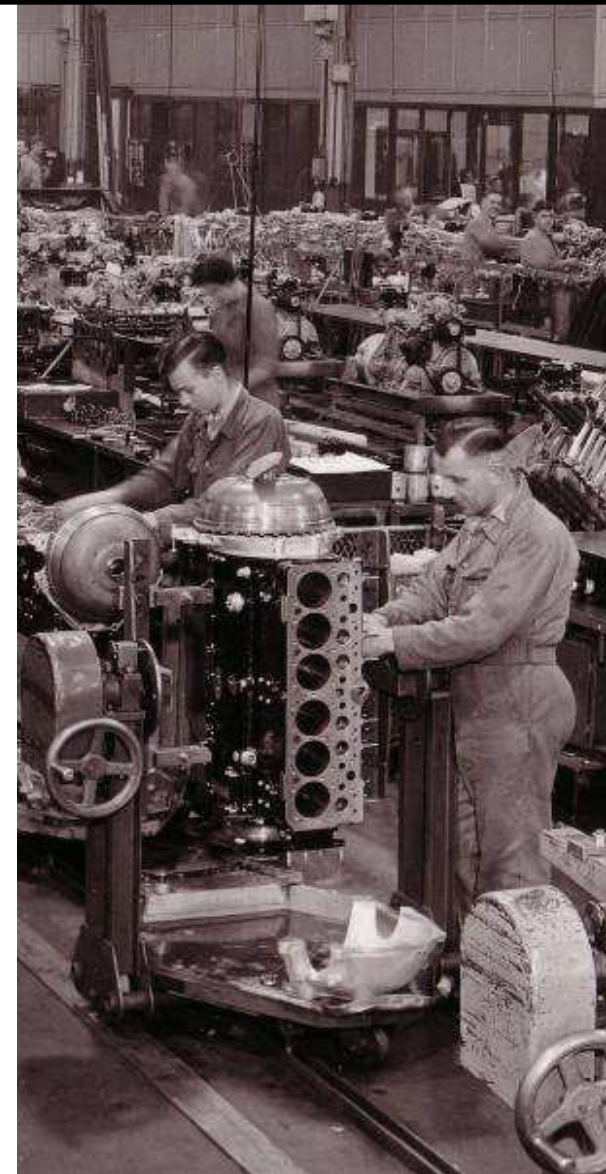
- The story of the V8 begins in the early 1950s.
- In the late 1940s, increasing levels of equipment and consumer desire for more power meant that Bentley and Rolls Royce needed more torque than could be delivered by the existing 4.56 litre straight-six.
- Output of the existing OHV straight-six was limited by the valve dimensions.
- The “F” head design of large overhead inlet valves and side exhaust valves was used in the “B” family of engines, first produced in 1946.
- This engine was limited by compression ratio and breathing through the exhaust ports...the stage was set for an entirely new engine.



“Running Out of Steam”



- The chief engineer at the time was Harry Grylls.
- He called lead engine designer Jack Phillips to his office one morning early in 1954:
- “Our car engine is running out of steam. Go away and think around a 50% increase in power and torque.”
- The straight-six had been in production for almost 20 years – a change was needed.
- More power meant more swept volume.
- A V6 “would be too unrefined”, a straight-eight was too long, and a flat-eight would interfere with steering lock.
- The only solution was a V8...



1959

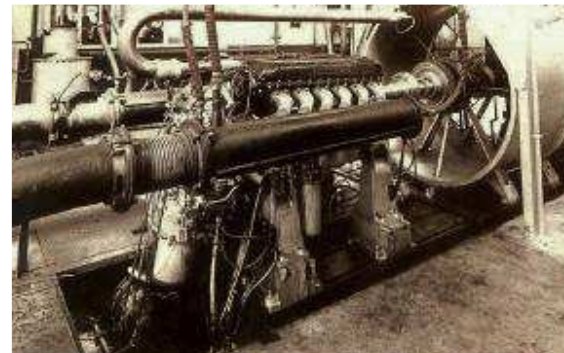
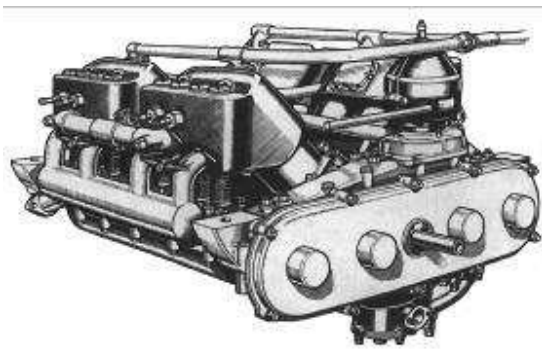
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The Case for a V8



- Harry Gyrlls gave Jack Phillips the following mandate:
 - 50% more power and torque than the straight-six.
 - No increase in weight and as little increase in cost as possible
 - Noise, smoothness and reliability at least as good as the straight-six.
- Jack Phillips established his core design team – Harry Bamford, Fritz Feller, Les Robinson and Reg Spencer.
- The company had great experience with V engines – from the first V8 of Sir Henry Royce in 1905 (for the “Legalimit”) to the famous V12 Merlin.



1959

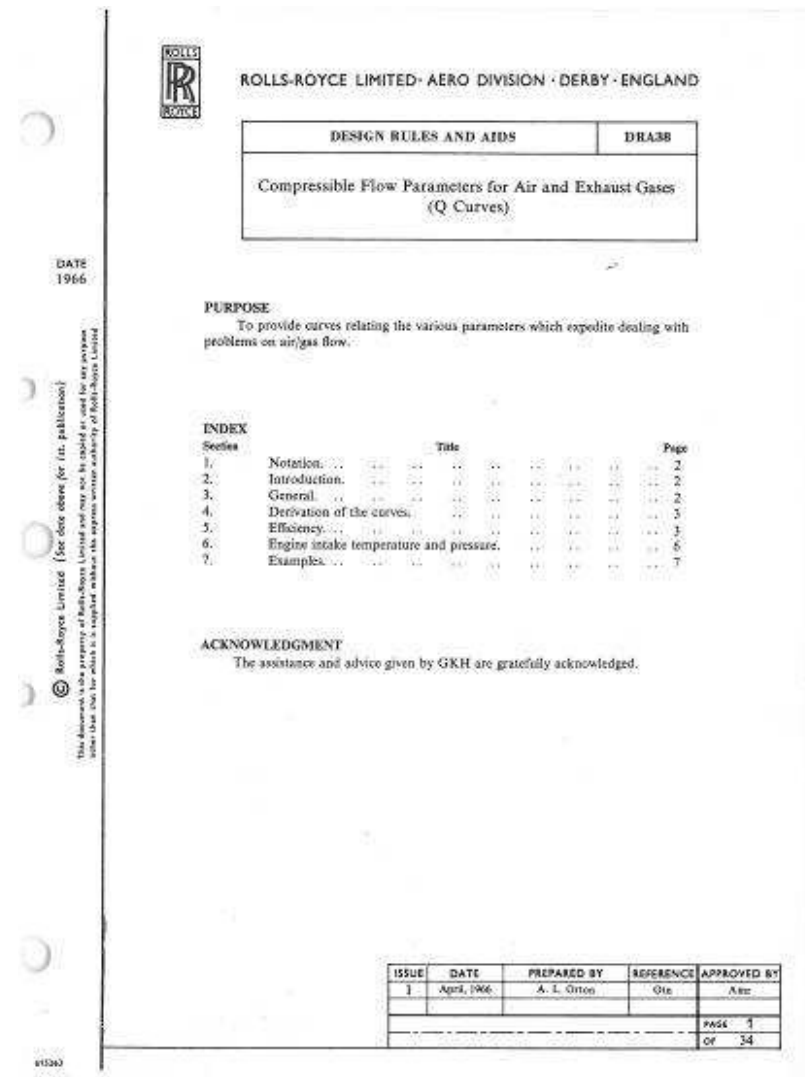
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Aeronautical Standards



- Their design followed in full measure the company's Aero Design Standards – the same used for the Merlin and Griffon V12 engines. Key principles were:
 - Use of high-silicon aluminium for the crankcase, to resist corrosion
 - Deep skirted crankcase with strong support for main bearings
 - Crankshaft lubrication fed from both ends
 - Waisted studs for the retention of cylinder heads and bearing caps
 - Controlled big-end bolt stretch

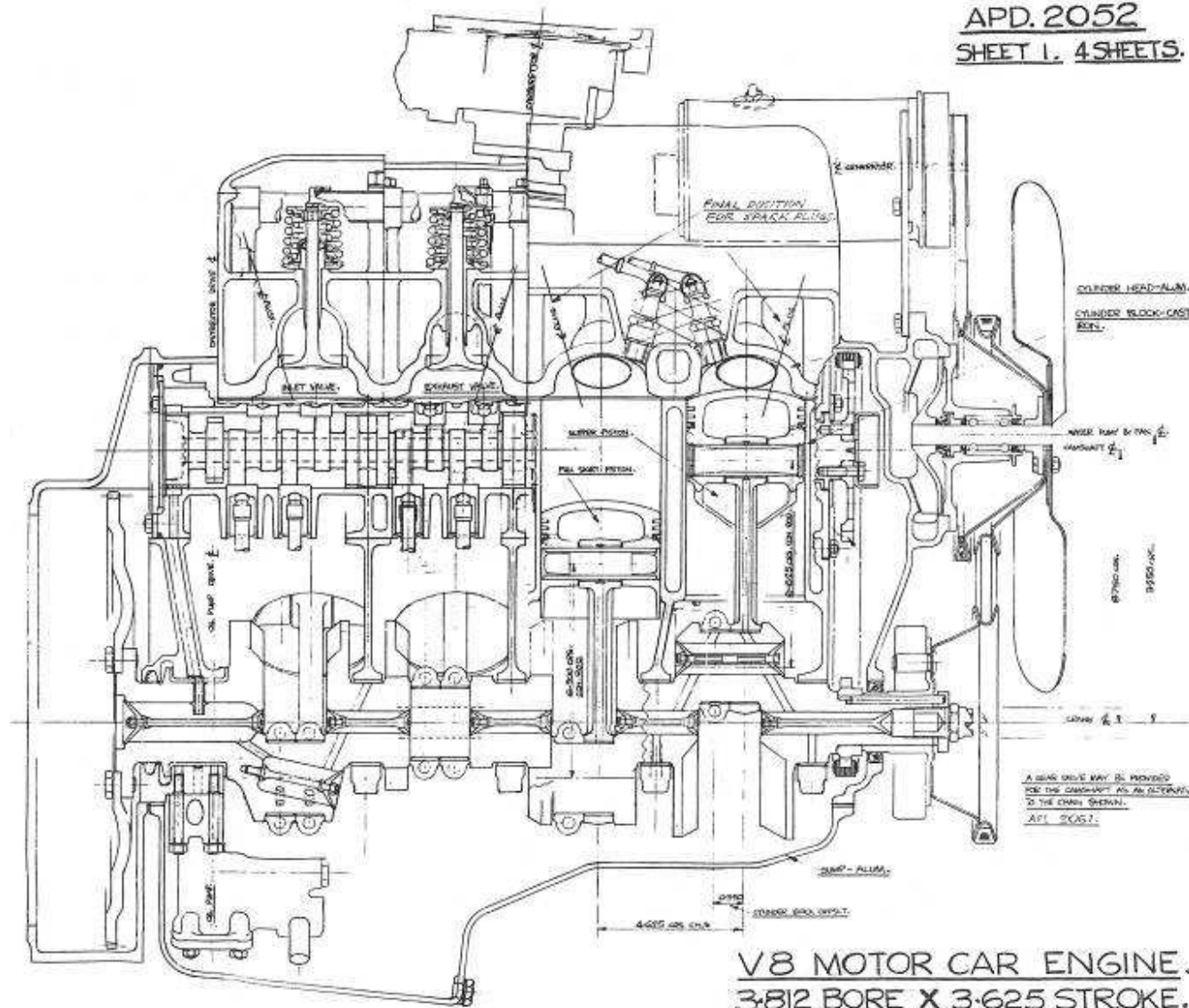


- Along with the Aero standards, there were some common V8 design principles that the team were to follow:
 - A 90°V-angle with a single camshaft inside the V
 - Rocker arms actuated via pushrods
 - Overhead or side valves
 - Intake ports on the inside of the V, exhaust ports on the outside
- Earlier, in October 1950, members of the Advanced Projects Division had done initial designs on a 5.4 litre V8 – coded APD2052. Many design features from the Merlin and Griffon engines were incorporated.
- This design mirrored the 1949 Cadillac V8 in principal dimensions...but was abandoned with improvements to the straight-six.

APD2052 – Original Drawing



APD. 2052
SHEET 1. 4 SHEETS.



1959

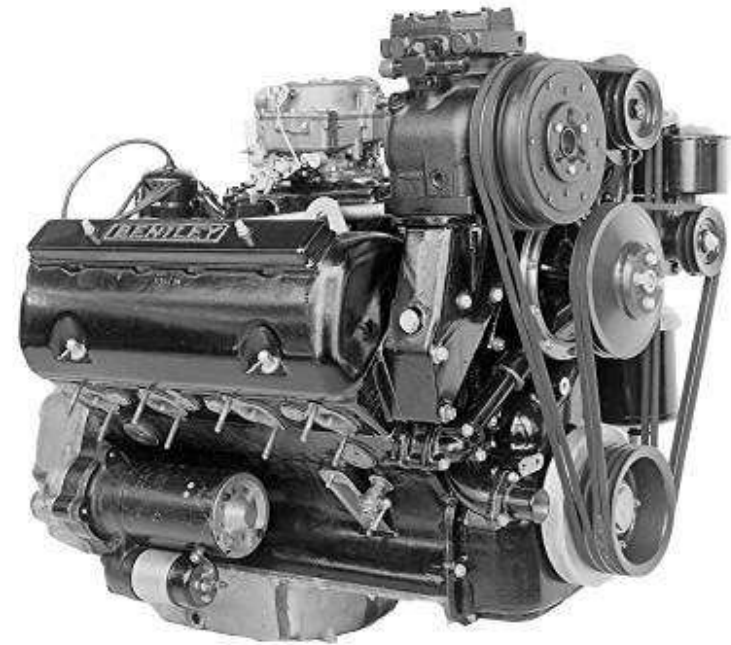
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The Wide Head Engine – Initial Design

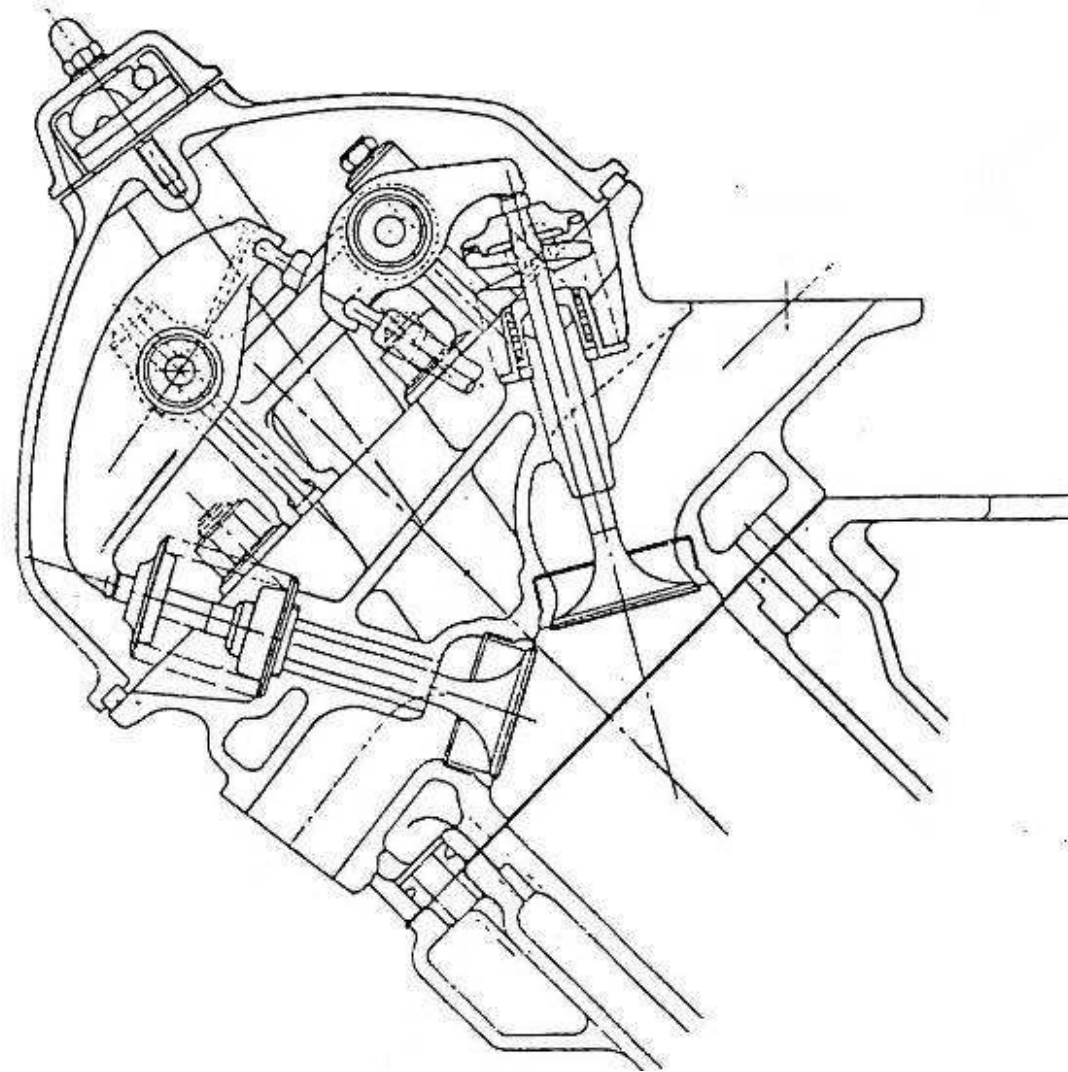


- The first iteration of the new V8 engine had a capacity of 5.3 litres, and ran a mere 18 months after the start of the design process.
- A prototype was fitted to an S1 in May 1955.
- The engine could not be lowered into production cars with the gearbox attached – a problem for manufacturing and service.
- The wide-head engine was too wide and too heavy, tappets were noisy, idle quality needed improving and more power was required – but the team knew that the V8 had potential.



The original 5.3 litre wide-head engine

The Wide Head Engine – Head cross section



1959

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From Wide Head to Narrow Head



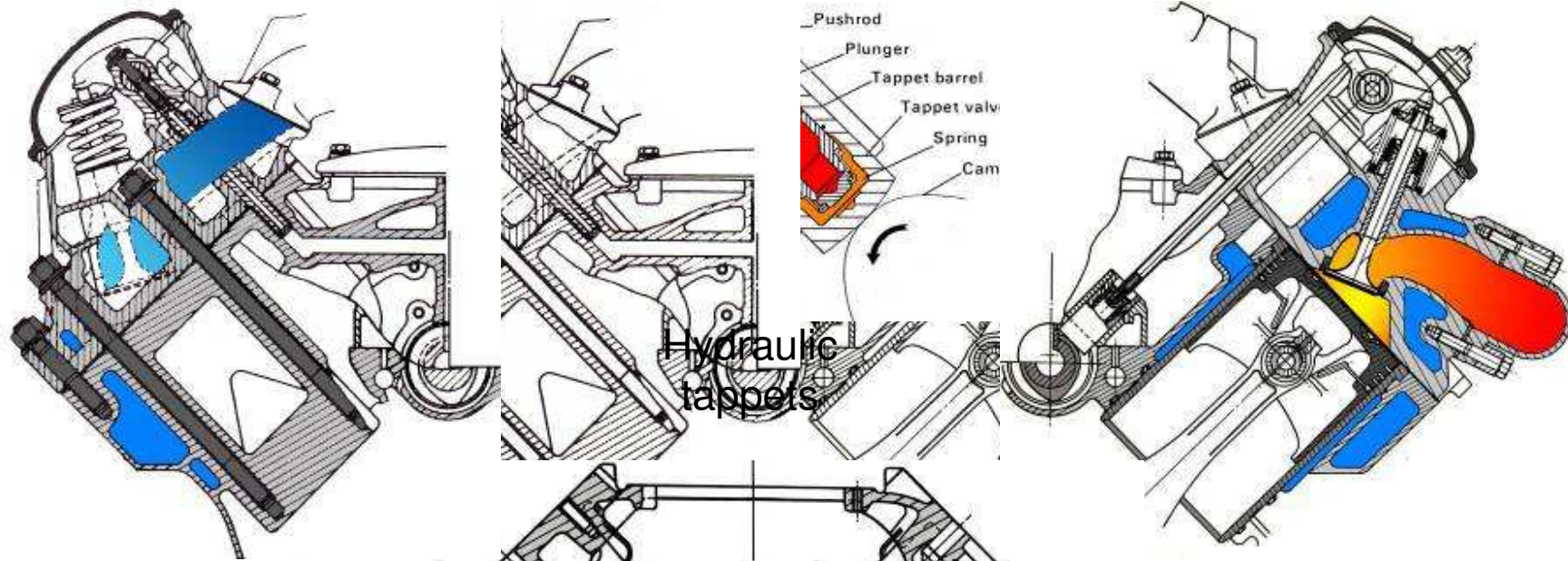
- Harry Gyrlls instructed that engine width must be reduced and the other problems tackled – resulting in the design of the narrow head engine.

Rolls Royce / Bentley V8 History	
Year	Engine
1905	Sir Henry Royce's "Legalimit". Only three built.
1950	APD2052 – abandoned before prototype
1955	New design - "L" Engine, wide head
1959	Revised design of "L" Engine, narrow head

- A redesigned cylinder head would solve the problems.
- The new head reduced engine width by seven inches, was 30lbs lighter, increased combustion squish area by a third and halved the amount of idle ignition advance required.
- A change in capacity to 6.23 litres provided the required extra power.

- Cross-plane crankshaft for better balance and refinement.
- Top-seated wet liners to keep hot liner distortion and therefore oil consumption to a minimum.
- Deep crankcase skirt and heavy ribbing - stiff assembly and smooth running.
- Wedge combustion chamber with central spark plug.
- Short exhaust ports meant heat-to-coolant loss down from 76% of power in straight-six to 54% in V8.
- Bearing surfaces large enough “to allow a 15-20% increase in power and torque over the lifetime of the engine” ...
- Excellent power-to-weight ratio of 2.7lb/hp with all auxiliaries, exhaust manifold and bell housing.

The 6.23 litre V8 – cross sectional details



90deg V, single central camshaft

104.4mm bore x
91.4mm stroke:
6.23 litre capacity

The Rolls Royce /
Bentley "L Engine"

Aluminium block,
grey iron wet liners

1959

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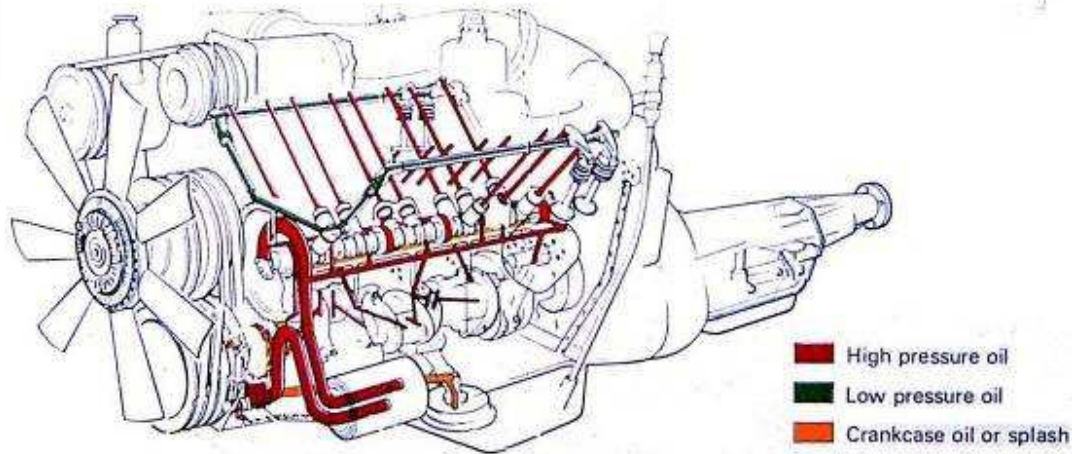
The American Rumour



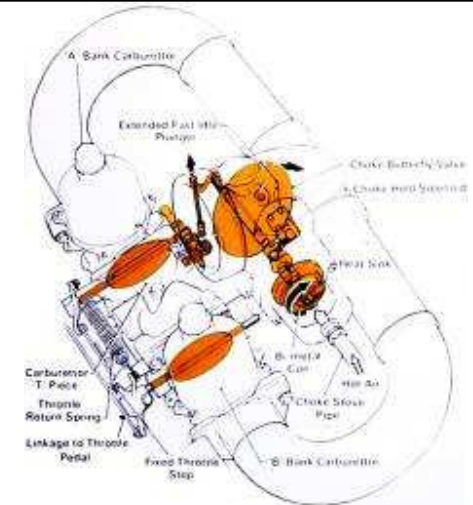
- It was suggested that the V8 was copied or even licensed from an American design. This is pure fiction!

	Rolls-Royce / Bentley	Cadillac	Chrysler	Chevrolet "small block"
Material	Aluminium Alloy	Cast iron	Cast iron	Thin wall cast iron
Crankcase depth	Deep skirt Y-Block	V-Block	V-Block	V-Block
Bore spacing	4.75"	4.4"	4.56"	4.4"
Oil Pump drive	Crankshaft front	Camshaft rear	Camshaft rear	Camshaft rear
Crank lubrication	Both ends	Single-end feed	Single-end feed	Single-end feed
Rocker Pivots	Shaft	Shaft	Shaft	Ball Pivot
Wet Liners	Yes	No	No	No
Waisted studs	Yes	No	No	No

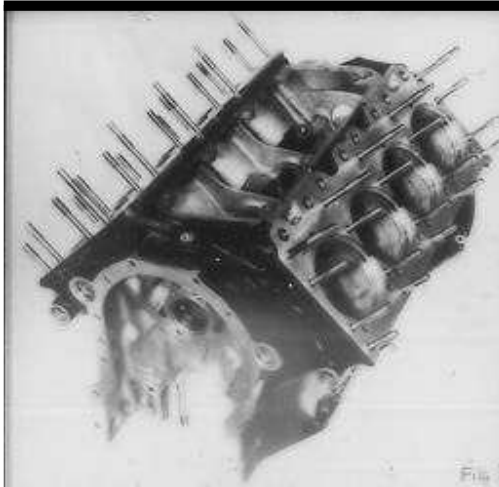
The 6.23 litre V8 – slide photos



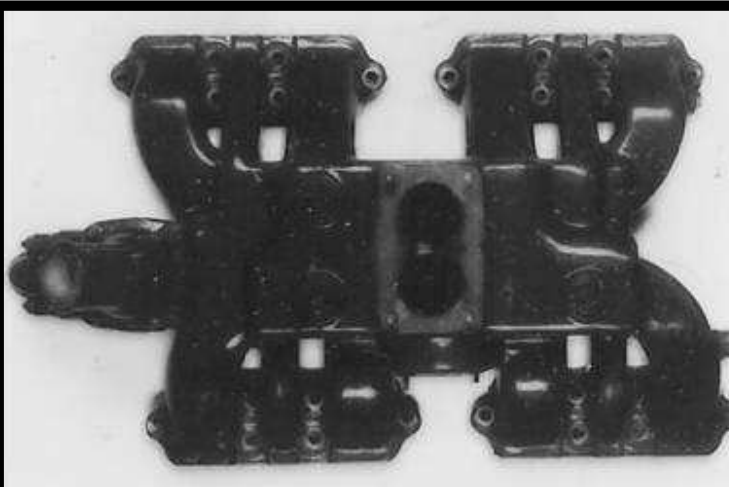
Lubrication system



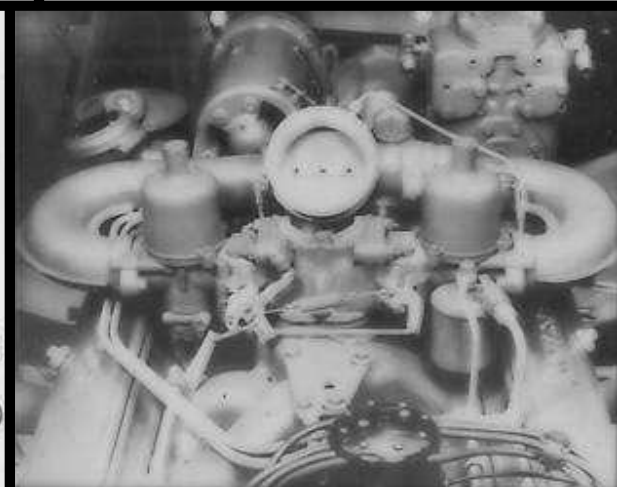
Throttle assembly



The original block



The complex intake manifold



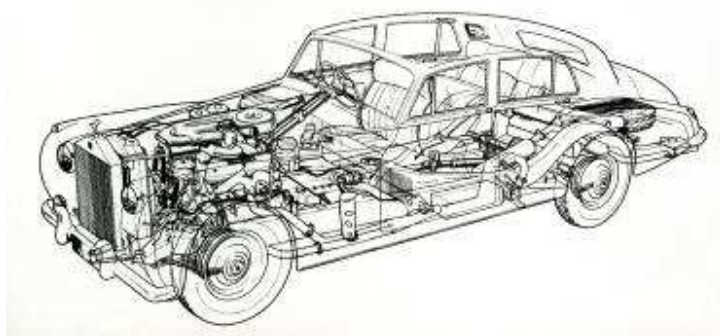
Throttle and "cow horns"

1959

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Launch of the V8 - Bentley S2



1959

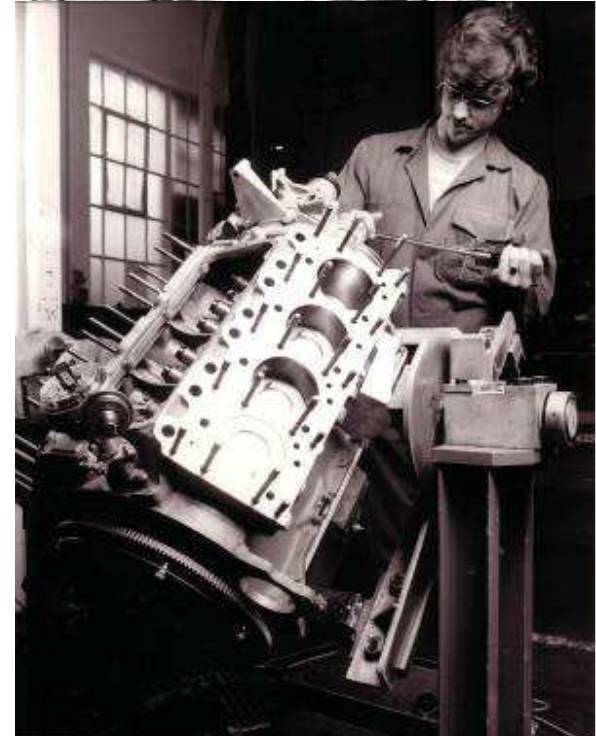
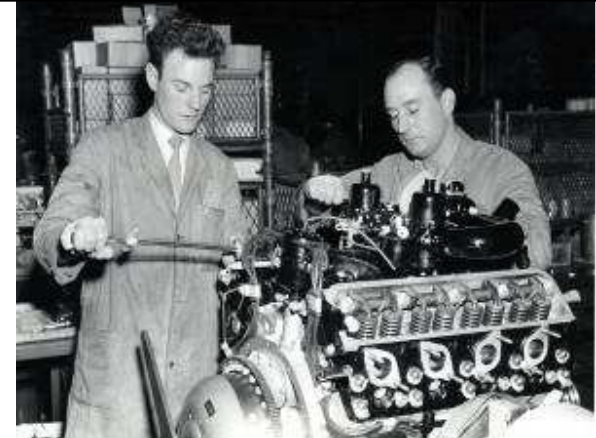
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Manufacturing The Engine – in Crewe



- A dedicated production line was set up, manned by skilled technicians who as today built each engine entirely by hand.
- Every engine was run-in and performance tested, on the same testbeds as were used for the Merlin engines during the war.
- One in every hundred engines was subjected to a 100 hour test, after which it was stripped and inspected.
- Inspectors measured parts for wear, but also used their experience and skill from aero engine testing to look for early signs of distress that indicated engineering action was needed.

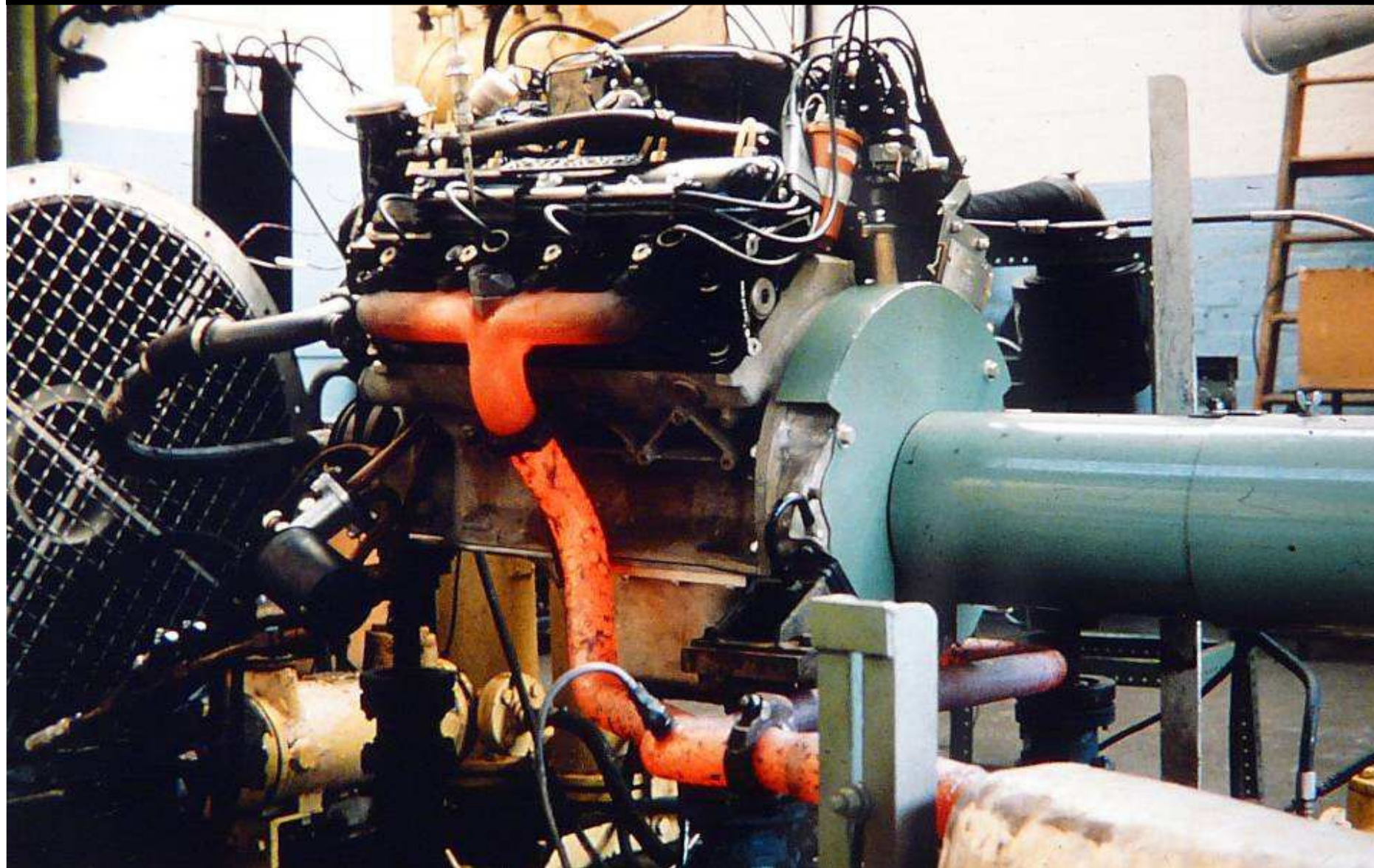


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Engine Power Test



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Changes for the S3



- Spark plug location was causing problems for service teams – front wheels had to be removed for access.
- Head modified slightly to angle the plugs to allow access from above.

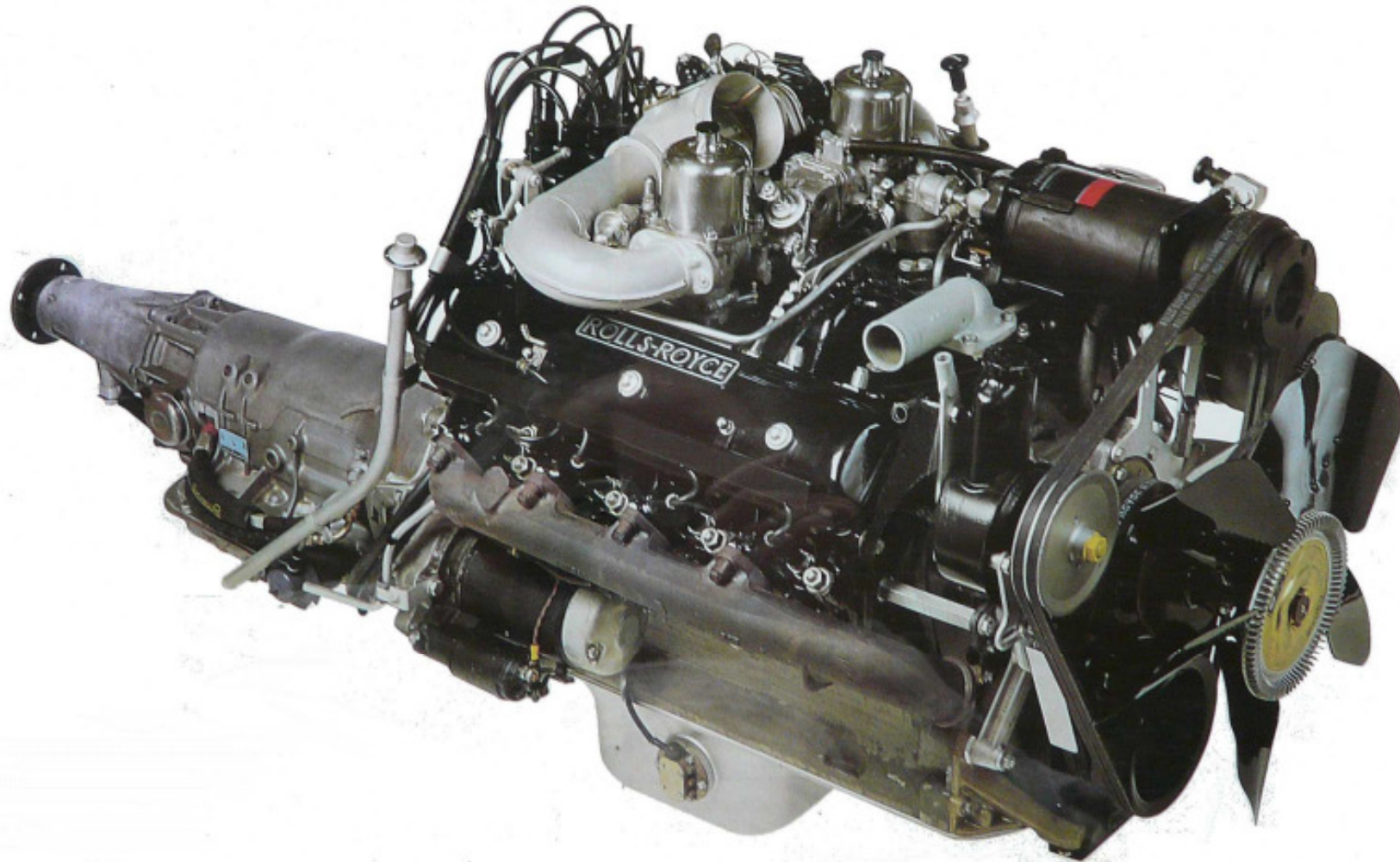


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The S3 Engine

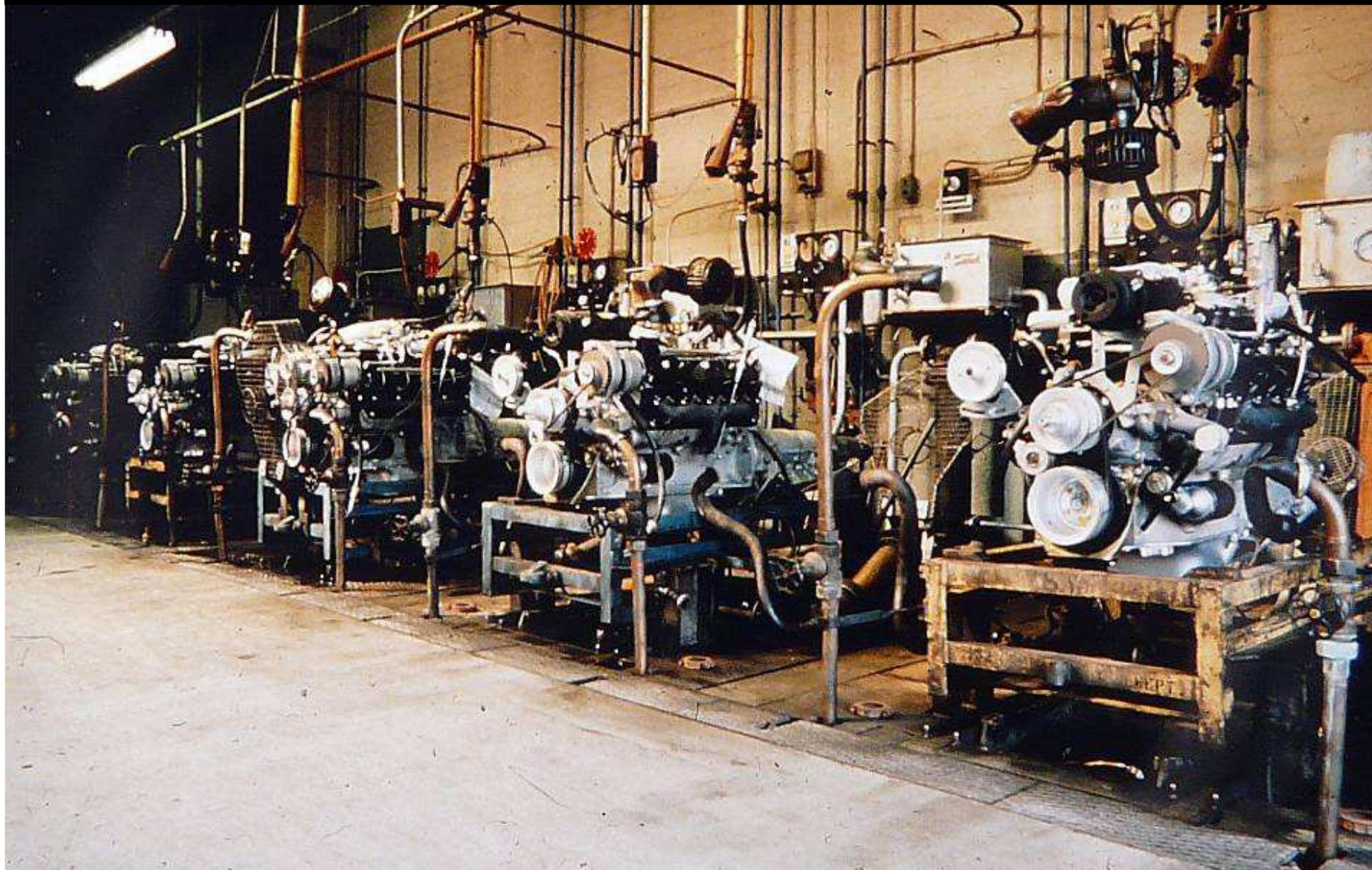


1959

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S3 Run In – Gas Beds



1959

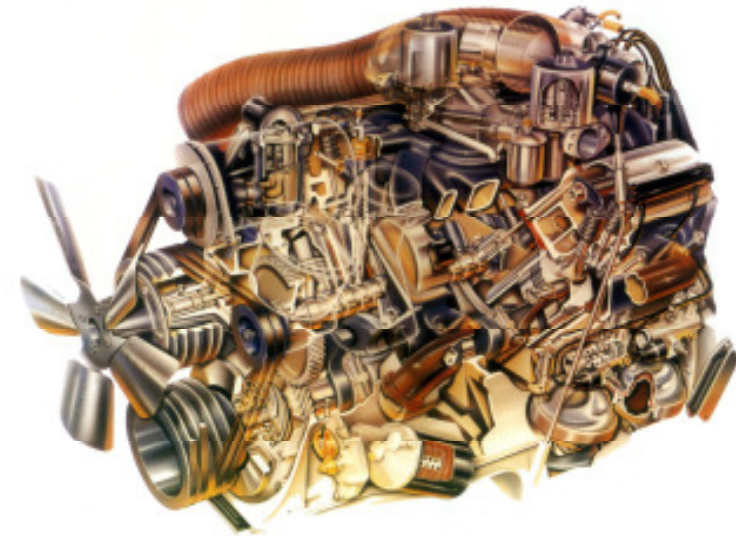
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Silver Shadow / T Series



- Engineering for the next generation of cars, the Rolls Royce Silver Shadow and Bentley T1, was ratified in 1962.
- Large company investment – careful scrutiny of all manufacturing costs.
- Expensive machined combustion chambers were now accurately die cast, and spark plugs repositioned. More squish area was designed-in to induce turbulence, and larger intake valves were accommodated.
- Induction system simplified and improved. Choke and throttle moved rearward.
- Exhaust manifolds stayed as simple cast pipes due to width restrictions.



1959

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Oil Dipstick



- The width restriction also meant it was now impossible to install the traditional flat-blade dipstick, which had a handy secondary use...as demonstrated by Jack Bunting, in this drawing by Les Maddock.

Capacity Increase



- In 1970 the capacity was increased to 6.75 litres, through stroking to 3.9". This capacity remains to this day.
- The front of the crankcase was extended to accommodate a new crankshaft, that featured integral balance weights.
- This also allowed design changes to makes the casting process easier.



1959

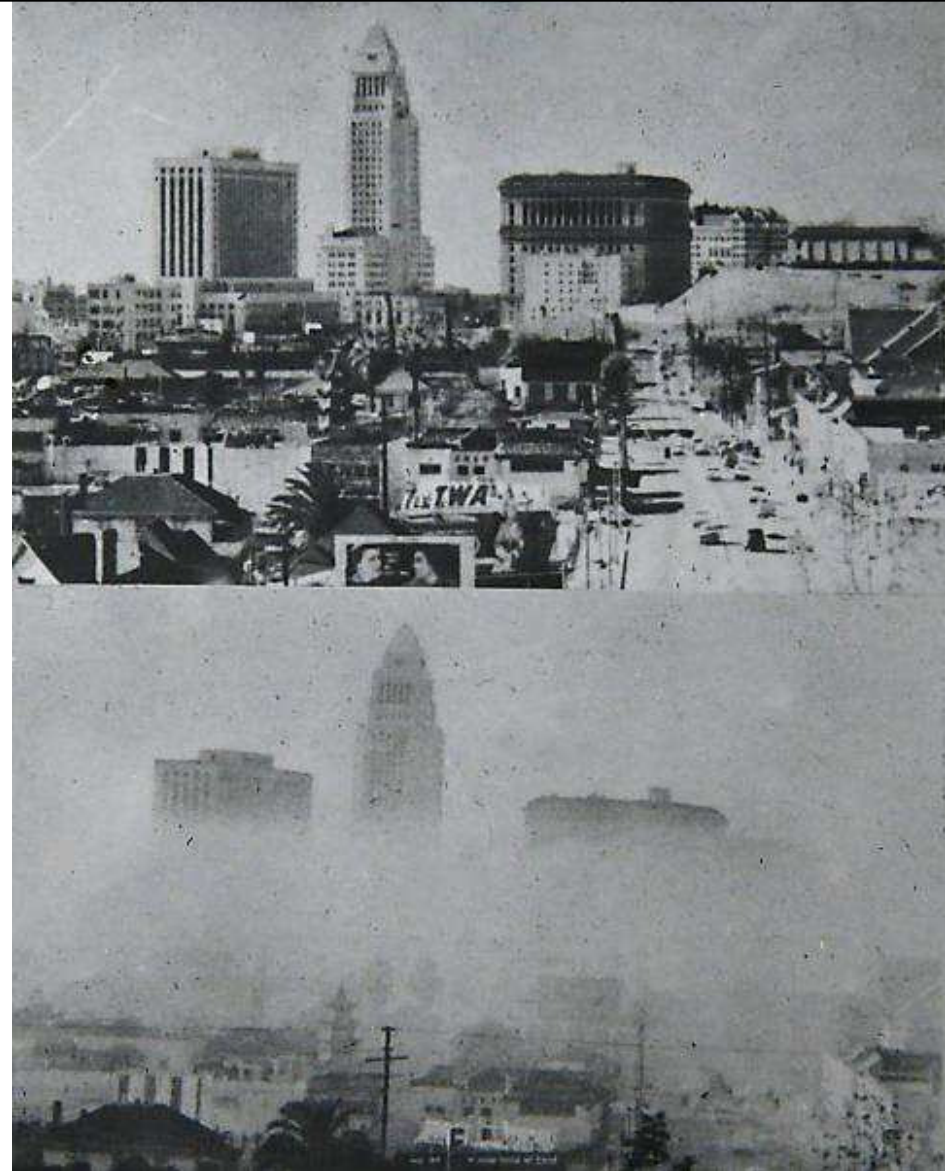
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Emissions Legislation



- In the late 1960s, US emissions legislation started to tighten in response to the increasingly obvious problem of urban pollution.
- These photos show Los Angeles with and without the shroud of smog caused by increasing numbers of cars in the city.
- Like every other car manufacturer who sold cars in the US market, Rolls Royce and Bentley had to start engineering their products to reduce polluting emissions.



1959

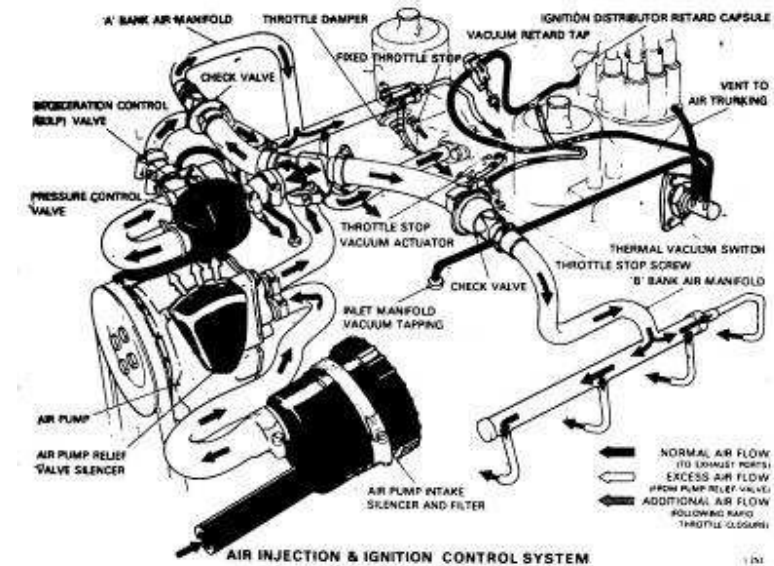
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Emissions Improvements and Testing



- An existing building at the factory in Crewe was converted to an emissions testing facility, with a nearby railway works producing the flywheels needed.
- Enclosed crankcase breather system introduced in mid-1960s.
- Secondary air injection was introduced for the US market in 1968.
- Combined with a mixture-weakening device operating at light throttle, these changes ensured the V8 met the latest emissions standards.



1959

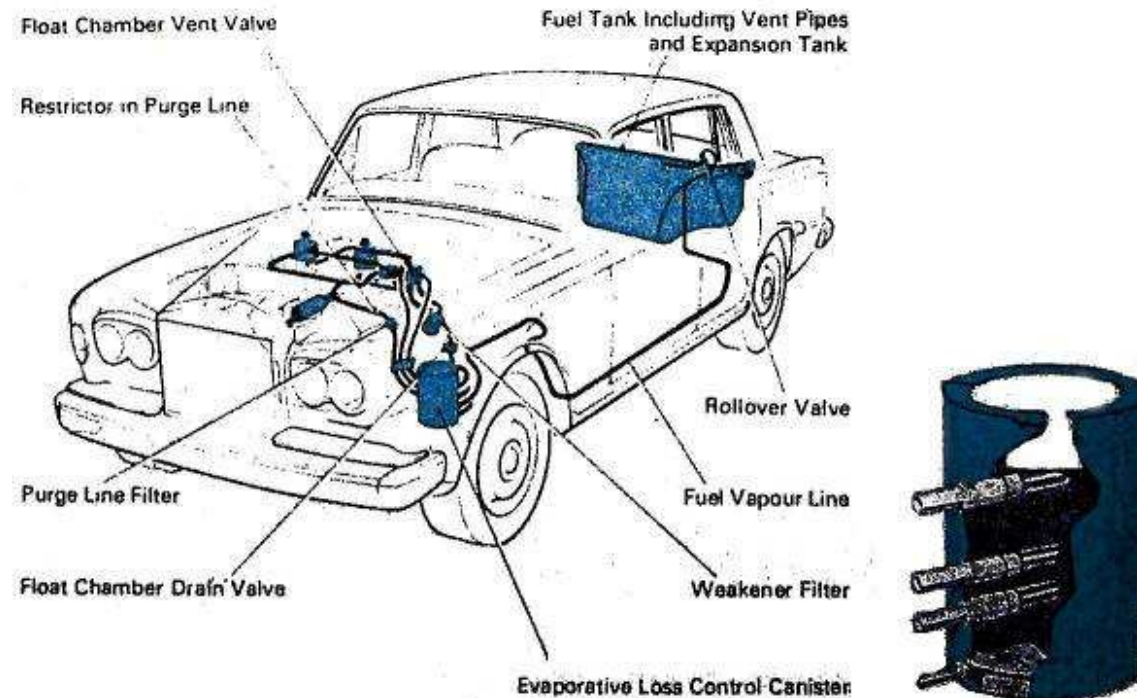
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Emissions Improvements and Testing



- The next stage was in 1973, with the introduction of exhaust gas recirculation to reduce NOx.
- SU HIF7 1.75" carburettors replaced the 2" HD8 units – this led to a small power loss, but more accurate fuel metering.
- Oxidation catalysts were introduced for US-bound cars in 1975.
- Fuel system evaporative emissions controls led to the design of an activated-charcoal based system.



Low Emission Fuel Supply System



- Tightening hydrocarbon emissions laws in the mid-1970s led to the design of a Rolls Royce patented Low Emission Fuel Supply System.
- Most hydrocarbon emissions come from the cold cycle, when oxidation catalysts cannot burn off the unburned hydrocarbons.
- This system distilled standard fuel on-board the car to remove the heavier fuel fractions
- The resulting higher-volatility fuel meant that less fuel needed when the engine was cold started, so reducing unburned hydrocarbons.
- However, the design was shelved with the step change in improvement in fuel metering brought about by the onset of fuel injection.

L380 and L410E Engines



- In search for better fuel economy, a smaller V8 was considered – codenamed the L380.
- Designed by Porsche for Rolls Royce in the late 1970s, the original bore and stroke sizes were adopted.
- Unusually, the combustion chamber was built in to the pistons, with the valves flush with the mating face of the cylinder head.
- Emissions control was difficult, and the reduction in power from the smaller capacity was considered unacceptable. The project was scrapped.
- Later, the design team went in the other direction – designing and building a V8 of 7.25 litre capacity – the L410E.
- While performance, fuel economy and lower emissions resulted, the larger engine was judged to be “politically wrong”, and was dropped.

Other Rolls Royce Engines



- The Engine Design team didn't confine themselves to the "L" engine. All the vehicles below featured a Rolls Royce / Bentley engine...



**Thorneycroft Nubian
6.5 straight-8**

Fuel Injection



- Bosch K Jetronic fuel injection was introduced in 1980.
- With closed-loop fuel control and a three-way catalyst, sudden and dramatic improvements were made to hydrocarbon, CO & NOx emissions.
- The Bentley Mulsanne and Rolls Royce Silver Spirit were the first of our cars to feature the system.



1959

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L410D – The Introduction of the Turbo

- A substantial increase in power and torque was requested for a faster version of the Mulsanne.
- A prototype was created using a Camargue engine, placing the Solex downdraught carburettor in a sealed “chest” that was pressurised by a single turbo.
- A proper design followed and was introduced as the Mulsanne Turbo at the 1982 Geneva motor show.
- **300bhp** and **600Nm** were now available.



L410IT – Turbo Developments



- After the introduction in the US market, fuel injection now became standard across all variants.
- Old two-tier intake manifold replaced with less restrictive, purpose-designed single-tier crossover manifold, fed by a low-loss air cleaner.
- Design of a stiffened head and crankcase
- Thicker cylinder liners
- Lower back pressure exhaust
- For the Turbo R:
 - New engine management
 - Further intake modifications
 - Round ports in cylinder head
 - **320bhp** and **660Nm**

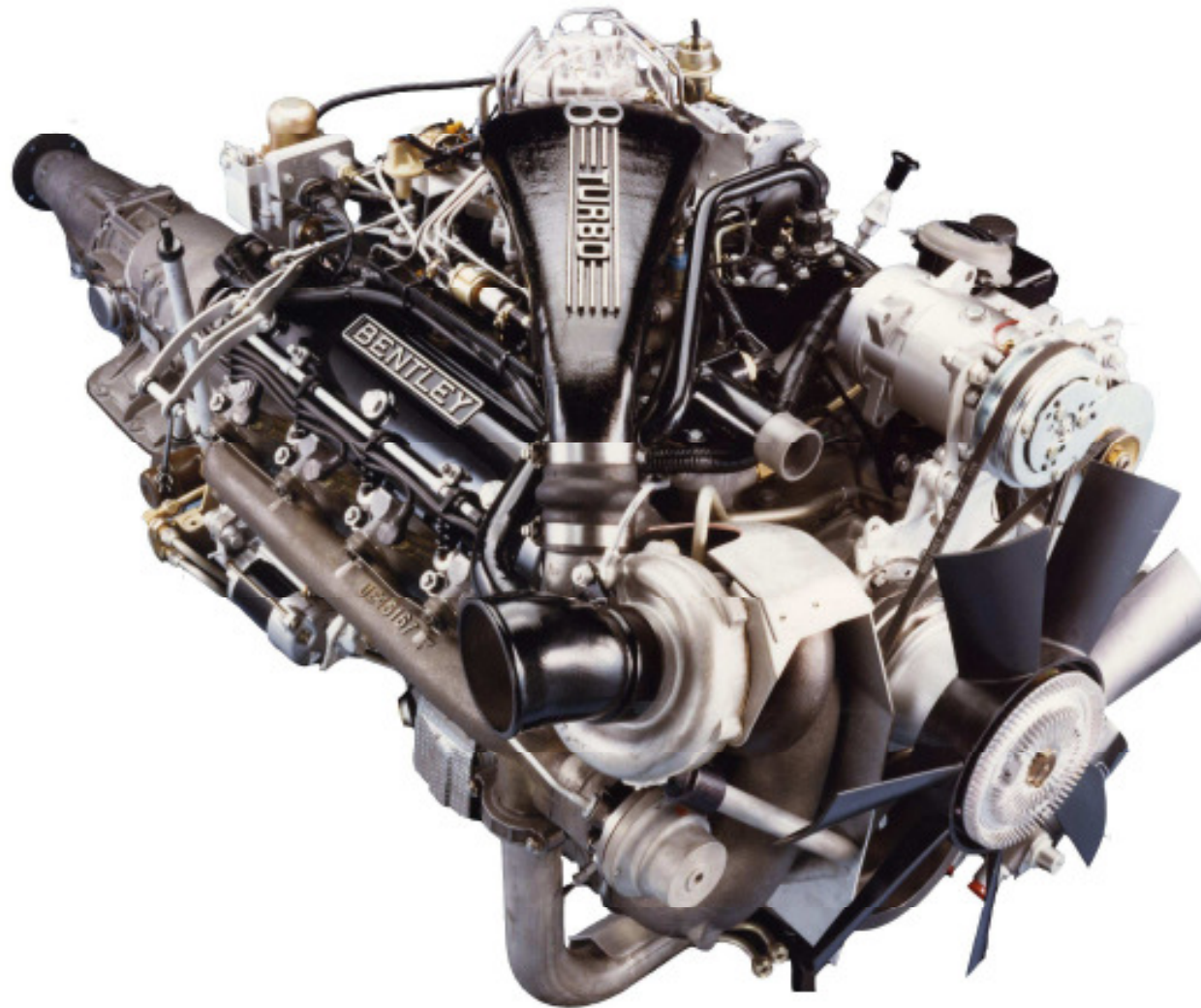


1959

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Mulsanne Turbo engine



1959

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Turbo Power Run



1959

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Further Development in the 1980s

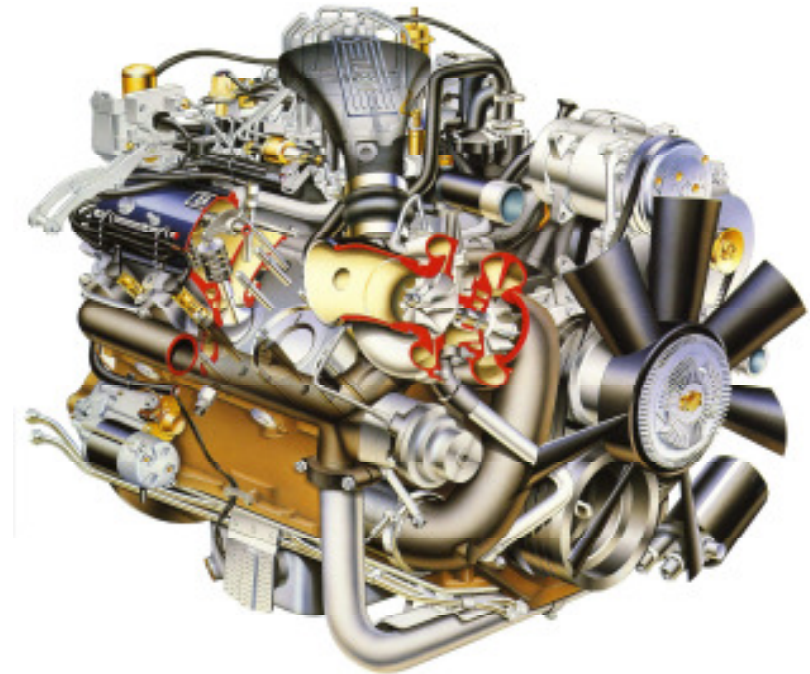


- Through the 1980s, the crankcase and crankshaft were retained having proven durability and reliability.
- The bottom deck of the cylinder head was stiffened during a change from square inlet ports to a more free-flowing, conventional design.
- Revisions to piston rings and liner surface form resulted in an oil consumption reduction to 22,000 miles per gallon.
- The camshaft was revised to eliminate the screw gear drive for the oil pump, and a front mounted lobe pump was installed. Meanwhile, the cam form was revised to a polynomial form.
- Front-end accessory drive was rationalised to a common standard.
- Intercooling was introduced on the turbocharged cars in 1989.

Natural Aspiration and Turbocharging



- Engines were now available in naturally-aspirated or turbocharged form, with 232bhp and 320bhp respectively.
- The Bentley Continental, Eight and Brooklands and the Rolls Royce Silver Spirit were powered by the naturally aspirated version.
- The more sporting Bentley Turbo R received the turbocharged unit.



1959



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90s development



- In 1994, use of Hot Film Air Meters, twin plenum chambers and tuned ram pipes meant a less restricted intake system and a raised output of 355bhp.
- In 1998, a change to a Zytec engine management system, with no air meters and a water-cooled intercooler, gave 420bhp for the Continental R.
- Production numbers for the 6.75 V8 dropped massively in 1998 as the BMW 4.4 litre twin-turbo V8 was introduced. Customers did not like the higher speed and lower torque of this engine however, and the venerable 6.75 litre unit was soon back in full production.
- The engine was reintroduced in October 1998 in Arnage Red Label
- A return was made to Bosch engine management in 1999, allowing the development of 400bhp without using “Super” grade fuels.



Twin Turbos



- Twenty years since the first addition of a turbocharger to the V8, it was time for another step change in performance. Two small turbos rather than one large unit would improve response and performance.
- Coupled with further updates to valvetrain, intake and exhaust and an upgrade to Bosch ME7 engine management, the new turbos resulted in a performance increase to 450bhp.
- Still very few changes to the base engine were necessary, which shows the robust design created to ensure quiet running back in 1956.



1959

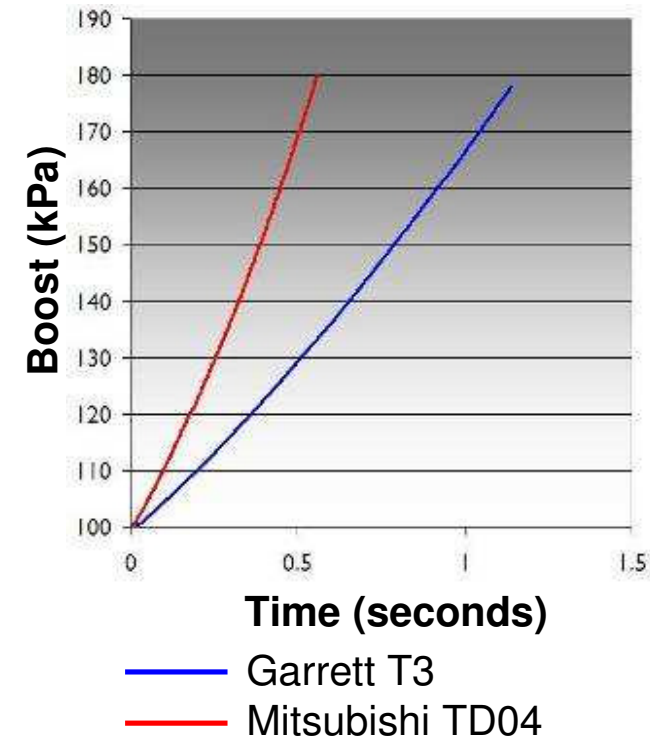
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Developments in 2007



- New emissions legislation (LEV2) and extended On-Board Diagnostics (OBD) rules compelled Bentley to develop the twin-turbo engine further for 2007 Model Year.
- New camshaft with increased valve lift (volumetric efficiency) and reduced overlap (idle stability). Cam now induction hardened rather than chill cast for improved kinematics.
- Increased valvetrain loadings was causing high pushrod wear. The “free-ball solution” solved this by fitting a lubricated ball bearing between the end of the pushrod and the rocker arm.
- New turbos were chosen, with an inertia reduction of 52% - making 90% of peak torque available between 1800 and 3800rpm.



Developments in 2007



- Updated engine management system, new catalyst washcoat specification and improved secondary air injection system.
- New ZF 6HP32 six-speed automatic gearbox.
- Validation of engine calibration and performance from -30 °C to +50 °C, and up to 2500m.
- Resulting performance: 500bhp, 1000Nm
- 9% improvement in volumetric efficiency
- 5.3% improvement in fuel economy
- Full LEV2 emissions compliance.

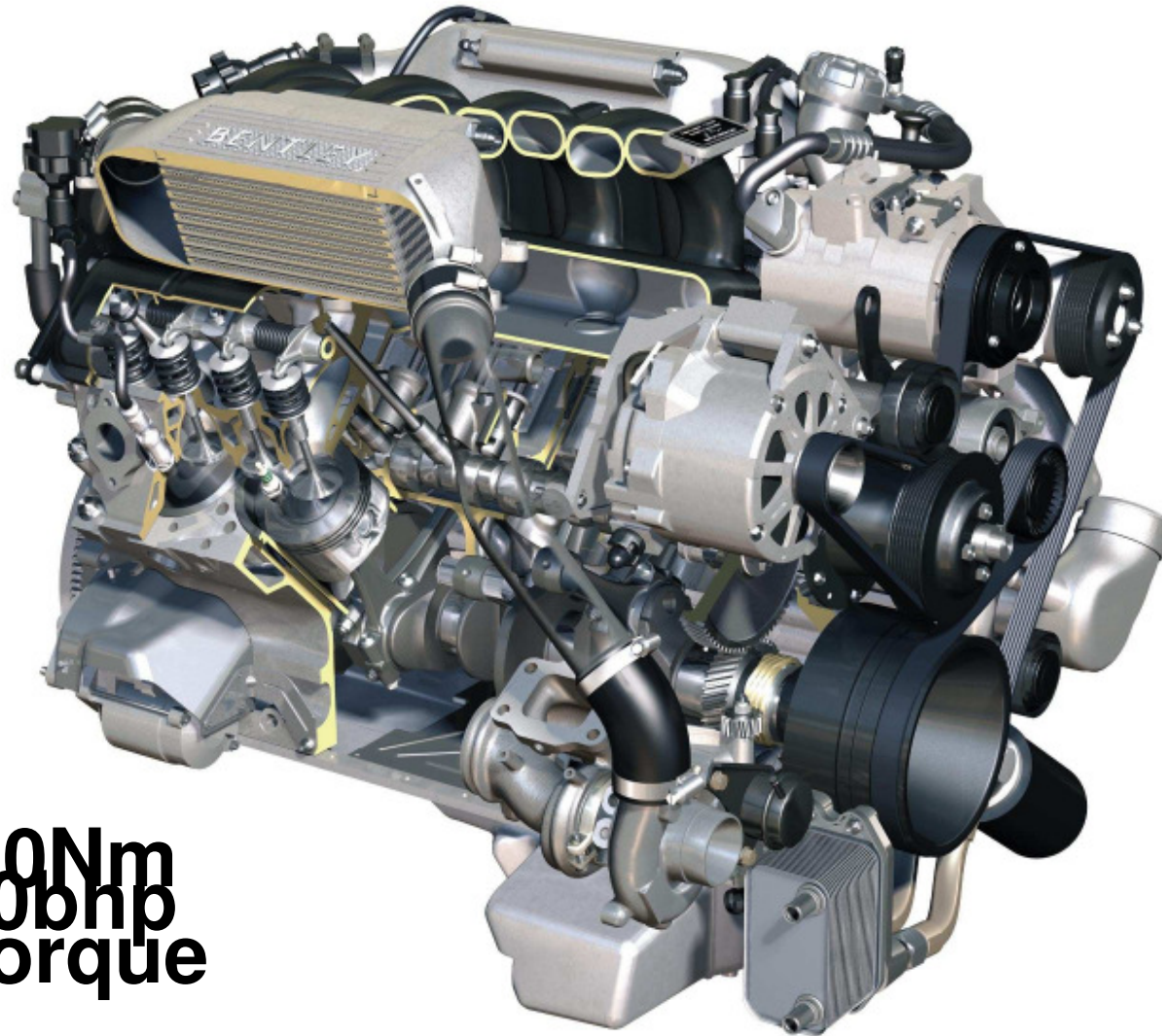


1959

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The current 6.75ltr V8 Twin Turbo



**1050Nm
530bhp
of Torque**

1959

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The Current V8 Family



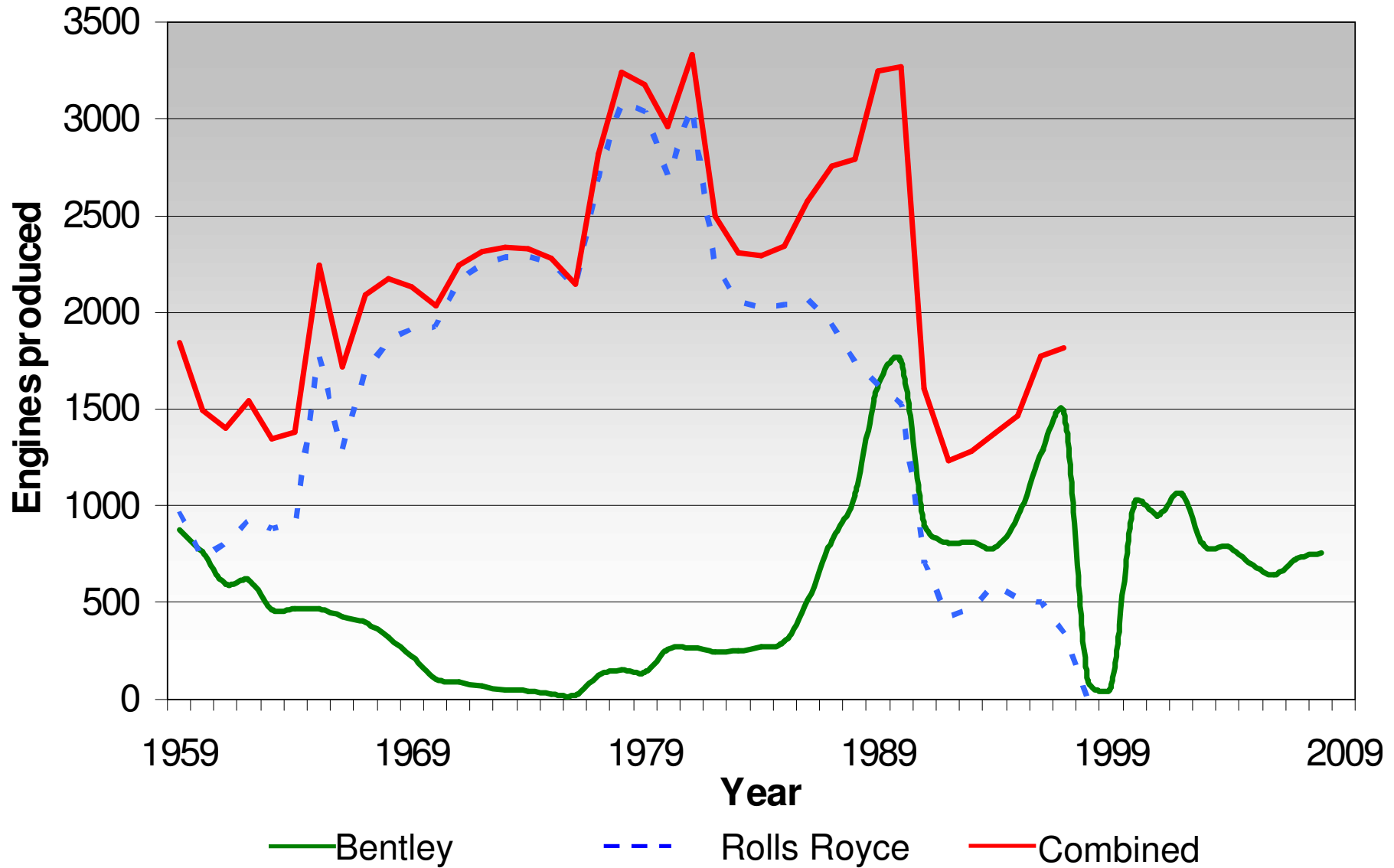
Continental

1959

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50 Years of Engine Production



1959

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And Still Made in Crewe...



- The engine is still made entirely by hand on a dedicated production line in Crewe
- The only machines that assist with production are a rotational balancer and some DC tooling – everything else prepared, fitted and checked by hand.
- Each engine is run-in on a pair of dedicated test beds.
- Production engines are periodically checked for power, while some are run on durability cycles and then stripped for inspection.



1959

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50 Years of the "L" Engine Team



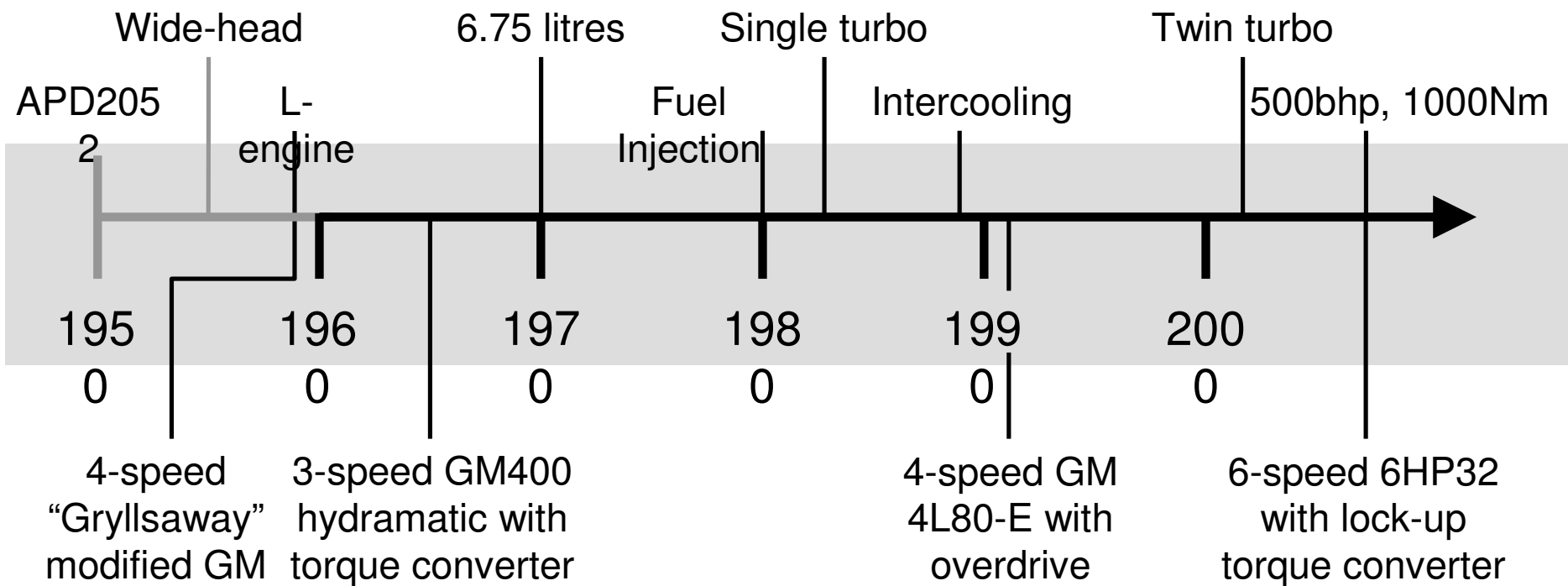
Engineering Director	Head of Powertrain	Head of Engine Design	Designers here tonight
Harry Grylls 1954 - 1970	Dick Garner 1950 - 1955	Jack Phillips 1954 - 1971 (Head of original design team)	Reg Spencer 1940 - 1960 (Core member of original team)
	[Hatched]		
John Hollings 1970-1981	Ron West 1971 - 1981	Harry Bamford 1974 - 1976 (Core member of original team in 1954)	Bill Porter 1940 - 1987 (Joined original team in 1955)
Ian Nelson 1981 - 1982	John Astbury 1983 - 1984 (part of team 1957 to 1991)	Les Maddock 1976 - 1992 (Joined design in 1961)	
Mike Dunn 1982 - 1991	Ken Lea 1983 - 1988		
Dr Ulrich Hackenberg 1999 - 2000	Rob Oldaker 1989 - 1997	[Hatched]	
H.J. Rothenpieler 2000 - 2003	[Hatched]	Norbert Becker 2001 - 2007	
Dr Ulrich Eichhorn 2003 - present	Brian Gush 2000 - present	Michael Fleiss 2007 - present	

1959

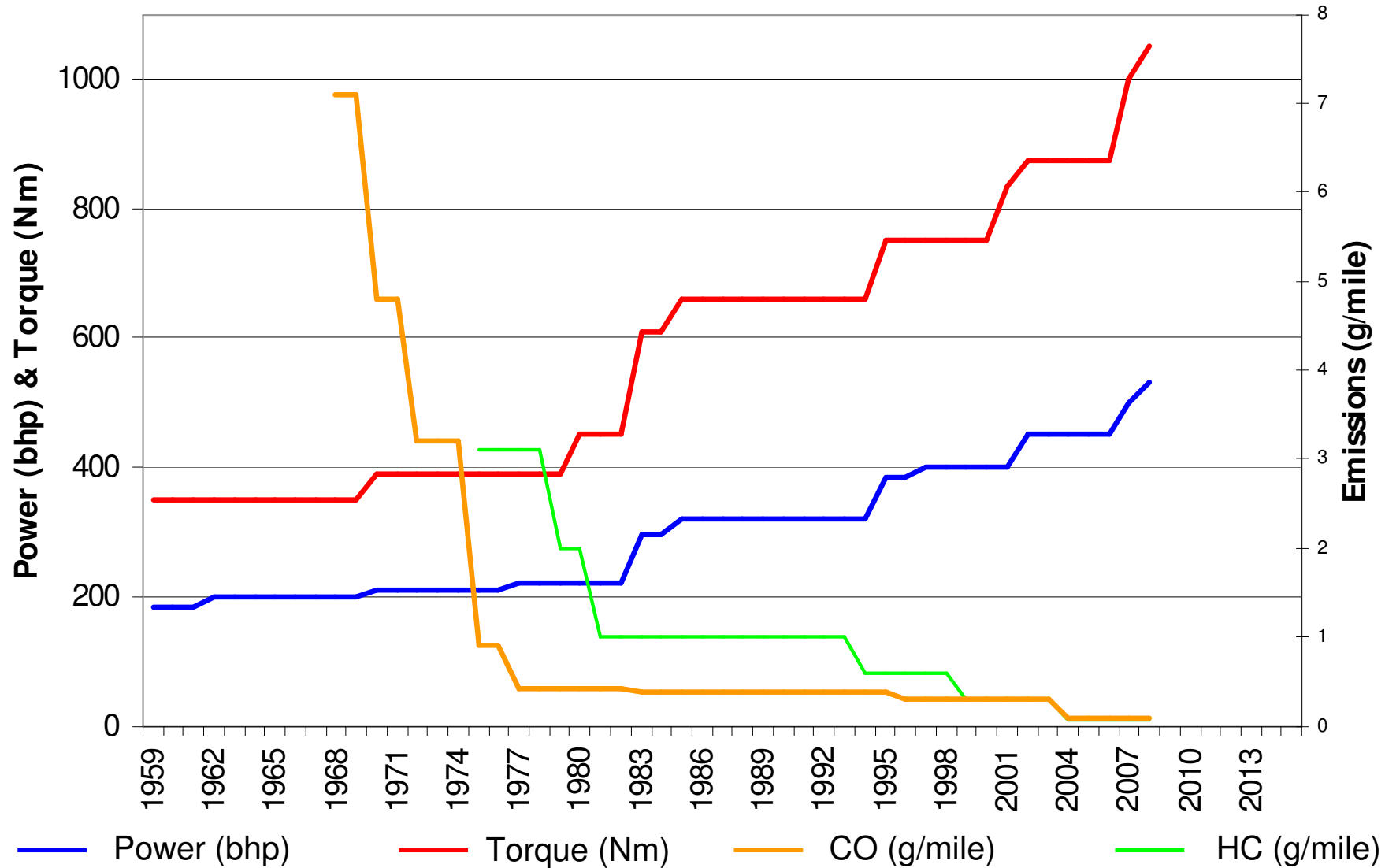
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Engine Timeline



Power and Torque Through the Years

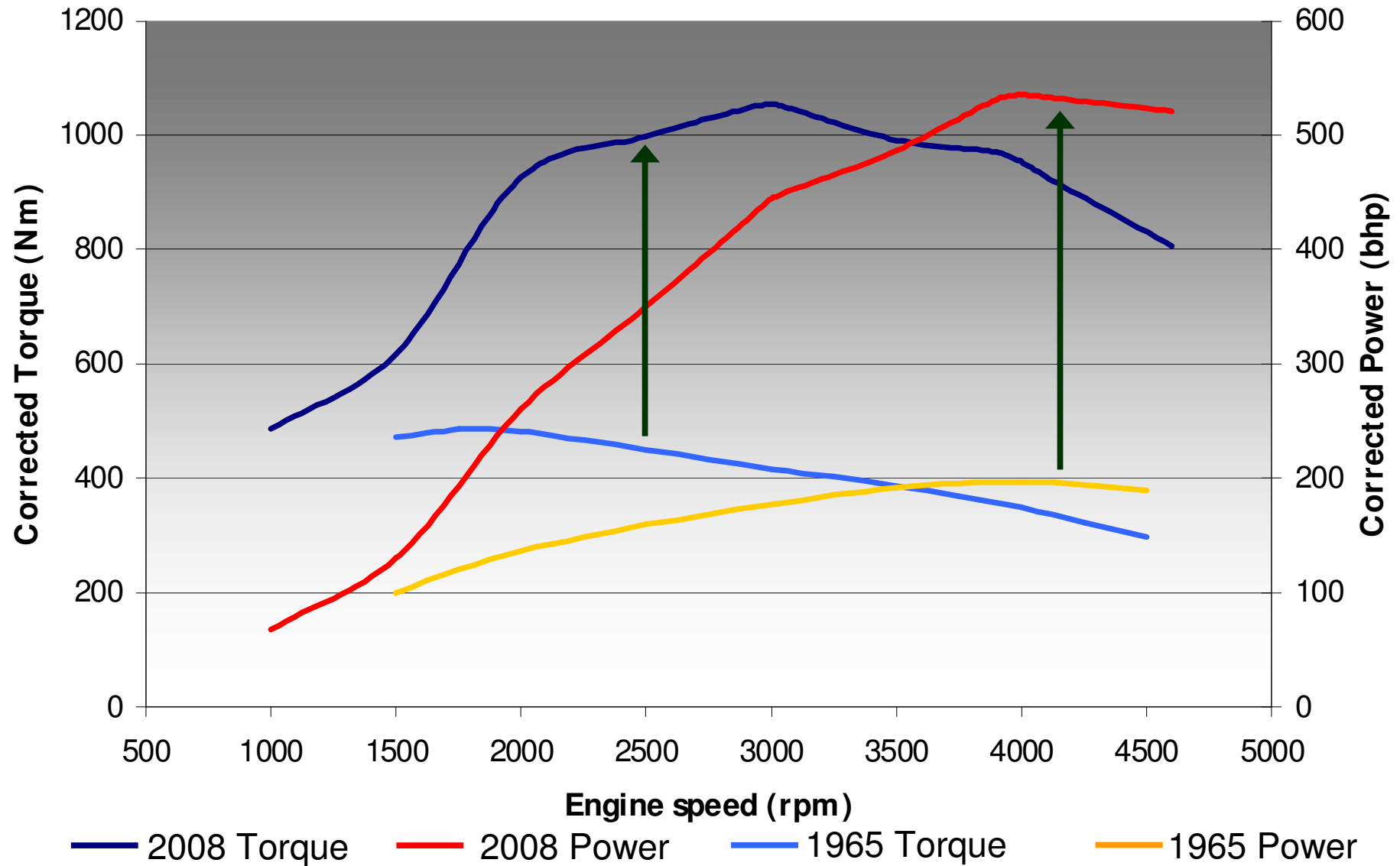


1959

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Power Curve Comparison

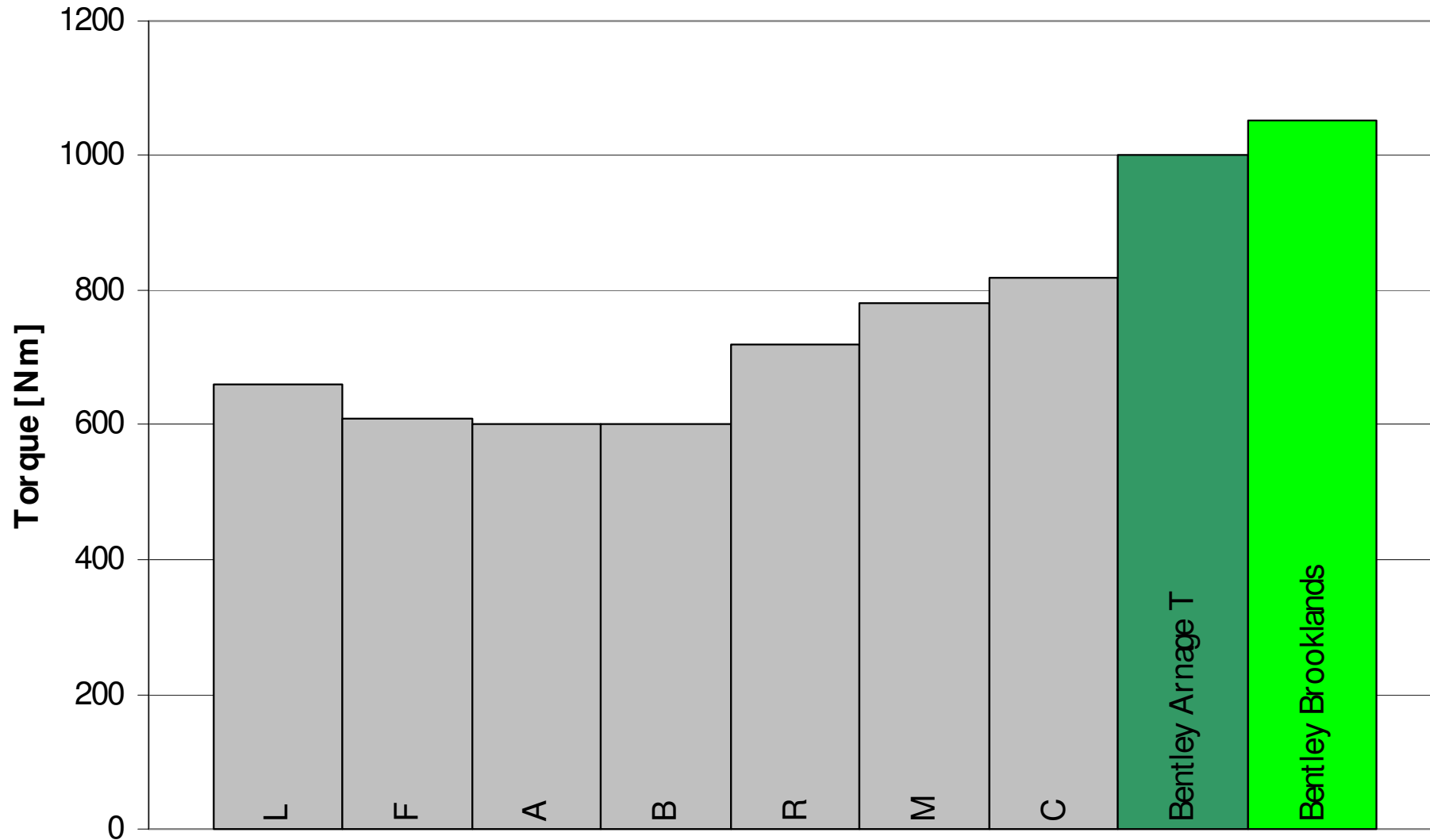


1959

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The Highest-Torque V8 in the World

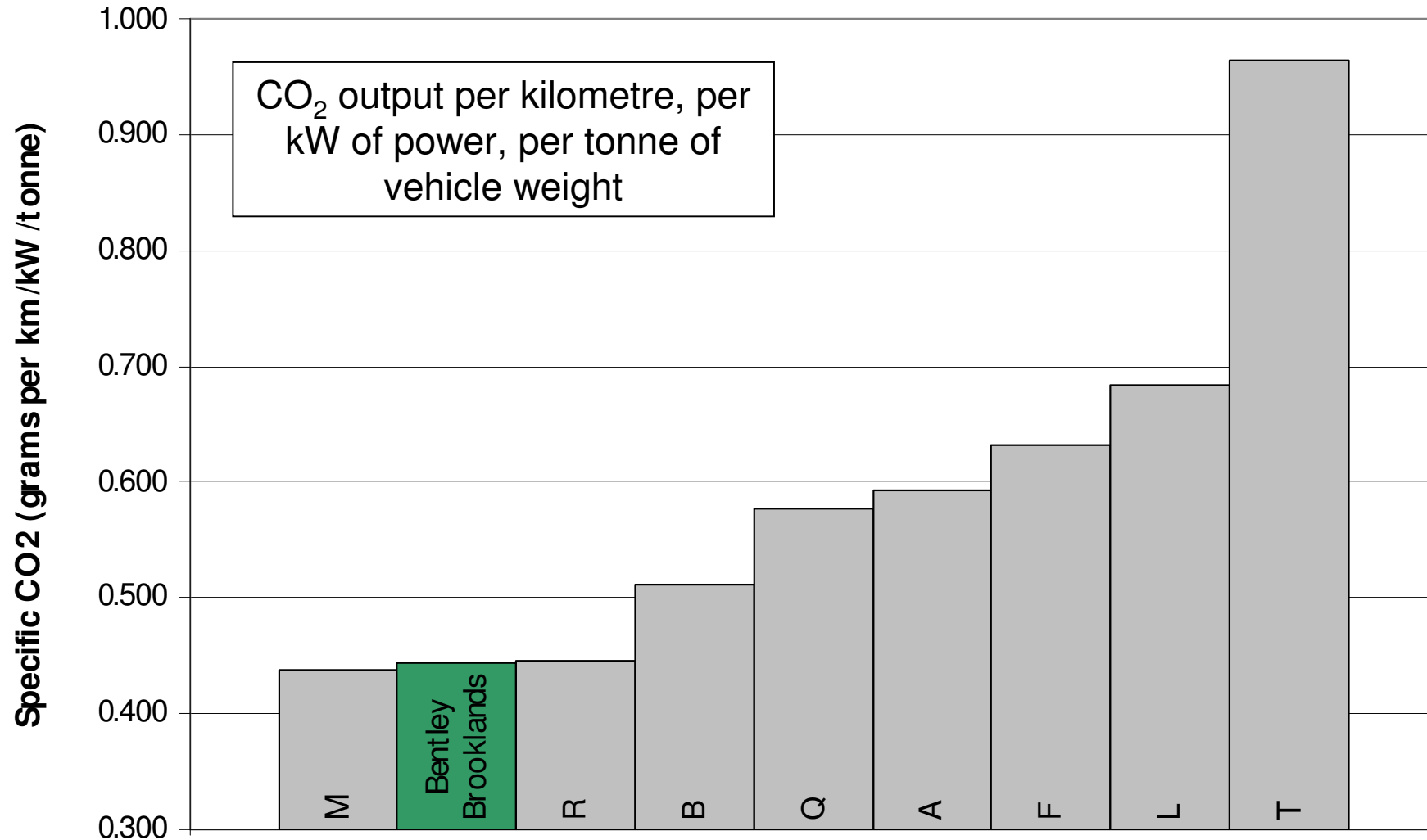


1959

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Specific CO₂



1959

50 Years of the Bentley V8

2009

- This year we celebrate 50 years of this remarkable engine
- Power and torque output have almost tripled since 1959 while the base block that has hardly changed.
- Highest torque automotive production V8.
- Emissions have been reduced more than 99% (NO_x, HC, CO)
- The Bentley 6¾ litre V8 has a long, distinguished and proud history and yet is a current clean unit, with a unique character
- The future is bright for this incredible machine.

And in to the Future...



1959

50 Years of the Bentley V8

2009