85. 2000 Ferrari 049B/2; 2,997cc; 795BHP @ 17,500RPM.

(Full details in Appendix 1)

See Figs. 85A and 85B on P. 6 A Power Curve is given on P.7.

In the F1-2000 type 651 chassis the type 049 90V10 engine powered Michael Schumacher to the 1st Drivers' Championship won by Ferrari since 1979 (see Eg. 59), a 20 year drought. He scored 9 victories and his new team-mate Rubens Barrichello another, making a team total of 59% of the possible. The Constructors' title was won again, obtaining 170 points (62% of possible).

Ferrari subsequently allowed Peter Wright (formerly of Lotus, where he created the ground effect of the types 78 and 79 for Colin Chapman) unprecedented access to most of the technical data on the 2000 car, subject to a 3 year embargo, and this was published in (987). Unless otherwise specified all basic data following is from that source.

Configuration changes from Type 048

The 049 engine vee angle had been increased to 90^0 ($+10^0$) and to B/S = 96/41.4 = 2.32 (probably + 6.6%). Combined, these changes lowered the C of G height further from 197.5 mm in 1999 to 187 (-5.3%). The engine had no balance shaft. A Daimler-Benz Patent taken out in 1962 (1025) had shown that a 90^0 V10 with a certain firing order could eliminate or greatly reduce the 1st and 2nd order bending couples which occurred with equal 72^0 ignition spacing, using instead $72^0+18^0 = 90^0$ and $72^0-18^0 = 54^0$ on alternate banks, the crank throws being still at 72^0. Ferrari used this system (although a different firing order), easily arranged by the electronics now available.

Weight and Ballast

The weight was now down to 106kg, including the clutch but excluding the ECU. This lightweight engine and chassis totalled under 463kg without driver and ballast so that, with Schumacher at 75kg, the ballast could be over 62kg (over 10%) to reach the rule minimum of 600kg. This ballast was tungsten, mounted as low as possible and it is clear from (1026) that fore-and-aft movement of a proportion was made to maximise lap speed on different circuits. Silverstone, for instance, was a ballast-forward venue, presumably to give high speed understeering stability and it is probable that Monaco was ballast-aft to improve traction and give a rapid oversteering turn-in.

Constructional details

As was by then conventional all valves were Ti-alloy, the exhausts being ceramic coated to reduce heat input, with VIA = 25^0 transversely and 6^0 longitudinally. Also conventional for the period so as to obtain full value from the enhanced B/S ratio, PVRS was used with N_2 filling, topped from a 0.7 litre 200 Bar bottle as required. The engine section was published (see Fig. 85A) and showed that a finger follower (without leverage) had been introduced between cam and PVRS piston, probably to reduce side thrust on that part and also reduce rubbing velocity and perhaps reducing inertia a little compared to thickening up that piston to act as a tappet (as had been done by Honda in the RA122E/B – see Eg. 74). It is possible that the piston could then be made in Al alloy. It is certain that "Diamond-Like Carbon" (DLC) coating was used to reduce friction on the valve gear rubbing surfaces (see Note 103).

Valve timing was one detail which Ferrari did not disclose to Wright. From the cam shapes it appears IOD and EOD were around 300^0, the inlet having a concavity to give rapid initial acceleration. The displayed cam angular location is believed to be simply a drafting convention since it shows 0^0 overlap. In (704), a FIAT/Modena University research paper of 1998, the valve timing chosen for a theoretical V10 was 60/75//80/55 i.e. 315^0 duration and 115^0 overlap, and this has been assumed for the 049 in Appendix 1.

The pistons were still Al-alloy by Mahle, oil-jet cooled as had become standard practice. It was stated by that supplier in 2005 (1055) that they had not completed development of a Be/Al-alloy piston (to rival Ilmor's 1999 innovation) before the material was banned by the FIA in 2001. The con rods were Ti-alloy, also by now standard, and they were I–section.

Comparison of Type 049 with Honda RA122E/B

The progress of Grand Prix engine design over 8 years of extremely high development expenditure (made possible by TV-stimulated sponsorship) can be measured by comparing authentic and fairly full data for the Honda RA122E/B (Eg. SO 20 in Appendix 1) with the Ferrari 049:-

Date	1992	2000	Difference
Source	(69)	(987)	
Make	Honda	Ferrari	
Engine Type	RA122E/B	049	
Configuration	75V12	90V10	
V cc	3,496	2,997	-14.3%
B/S	88/47.9 = 1.837	96/41.4 = 2.319	+26%
100/Smm	2.09	2.41	+15.7%

See Appendix 1 and its Glossary for meaning of abbreviations

		INLET GEOMETRY		
LIN/S	Shut	4.47	4.15	
LIN	Open/Shut ratio	1.12	1.30	
Outer tract angle non-orthogonality to valve head		20^0	20^0	
VIA		29^0	25^0 & 6^0 longitudinally	
Downdraught		42^0	42^0	
(Flow Turning)		(48^0)	(48^0)	
IVA/PA		0.344	0.354	
IVL/IVD		0.315	0.384	+22%
PVRS Piston Dia. / IVD		0.90	0.74	
		EXHAUST GEOMETRY		
EVA/PA		0.202	0.236	+16.8%
EVL/EVD		0.357	0.427	+19.6%
EVA/IVA		0.59	0.67	+13.6%
Updraught		35^0	28^0	
(Flow Turning)		(55^0)	(62^0)	
		BOTTOM-END GEOMETRY		
CP/S		83.5%	99.0%	+15.5%points
(CP/S)/√(B.NP)		0.182	0.187	
CP/MJ		74%	85%	
GP/S		41.8%	45.9%	
CRL/S		2.32	2.68	+15.5%
PH/B		1.96	2.13	+8.7%
w/S		1.5/47.9 = 3.1%	1.0/41.4 = 2.4%	
Red Line (RL) RPM		15,000	18,000	+20%
RL MPS m/s		23.95	24.84	

PERFORMANCE

Fuel		"Real" Petrol (Gasoline)	102 RON	
R		12.9	12	
PP	BHP	764	795	+4%
@ NP	RPM	14,400	17,500	+21.5%
PP/V	BHP/Litre	218.5	265.3	+21%
PP/IVA	BHP/Sq.Cm.	3.04	3.10	
TP	Lb. Ft.	297	253	-14.8%
@ NT	RPM	12,000	15,500	
(NP – NT)/NP		16.7%	11.4%	-5.3%points
W	kg	154	106*	-31.2%
PP/W	BHP/kg	4.96	7.5	+51.2%

* Including clutch, excluding exhausts and ECU. Honda specn. unknown.

BMPP	Bar	13.58	13.57	
@ MPSP	m/s	22.99	24.15	+5%
BMTP	Bar	14.47	14.40	
@ MPST	m/s	19.16	21.39	+11.6%
MGVP	m/s	66.82	68.18	
B.NP	m/s	21.12	28.0	+32.6%
MVSP	m/s	5.84	9.30*	+59.2%
MPDP	g	6749	8408	+24.6%

* Subject to IOD assumption of 315^0, as stated above.

Essentially, following the theory given in the General Review and taking advantage of PVRS and DLC to avoid valve gear limitations, the Ferrari 049 extended the process already described in Eg. 74 for the Honda 1992 development relative to the 1982 Cosworth DFV. A 21% increase in PP/V was obtained by increasing (1/S) nearly 16% plus a 5% rise in MPSP while holding BMPP at the same level of 13.6 Bar. Retaining the latter value by retuning the inlet and exhaust systems, however, even with VIS, meant that the value of (NP – NT)/NP dropped 5%points to only 11%. This did not mean that the engine could not be operated far below Peak Torque RPM. Telemetry on TV from Suzuka, for example, showed it pulling away from the hairpin and chicane in 1st gear (of a 7 speed box) from about 8,000 RPM, i.e. only 46% of NP. This was to the credit of the ECU, VIS and the fuel injection system. The latter had its nozzles mounted above the inlet trumpets, as used by Renault since 1993.

The 22% increase in IVL/IVD, made possible by the improved valve gear, was quite remarkable and indicates that previous inlet flow theories had been too conservative. It may be that with paired inlet valves at narrow VIA there is interference with the flow by the wall which requires compensation. There was a matching 20% increase in EVL/EVD.

Presumably CRL/S was raised 15% to reduce piston friction.

Internal performance analysis

An internal performance analysis for the 049 engine can be constructed as follows:-

		NA, Petrol at STP	
DATE		2000	
MAKE		Ferrari	
TYPE		049	
MDR		1	
V cc		2,997	
NP RPM		17,500	
R		12	
ASE		0.63	
EV		1.31	Note (i)
EC		0.7	Note (ii)
EM	To Balance	0.62	Note (iii)
PP	BHP	795	

Note (i): EV from (1045) for a Ricardo "Wave" programme estimate on a hypothetical V10 of 96 x 41.4 = 2,997cc at 17,500RPM. Note also that Geoff Goddard, former Chief Designer of Cosworth, stated in late 2004 that the best racing engines were then obtaining EV = 1.4 (1045).

Note (ii): It is assumed that the 049 combustion chamber had the same EC (rounded number) as the 1922 Vauxhall-Ricardo 3 Litre (242), although much less favourable on (Surface Area/Volume) ratio, because of having Barrel Turbulence (aka "Tumble Swirl") and Squish to compensate for that. Ref. (453), adjusted by (595), also supports the EC value used.

Note (iii): The Elf fuel company web-site at May 2003 (897) stated: "In a F1 engine ...at full power, friction induced by...moving parts absorbs up to 40% of the mechanical energy produced by the combustion of the fuel", i. e. EM = 0.6. Elf would have been knowledgeable about the Renault GP engines and they mentioned 18,000RPM and the equivalent of 24 m/s MPS.

The author's analysis based on old data (see Note 99) suggested EM = 0.58 and it would be expected that improvements would have been made later in design and lubricants.

Clutch and Gearbox

Ferrari chose not to use the smallest clutch then available (3.84'', 97.5mm), adopting a 4.5'' (114.3mm) 3-driven-plate-diameter carbon-carbon AP design so as to preserve a margin for race restarts after a safety car as well as pit-stops (now usually 2 per race, although in the low-speed-limited pit lane not as severe as racing starts).

The 7-forward speed and reverse, Ti-alloy-cased gearbox weighed 45kg, including the hydraulic change-gear mechanism, i.e. 42% of the engine weight. It is likely that DLC was used on the gear wheels, which varied in width from 10mm for 7th gear to 12mm for 1st and also likely that the internals were scrapped after every race (to judge by a (999) statement of this procedure for the 1993 Williams FW15).

Operational details

Fuel consumption averaged about 68 Litres/100km, with a range of 63 to 72 depending on the circuit.

The 049 engine suffered only 2 engine-related DNFs in 2000, one being unusual in that an Iconel exhaust pipe cracked and leaked hot gas onto a CFC rear suspension part which then failed.

The Ferrari Team

In 2000 the Ferrari racing team made good use of talents from across the world:-

Major financiers:-	FIAT	Italian
	Philip Morris (Marlborough)	American
Ferrari President	Luca di Montezemolo	Italian
Team manager	Jean Todt	French
Technical Director	Ross Brawn	British
Chassis Chief Designer	Rory Byrne	South African
Engine Director	Paolo Martinelli	Italian
Engine Chief Designer	Gilles Simon	French
Chief Mechanic	Nigel Stepney	British
No. 1 Driver	Michael Schumacher	German
No. 2 driver	Rubens Barrichello	Brazilian
Tyre supplier	Bridgestone	Japanese
Fuel and Oil Supplier	Shell	British
Workforce		Italian

This welding-together of an international group to achieve success in an international arena reflected the highest credit on Jean Todt and on Signor di Montezemolo, the man who persuaded him to transfer from a successful career at Peugeot to Ferrari in 1993. Todt then secured the transfer from Benetton of Schumacher, Brawn and Byrne for 1996

Post 2000

Having reached the top in 2000 Ferrari, with the same team of people, continued to dominate Grand Prix racing for 4 more years, up to the end of 2004. This continuing success over 2001-2004 was against major well-financed opposition, including as engine makers:-

- Mercedes-Ilmor
  Daimler-Chrysler increased their stake in Ilmor from 25% to 55% in September 2002, following Paul Morgan's death in a flying accident in May 2001. They then went up to 70% in October 2003. Finally they bought 100% in 2005 and re-named the company "Mercedes-Benz High Performance Engines". (Mario Illien with Roger Penske and Paul Morgan's widow then bought back the Special Projects Division and re-named it Ilmor Engineering as before, but had it no connection with the Grand Prix engines).
  The Mercedes-Ilmor engines powered McLaren
- Cosworth Racing, owned by Ford from October 1998, powering e.g. Jaguar (also Ford owned) from the start of 2000.
- Honda from the start of 2000, powering BAR.
- BMW also from the start of 2000. powering Williams.
- Renault from the start of 2001, powering Benetton, who were renamed as the Renault team in 2002.
- Toyota from the start of 2002, a complete car + engine team financed by the world's 2nd largest car manufacturer.

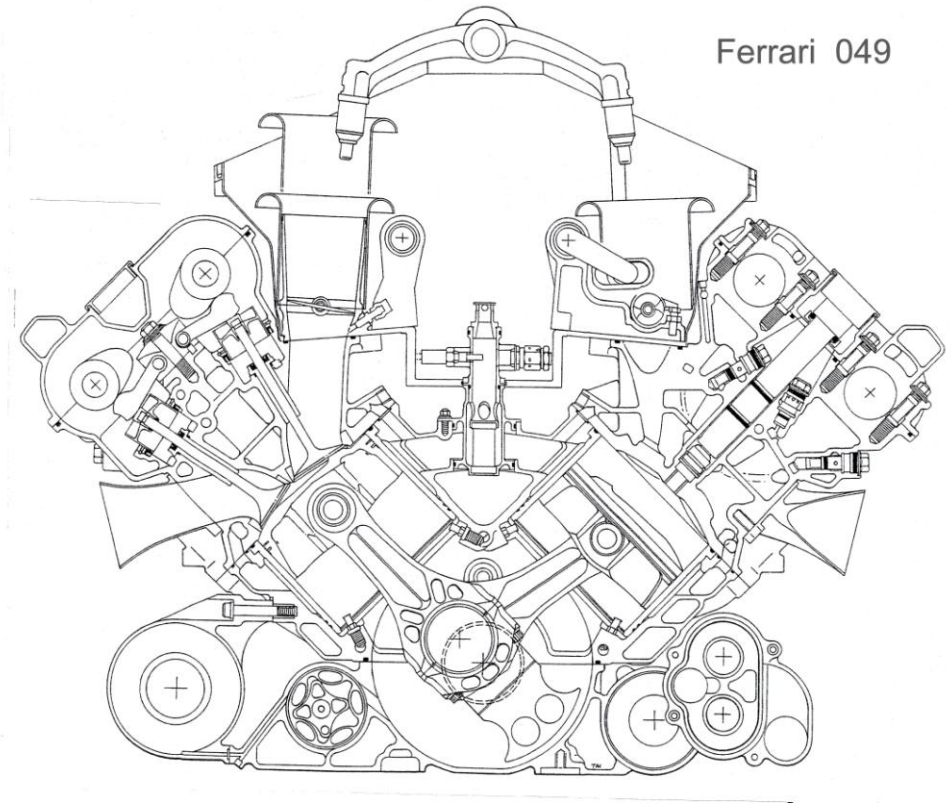

Figure 85A
2000 Ferrari 049B/2
90V10 96/41.4 = 2.319 2,997cc

Most details have been noted in the text, but this section shows the overhead injector rail, the Variable Intake System (VIS, adjustable length inlet tracts to tune them to the RPM), the control valves for the PVRS and the cooling-oil jets under the pistons. These have B/PH = 2.13 and are 2-ring slipper-type. Finger cam followers relieved the PVRS pistons of side thrust.

DASO987

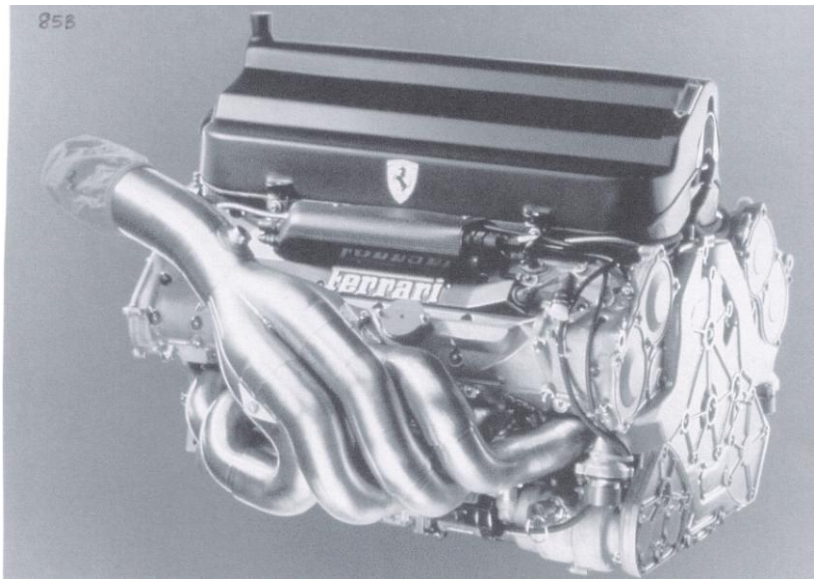

Figure 85B

This illustrates the high-exit exhaust system introduced by Ferrari during 1998. The pipes, as standard, are of equal length.
The inlets are covered for protection during transport

DASO 733

POWER CURVES

Eg.	85
DASO	987
YEAR	2000
Make	Ferrari
Model	49
Vcc	2997
Ind. System	NA
Confign.	90V10
Bmm	96
Smm	41.4

VIS in operation

N kRPM	P HP	MPS m/s	BMEP Bar
12	528	16.56	13.14
12.5	572	17.25	13.66
13	609	17.94	13.99
13.5	641	18.63	14.18
14	667	19.32	14.23
14.5	689	20.01	14.19
15	720	20.7	14.33
15.5	747	21.39	14.39
16	767	22.08	14.31
16.5	782	22.77	14.15
17	792	23.46	13.91
17.5	795	24.15	13.56
17.8	789	24.564	13.23
18	769	24.84	12.76

Powers as published were Italian CV and have been divided by 1.014 to convert to HP