CORRECTIONS & ADDITIONS

CORRECTIONS & ADDITIONS INDEX

CORRECTIONS & ADDITIONS Contents

Page

CORRECTIONS **(7 November 2011)**

Appendix 1 : 1962 BRM P56
Lines 49/50 PP = 197 BHP @ 11,000 RPM.
Lines 51/52 TP = 101.5 lbft @ 9,500 RPM.

DASO1088. *Motor Racing*. March 1963.

Appendix 1 : 2003 BMW P83 (not CoY)
Lines 18/19 B = 96mm (so S = 41.42mm for 2,998cc).
Line 54 B/S = 2.318.
Line 24 IVD = approx. 41.4mm
Lines 49/50 PP = 927 BHP* @ 19,000 RPM.
*Converted from 940 PS.
Line 124 W = 84 kg.

DASO1095. *Ten Years of BMW F1 Engines*. Paper by Prof. Dr-Ing. Mario Theissen et al. 2010.

Technical Innovations : 1956 Eg. 34 Ferrari-Lancia D50
● Re: Chain drive to OHC
[1922 John Weller AC 2 Litre]

ADDITIONS

Appendix 1 : 1956 Ferrari-Lancia D50
Line 124 W = 170 kg.

DASO1089 *Turin Drawings*. G.Goldberg, Self-published. 2009.

Technical Innovations : 1936 Eg. 22 Auto-Union C
●Wet cylinder liners
[1922 Both Harry Ricardo Vauxhall TT and John Weller AC 2 Litre. Both in Al-alloy blocks]

CORRECTIONS & ADDITIONS **(16 October 2013)**

CORRECTIONS

Appendix 1: Eg. 6 1914 Mercedes
Line 17: R: Measured as 4.89 (was *estimated as 5*).
Line 23: VIA: 50^0 (not 60^0).
Data by courtesy of Eddie Berrisford while restoring a car of this type.

2NA Era: Eg. 34: 1956 Lancia-Ferrari
P.9: 2nd line: Francesco Falco's name was mis-spelt as *Faleo*.
P.10: PS2: An Italian source states that the 4WD D50 Lancia was *not* completed.

CORRECTIONS & ADDITIONS **(30th November 2013)**

CORRECTION

"Significant Other" engines and Appendix 1
SO1. The 1889 Daimler was 16V2 *not* 14V2.

ADDITION

Egs. 69, 70, 71 at p.2

The Honda Formula 2 engines were:-

1965 B/S = 72/61.2 = 1.176, V = 997 cc.
Jack Brabham estimated the power as 130 HP @ 10,000 RPM.

1966 Completely redesigned, smaller and lighter;
B/S = 78/52 = 1.5, V = 994 cc;
150 HP @ 11,000 RPM.

DASO 1110; draft 1967 manuscript by K. Ludvigsen, supplied by his courtesy.

CORRECTIONS & ADDITIONS **(24 February 2015)**

ADDITION

Appendix 1 Egs. 54, 56, 57, 59 at Rows 34 & 35: Ferrari 312B, various T chassis

The steel-backed plain bearings of the Ferrari 312B/T5 of 1980 had diameters of:-

2 x Intermediate Main Journals (MJ) 56 mm (the end bearings were roller);
12 x Crank Pins (CP) 38.5 mm.

The bearings were Clevite type CL112, able to take a pressure of 12,000 psi. These were claimed at the time to be superior to any other make.

DASO 1118, data supplied by courtesy of Bo Skånhed.

It may be reasonably assumed that previous 312B engines had the same sizes.
The ratio MJ/CP = 56/38.5 = 1.45 was higher than usual for NA engines, egs:-

1965 Climax FWMV6 50.8/41.3 = 1.23;
1967 Cosworth DFV 60.3/49.2 = 1.23;
2000 Ferrari type 49 48/41 = 1.17.

The reason was that the 312B had only 2 Intermediate journals on its 6-throw crank and therefore needed a larger diameter for stiffness than the listed 1-bearing-per-throw engines. This will have offset to some extent the frictional gain from fewer bearings.

Continued below:-

CORRECTIONS & ADDITIONS **(August 2015.)**

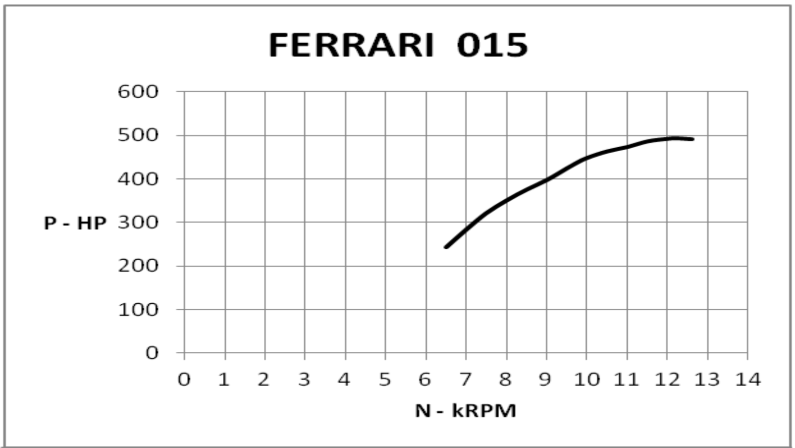
ADDITION

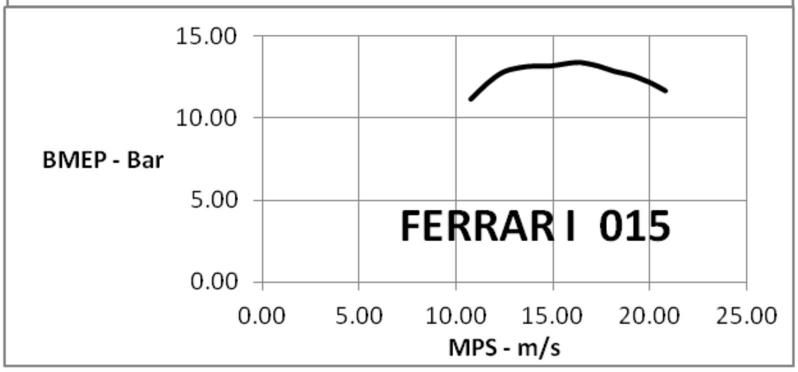
POWER CURVES

Eg.	54
DASO	1122
YEAR	1975
Make	Ferrari
Model	15
Vcc	2992
Ind. System	NA
Confign.	180V12(F12)
Bmm	80
Smm	49.6

N kRPM	P HP	MPS m/s	BMEP Bar
6.5	242	10.75	11.14
7	283	11.57	12.09
7.5	321	12.40	12.80
8	350	13.23	13.09
8.5	375	14.05	13.20
9	397	14.88	13.19
9.5	424	15.71	13.35
9.75	437	16.12	13.41
10	448	16.53	13.40
10.5	463	17.36	13.19
11	473	18.19	12.86
11.5	486	19.01	12.64
12	492	19.84	12.26
12.2	493	20.17	12.09
12.6	491	20.83	11.66

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



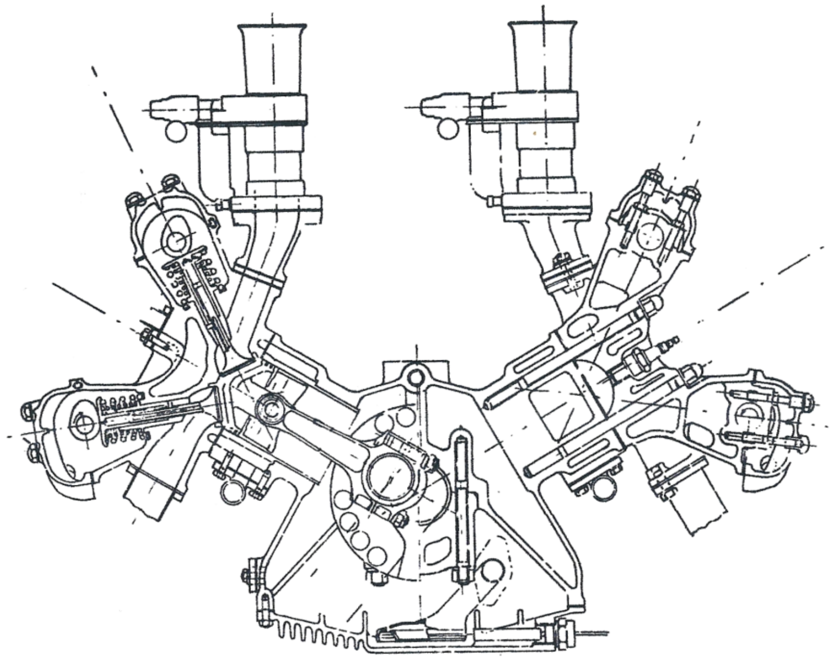


ADDITION

(September 2015)

Eg.40 1961 Ferrari type 156/120^0

DASO 1126 has provided a cross-section of this type of 6-cylinder Ferrari engine, Bore (B) 73 mm, Stroke (S) 58.8 mm, B/S = 1.241, Swept Volume (V) 1,477 cc. This is shown on the Figure below:-



Scaling (on an enlarged print) shows that this is not the engine described in 2nd Naturally-Aspirated Era (2NA) Part 3 and in Appendix 1, although that data is well sourced. In particular, the cylinder head is quite different in detail, as follows:-

Eg. 40	New data
DASO 54 & 711	DASO 1126
VIA 60^0	74^0
Same as 1958 type 246	Same as 1956 ex-Lancia D50
IVD 41.6 mm	35 mm

DASO 711 states that there were 2 sizes of inlet valve, the 2nd being 38.5 mm which by implication was also at VIA = 60^0. Correspondent Ron Rex has suggested that VIA 60^0 applied to the 1961 re-vamp of the original 65^0 bank angle type 156 and that the 120^0 engine was always VIA 74^0

Ferrari have always been a prolific maker of engine types and it would be typical practice to experiment with different configurations. It may be supposed that the Peak Power (PP) quoted for Eg. 40 of 192 HP @ 9,500 RPM was for a "Big-valve" engine, as previously listed, and that the "Small-valve" engine was intended to have a broader Torque curve, although less PP, to suit twisty circuits like Monaco. If it *was* actually raced at Monaco in 1961 it did not win because the Ferrari team were beaten by Stirling Moss in an old Lotus with a 4-cylinder Climax engine.

Drawing details

IVD = 35 mm, so IVA/PA = 0.23;
IVL = 10 mm, so IVL/IVD = 0.286;
EVL = 33 mm, so EVL/IVL = 0.94.

LIN = 315 mm, so LIN/S = 5.36.
By Note 27, the inlet resonant speed would be 8,400 RPM.

It is probably safe to assume that the "Bottom-ends" of the engines were the same:-

CRL = 126 mm (given in www.f1technical and as scaled);
so CRL/S = 2.14.
At 9,500 RPM MPDP = 3,658 g.

PH = 64 mm, so PH/B = 0.88; PH/S = 1.09.

MJ = 55 mm;
CP = 39 mm, so CP/MJ = 0.71 and CP/S = 0.66;
GP = 19.5 mm, so GP/CP = 0.5.

Design features

- "Jano" tappets – a design dating from his 6-cylinder sports Alfa Romeos in 1927 (his 1924 P2 Alfa had finger followers);
- Shown with 40 mm bore carburettors, the same as the "Big-valve" engine, which had Weber 40 IF3C (given in www.f1technical).
- Inlet tract downdraft = 10^0; exhaust 0^0 (both relative to the plane of the piston crown).

References

DASO 54 SAE 818A W. Gay Jan. 1964 (This Ford paper, principally concerned with the 1963 Indianapolis engine, had some comparative data for the Ferrari 156, presumably official).
DASO 711 CLASSIC RACING ENGINES K.Ludvigsen Haynes 2001.
DASO 1126 Ferrari 156/120 drawing copied to the author by courtesy of Ron Rex.

CORRECTIONS & ADDITIONS

CORRECTION

(October 2015)

3rd Naturally-Aspirated Era (3NA) 1989-2000 Part 1 1989-1994

Since writing this section and producing the tabulated data in Appendix 1 some more information has become available on the Honda engines of the McLaren cars which were GP "Car-of-the-Year" for 1989 to 1991 (Egs. 72, 73 and 74).

Although Honda were very frank in describing their last engine in their "Second Era" of racing, the 1992 RA122E/B (DASO 69) (which is on the website in "Significant Other"), they revealed very little about the 1989-1991 units. The data now given here (references are detailed below) and compared with the original is therefore a mixture of official Honda and some of lesser authenticity. In those far-off times before the FIA imposed "virtually-non-development" rules, engine builders often modified their engines from race-to-race as well as season-to-season. Consequently, it cannot be certain that data available is consistent from dimensional to performance figures from different sources. Bearing that in mind, this Correction tries to steer a reasonably believable balance.

Eg. 72 Honda 1989 RA109E 72V10 3½ Litre

(1). The V10 Balancer

The original website text, based on (727), described the V10 balancing shaft as located in the Vee. A Honda paper published in their Technical Review (1127) shows that it was actually placed alongside the crankshaft. Fig. 72C below illustrates this. The paper refers specifically to the 1990 RA100E engine but it is presumed that the same necessary configuration applied to the RA109E.

Continued on P. 6

Fig. 72C

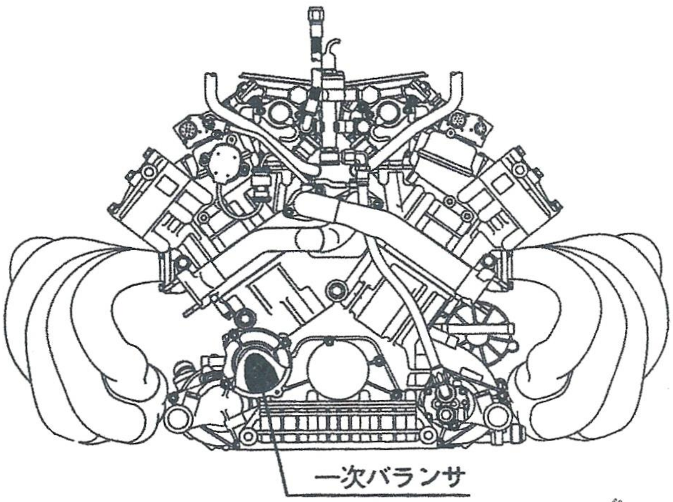


図3　1次バランサ付　RA100E型エンジン

(2). Performance

Appendix 1	Update
B = 89 mm; S = 56.2 mm (47)	B = 92; S = 52.55 (1128, *plus 0.05 on S)*
B/S = 1.584	B/S = 1.751
V = 3,496 cc	V = 3,493 (www.allf1)

On review of the source (47) it now seems that this data *may* have applied to the 1988 precursor of the 1989 race engine.

PP = *610* HP	642 (1121)
@ NP = *13,000* RPM	@ 12,800 (1129)
BMPP = 12.01 Bar	12.85
@ MPSP = 24.35 m/s	@ 22.42
W = 150 kg	160 (1121)
PP/W = 4.07 HP/kg	4.01

Eg. 73 Honda 1990 RA100E 72V10 3½ Litre

Appendix 1	Update
B = 92; S = 52.55	B = 93 (1121)
	S = *51.42*
B/S = 1.751	B/S = 1.809
V = 3,493	V = 3.493 (991)
PP = 650	670 (1121)
@ NP = 13,800	@ 12,250* (1121)
BMPP = 12.07	14.01
@ MPSP = 24.17	21.0
W = 146	160 (1121)
PP/W = 4.45	4.19

*Given officially by (1121) and supported by a max. of 12,500 shown officially in (1127).

Eg. 74 1991 Honda RA121E 60V12 3½ Litre

Appendix 1	Update
B = 86.5; S = 49.6	B = 90; S = 45.76 (1129* *less 0.04 on S)*
B/S = 1.744	B/S = 1.974
V = 3.498	V = 3,493 (991)
It now seems possible that these dimensions were relevant to the 1st 60V12 raced in the early part of 1991.	These dimensions are probably those of the complete redesign raced from the middle of the year (tentatively labelled *RA121E/B*).
PP = 764 [*Table error; should have been 724 (69)*]	724 (1121)
@ NP = 13,700 (69)	@ 13,800 (1129)
BMPP = 14.27 [*Should have been 13.52*]	13.44
@ MPSP = 22.65	@21.05
W = 160 (69)	154 (1121)
PP/W = 4.78	4.70

*The 1992 Honda RA122E/B 75V12 3½ Litre was officially
B = 88; S = 47.9; B/S = 1.837; V = 3,496 (69). it casts doubt on the above dimensions, as it would be expected that B/S would be larger in the later engine.

DASO references

47 Data supplied by Brian Lovell (former MD of Weslake Developments) on 18 April 1992.

69 JSAE 9301494 (in Japanese, translated by Butcher and Taniguchi) via Brian Lovell on 11 March 1993.

727 McLAREN A. Henry Haynes 1999.

991 Honda press release, December 1990.

1121 Honda R&D website Technical Review: F1 Special, December 2009. Source advised to author by courtesy of Ron Rex, July 2015.

1127 Honda R & D Technical Review, Vol. 3, (1991) In Japanese. Copied to author by courtesy of Ron Rex, July 2015.

1128 *Autocourse* 1987-90.

1129 Captions in Honda Motegi museum.

CORRECTIONS & ADDITIONS

CORRECTION and addition

(8 October 2015)

2002 Honda RC211V

On P.17 of the section "Grand Prix Motorcycle Engine Development, 1949-2008" the best data available was provided on the new MotoGP 2002 Honda RC211V 990 cc engine. Speculation on the Bore (B) and Stroke (S) of this 75.5V5 was that it was a 2 mm increased-bore derivative of the Honda RC45 90V4 750 cc Superbike engine, which was B = 72 mm x S = 46 mm, B/S = 1.565, *plus* a 5th cylinder to reach the MotoGP 4-stroke regulation 990 cc.

Better data has now been extracted from a Honda R & D Technical Review seen recently (see ref. 44 below; this continues the ref. numbers of the m/c section). While providing much interesting information, Honda gave it mostly in relative form. However, a cross-section, shown below on P.8 (suitably enlarged), enabled the B x S dimensions to be derived from the B/S ratio.

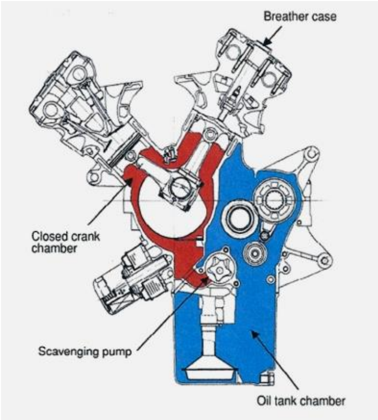


Fig. 8 Structure of crankcase

2002 Honda RC211V

75.5 V5 B = 72 mm; S = 48.6 mm; B/S = 1.605; V = 989.4 cc

Honda, therefore, had retained the Bore dimension of the RC45, and no doubt it's valve gear, and lengthened the Stroke, with a 5th cylinder at the front. Honda examined configurations from 2 to 8 cylinders before choosing 5 as providing the best machine Power/Weight ratio within the rules.

The Review power of the RC211C was given as:-

PP = "over 160 kW" = "over 214 HP"

The website had accepted a figure of 220 HP (1) so that still seems appropriate for this analysis. However, (1) suggested that Power Peak speed (NP) was 15,500 RPM. The Review has one dimensional figure which shows Maximum speed as 14,000 RPM. A relative power curve indicates that this was *also* NP. Performance is therefore taken as:-

PP = 220 HP
@ NP = 14,000 RPM.

So that BMPP = 14.21 Bar
@ MPSP = 22.68 m/s.

This is virtually identical to the RC45 performance (32):-

BMPP = 14.4 Bar
@ MPSP = 22.2 m/s.

<u>Crankcase development</u>

The Review reports that the power had been increased by 4% by scavenging the oil into a "*semi-dry-sump*" cum gearbox case integral with the engine, shown as blue on the section. This was 1 kg lighter than a full "dry-sump" system. Of course, the oil did not fill all the space. Being a 2-wheel machine the oil level would remain parallel with the crank axis when banked over and cornering steadily. Each crank chamber throw was sealed and was kept 70 kPa (10 psi) below atmospheric pressure.

<u>Valve gear</u>

Fig. 10 of the Review, shown RHS, has been used (suitably enlarged) to determine the dimensions of the RC211V valve gear:-

VIA = 24^0

IVD = 30 mm; IVL = 9.3 mm; IVL/IVD = 0.31.

4 v/c; IVA/PA = 0.347.

MGVP = 65.4 m/s.

If IOD = 320^0, the CVRS MVSP = 4.9 m/s.

EVD = 25 mm.

LIN = 169 mm; LIN/S = 3.48;

From Note27, the resonant RPM would be 15,700, but clearly the 1.5 area ratio of the inlet tract reduces this.

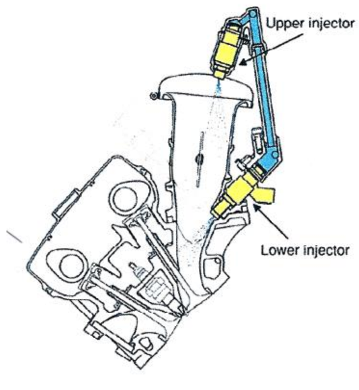


Fig. 10 Twin injector

Reciprocating parts

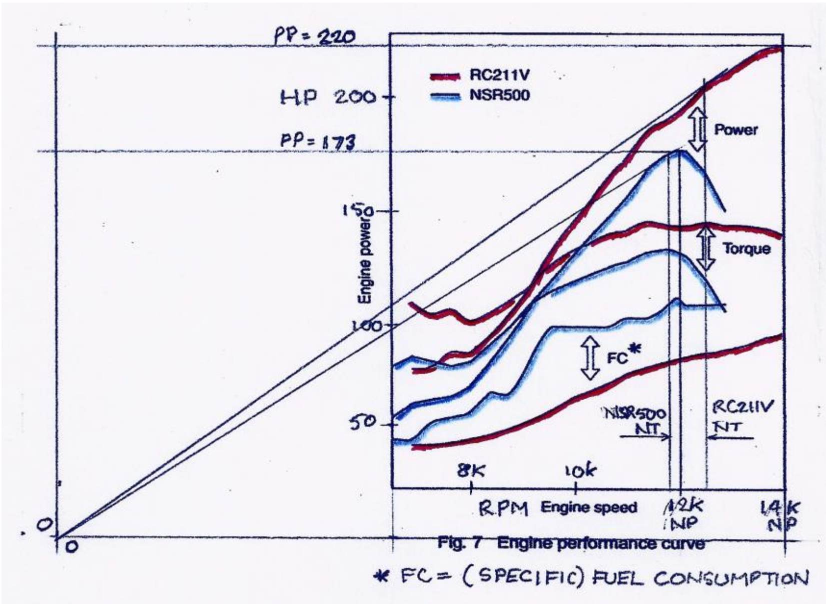
PH = 35 mm; PH/B = 0.49; PH/S = 0.72.

CP = 30 mm; CP/S = 0.62; GP = 15 mm; GP/CP = 0.5.

CRL = 98 mm; CRL/S = 2.02.
At 14,000 RPM, MPDP = 6,644 g.

Power curves

Honda provided *relative* power curves for the 2002 RC211V 4-stroke and the NSR500 2-stroke. If it is accepted that the *actual* powers were 220 HP @ 14,000 RPM for the former and 173 HP @ 12,000 RPM for the latter in 2001 tune (as in Appendix 4) then the curves can be completed to find the origin. This is shown on the chart below:-



This chart emphasises the minute gap between Peak Power and Peak Torque of the super-tuned 2-stroke (as described on P.15 of the motorcycle section) and the broad Torque range of the 4-stroke. Also, with the relative values of FC (the absolute numbers cannot be found), it shows the much higher Thermal Efficiency of the 4-Stroke, which is also described in the section on P.17.

2006 Honda RC211V

Having won the Championships in 2002 and 2003 with Valentino Ross riding, but lost them to a revamped Yamaha after Rossi transferred to that team in 2004 and 2005, Honda redesigned both the chassis and engine for 2006 (45). It was used after beginning the season with a modified 2005 machine.

No B x S dimensions were given in the ref, paper but the engine changes accomplished the following relative to the 2005 model:-

60 mm reduced length
30 mm reduced width.

Within this smaller envelope the distance between crank and the gearbox countershaft was cut by 27 mm; each cylinder pitch was 5 mm smaller; crank width dropped by 21 mm. The con.-rods were shortened by 4 mm. The front cylinder inclination was reduced by 6^0.

Weight was reduced by 7% and with less friction power increased by 3% to “over 180 kW” = “over 240 HP” @ about an extra 500 RPM. If 245 Hp at 14,500 RPM was achieved, then

BMPP =15.3 Bar.

There was a new electronic throttle control system. With the front 3 cylinders opened manually as before, the rear 2 were opened by a motor more slowly at low speeds to prevent wheel spin.

The effort brought its reward by regaining the Championships, Nicky Hayden being the rider.

References

32. Details of machines in Honda's Motegi museum.

44. (= DASO 1130). Honda R&D web site Presentation of RC211V equipped with 4-stroke engine. October 2003.

45. (= DASO 1131). Honda R&D web site Presentation of 2006 Model RC211V. October 2007.

CORRECTIONS & ADDITIONS

ADDITION

10 October 2015.

Note 118 Part 2

Correspondent Barrie Hobkirk has kindly cleared up a caption doubt about a bonnet bulge in the photo of Moss' Maserati in practice at the British GP in 1956, as follows:-

"*That car (Chassis 2523 at the time of the photo) was tested and raced with both normal and injected 250F engines. The bulge was to clear the carb opening mechanism. For the British GP, Moss chose to use a normal engine over the injected version. If you look at the top of Page 2 of your same article, you will see a photo of that Injected engine fitted to chassis 2522 for the earlier Goodwood meeting. The carb opening mechanism is visible there. That car also had a bonnet bulge for that race.*"

CORRECTIONS & ADDITIONS

ADDITION

30 October 2015.

Note 13 Part II Piston Ring Flutter as a limit to Piston Speed

The ref. note showed that the basic condition for the onset of flutter of a plain rectangular-section Piston Ring was:-

$$w.\ MPD = \left(\frac{\Delta p}{DR}\right)$$

where w = Ring axial width;
MPD = Maximum Piston Deceleration (at outward end of stroke);
Δp = piston groove pressure above the Ring;
DR = Ring density.

Engine data for 1931 – 1983 showed that, in practice, Δp did not vary significantly over a wide range of NA and PC racing engines so that the empirical result, for cast-iron rings, was:-

w.MPD = about 4,000 mm.g

Note 13 Part II then discussed how engines in the 3rd NA Era, after 1988, were operating above that figure. It was concluded in Postscript 2 from practical observations that this was achieved because the normal operating RPM were so much higher than the natural frequency of radial vibration of the top ring that it could not resonate, i.e., flutter.

Honda data, 2000 – 2008

The Honda website Technical Review F1 Special (DASO 1121) in its constituent paper F1-SP2_08e, amongst other details of the development of the engines they built over 2000 2008, discussed their Piston Ring designs. These will be described here chronologically and then discussed in relation to Note 13 Part II.

The best estimate for maximum MPD has been added to the Honda information, assuming that Con. Rod. Length/Stroke (CRL/S) = 2.5 [for comparison Cosworth CA/6 ratio was 2.57 (Note 108) and Toyota RVX-09H was 2.724 (Note 111). The latter gives only 1.4% lower MPD cf. 2.5].
The values for S, w and Max. RPM are from the ref. Honda paper.

Continued on P.11

	S mm	w mm	Max. RPM	Max. MPD g	w.MPD mm.g
2000	42.24		17,500	8,676	

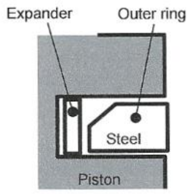
As on production engines, with a rectangular top ring and a spring-expanded oil control ring.

2001	42.24		17,800	8,976	

As 2000.

2002	40.52	0.9	18,600	9,402	8,462

The steel top ring with w = 0.9 mm (35/1000''), w/S = 2.2%, had a spring-expander (see fig. RHS from the ref. Honda paper)*.
Only 1 ring was fitted at first, which gave a 10 kW (13.4 HP) power gain but increased oil consumption to about 30 km/litre. This restricted its use to short-distance Qualification runs.



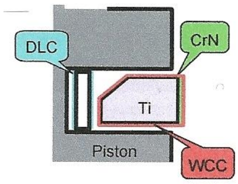
Expanded piston ring

2003	40.52	0.9	18,800	9,605	8,645

The FIA rules changed so that the same engine had to be used for both Qualification and the race. Honda therefore adopted 2-ring pistons with the same type in both grooves. This raised flutter onset by 1,000 RPM. Oil consumption returned to about 100 km/litre.
This configuration applied to 2003, 2004 and 2005.

2004 } 2005 }	40.52	0.9	19,200	10,018	9,016
2006	40.52	0.9	19,600	10,440	9,396

In this year an expanded Ti-alloy top ring was adopted (see the figure*). With a density (DR in the above formula) of only 60% of steel this would be expected to raise flutter onset MPD by 74%. The effect was reported as "*...tremendous, preventing the increase of pressure in the crankcase due to fluttering, not only at wide-open throttle but also when the throttle was off*" [closed-throttle being the more severe case for flutter]. Measured pressure pulses in the crankcase, which were 100 kPa (14.5 psi) with steel rings [at an unspecified RPM, but probably the figure at which flutter was most severe] disappeared. Oil consumption dropped to 150 km/litre.



Titanium expanded piston ring

To provide a satisfactory surface-rubbing situation the Ti-alloy rings had to have special coatings, as shown on the figure.
Toyota made the point that, whereas in a production engine a lot of the heat into the piston had to flow out via the piston rings to the cylinder walls, in a Grand Prix engine whose piston was mostly cooled by crankcase oil jets, the poorer thermal conductivity of Ti-alloy compared to steel [about 1/3rd of stainless steel] did not cause a problem.
This design was retained for 2007 and 2008, which had Maximum RPM reduced to 19,000 by FIA rule, so that w.MPD fell by 6%.

---

*It is hoped that there will not be any objections to the use of figures here in a not-for-profit site whose intention is to aid study.

Discussion

The Honda paper does not give enough data to enable the absolute values for flutter onset of either the spring-loaded steel ring or the spring-loaded Ti-alloy ring to be determined. The Ti ring takes advantage of the density term in the theory to produce a large increase - only made possible by surface coatings to overcome the propensity of titanium to scuffing. The very-enthusiastic Honda description of the improvement *suggests* that it may have actually raised flutter onset *above* the 2006 engine Max. RPM of 19,600 – it would not have been very helpful to raise it into the normal operating range! If so, the spring-loaded Ti-alloy ring flutter was possibly (0.9 mm x 10,500 g) ,say, 9,500 mm.g. This is nearly 2.4 times the established plain iron ring figure of about 4, 000.

The above is highly speculative and must await release of better figures to show if it is correct or not.

Whether other engine makers used any of the techniques described by Honda is, at present, also unknown. Renault, Ferrari and Mercedes all succeeded in running engines of similar dimensions up to nearly 20,000 RPM with much greater success.

Disuse of the Dykes' ring

It is curious that the Dykes' L-shaped piston ring, invented in 1947 and which prevents flutter at any value of MPD, has apparently not been used since about 1966. This was when Keith Duckworth adopted the "super-thin" plain ferrous ring for the DFV (0.030/1000'', 0.76 mm) (see The Unique Cosworth Story).

One possible reason for this disuse of the Dykes' ring – apart from cost which, until recently, was no objection in a racing engine – *may* be that it is prone to fatigue failure. The necessary re-entrant corner of the L-shape must give rise to a high local stress-raiser as the inner leg of the ring is thrown against the top of its groove to restrain the outer leg (see Note 13 Part II sketch). The steady rise of RPM post-1988-to-2006 may have meant too-short a fatigue life as a consequence.

In theory the ring corner stress concentration could be eased with a radius and a corresponding chamfer on the groove. In practice this might be too difficult on such a small part.

CORRECTIONS & ADDITIONS 18 **November 2015**

Eg. 10 1924 Alfa Romeo P2

DASO 1133 (see refs. below) provides data not seen before.

CORRECTION

Power

The power number given in previous references was actually in Italian CV. The peak figure of 145 HP @ 5,500 RPM was therefore 143 BHP.

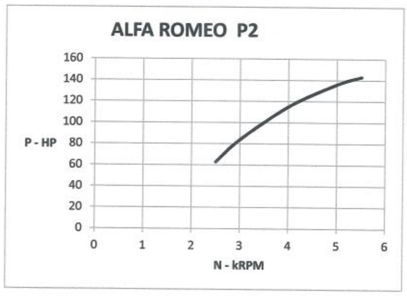
As an **ADDITION** a Power Curve is shown at RHS:-

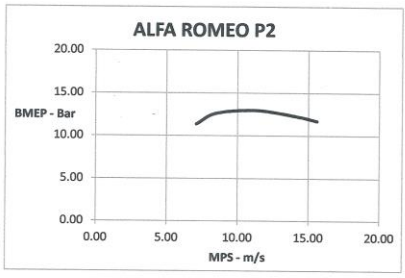
POWER CURVES

Eg.	10
DASO	1133
YEAR	1924
Make	Alfa Romeo
Model	P2
Vcc	1,987
Ind. System	PC
Confign.	IL8
Bmm	61
Smm	85

N	P	MPS	BMEP
kRPM	HP	m/s	Bar
2.5	63	7.08	11.35
3	84	8.50	12.61
4	115	11.33	12.95
5	136	14.17	12.25
5.5	143	15.58	11.71

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





Other data

	Appendix 1	DASO 1133
IVD mm	38*	"Diametro luce"
Overall *head*		= *Port* dia.
		35.5
VIA^0	102	104
IVP ATA	1.71	0.75 kg/cm^2 boost
		= 1.73 ATA

*This figure (and many others in Appendix 1 where no specific dimensions were available) was derived by scaling from the Bore on an enlarged print with a rule graduated in 60 units to 1 inch.

Eg. 18 1932 Alfa Romeo B (“P3”)

From DASO 1133

CORRECTION

Power

The power was also CV and the 215 HP @ 5,600 RPM is therefore 212 BHP.

As an **ADDITION** a Power Curve* is shown at RHS:-

*The figures at lower RPMs are suspect.

Other data

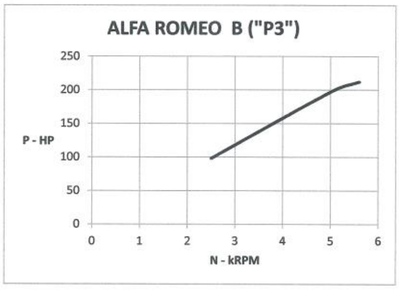
	Appendix 1	DASO 1133
IVD mm	39	*Port* 34
VIA^0	100	104
IVP ATA	1.76	0.75 kg/cm^2 boost 1.73 ATA

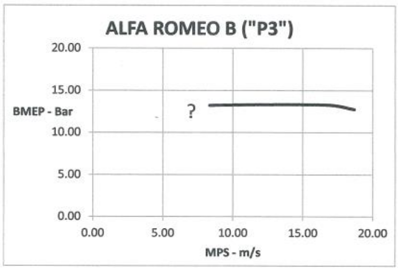
POWER CURVES

Eg.	18
DASO	1133
YEAR	1932
Make	Alfa Romeo
Model	B ("P3")
Vcc	2,655
Ind. System	PC
Confign.	IL8
Bmm	65
Smm	100

N	P	MPS	BMEP
kRPM	HP	m/s	Bar
2.5	98	8.33	13.21
3	118	10.00	13.26
4	158	13.33	13.31
5	197	16.67	13.28
5.25	205	17.50	13.16
5.5	210	18.33	12.87
5.6	212	18.67	12.76

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

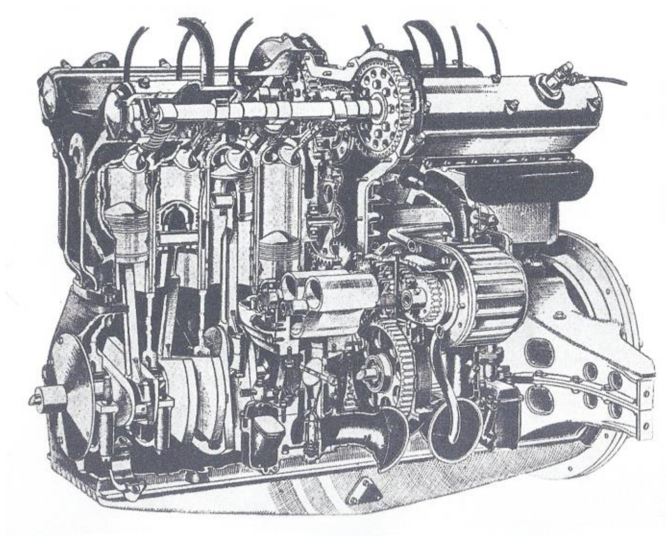




ADDITION

A cutaway drawing from (4) is shown below.

(Artwork credit L.C. Cresswell)



Eg. 26 1948 Alfa Romeo 158/47

From DASO 1133

CORRECTION

Power

The ref. has 275 CV @ 7,500 RPM, = 271 BHP, where the App. 1 figure was 310 HP.

Other data

	Appendix 1	DASO 1133
R	“7.5”	6.5
IVP ATA	“3.2”	“2.5 kg/cm^2 boost” = 3.42 ATA.

This DASO 1133 figure is out of step with the power and boost data given (below) for the later 158/159 engines, and is therefore disregarded. The App. 1 figure is more likely.

Eg. 28 1950 Alfa Romeo 158 (per DASO 1133; previously considered to be 159)

From DASO 1133.

CORRECTION

Power

The ref. has 350 CV @ 8,500 RPM, = 345 BHP, where the App. 1 figure was 370 HP @ 8,900 RPM.

Other data

	Appendix 1	DASO 1133
IVP ATA	"3.5"	2.5 kg/cm^2 boost = 3.42 ATA.

Eg. 29 1951 Alfa Romeo 159M

From DASO 1133.

CORRECTION

Power

Appendix 1 had 400 HP @ 9,000 RPM.

The DASO 1133 figure for the Barcelona spec. engine is 425 CV @ 9,300 RPM, = 419 BHP. The figure at 9,000 RPM is 411 BHP.

As an **ADDITION** a Power Curve* is shown at RHS:-

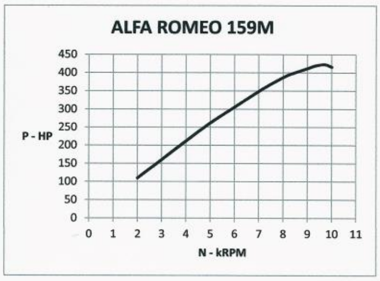
*The figures at lower RPMs are suspect.

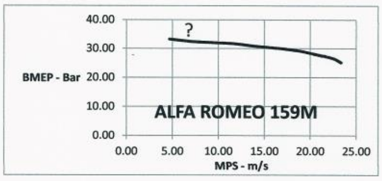
POWER CURVES

Eg.	29
DASO	1133
YEAR	1951
Make	Alfa Romeo
Model	159M
Vcc	1480
Ind. System	PC
Confign.	IL8
Bmm	58
Smm	70

N kRPM	P HP	MPS m/s	BMEP Bar
2	110	4.67	33.26
3	161	7.00	32.45
4	212	9.33	32.05
5	262	11.67	31.68
6	306	14.00	30.84
7	349	16.33	30.15
7.5	369	17.50	29.75
8	387	18.67	29.25
8.3	396	19.37	28.85
9	412	21.00	27.68
9.3	419	21.70	27.24
9.7	423	22.63	26.37
10	416	23.33	25.15

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



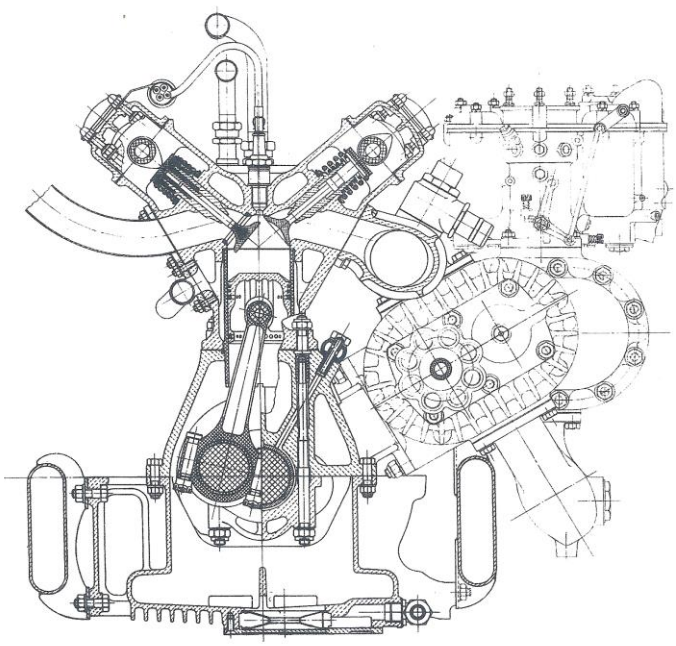


Other data

	Appendix 1	DASO 1133
R	7.5	6.5
IVD mm	36	*Port* 30
IVP ATA	3.9	3 kg/cm^2 boost = 3.9 ATA.

ADDITION

A section of the 159M from (1133) is shown below.



CORRECTIONS & ADDITIONS

ADDITION

18 November 2015.

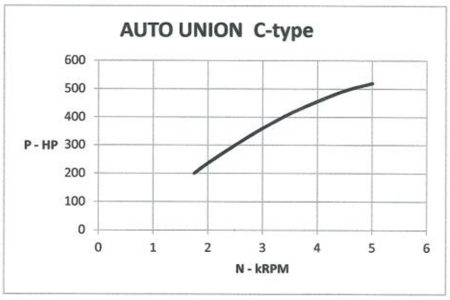
Eg. 22 1936 Auto Union C-type

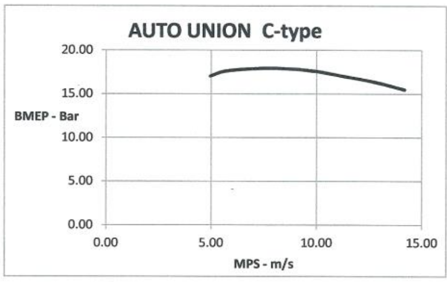
From DASO 1132
A Power Curve is shown at RHS.

POWER CURVES

Eg.	22
DASO	1132
YEAR	1936
Make	Auto Union
Model	C
Vcc	6,008
Ind. Systen	PC
Confign.	45V16
Bmm	75
Smm	85

N	P	MPS	BMEP
kRPM	HP	m/s	Bar
1.75	200	4.96	17.02
2	236	5.67	17.58
2.5	300	7.08	17.87
3	360	8.50	17.87
3.5	413	9.92	17.58
4	456	11.33	16.98
4.5	494	12.75	16.35
5	520	14.17	15.49





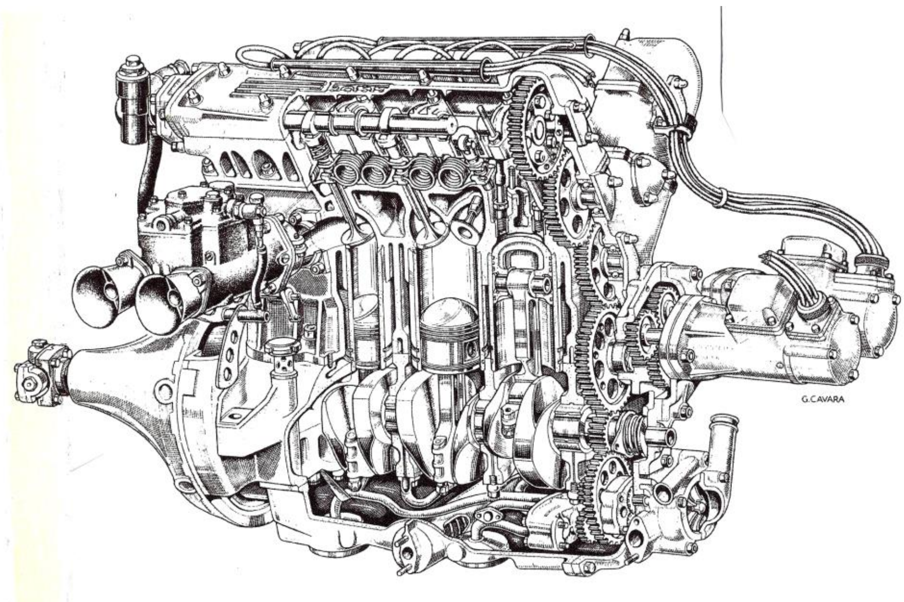
CORRECTIONS & ADDITIONS

ADDITION

18 November 2015.

Eg. 31 1953 Ferrari 500

From DASO 1135 a cutaway drawing is shown at RHS.



References
DASO 1132. *Automobile Quarterly* Vol. 8 No. 1 1969.
Article by K.Ludvigsen. Advised by courtesy of Ron Rex, October 2015.
DASO 1133. LE VETTURE ALFA ROMEO dal 1910. L.Fusi. Ed. Adiense. 1965.
Advised by courtesy of Ron Rex, October 2015.
DASO 1135. 1953 Ferrari 500 cutaway published by *Quattroruote.*
Copied to the author by courtesy of Ron Rex, July 2015.

CORRECTIONS & ADDITIONS

ADDITION

16 January 2016

2nd Naturally-Aspirated Era (2 NA) Part 2

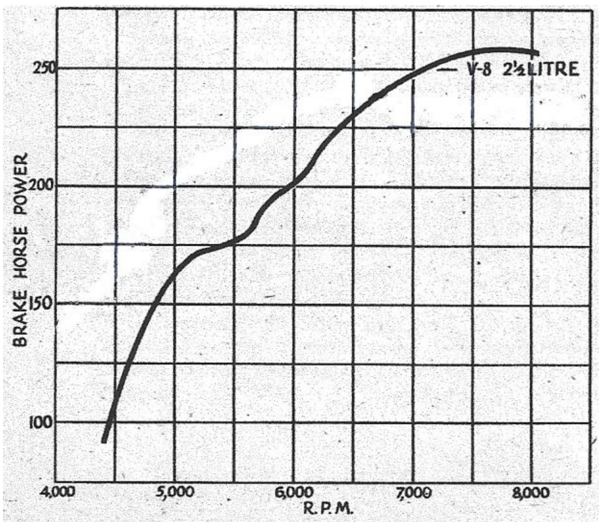
Eg. 38: Concerning the Coventry Climax type FPE 90V8 2.5L

Connaught and Kieft both spent money preparing to race the Climax FPE engine in 1955. Their efforts were, of course, abortive.

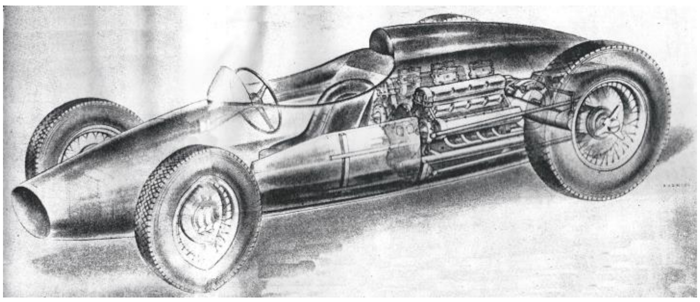
Connaught

This company's first Grand Prix car was the B-type, front-engined with an IL4 2.5L Alta, which was shown in August 1954 with streamlined bodywork. The fitting of the Climax FPE had been contemplated but Denis Jenkinson in *Racing Car Review* (*RCR*) *1955* (covering the 1954 season) reported:-" *During the summer a V8 Coventry Climax engine was put through some test-bed running by Connaughts but it was found to have an entirely unsuitable power curve for the….new car. There was slightly more power…than…the Alta engine, but a less useful torque curve…the engine was subsequently discarded for use in the new car for the time being*".

The FPE Power Curve shown here [from *Motor 9 December 1959*] illustrates the kink between 5,000 and 6,500 RPM which Connaught disliked. This kink was probably from unfavourable inlet tract resonances.



In parallel Connaught had designed a completely different car to take the FPE, intended for the 1955 season, the mid-engined C-type. *Autosport 4 December 1953* had a drawing of this project, shown at the RHS:-



Since Climax decided not to go on with the FPE the C-type Connaught never appeared. *RCR 1958* reported that, after rough assembly, it was broken up.

A special 5-speed pre-selector gearbox/rear axle unit had been designed by Connaught for the higher-revving FPE. When the company was forced to give up and the assets were auctioned in September 1957 a prototype of this unit was included in the sale.

The auction included a serial number "C 8" car which was actually a space-frame version of the front-Alta-engined B-type with (probably) the revised De Dion back axle and inboard disc brakes of the original C-type.

If Climax had known that their engine had a superior Power/Weight ratio to the continental competition (see Note 61) they could have re-tuned it for less top-end power and a better torque curve to meet Connaught's objection.

Kieft

This firm built two chassis in 1954 to take the FPE. When Kieft gave up racing these were sold into private hands. Similarly Climax disposed of their FPE engines.

In September 2002, after 48 years, and much effort (including some chassis mods. and the replacement of parts whose life was doubtful, the chassis and engine were united as had been intended. It was then campaigned in VSCC events. A full account of this saga can be read on the internet in the provenance article prepared for Bonhams when the completed car was auctioned in September 2012. It is still racing. The car is illustrated below:-

Wikipedia article on Climax engines

An interesting detail is that Climax had redesigned the FPE cylinder heads to 2 plugs/cyl. during development (and these was fitted to the Kieft unit, although only 1 plug/cyl. was used). On the later derivative FPF IL4 1.5L engine, 1 plug/cyl. was found to give the best results (*Motor 10 October 1956*) and this was kept during subsequent enlargements up to 2.5L.

CORRECTIONS & ADDITIONS

CORRECTION

21 January 2016

Progress over 64 years of Grand Prix racing:- 1951 to 2014

Fig. PA2 – 9

The R.R.C. Walker Cooper driven by Maurice Trintignant which won the 1958 Monaco GP was actually a new T45, not the modified T43 driven by Stirling Moss which won the preceding 1958 Argentine GP. It was fitted with a Climax FPF engine slightly enlarged further on the bore from 1,964 cc to 2,014 cc (*M. Sport June 1958)*. This must have been an Alf Francis modification, since it is not referred to in Hassan's FPF paper (33).

CORRECTIONS & ADDITIONS

ADDITION

21 January 2016

Egs. 47/62. 1968/1982 Cosworth DFV: The Unique Cosworth Story

The new authorised biography of Keith Duckworth by Norman Burr (DASO 1136, see ref. below) provides some extra details on the Cosworth DFV.

1967

- (p.87). The first engine (701) was written-off because BSA "Gold Star" steel wire coil valve springs were fitted and one of these failed and a valve went through a piston. Later valve springs were made by the German specialist Schmitthelm (p.88).
- (p.87). The lash-up needed for oil scavenging was despite having run extensive tests on a 1-cylinder rig before the system design was finalised. This adds to the caution about rig-tests given in Note 106.
- (p.89). The electro-mechanical rev-limiter fitted initially was not a success because it needed to count 10 firing strokes to act and before that the over-revving would have damaged the engine.

1971

- The crankshaft damper fitted as a mod.in 1970 when in valve-gear vibration trouble was removed after the quill hub was successful.

1981/1982

- Ti-alloy was introduced for valve-spring retainers and later for inlet valves.

DASO 1136. *FIRST PRINCIPLES. The official biography of Keith Duckworth, OBE.*
N.Burr. Veloce. 2015.

CORRECTIONS & ADDITIONS

ADDITION

Eg. 54. Introductory remarks on the 1972 Ferrari 312PB

23 January 2016

Eg. 54. Introductory remarks on the 1972 Ferrari 312PB

These remarks described the crank problems of the Ferrari 312 engine, reporting that when this was fitted in the 1971/1972 312PB sports-racing car the 4 bearing GP crank had to be replaced with a 7 bearing crank to obtain more than 24 hour life.

Actually, in 1972 the other-wise all-conquering 312PB team, although entered for Le Mans and run in the Test Weekend, was withdrawn a week before the race. Denis Jenkinson reported (*Motor Sport July 1972*) "*the flat-12-cylinder engine failed to stand up to very long flat-out tests*".

In the 10 312PB wins/10 races contested in the Prototype Sports Car Championship the longest race was the Sebring 12 Hours (finished 1st and 2nd), the usual time being about 6 hours.

It seems 24 hours at Le Mans speeds was thought by Enzo Ferrari to be "*A race too far*"!

CORRECTIONS & ADDITIONS

ADDITION **29 January 2016**

Significant Other

Eg. SO 24 Ford-Butch Mock Motorsports (BMS) Nascar

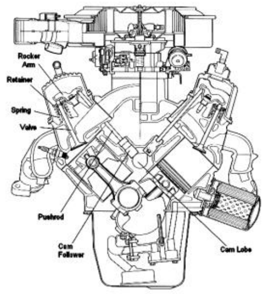
Big 90V8 NASCAR engines with mandatory 2 valves per cylinder (2 v/c) and Push-Rod-operated Overhead Valves (PROHV) and steel Coil Valve Return System (CVRS) run up to values of Mean Piston Speed at Peak Power (MPSP) which are nowadays quite usual (MPSP = 22.7 m/s in Eg. SO24) but at exceptional values of Mean Valve Speed (MVS*), considering their valve gear.

In SO24 MVS at Peak Power was estimated at MVSP = 4.7 m/s on the assumption that Inlet valve Opening Duration (IOD) was 354^0. This is discussed on P.19.

*MVS = $\frac{12 \times \text{Inlet Valve Lift (mm(} \times \text{(RPM/1000)}}{\text{IOD}^o}$ m/s (1st defined in DASO 1139, see below).

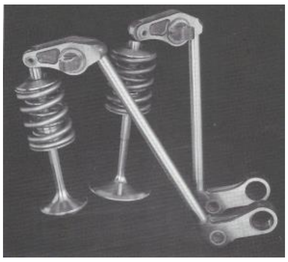
A section of the basic Ford Small Block engine from which the racing engine was derived is given RHS.

(www.epi-eng.com)



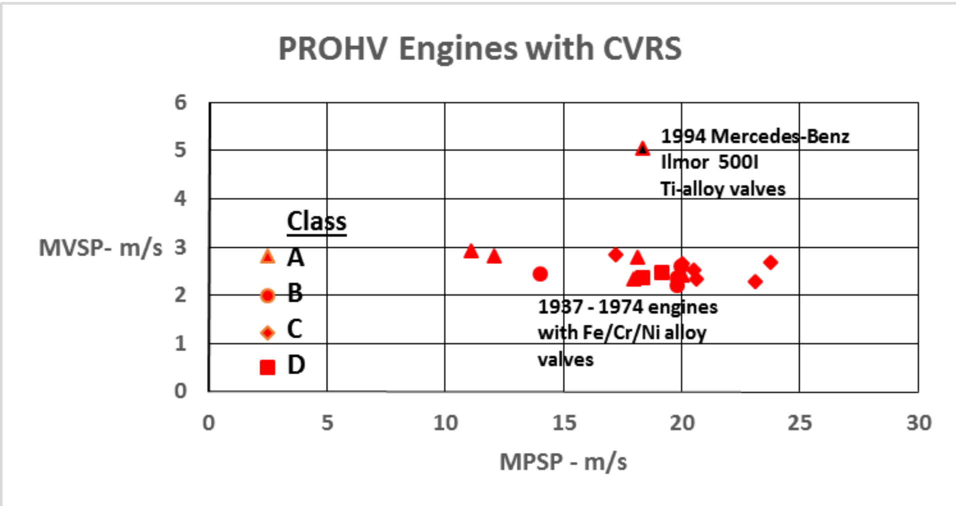
The IOD of 354^0 is the timing used by Mario Illien when designing the special 2 v/c PROHV Mercedes-Benz 500I 90V8 3.43 L TC engine for the 1994 Indy 500 race (this unit took great and successful advantage of a rule change which was *intended* to encourage development of *US stock block* engines) (468). The valve gear is shown RHS (468).

As on the US engines the valves were Ti-alloy with drilled stems.



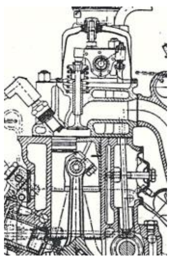
The 500I MVSP was 5 m/s at MPSP = 18.37 m/s.

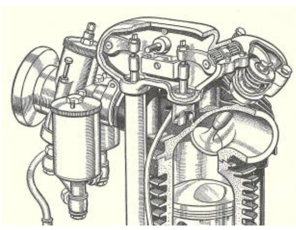
The PROHV gain by using this valve material (and more "scientific" cam profiles) is shown very clearly by the chart below:-



PROHV engines with Fe/Cr/Ni- alloy valve material over a wide range of Classes (defined below) are shown to have averaged about 2.5 m/s, i.e. only half of the engine with drilled Ti-alloy valves.

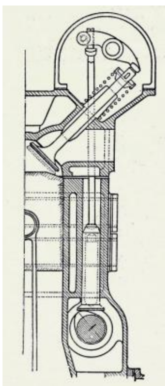
<u>**Class A**</u>:- Plain crankcase-camshaft push-rod-and-rocker gear with Valve Included angle (VIA) between 0 and 40^0.
Figure example shown:- BMC A-type used as the basis of the 1963 Formula Junior.
Engine plotted at MPSP = 11.14 m/s and MVSP = 2.92 m/s.
(Figure credit *M. Sport May 1964)*

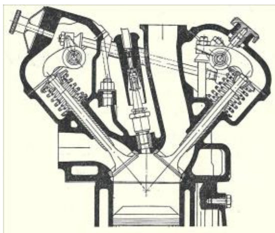




<u>**Class B**</u>:- As A with VIA between 41 and 90^0.
Example shown:-1947 JAP 500cc Speedway,
Plotted at 19.80, 2.37.
(DASO 73. *MOTOR CYCLE ENGINES, 1951*)

<u>**Class C**</u>:- "Riley"-type (RHS)
with high dual camshafts and VIA = 90^0
Eg.1937 ERA C-type, plotted at 23.81, 2.67
(*M.Sport March 1959)*





Class D:- "BMW-328"-type with exhaust operated by by 2 pushrods, VIA = 80^0.
Eg. Bristol 605 representing BS4,
plotted at 19.20, 2.45.
(M. Sport March 1959)

Hollow-head valves?

It seemed possible that some of the NASCAR engines could be running with Ti-alloy valves which not only had drilled stems but also had hollow heads to further reduce mass. Del West, the specialist manufacturer of Ti-alloy valves, was asked that question in 2014. They replied that, although such valves had been tested, none had been raced because there is a minimum mass rule for these parts.

Other valve gears for comparison

Engine	Valve operation	Valve Material	Valve Return System	MVSP/MPSP m/s
1938 Norton 500 TT	Double Overhead Camshaft (DOHC)	Fe/Cr/Ni alloy	Steel Hairpin (HVRS)	3.14/21.22
1955 Mercedes-Benz M196	DOHC	"	Desmodromic (DVRS)	5.18/19.49
1982 Cosworth DFV	DOHC	Ti-alloy inlet, Fe/Cr/Ni exhaust	Steel Coil (CVRS) [With damping between 2 springs]	4.96/24.40
2006 Cosworth CA/6	DOHC	Ti-alloy	Pneumatic (PVRS)	11.6/25.51 [*Assuming* IOD = 320^0]

Reference

DASO 1139 The Piston Engine; article by S. Tresilian; ***Automotive Design Engineering 3 February 1965.***

CORRECTION?

4 February 2016

Note 78. The engine Stewart Tresilian designed for Connaught

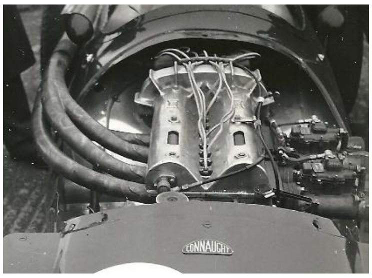
The advantage from increasing Bore/Stroke ratio

Stewart Tresilian (RHS DASO 1139) was a pre-WW2 advocate of reducing the Stroke(S)/ Bore(B) ratio of Normally-Aspirated (NA) poppet-valve piston engines as a way of increasing the Volume Specific Power (Power/Swept Volume (PP/V)). With a "Bottom-End" limit of [Mean Piston Speed (MPS)]^2 set by the piston material this would allow higher RPM – *provided* that the "Top-End" limit, characterised by [Mean Valve Speed (MVS)]^2, set by material and gear design could be managed (MVS defined in footnote on P.18). He proposed to do the latter by returning to 4 valves per cylinder (4 v/c) from the 2 v/c which had been general for NA engines since the 1922 FIAT Grand Prix design. With the total valve area the same as required for 2 v/c the individual valve lift would be reduced by a factor of 1/√2 and so, at the same MVS limit, the RPM could be 41% higher. In 1939 he envisaged an S/B ratio of 0.75 (B/S, as now more commonly used, = 1.333) (DASO 1138, see refs. below). The degree of change suggested is shown by comparing this with the B/S of the NA engine with the highest PP/V of the time, the 1938 Norton TT 500 cc 1-cylinder motorcycle, at 0.87. This was 2 v/c. The 2 v/c sports Lagonda 60V12 4.5 litre which Tresilian had just designed under W.O.Bentley had B/S = 0.89.

The Connaught engine design – the size question

It is generally known that Tresilian designed for Connaught in 1952 or thereabouts a 4-cylinder high B/S engine with 4 v/c ((587) and Note 78). The late Brian Lovell reported this as 2 litres. It is now thought that this was a misunderstanding. Although races at the time were being run to the 2 litre NA F2 rules, this was only a temporary situation. Already, in October 1951, rules had been promulgated for a 2.5 litre NA/0.75 litre PC formula to begin in 1954. It is very unlikely that Connaught would have wanted a new 2 L engine which could only have been ready for half of a 1953 season, unproven, at the best. Their desire must have been for 2.5 L.

This view is supported by an article by John Bolster which appeared in *Autosport 4 December 1953* describing how Connaught wanted to enter full Grand Prix racing in 1954, if a financial crisis of the moment could be survived. The firm told Bolster that they would first use a new 2.5 litre IL4 Alta engine for the "B"-type car they had in hand (see figure on RHS showing the 1956 engine), the V8 Coventry Climax would take over as soon as it was available and " *in reserve there is a four cylinder of Connaught design which will be developed if necessary*". This is a clear indication that the new IL4 was 2.5 L.



Unfortunately, although money was found to race the Alta-engined B-types until it ran out in May 1957, obtaining as the high point the October 1955 Syracuse victory, the Climax engine was not suitable and was dropped by its builders anyway (as described on P.16). Some work *was* done on the alternative IL4, as will be described.

The new IL4 engine parts offered for sale

When Connaught Engineering had to close all the assets were put up for auction in September 1957. The sales catalogue included the following:-

LOT
270 **Quantity of components and patterns for 4-Cylinder Connaught Racing Engine,** including 3-5 Bearing Laystall Crankshafts 8-100 m.m. Bore Liners, Crankcases and Bearing Caps, and 4 Part Machined Con rods

It is not known if this Lot was sold or, if sold, who bought it.

Probable engine dimensions

Given the Bore was 100 mm, a 79.5 mm Stroke would give 2,497.6 cc and B/S = 1,258. This compares with the 1.333 which Tresilian might have wanted ideally. Perhaps the specialist liner makers (Laystall 'Cromard'?) could only supply at 100 mm?

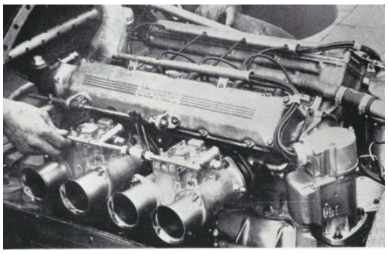
If the engine *had* been *originally* designed for 2 litres (and then a stretched 79.5 mm stroke crank made or contemplated for the new formula) the possible Stroke dimension would have been 63.6 mm for 1,998 cc and B/S would have been 1.572. This seems unlikely at that date.

The conclusion is that the Tresilian engine *was* a 2.5 litre.

Design considerations

The Alta which Tresilian's design might replace was B/S = 93.5/90 mm = 1.039. Originally, with sand-cast Al-alloy pistons, it was limited to 6,700 RPM to give a life for a race finish, which did not give enough power to win classic GPs. Mike Oliver fitted forged pistons in mid-1956 and it could then run to 7,500 (MPS = 22.5 m/s) reliably (701), but still not enough to defeat the opposition.

Tresilian knew in 1952 that Ferrari had already built an IL4 2.5 litre with 2 v/c of 94/90 mm = 1.044. Even, perhaps, limited to a Bore of 100 mm by liner supply he could anticipate beating that. The expected return of Mercedes-Benz in 1954 was something else! Nevertheless, Ferrari *did* succeed in beating the German car twice in that year, but *by using redesigned 2 v/c engines of 100/79.5 mm* (see figure at LHS (DASO 790)), the very B/S ratio which Tresilian had adopted for his 2.5 litres! These new Ferrari engines had VIA of 100^{0} and history tells us that such a wide VIA with high compression ratio was generally disappointing in BMEP because the "humped" piston gave an "orange-peel-shaped" combustion chamber. What VIA Tresilian used is not known. He went on to BRM in 1953 or 1954 to design a high B/S ratio 4 v/c engine for them of B/S = 4.05''(102.87 mm)/2.95''(74.93) = 1.373, just about the ratio which he had proposed in 1939. The finally-resulting IL4 had VIA = 79^{0}, still too wide for high Combustion Efficiency, but this may have been a Berthon choice when he rejected the Tresilian 4 v/c in favour of 2 v/c with hollow lightweight valves. This was a good idea in theory but in practice it was bedevilled for 2 years by inability to weld soundly the necessary head closures (1141).



Some other deductions on the Connaught design

- It would, of course, have been DOHC to operate its 4 v/c. The engine built by BRM had hairpin valve springs (HVRS, until 1960) but again this may have been a Berthon choice;
- The crank is known from Lot 270 to have had 5-bearings. Tresilian changed his mind when he designed the BRM unit because that was only 4-bearings with a massive counter-weight in the centre (this is shown in DASO 1140). His reasoning for this was given later in DASO 1139:- "*Counterweights should be situated where main bearing loads would be high, and bearings where the loads are* low" Another Berthon alteration, in 1958, was to use 5-bearings because it was thought that the crank was deflecting at the back and causing cam driving gear failures (DASO 1141); Tresilian is known to have been unhappy about that (1138). It is hard to see how a shaft 2 3/8''/2 1/2'' in diameter supported by 2 bearing at the back could deflect enough to damage a spur gear. There seems to be no specific report that the cam gear problem was solved. Cam-gear-train resonance with torque excitation is well known to have caused failures with the Cosworth DFV of 1967, the Ilmor-Chevrolet of 1985 and long before that with the first Rolls-Royce aero engine in 1915. Certainly the 5-bearing crank engine still vibrated and caused car problems in 1959 – sheet-metal failures (see Note 118 Part 2) and a tremendous crash when a front brake pipe fractured (DASO 56).

  Tony Rudd in DASO 40 states the 1958 5-bearing crank cost nearly 19 HP compared to the 1957 4-bearing, as measured by heat-to-oil.

- The BRM engine had 4-bolt con-rods (also shown in DASO 1140) and it is probable that the Connaught was the same;
- Since Tresilian wanted a top-flange-located cylinder liner for the BRM (following Rolls-Royce *Merlin* 100 Series with which he was familiar) (DASO 1137), he would have chosen the same for the earlier engine. Once again Berthon selected something else - liners screwed into the head like the contemporary Ferrari. Tresilian noted in DASO 1137 that this led to trouble in obtaining liners parallel with each other.

The ultimate success of high B/S and 4 v/c – with additional ideas

The Berthon modified P25/P48 IL4 BRM with B/S = 1.373, having numerous problems and, perhaps, not the best team management, only achieved one classic Grand Prix victory in 6 years. With the now-reliable hollow 2 v/c layout and B/S = 68.5 mm/2'' (50.8 mm) = 1.348 in the new P56 V8 for the 1.5 litre formula of 1961 the concept finally came good in winning the 1962 Championships. Sadly, Stewart Tresilian died in May 1962 at the age of 58 and did not see that. But the final success of high B/S and 4 v/c came in 1967 when two additional features were added to Tresilian's 1939 idea in Keith Duckworth's Cosworth DFV, having

B/S = 3.373'' (85.67 mm)/2.55'' (64.8 mm) = 1.322 :-

- Narrow VIA (32^0) to give a flat-top piston – developed by Weslake in a 1964 research unit;
- "Barrel turbulence" (aka "Tumble swirl") – developed by Duckworth in the Cosworth FVA of 1966.

In 1989 the advance of higher B/S ratio would be furthered by the use of all-Ti-alloy valves and, from 1990, by the Pneumatic Valve Return System, so that by 2005 B/S had reached nearly 2.5. This will now never be exceeded as the FIA in 2014 introduced more prescriptive rules limiting B/S to about 1.5.

References

DASO 1137. I Mech E talk on *Racing Cars* by S. Tresilian, 19 March 1962.
DASO 1138. CV of S.Tresilian by R.Hodgson 2001. See www.designchambers.com
DASO 1139 The Piston Engine; article by S. Tresilian; *Automotive Design Engineering 3 February 1965.*
DASO 1140. www.ianmacfarlane.co.uk
DASO 1141. *Autocar* 4 April 1958.

CORRECTIONS & ADDITIONS

19 February 2016

ADDITION

Note 12. Speed Correlation Function (SCF)

The SCF provided a good prediction for NP for most CoY engines:-

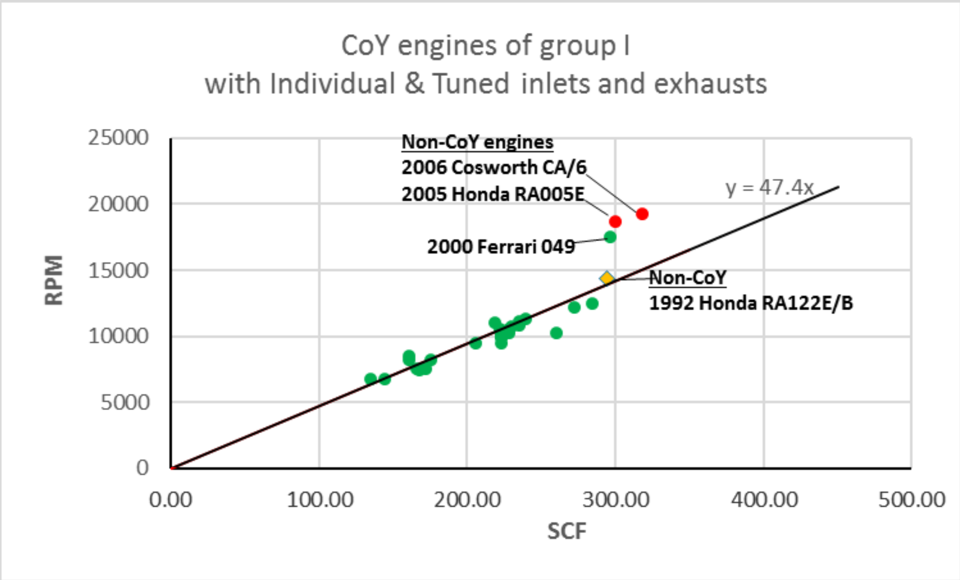
- For an 18 engine sample of the **T** group (**Tortuous Inlets and Simple Exhausts)** the mean deviation from **NP = 38.6 x SCF** is **5.7**%;
- For a 15 engine sample of the **I** group (**Individual and Tuned Inlets and Exhausts)** the mean deviation from **NP = 47.4 x SCF** is **3.6**%.

However, Eg. 85, the 2000 Ferrari 049, was 22% above the predicted NP. In Note 12 it was suggested that this might have resulted from the IVL/IVD ratio of 0.384, significantly higher than earlier engines.

Two later engines have extended the data:-

- SO29 2005 Honda RA005E;
- SO25 2006 .Cosworth CA/6 (The IOD for this engine is *assumed* to be 320^0).

These are shown on the Figure on P.24. They are also well above the prediction:-



While the CA/6 at 28% above prediction had IVL/IVD = 0.387, the RA005E at 31% had only 0.325. This seems to disprove the earlier suggested effect of high IVL/IVD causing the extra speed.

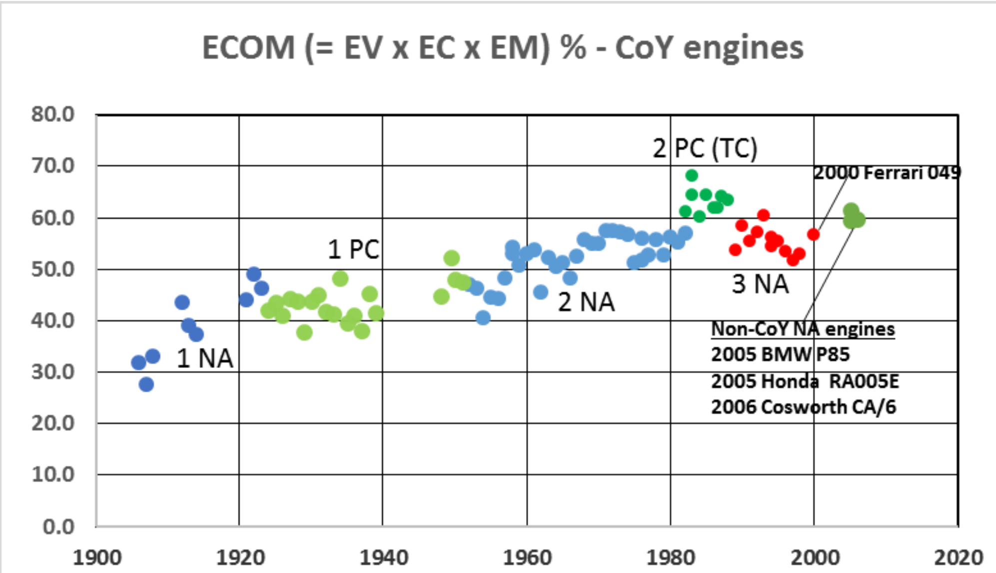
Other possible causes of NP >> 47.4 x SCF

Efforts were made in the later years of the 3rd Normally-Aspirated Era (3NA) to reduce friction which had been increasing as NP was pushed up. Better lubricants were produced and the new surface coating treatment Diamond-Like Carbon(DLC) was introduced from 1994 (see Note 103). The application of DLC was steadily extended.

These anti-friction actions may have produced the extra speed above prediction.

Higher Efficiency

If friction *was* much reduced from about 1994 onwards, this should show in higher values of Combined Efficiency (ECOM = EV x EC x EM). The Figure below shows that this was the case:-



The hypothesis of reduced friction leading to NP up to 30% higher than SCF derived from earlier engines seems to be valid. It may be disproved when complete data is available for the engines of 1989 to 2006. It is hard to know when that much-to-be desired situation might arise, considering that Renault have never released officially even the Bore and Stroke of their RS series from 1989 to 1997. Neither have Mercedes for their 1998 – 1999 engines.

P.S. on current RPM

The age of ever-rising Grand Prix engine RPM is now over for ever. The “Red Line” reached 20,000 in the first year of the 2.4L V8 formula in 2006, a maximum of 26.5 m/s.

The FIA decreed a reduction to 19,000 in 2007 and then to 18,000 in 2009 – these lower speeds helped to achieve the longer engine lives also mandated.

The 2014 1.6L V6 TC formula imposed a maximum fuel flow rate of 100 kg/hr at 10,500 RPM so that there was no point in going far beyond that at a weakening Fuel/Air ratio. TV telemetry seems to show flicks up to 12,000. The rule limit of 15,000 RPM was always going to be a dead letter, and it is surprising that it was ever specified. With the also-prescribed cylinder dimension of 80 mm Bore leading to 53 mm Stroke a maximum in practice of 12,000 RPM represents 21.2 m/s.

CORRECTIONS & ADDITIONS

26 September 2016

3rd Naturally-Aspirated Era (3NA)

Eg. 75 1992 Renault RS4

It was recorded in Eg.75 that Renault would not supply significant data on any of their engines in the 3rd NA Era, even 18 years after their retirement in 1997.

This policy changed in 2016 when Haynes were given some internal details of the RS3C and RS4 of 1992 for their book on the Williams FW14B (DASO 1184; see References below). This provided Bore (B) and Stroke (S) for these two engines and also the Valve Head Diameter for their Inlet and Exhaust Valves (IVD & EVD). A reproduced works drawing enabled the Maximum Valve Lift (VL) to be scaled and also confirmed the 20^0 non-orthogonality of the inlet port giving Tumble Swirl.

Difference in B/S from Appendix 1

	Appendix 1, Eg. 75	Actual
RS3C	-	93 mm/51.5 = 1.806
RS4	93 mm/51.5 = 1.806	96 mm/48.3 = 1.988

Therefore Appendix 1 actually gave the *correct* figures for the RS3C which was raced very successfully in 1992 up to and including Round 10 (Germany), securing 8 wins with the FW14B. After that the RS4 took over as the race engine. As described in Eg. 75 the simultaneous imposition by the FIA at very short notice of "real petrol" as fuel then caused a loss of reliability. The Win/Race ratio dropped from 8/10 to 2/6.

The increase in B/S for the RS4 over the RS3C was much greater than suspected at the time. Consequently the 1993/94 RS5/RS6 were probably the same as the RS4. The 3 litre engines from 1995 to 1997 shown in Appendix 1 may or may not be correct in B/S ratio.

1992 Renault RS4

www.allf1.info/links.php

Valve data

For the first time values of Valve Diameter have been given in DASO 1184. It is interesting that these correspond to the general non-dimensional ratios in Note 107 for Narrow VIA/4 v/c engines, as shown below:-

Contd. on P.26

Contd. from P. 25

	RS3C	RS4	Note 107 trend
VIA		20^0	
IVD/B	38.4 mm/93 = 0.413	39.6 mm/96 = 0.413	0.411
EVD/IVD	32/38.4 = 0.83	33/39.6 = 0.83	
Valve actuation	DOHC; PVRS; tappets	DOHC; PVRS; finger followers	
IVL/IVD		10.75/39.6 = 0.271	
EVL/EVD		13.6/33 = 0.412 The value of EVL/EVD Is a complete surprise!	

It is not possible to measure the Inlet Valve Opening Duration (IOD) from the drawing, but it is clear from the cam shape that it must have been of the same order as the "*classic*" Cosworth valve timing of 58/82//82/58 giving IOD = 320^0 . This value is assumed in the standard performance analysis shown at Col. B in Appendix 9. Renault did not give the RS4 value of Peak Power for DASO 1184 but the good sources DASO 563 and 589 agreed on 760 HP @ 14,200 RPM and this has been retained.

Speed Correlation Function (SCF)

At +16% the value of GS shown at Row 119 in Appendix 9 is disappointingly higher than the SCF trend of 47.4 (*disappointing* for this analyst – but *gratifying* for Renault, whose V10 produced as much power as its rival V12 Honda RA122E/B which gave 764 HP @ 14,400 RPM on "real petrol" (DASO 69)). Following the argument in C & A at p.23 19 February 2016 it is possible that Renault in 1992 were already making use of the ultra-low-friction surface treatment Diamond-Like Coating (DLC). Note 103 speculated that this might not have been used until 1994, but there is no firm data on this.

World Championships

In the active-suspension Williams FW14B the 1992 Renault engines powered the Drivers' Championship (Nigel Mansell) and the Constructors' Championship, gaining at last the honours which had eluded them for 15 years.

References

DASO 69. JSAE 9301494
DASO 563. *Autocourse* 1992 Annual.
DASO 589. Heritage Motor Centre. Data panel for 1992 Williams FW14B on exhibition.
DASO 1184. WILLIAMS FW14B. S. Rendle. Haynes. 2016.

CORRECTIONS & ADDITIONS

29 September 2016

2nd Naturally-Aspirated Era (2NA)

Eg. 35 1957 Maserati 250F

DASO 1185 (Referenced below, advised by Ron Rex) gave some details of the 1957 Maserati 250F.

The main difference from Eg. 35 is that it shows the Inlet Valve Head Diameter (IVD) was increased from the initial 46 mm to 48. DASO 27, referring to the "large port" engine but without quoting the size, dates it to April 1955. The associated carburetter change was from 42DCO3 to 45DCO3 (Carb. Bore area/Valve area change from $42^2/46^2$ = 83.4% to $45^2/48^2$ = 87.9%).

Both the Maserati works and Stirling Moss privately experimented with fuel injection into the inlet ports in place of Weber carburetters. Note 118 Part 1 (p. 7) and Note 118 Part 2 (p. 2) give illustrations of the systems used and the resultant effects. These were considered to be unsatisfactory and neither persisted with the change.

There were small differences in IVL and IOD from the figures used from 1954 Maserati build records. Contd. on p. 27

Contd. from p. 26

The power output was confirmed at 271 HP @ 7,500 RPM. Eg. 35 expressed a 10% doubt on the power because of a known tendency for Maserati to exaggerate (see Note 6). There is no mention by Alfieri of Nitromethane in the fuel.

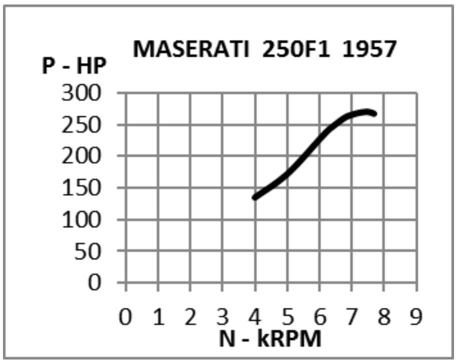
The new figures are incorporated in the standard performance analysis in Appendix 9. A Power curve is shown below.

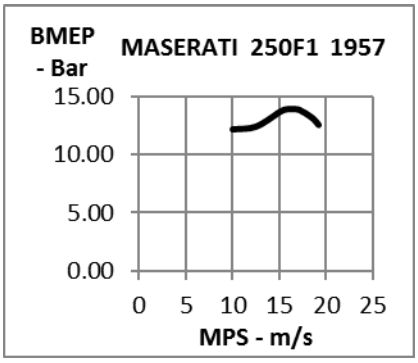
Regarding the re-calculated Speed Correlation Function (SCF), this is still close in GS to the trend value of 47.4

POWER CURVES

Eg.	35			
DASO	1185			
YEAR	1957			
Make	Maserati			
Model	250F1			
Vcc	2494			
Ind. System	NA			
Confign.	IL6			
Bmm	84			
Smm	75			
	N	P	MPS	BMEP
	kRPM	HP	m/s	Bar
	4	135	10	12.11
	5	172	12.5	12.34
	6	227	15	13.58
	6.2	238	15.5	13.77
	6.4	247	16.00	13.85
	6.8	262	17	13.83
	7	266	17.5	13.64
	7.2	269	18	13.41
	7.5	271	18.75	12.97
	7.7	268	19.25	12.49

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





Fangio at the Nurburgring

The most famous race of the Maserati 250F was that won by Juan Fangio in 1957 at the old 22.80 km (14.167 mile) Nurburgring. During this race he drove a record lap about which he admitted "*I never drove quite like that before and I never drove quite like that ever again!*" (DASO 1083). It is interesting to put this into perspective with other fastest laps on that circuit with 2.5 litre Naturally-Aspirated formula cars over 1954 – 1958, as follows:-

Contd. on p. 28

Contd. from p. 27

Date	Car	Driver	Nurburgring lap time Practice (P) or Race (R) Min. Sec.		Speed kph (MPH)	
1954	Mercedes-Benz W196	Fangio	P	9. 50.1	139.10 (86.43)	Datum
1955*	"	"	P	9. 33.3	143.17 (88.96)	+2.93%
1956	Ferrari-Lancia D50	"	R	9. 41.6	141.13 (87.69)	+1.46%
1957	Re-surfaced (DASO 1083)					
	Maserati 250F	"	R	9. 17.4	147.26 (91.50)	+5.87%
1958	Vanwall	Moss	R	9. 9.2	149.45 (92.87)	+7.45%

*No 1955 German GP. Time set in Mercedes works test with short-wheelbase W196 (215 cm, 8.5% less than 1954 235 cm chassis). DASO 32.
No 1959 or 1960 GP at the Nurburgring.

Fangio in 1957 at the age of 46 brought Maserati their only F1 Championships and only the 2nd "GP Car-of-the-Year" in their 33 year participation in Grand Prix racing (the 1st was the 8C3000 in 1933). However, unlike their rivals, they had always built GP cars for sale, carrying on from Bugatti in that way. Maserati no. 2508 is famous as the car which enabled Stirling Moss to show his ability.

References

DASO 27. MASERATI. A. Pritchard. ARCO. 1976.
DASO 32. DESIGN and BEHAVIOUR of the RACING CAR. S. Moss & L Pomeroy. Kimber. 1963.
DASO 1083. FANGIO – a Pirelli Album. S.Moss. Pavilion. 1991.
DASO 1185. Les Moteurs de Course. G.Alfieri. VII Congres Technique Internationale de la FISITA. 1958.

CORRECTIONS & ADDITIONS

5 October 2016

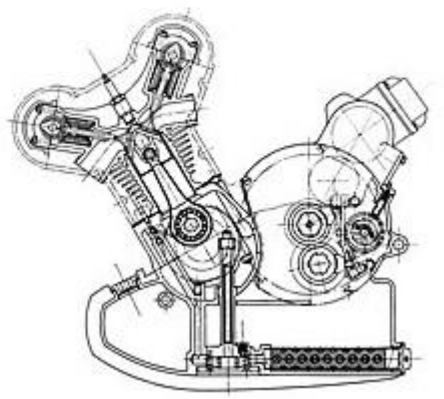
Gilera 1957 500 cc and 1939 Rondine 500 cc

Through the courtesy of Mitchell Kay of MV Meccanica Verghera Ltd, who have replicated 1957 Gilera 500 cc racing motorcycles from an original, detailed data has become available on this engine (DASO 1187. See References below). During the career of the machines there were practically no internal details ever released. A standard performance analysis is given in Appendix 9. The power of the replicas was given as 56 HP @ 10,000 RPM. It is believed this is a back-wheel rolling-road figure and so 10% has been allowed for tyre and chain losses to assume 62 HP at the crank, as for other engines analysed. This is still about 10% less than Gilera claimed and which was repeated in Appendix 4 (not an unusual situation with Italian power outputs, quite apart from the 1.4% smaller Cavallino Vapori!).

A cross-section of the engine by Mark Kay is shown.

1957 Gilera Grand Prix
Transverse IL4a/c 52 mm/58.8* = 0.884 499.5 cc
62 HP @ 10,000 RPM

*58 mm 1948 – 1953.
The 1948 engine was claimed to give 45 HP @ 8,500 RPM. Claims for later developments are tabled in Appendix 4.



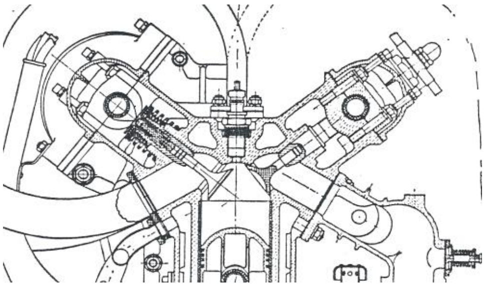
Contd. on P. 29

Contd. from P. 28

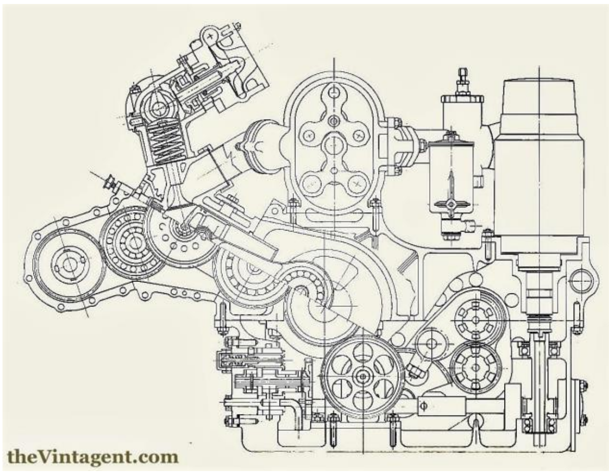
Gilera Rondine

The post-WW2 Normally-Aspirated (NA) Gilera transverse 4-cylinder aircooled (a/c) 500 cc engines, designed under the direction of Piero Remor and raced from 1948 to 1957, were strongly influenced by the pre-War Pressure-Charged transverse 4-cylinder watercooled Gilera. This was developed from the Compagnia Nazionale Aeronautica (CNA) Rondine (*Swallow*) engine designed in 1933 by Carlo Gianini, which was itself an outcome of a transverse 4-cylinder aircooled 500 cc conceived and built in various forms by Gianini and Remor from as early as 1923 – the full history is given in DASO 1188. The work of PieroTaruffi as development engineer, rider and team manager at various times over the history of these machines up to 1955 is also very important.

It is clear that the Rondine "top-end" was modelled on the Alfa Romeo "P3/P3B" of design dates 1931 - 1933. This can be seen by comparing the engine sections below.



1933 (Design) Alfa Romeo P3B
Bore 68 mm
DASO 184



1933 (Design) CNA Rondine
Transverse IL4 w/c
52 mm/58 = 0.896 493 cc

The item at the top of the inlet camshaft is a water pump.
The vertical item on the RHS is the magneto.

The following features were common between the P3B and the Rondine:-

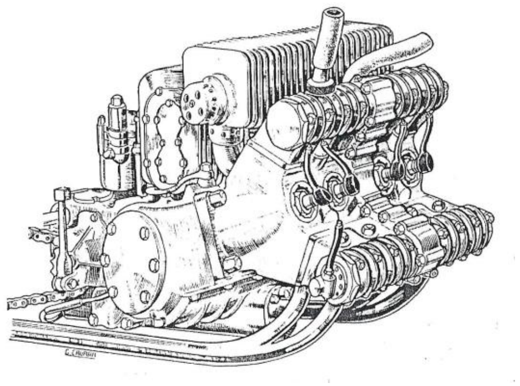
● DOHC* ● Wide VIA (100^0)** ● IVD/B = 0.6 (31 mm/52 = 41/68)*** ● Mid-camshaft-drive*
● "Mushroom" tappets* ● Updraft inlet ports* ● Masked sparking plugs*
● Integral head and block ● Al-alloy static structure with Fe-alloy dry cylinder liners*
● Water-cooled
● Roots supercharger (but Bugatti-type 3-lobe rotors with labyrinth tip seals, not plain 2-lobe).

There were two features where Gianini did not follow Vittorio Jano's P3B:-

1. The B/S ratio was much higher: 52 mm/58 = 0.896, not 0.68.
   The original Gianini/Remor 4-cylinder of 1923 had been 51/60 = 0.85.
   [Carlo Guzzi had been resurrecting high B/S since his 1919 prototype 500 cc had 88 mm/82 = 1.073, although in 1926 he settled on 68 mm/68 = 1 for a new 250 cc.]
2. The "bottom-end" bearings were roller (and presumably ball), where Jano had used plain bearings (Note 18 discusses the features of each type).

The cross-section of the Rondine is almost certainly of the 1933 design, since the supercharger delivery is direct to the inlet ports. When the motorcycle was sold to Gilera in 1935, Taruffi inserted a plenum chamber-cum-intercooler. This is shown on the drawing on P. 30.

*Carried over to the post-War NA a/c engine. **Although VIA of 80^0 , then 90^0 and *finally* 100^0 have been published for the post-War engines, photos show that it was always 100^0 .
*** Increased finally in 1957 to 34 mm/52 = 0.65.



DASO 1190

1939 Gilera Rondine
75 HP @ 9,000 RPM (see comment below)
NB! No source gives the supercharger pressure. It is *assumed* in the analysis to be the same as the P3B at 1.7 ATA.
Note the camshaft drive in the middle.
Showing the intercooler.
The original design had a water pump driven off the inlet camshaft, which is not seen on this drawing. Possibly it was found that thermo-siphon cooling was sufficient.

The great days of the Gilera Rondine were in 1939, when Dorino Serafini beat Georg Meier's supercharged BMW to the 500 cc European Championship (much to Adolf Hitler's disgust!).

A comment on power. DASO 1188 records the opinion of Harold Willis, the development engineer for Velocette, that the Gilera gave no more than 50 HP! It is suggested that he was judging from the speed relative to his 500 cc single-cylinder but not taking into account the greater frontal area and weight of the Italian bike which sapped driving power. It is known that the BMW had 55 HP (DASO 30 reporting works data). It was a 14% lighter motorcycle (302 lb v. 350; DASO 1188), although also hampered by its frontal area, and the Gilera beat it.

References
DASO 30. B.I.O.S. 21 (post-WW2 Intelligence report on German auto industry). HMSO. 1949.
DASO 1187. www.mv-agusta.co.uk. Data courtesy of Mitchell Kay 14 September 2016.
DASO 1188. GILERA ROAD RACERS. R. Ainscoe. Osprey. 1987.
DASO 1189. www.theVintagent.com.
DASO.1190. ITALIAN RACING MOTORCYCLES. M. Walker. Redline. 1998.

CORRECTIONS & ADDITIONS

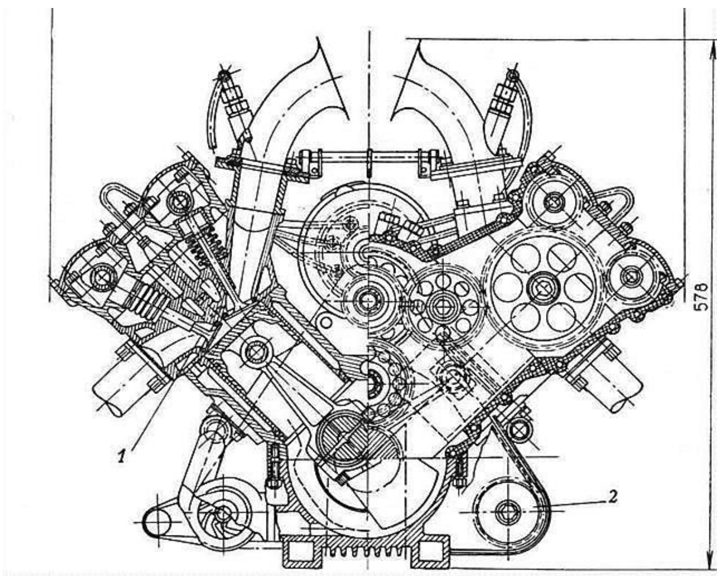
10 October 2016

2nd Naturally-Aspirated Era (2NA)

Eg. 47 The Unique Cosworth Story

When "The Unique Cosworth Story" was written no full cross section of the DFV engine was known to this author. A, perhaps belated, search of the Internet has now found the drawing shown at RHS.

Credit:
- March 701.Formule1constructorsf1.com



This section enables a correction of a detail on Fig. 47D of Eg. 47 – the oil scavenge offtake in the crankcase. The original figure was known to be wrong by the advice of Michael Costin; the new illustration shows how the oil was swept horizontally into the cast-in scavenge channel by the windage from the rotating crank.

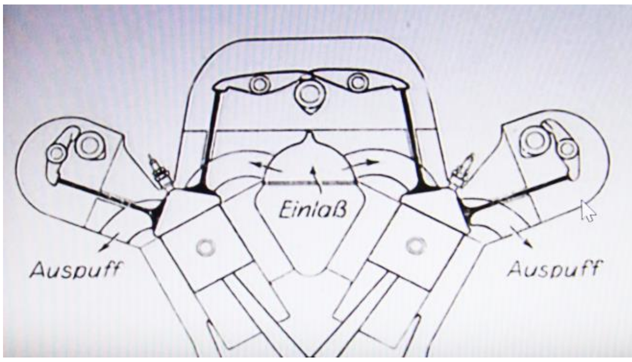
As a March 701 installation the section is of a 1970 DFV. The curved inlet horns may not have been used in practice.

CORRECTIONS & ADDITIONS

10 October 2016

ILLUSTRATIONS for Appendix 5 Part 1

Fig. 19 1939 Auto Union D-type



www.youtube.com. Racing the Silver Arrows of Zwickau

This 60V12 engine continued the Auto Union 45V16 economy on camshafts to some extent (it had only one) by operating 4 rows of valves with three camshafts. The way this was done is illustrated in the figure at LHS.

Although the figure is diagrammatic, it is probably to scale.

Addendum to Maserati 250F

15 October 2016

Power absorbed in oil supply

Guilio Alfieri included in DASO 1185 an interesting note on the power absorbed by the oil pumps in the 2.5 Litre 250F. With a plain bearing surface total of 156 square centimetres fed at 6 kg/square centimetre (85 psi) these required 18CV representing 6% of the power before deducting the pump loss.

CORRECTIONS & ADDITIONS

6 January 2017

ADDITION

How many valves per cylinder?

This article described engines with 0, 1, 2, 3, 4, 5 and 8 valves per cylinder (v/c), with a P.S. on 6. A correspondent has now kindly supplied data on a 1980 Yamaha experimental Grand Prix engine with ***7*** v/c (DASO 1192; see references below)!

The “missing link” therefore existed and the series from 0 to 8 is complete.

Background to the Yamaha experiment

Yamaha racing motor-cycle engines were 2-stroke from their start in 1957 with the smaller classes. They gradually built larger engines until, in 1974, they won the Manufacturers’ Championship in the premier 500 cc class. Yamaha improved this in 1975 when Giacomo Agostini won the Riders’ Championship as well, the first 2-stroke-mounted rider to do this on a 500.

During the following years, all won on 2-strokes, Yamaha gained both Championships in 1978, 1979, and 1980.

Honda’s 4-stroke attempt to beat the 2-strokes

Meanwhile, Honda, who had retired from a very-successful participation with 4-stroke engines in all classes of Grand Prix motorcycle racing in 1967 (although they had never won the premier Riders’ Championship) had returned to 500 cc competition. They believed that a 4-stroke could still win, although their previous method of raising Volume-Specific Power by increasing the number of cylinders was now denied by a FIM rule introduced in 1970 limiting 500 cc engines to 4 cylinders. The 2-strokes were developing 120 – 125 HP (see Appendix 4}. Honda’s last 500 cc 4 cylinder engine in 1967, the RC181, produced 95 HP @ 14,500 RPM (11.8 Bar @ 21.7 m/s)(DASO 354)(see Note 92). If BMEP could be maintained at the RC181 level then to get, say, 130 HP would require 14,500 x (130/95) = about 20,000 RPM. If the MPSP was still limited by piston material to 21.7 m/s then the Stroke (S) would have to be 32.6 mm. Actually, Honda chose 36 mm (DASO 1193). A circular Bore (B) would then be 66.5 mm and B/S 1.85.

Continued on P. 32

Continued from P. 31

To retain the same breathing as the RC181 the IVA/PA ratio would have to be the same (0.326). If this was done with 4 valves per cylinder (2 inlet), as used in all the earlier Honda engines, it would mean IVD = 27 mm. But the MVSP would be beyond the limit set by the valve gear technology of the time, using steel-alloy valves with steel Coil-spring Valve Return System (CVRS); assuming IVL = 0.3 x IVD and IOD = 300^0 it would be 6.5 m/s, where (with the same assumptions) the RC181 was 4.2 m/s. More smaller valves with less lift were therefore needed and Honda chose 8; (4 inlets with IVD = 19.5 mm). How then to accommodate 8 v/c? Thinking "Outside the circle" gave the answer:- a "race-track" section! The dimensions were:- length 93.4 mm and width 41 mm, the ends being semi-circular, and PA = 138.75 cm^2. The IVA/PA ratio was 0.344. The 4 inlets in a row were opposed by 4 exhausts.

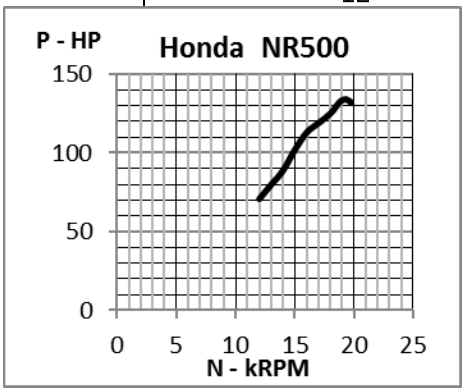
Honda raced the NR500 for 3 years but never looked like beating the 2-strokes in Grands Prix. Development had taken the power up to a competitive level – 134 HP @ 19,250 RPM (12.47 Bar @ 23.10 m/s)(DASO 354) – but weight was against it. Four overhead camshafts with their driving gears and 32 valves with 64 springs were all extra to the 2-strokes.

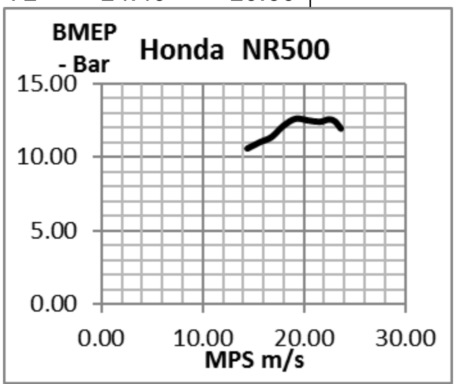
A power curve is given below.

POWER CURVES

PEP		N	P	MPS	BMEP
DASO	354/ 1193	kRPM	HP	m/s	Bar
YEAR	1983	19.75	132	23.70	11.97
Make	Honda	19.25	134	23.10	12.47
Model	NR500	18.75	132	22.50	12.61
		18	125	21.60	12.44
Vcc	499.5	17	119	20.40	12.54
Ind. System	NA	16	113	19.20	12.65
Confign.	90V4	15	102	18.00	12.18
Bmm	"66.5"	14	89	16.80	11.39
Smm	36	13	80	15.60	11.03
		12	71	14.40	10.60

Powers as published were kW and have been multiplied by 1.34 to convert to HP





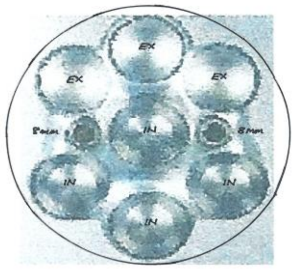
Yamaha 001A 4-stroke

Yamaha, the 2-stroke Champions during the inception and building of the Honda NR500. undoubtedly got to hear about it. They seem to have decided to hedge their bets for future wins by producing their own 4-stroke 90V4. All the considerations listed above for the Honda would have applied to the Yamaha design, but, although they probably knew about the "Race-track" cylinder, they did not hesitate to use a circular cylinder with B/S = 70 mm/32.4 = 2.160.

Continued on P. 33

Continued from P. 32

However, they could not get 8 valves into the bore but only 7. Their arrangement is shown below (DASO 1192), with 4 inlets and 3 exhausts, and 2 x.8 mm spark plugs.



IVD (by scaling) was 19 mm and IVA/PA = 0.295.

The photo shows that the inlet valves are inclined at about 20^0 to the cylinder axis and the exhaust valves were parallel to it.

DASO 1192 states that the 1980 001A engine produced 123 HP @ 18,000 RPM (12.28 Bar @ 19.44 m/s).
No doubt this could have been improved with development.

Yamaha 2-strokes were supplanted in the Championships by Suzuki in 1981 and 1982, but they never tried to race their 4-stroke. They had the same weight problem as Honda and saw that company could not win races with the NR500. The project was dropped. More analysis is given in Note 92.

Yamaha 5 v/c and 6 v/c engines

Yamaha's description of the 001A engine suggested that they increased the v/c in order "*to improve intake/exhaust/combustion efficiency*". The above reasoning shows that it was forced on them by valve gear design and material in the late '70s if they wished to run at high B/S..

Yamaha did experiment with a 6 v/c engine according to DASO 1192. They stated that their experience did lead them to the 5 v/c introduced in the 1985 FZ750 motorcycle, and this *was* in the belief that higher efficiencies could be obtained (see the basic article "How many valves per cylinder" for more on 5 v/c configurations). They persisted with this v/c into the MotoGP era but finally gave in to the more-or-less standard 4 v/c in 2004.

Increased B/S from the '80s to the '00s

The Honda and Yamaha engine designs with higher-than-typical B/S in the late '70s/early '80s were governed by valve gear, as shown. The advance to ever-higher B/S and higher RPM became possible ***with efficient 4 v/c*** when all-Ti-alloy valves became available, followed by the Pneumatic Valve Return System (PVRS), and then Diamond-Like Carbon (DLC) anti-friction coating (see Note 15). Finally B/S reached 2.465 in the 2005 BMW P85 prototype (see Note 112 and Appendix 1 at SO27). "Finally", because the FIA then ruled out any further increases.

References

DASO 1192. www.rossifumi46.fr. Advised by courtesy of Abel Lord.
DASO 1193. www.motorcyclespecs.co.xa
DASO 1194. www.deejay51.com Motegi Museum pics.

P.S.

The theories for Mean Piston Speed (MPS; at Peak Power this is MPSP)
and Mean Valve Speed (MVS; at Peak Power MVSP)
are given in Note 13 Part I and Part III, respectively.

CORRECTIONS & ADDITIONS

23 May 2017

ADDITION

A tribute to Geoffrey Taylor of Alta

Geoffrey Taylor (1903 – 1966) founded the Alta Car and Engineering Co. in 1931, having already built himself a prototype of a car which he intended to market. The name "Alta" he obtained from a Canadian abbreviation for Alberta and he liked the sound of it. There is actually an "Alta Lake" in British Columbia and it is derived from the Spanish for "High up". Very appropriate.

For over a quarter of a century Alta cars and engines played a significant part in English motor-racing and they all sprang from the mind of Geoffrey Taylor. From 1945 to 1957 he was the only supplier of pure-bred racing engines in the UK (the Bristol engine from 1952, although very effective, was a tuned-up BMW-basis sports car unit).

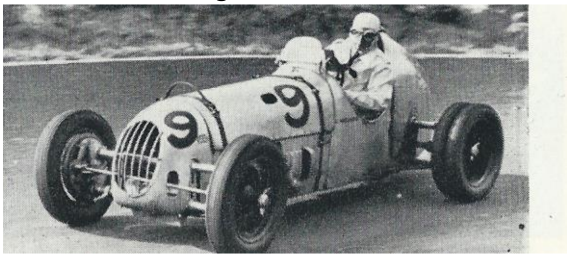
Pre-WW2.

Following his 1929 prototype, the first Taylor car offered for sale was with an engine of IL4 60 mm/95 = 0.632 1,074 cc. It could be bought either Naturally-Aspirated (NA) or Mechanically-Supercharged (MSC). It had an Al-alloy block and head, as did all later Altas. . All Alta engines built were 4-cylinder, DOHC and 2 v/c, with finger cam followers.

In the 8 years before WW2 there followed larger engines:- an IL4 69 mm/100 = 0.69 1,496 cc and an IL4 79 mm/100 = 0.79 1,961 cc. The latter two units were basically the same with different wet liners in the Al-alloy block.

The most successful pre-War Alta was a 2 litre, later converted to 1½ litre, rebuilt in 1937 from a crash and sold to George Abecassis at a figure only a quarter of a new B-type ERA price. His greatest achievement was to beat "B. Bira" driving his famous B-type ERA "*Romulus*" in the 1938 Imperial Trophy at Crystal Palace, a particular stamping-ground for the highly-talented Siamese. The Final was run in heavy rain and Abecassis had ingeniously fitted twin rear wheels, a "first" for circuit racing, though seen before in hill-climbs. See Figs. 1 and 2 below.

Fig. 1



DASO 1

George Abecassis driving his 1½ litre Alta. Note the twin rear wheels. Suspension was all-independent to the Sizaire/Lancia pattern, with all-4 wheels sliding on fixed pillars, the roll axis being at ground level. The driver is apparently wiping his goggles.

Fig. 2

Wikipedia/ John Chapman

A pre-WW2 supercharged Alta engine, not known whether 1½ or 2 litre. Note the twin SU carburetters feeding the low front-mounted Roots-type blower, made by Alta. True 1½ litre output 140 BHP (DASO 737) @ 5,800 RPM.

Post-WW2

Post-WW2 Taylor was quickly off the mark in late 1945 to design a new 1½ litre MSC car, the engine being IL4 78 mm/78 = 1 1,491 cc. Post-War difficulties delayed the debut to 1948. This car also had all-independent-suspension (see Note 66B). Sold to low-budget drivers this GP car and a 1952 F2 2 litre NA adaption did not obtain success.

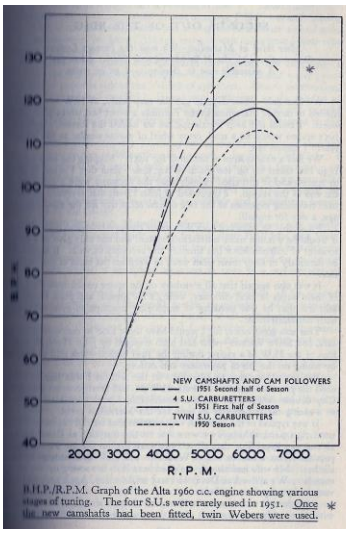
However, Taylor's close neighbours at HW Motors saw the way in 1950 to build and campaign a F2 car with his new 2 litre engine:- IL4 83.5 mm/90 = 0.928 1,971 cc (this is also covered in Note 66B). The power output of this engine in various 1950 and 1951 tunes is shown at Fig. 3 on P.35.

The engines were raced on 80% alcohol-base fuel (DASO 147). Development for the 1951 HWM was carried out with the help of HWM's Chief Mechanic, Alf Francis [seen in Note 66B].

In both the 1950 and 1951 seasons, the former with 2-seater-width bodies and the following year with true *monoposto*s, the overall performance of the HWM team on the smallest of budgets was truly remarkable. The highlight of 1950 was Stirling Moss' 3rd place at Bari behind two 159 Alfa Romeos. In 1951 it was Moss' 3rd place at Monza in a F2 race behind Ascari and Villoresi on two works V12 Ferraris.

The Taylor designed-and-built Alta engines made the HWM team possible. In particular the unit stood up to lengthy slipstreaming by Moss of Villoresi's Ferrari at Monza.

Fig. 3
In 1951 Taylor was one of the first to fit the new Weber double-choke carburetters.
Fuel was 80% methanol (DASO 147)

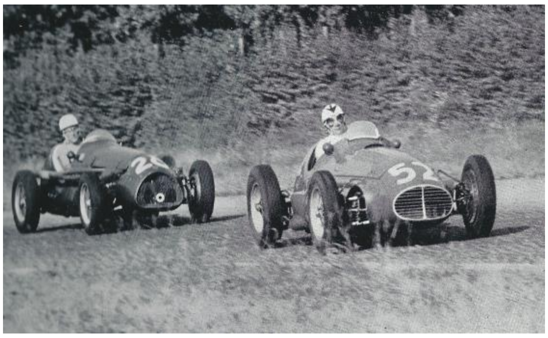


DASO 147

Alta and HWM parted company in 1952 and the internals were redesigned by R.R. Jackson.

However, the following year after Moss decided to rebuild his season around a standard Cooper chassis with his well-tuned Alta engine (dropping a special chassis which did not fulfil its theoretical promise), a combination of SU port fuel injection and Shell nitro-methane additive produced 186 BHP (DASO 1) (Francis reported 200 was seen (147)). The %age of the oxygen-bearing constituent has not been reported.
In the 1953 Italian Grand Prix Moss was able to hold a works Maserati for speed, although far behind in laps from pitstops (see Fig. 4).

Fig.4



1953 Italian Grand Prix.
Stirling Moss slipstreaming a works Maserati driven by Felice Bonetto.
Apart from refuelling stops, with the car doing only 4 MPG on the nitro-methane mix (147) the rear tyres could not stand the speed and lost treads.
With bolt-on wheels much time was lost in changing.

M. Sport October 1953

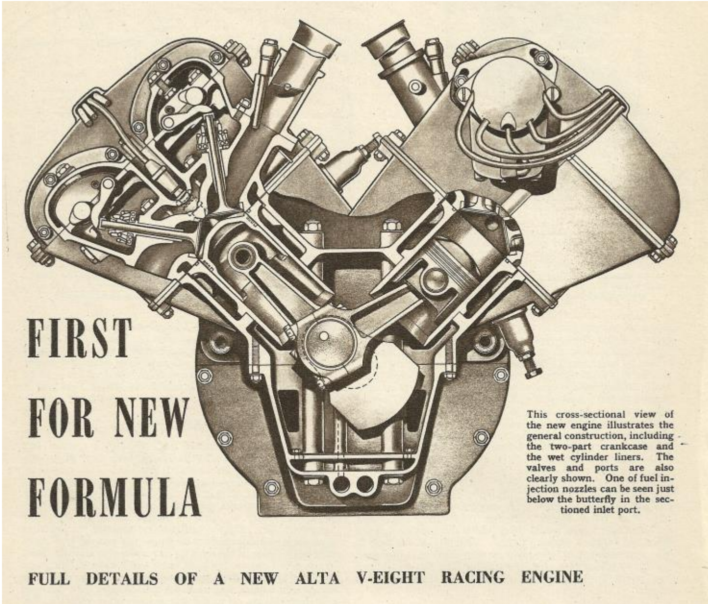
Although not a direct Alta development, this performance again showed the strength of the engine.

Re-tracking a little in time, the FIA in October 1951 had published rules to be effective in 1954 for Grand Prix cars with 2½ litre NA engines (an option at 750 cc PC was generally ignored). Geoffrey Taylor immediately began to design a 90^0 V8 75 mm/70 = 1.071 2,474 cc. This was his first "over-square" project. The result was published in "*Autocar*" 26 December 1952 (see Fig. 5 on P.36). It was stated in the article that a prototype was under construction and "*it is hoped that it will be…ready for test in approximately four months' time*". In fact, the V8 never appeared, for reasons unknown, probably due to lack of development money but also considering what customers could afford to pay for the units.

Continued on P.36

Fig. 5

1952 Alta V8 project
An interesting detail is that the wet cylinder liners were to be held in compression, a basically bad feature (see Note 71B) but the top sealing was to be by Wills rings. These have resilience in compression and so could have accommodated differential expansion.



Instead of the V8 Taylor produced for Connaught in 1954 a. new 4-cylinder engine:- IL4 93.5 mm/90 = 1.039 2,472 cc. It first appeared – in a demonstration of the prototype all-enveloping car – in August 1954, but not in a race until 1955. This engine is included in Illustrations for Appendix 5 at P.14. It had a new feature (presumably in the preceding 2 litre) in that the 4 cylinders were cast as a 1-piece iron block bolted into the Al-alloy crankcase cum water jacket

Over the next 2 years Michael Oliver and the late Brian Lovell of Connaught developed this basic Alta engine, enlarging the 2'' inlet valves by ⅛'' (+13% area) and replacing the sand-cast Al-alloy pistons with forged to permit +500 RPM to 7,500 reliably (22.5 m/s MPS instead of 21). Somewhat ironically Connaught's moment of glory came as early as October 1955, when the "rookie" Tony Brooks thrashed the works Maserati team at the non-Championship Syracuse GP (see Fig. 6). Small British races provided firsts, but Connaught's severely-cash-limited team could not obtain Championship wins. It was forced to close half-way through the 1957 season.

Fig. 6

sportscars.tv

With his customer gone, Geoffrey Taylor called it a day in building racing engines and Alta ceased to exist. His post-War engines had provided much of the basic power to scale the foothills in the climb of British teams to the summit of Grand Prix racing.

CORRECTIONS & ADDITIONS

10 July 2017

2nd Pressure-Charged Era (2PC): Egs. 66 - 68: Porsche P01

My regular correspondent, Ron Rex, has advised me that the long-time Porsche engineer Hans Mezger in his autobiography (DASO 1197) published full power data on the P01 TC engines of 1983-– 1987 (badged as "TAG" after the group which financed them for McLaren).

Mezger's data not only gave the Race power for all the years raced but also the Qualification figures. This is unusually comprehensive. Figures are given below, adjusted to the usual website units. Note that the power figures are *rated maxima* but *not peak* as Porsche did not test the P01 to that condition.

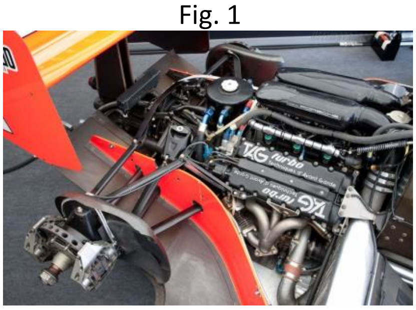
80V6 82 mm/47.3 = 1.734 V = 1,499 cc

	1983	1984	1985	1986	1987
Fuel	102RON Petrol	Same	From mid year, Toluene based	Same	Same`
R	7	7.6	7.8	8.5	8.9
Race rating					
MDR*	2.94	2.94	3.04	3.13	3.31
Maximum Power BHP	769	799	838	888	937
@ RPM	11,400	11,600	11,800	12,000	12,300
MPS m/s	17.97	18.29	18.60	18.92	19.39
BMEP Bar	40.29	41.12	42.42	44.17	45.48
ECOM	66.7%	66.2%	65.5%	64.6%	62.0%
Difference from published Power		+6.5%	+4.8%	+4.5%	
Appendix 1 has been updated to the Mezger data					
Qualification rating					
MDR*	3.0	3.17	3.36	3.45	3.54
Maximum Power BHP	789	848	917	967	1036
@ RPM	11,400	11,800	12,000	12,100	12,300
MPS m/s	17.97	18.60	18.92	19.08	19.39
BMEP Bar	41.32	42.91	45.63	47.72	50.29
ECOM	67.0%	64.0%	63.8%	63.3%	64.1%

*Assuming that the TC intercoolers reduce T2 to 40^{0}C as described in Note 10B.

Fig.1 below shows the right-hand intercooler installation for the P01.

Fig. 1

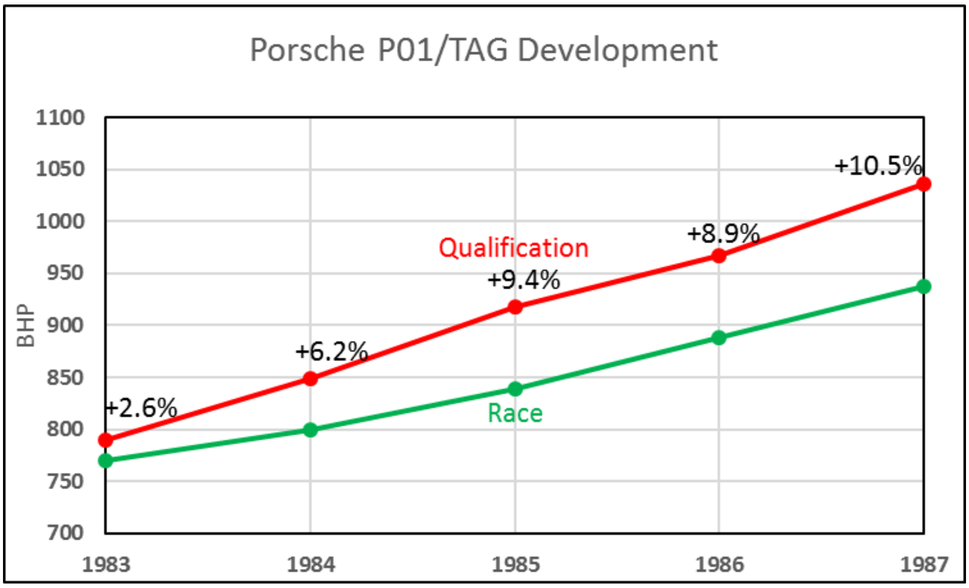


Note that the wastegate position differs from Fig.66A.

enginelabs.com

The relation between Race and Qualification ratings is shown on Fig. 2 on P. 38

Fig. 2

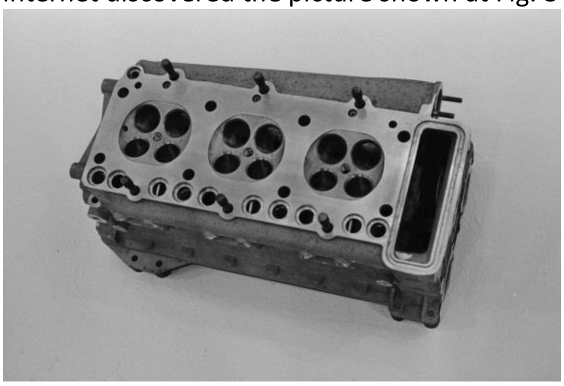


Comparisons with engines in their final development

It is interesting to compare certain parameters in the P01 with two other engines in their final developments:-

	Cosworth DFV 1982D	Porsche P01 1987(not CoY)	Honda RA168E 1988(CoY)
	NA	PC (TC)	PC (TC)
ECOM	57.0%	64.1%	63.4%

Mezger unfortunately did not give any new internal data for the P01. As shown in Note 107 there is doubt over the IVD of 30.5 mm which has been published. A recent search through the internet discovered the picture shown at Fig. 3 below.



From an enlargement it was possible to scale IVD relative to B, the ratio being 0.39 so that IVD = 32 mm. With this dimension the values of MGV for the above 3 engines are given below.

porschecarshistory.com

MGV m/s	75.2	63.7	68.7
BNP m/s	16.1	16.8	16.5

This corrects the remark previously published that the P01 valve gear was "doing well", as it is seen to be in the same ball-park as the others, all being CVRS.

Some P01 parts

No cross-section of the P01 is available but Fig.4 shows some of the critical parts.

The piston shows 4 rings, which is extremely unusual. It is not known which standard of engine is illustrated.

forums.finalgear.com

CORRECTIONS & ADDITIONS

6 September 2017

2nd Naturally-Aspirated Era (2NA) Egs. 54, 56, 57, 59 Ferrari 312B (chassis T1 to T4)

Thanks again to my correspondent Ron Rex, who has passed to me information from the chapter in “*Ferrari Monoposto 1948–1997*” (DASO 1198, see ref. below) written by the designer of the Ferrari 312B, Mauro Forghieri, some updates can now be provided for that series of engines.

	1975	1977	1979
	Drivers’ and Constructors’ Champions (CoY)		
Chassis	T	T2	T4
PP BHP	493	496	513
@ NP RPM	12,200	12,500	12,800
These powers differ from those previously published by:-			
	-0.4%	-2.7%	-0.4%
BMPP Bar	12.09	11.87	11.99
@MPSP m/s	20.17	20.67	21.16
W kg			145
			-9.4%

Appendix 1 has been updated to the DASO 1198 figures.

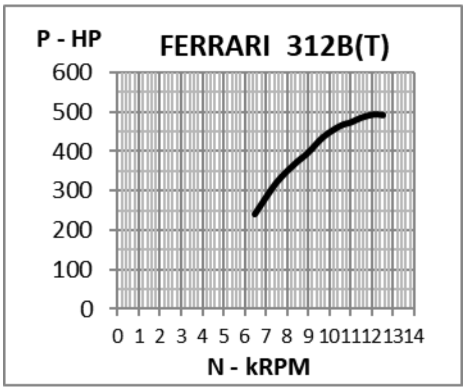
Typical Power Curve

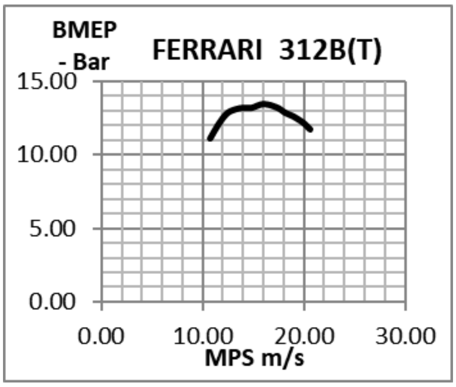
A Power Curve is available for the 1975 engine and is shown below to the standard website format.

POWER CURVES

PEP		N	P	MPS	BMEP
DASO	1198	kRPM	HP	m/s	Bar
YEAR	1975				
Make	Ferrari	6.5	242	10.75	11.14
	312B				
Model	(T)	7	283	11.57	12.09
		7.5	321	12.40	12.80
Vcc	2992	8	350	13.23	13.09
Ind. System	NA	8.5	375	14.05	13.20
	180				
Confign.	V12	9	397	14.88	13.19
Bmm	80	9.7	436	16.04	13.44
Smm	49.6	10.5	464	17.36	13.22
		11	473	18.19	12.86
		11.5	485	19.01	12.61
		12	492	19.84	12.26
		12.2	493	20.17	12.09
		12.5	491	20.67	11.75

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





.Efficiencies

Data is given in DASO 1198 for the 1978 312B(T3) engine (not CoY) which includes the Specific Fuel Consumption (SFC). It enables the Brake Thermal Efficiency (BThE) and Volumetric Efficiency (EV) to be determined by the methods given in Note 37.

PP 500 BHP @ NP 12,500 RPM (11.96 Bar @ MPSP 20.67 m/s)

SFC 250 g/CV.Hr (0.558 lb/BHP.Hr)

BThE = 23.8%

EV = 132%

312B compared with the DFV

The 1979 312B comparison with the contemporary Ford-Cosworth DFV can be updated to DASO1198 figures, as follows:-

Engine	312B	DFV	312B v. DFV
B/S	80/49.6 = 1.613	85.6742/64.77 = 1.323	
PP HP	513	480	+ 6.9%
@ NP RPM	12,800	10,800	+ 18.5%
		Typical	
BMPP Bar	11.99	13.31	- 9.9%
@ MPSP m/s	21.16	23.32	- 9.3%
ECOM	50.5%	55.6%	-5.1 points
BNP m/s	17.07	15.4	+10.8%
W kg	145	≈ 160	- 9.4%
PP/W HP/kg	3.54	≈ 3	+ 18%
IVA/PA	0.272	0.324	-16%
IVL/IVD	0.341	0.301	+13.3%
Crank Factor (100*CP/S)/(BNP)^0.5	14.6	19.3	-24.3%

The Crank Factor is surprisingly small. It is based on a given CP of 30 mm, which was a reduction of the figure given for the original 312 design of 38 mm. It may be a misprint. If it was really 38 the factor would be 18.5.

The performance improvement of the 312B from 1969 to 1979 was from 454 HP (DASO 1198) to 513 (same in 1980), a 13% rise in 11 seasons. This compares with the DFV achieving 405 HP to 535 (Judd-tuned) = +32% in 16½ seasons (see Note 84).

Reference

DASO 1198 Ferrari Monoposto 1948–1997 B. Alfieri Automobilia 1997.

CORRECTIONS & ADDITIONS

22 September 2017

ADDITION

2nd Naturally-Aspirated Era (2NA) Eg 47 etc The Unique Cosworth story

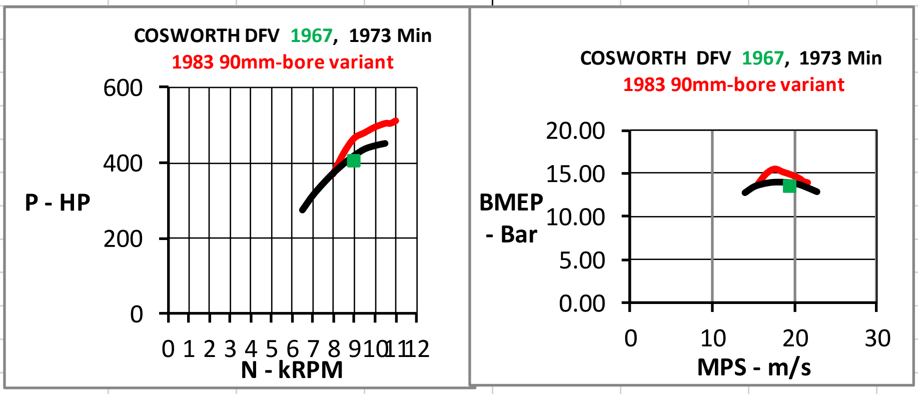
For many years no Ford-Cosworth DFV power curve was published, although presumably purchasers were supplied with them. A curve for the 90 mm-bore, short-stroke, variant was finally (1993) produced in ref. (65) and was shown in this website under Eg. 47. Actually, this should be identified as the “Interim DFY” referred to in Note 88, which was raced by some teams for a period in 1983. A search of the internet recently produced a DFV power curve for 1973, labelled as “Minimum” (see ref. below). (Contd. on P. 41).

This showed a Peak Power (PP) of 450 HP @ 10,500 RPM, which compares with the website "Typical" figure of 460 HP @ 10,250 RPM (Note 84).

This 1973 curve is shown below, compared with the first quoted 1967 DFV maximum power of 405 HP @ a vibration-limited 9,000 RPM and with the 90-bore curve which had PP of 512 HP.@ 11,000 RPM.

POWER CURVES

Eg.				
DASO	www.historic/dfv/specs. L.Gardiner			
YEAR	1973			
Make	Cosworth			
Model	DFV			
Vcc	2987.1			
Ind. System	NA			
Confign.	90V8			
Bmm	85.6742			
Smm	64.77			
	N	P	MPS	BMEP
	kRPM	HP	m/s	Bar
	6.5	276	14.03	12.72
	7	314	15.11	13.44
	7.5	345	16.19	13.78
	8	373	17.27	13.97
	8.5	397	18.35	13.99
	9	418	19.43	13.91
	9.5	435	20.51	13.72
	10	444	21.59	13.30
	10.5	450	22.67	12.84



CORRECTIONS & ADDITIONS

27 September 2017

ADDITION

2nd Naturally-Aspirated Era (2NA) Egs. 45 & 46 REPCO-Brabham 620 & 740

From a source advised to me by my Australian correspondent Ron Rex (DASO 1199, see below) some further authentic details of the REPCO-Brabham types 620 and 740 have been obtained.

1966 Type 620

Generally the figures in Appendix 1 are confirmed.

- Pistons were slipper-type* die-cast Al/Si-alloy. REPCO were proud to be the only F1 engine maker in 1966 who produced their own pistons and rings - "…*even Ferrari used Hepolite pistons…*".
- The 2 iron compression rings were 1/16'' (1.59 mm) wide (w) so that at Peak Power RPM (NP) of 8.000 with a Maximum Piston Deceleration (MPDP) of 2,564 g, the ring factor

w.MPDP = 4070 mm.g (Contd. on P. 42)

This was just on the edge of piston-ring flutter (see Note 13 Part II). The necessarily-long con.-rods were helpful here, with CRL/S = 2.65, as a more usual (for the date) figure of 2 would have raised the ring factor by 5%.

- The dry cast-in iron liners had been retained but these gave trouble by distorting and allowing blow-by. Late in 1966 wet liners were adopted.

*The use of slipper pistons is worth mentioning here because, although not new (Norton had used the type in 1938 at least and eg. also the Climax FPF with which, as technical supporters in the Antipodes, REPCO were very familiar), in 1966 Keith Duckworth's FVA had fully-skirted pistons and his DFV had the same in 1967. This despite Harry Ricardo having invented the slipper-type before using it in his 1922 TT Vauxhall (it was patented in 1918, requiring a royalty for use, but this should have expired in 1938). Post the DFV the slipper piston became universal for racing engines.

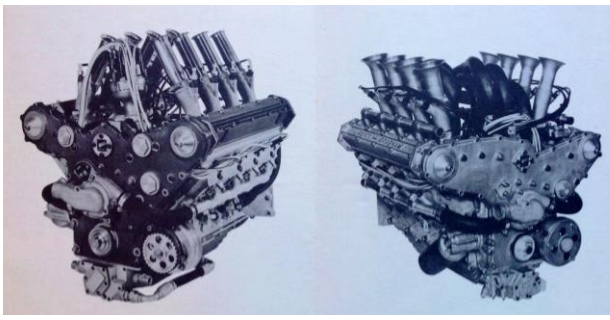
1967 Type 740

Some dimensions for the 740 have now been added to Appendix 1.

- Phil Irving was the designer of the 620 but by late 1966 relations with his boss, REPCO Engine Parts Group Chief Engineer Frank Hallam, had deteriorated. The arrival in Melbourne from England of designer John Judd at Jack Brabham's request, not previously advised to Irving, was the last straw and he left the company. Norman Wilson, after some initial work by Judd, then did the 740 new parts (crankcase, heads and pistons).
- The 740 had a duplex timing chain where the 620 was single.
- The failure of a 740 REPCO-forged con.-rod at Monaco (its first classic GP, in Brabham's pole-sitting car, on the 1st lap!) was found later to be due to a detailing -or possibly machining- clash between the retaining-bolt heads and the rod, causing stress concentrations. Meanwhile Carillo rods had been adopted. Presumably these had that firm's standard "H" section.
- Concerning the heat in the 740 Vee from the central exhaust system, this *did* affect the Lucas fuel-injection distributor. Sometimes a duct was fitted to feed cooling-air into the Vee. Apparently a heat shield cured the problem, but it is still a matter of speculation as to whether the engine power was reduced by heating the inlet tracts.
- An interesting detail is that the main bearing cap-retaining studs were carried through to the top of the crankcase and nutted there. Mechanics sometimes tightened these nuts to such a torque that, under differential expansion of Al-alloy case and steel studs, the latter were over-stressed and broke! As the bearing caps were also cross-bolted in the 740 this presumably was not immediately fatal. It was apparently hard to get the mechanics to keep the cold load down to a level where the studs were just correctly tensioned when hot.

Comparison between 620 and 740

A pictorial comparison between the 1966 (LHS) and 1967 engines is shown below



REPCO via DASO1199

The REPCO-Brabham team and engines were a triumph for the Antipodes in terms of a shrewd concept, technical capability (with Phil Irving's help) and ANZAC drivers and chassis designer. This was achieved with the two bases of the Grand Prix campaigns 11,000 miles apart!

Ref. DASO1199 https://primotipo.com/category/rodways-repco-recollections/.

CORRECTIONS & ADDITIONS

13 October 2017

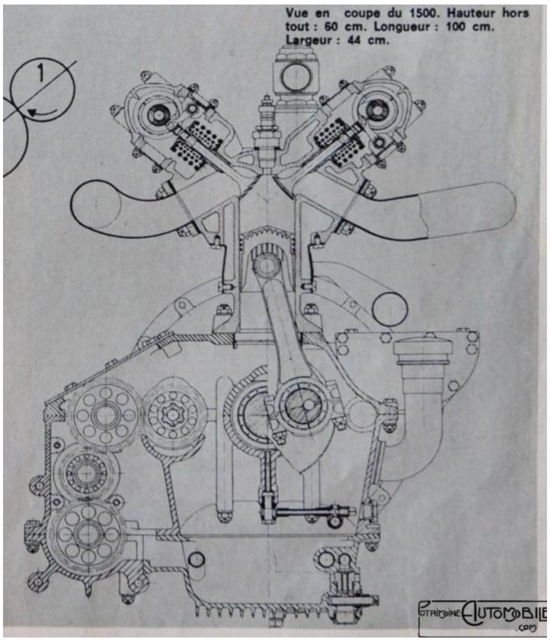
ADDITION

1st Pressure-Charged Era (1PC): Part 1 Eg. 13 1927 Delage 15-S-8

As described in Eg. 13 the 1926-type Delage 15-S-8 had the exhaust on the LHS of the engine (looking aft) and the heat from this burnt the feet of the driver, also seated on the LHS. Therefore, for 1927 the inlet and exhaust systems were reversed.

When Eg. 13 was first written only a cylinder-head portion of a cross-section was available. Since then a full cross-section has been found and this is shown as Fig. 1 below.

Fig. 1



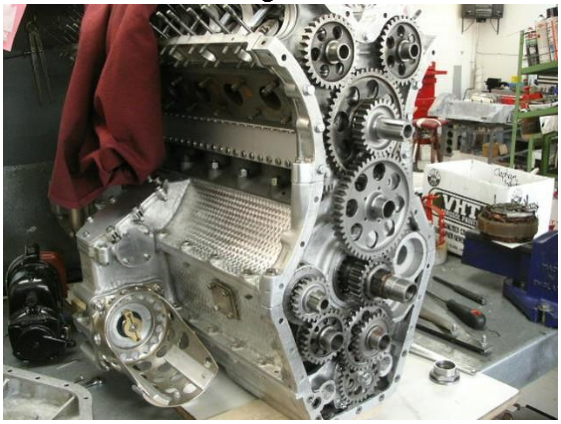
patrimoineautomobile.com

This is looking aft (the flywheel cover at the rear is seen). The gear train on the LHS is actually at the middle of the crankcase, driven by a layshaft to the top RH gear from the gearcase at the front of the crankcase. The purpose of this train was to drive the magneto from the lowest gear (the layout is shown on Fig. 13B of Eg. 13).

This seems a very complicated way to provide the ignition! It is a mirror image of the 1926 method of driving the 2 superchargers in parallel then used on the RHS of the engine (according to the description in ref (4). Unfortunately no photograph of the 1926 layout is known). As stated in (4) this mag. location meant that for 1927 a single x2 length blower had to be driven from the front gearcase.

A photograph of the front gearcase, at Fig. 2 below, shows that this was the same part in 1927 as used in 1926, because the former RHS supercharger drive is still present as a machined location, although no longer used. The opposite LHS gear drove the magneto. The gear with the stub shaft drove the new supercharger at engine speed.

Fig. 2



google. carver

CORRECTIONS & ADDITIONS

14 August 2018

ADDITION

3rd Naturally-Aspirated Era (3NA). Part 2.

Eg. 82. 1998 Ilmor FO110G

Thanks to correspondent Bosse Skanhed, who provided recently a copy of an interview with Mario Illien in *Auto Motor und Sport* for December 2005 (DASO 1202), the author is able to give the official background to that designer's V10 engines over the 15 years 1991 to 2005.

The tabulated figures, plus analysis for BMPP and PP/W are given below.

15 YEARS of ILLIEN'S F1 V10 ENGINES

Source:- *Auto Motor und Sport* December 2005 Interview with Mario Illien. DASO 1202

Year	Type	Config'n.	V – cc	PP – PS	PP – BHP	NP – RPM	BMPP – Bar	W – Kg	PP/W – PS/Kg
1991	2175A	72V10	3499	696	686.5	12800	13.72	126	5.52
1992	2175B	"	3499	765	754.5	14000	13.78	123	6.22
1995	FO110	75V10	2997	690	680.6	15000	13.55	123	5.61
1996	D	"	2997	720	710.2	15500	13.68	123	5.85
1997	E	"	2997	740	729.9	16000	13.62	124	5.97
1997	F	72V10	2998	760	749.6	16000	13.98	113	6.73
1998	G	"	2998	775	764.4	16250	14.04	107	7.24
1999	H	"	2998	805	794.0	17000	13.94		
2000	J	"	2998	805	794.0	17000	13.94		
2001	K	"	2998	810	798.9	17500	13.63	86	9.42
2002	M	90V10	2998	835	823.6	18100	13.58	100	8.35
2003	M	"	2998	870	858.1	18900	13.55	100	8.70
2004	Q	"	2998	905	892.6	18200	14.64	100	9.05
2005	FO110R	"	2998	928	915.3	18700	14.61	97	9.57

Types C, L, N, and P were Research engines and were not raced.

The 2175B was also raced in 1993 and 1994.

It is regretted that, after Ilmor began to supply Mercedes-Benz with 3L engines in 1995 (the FO110 series), they no longer published the Bore and Stroke dimensions. The most that can be said is a quote by Illien in the interview:-

"*Our engines were rather long-stroke. This improved the combustion and the driveability*".

. Fig.1 provides a portrait of Mario Illien and some of his engines.

Fig. 1

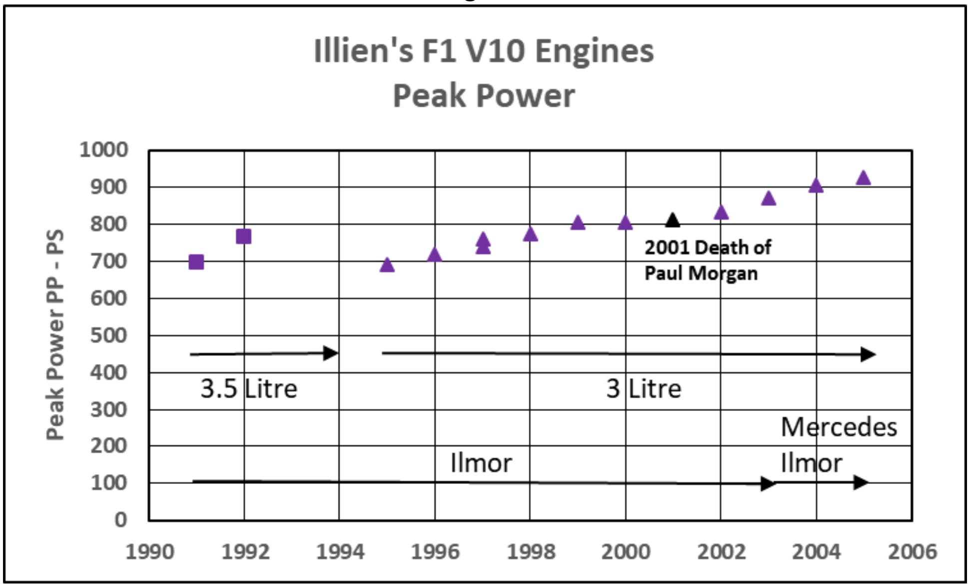
DASO 1202

"., Charts derived from the table are given on P. 45 – 47.

<u>Comments on the charts</u>

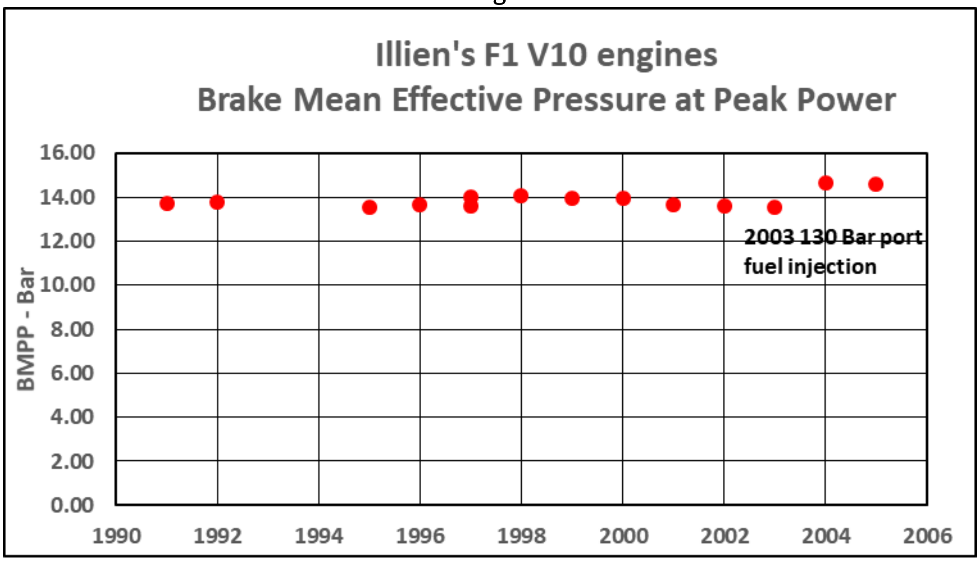
The charts are annotated with significant points in the period. One such was the death in May 2001, in an accident with his Hawker *Sea Fury,* of Paul Morgan, the joint founding partner with Mario Illien (see Fig. 2

Fig. 2



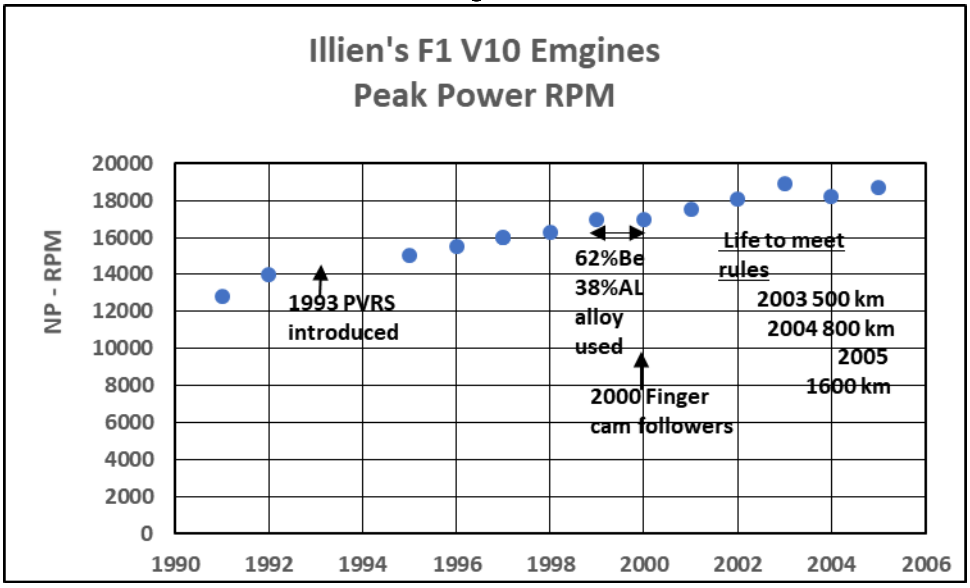
. This led to Daimler-Chrysler buying his widow's 25% company share, + 5%, in 2002 to increase their stake from the 25% bought in November 1993 to 55%. The firm was then re-named "Mercedes Ilmor". Daimler Chrysler purchased full ownership in 2005 and further re-named it "Mercedes-Benz High Performance Engines". Mario Illien left the company.

Fig. 3



From Fig. 3 it will be seen that, over most of the period 1991 to 2003 the BMPP was held at an average of 13.75 Bar, +2%, -1½%. In 2004 the port fuel injection system pressure was raised from 16 Bar to 130 Bar and a 6% BMPP increase was obtained. Therefore, most of the 3L power increase of 26% over the 9 years 1995 to 2003 was obtained was by raising the Peak Power RPM (NP) from 15,000 to 18,900 (+26%) (see Fig. 4 on P. 46)

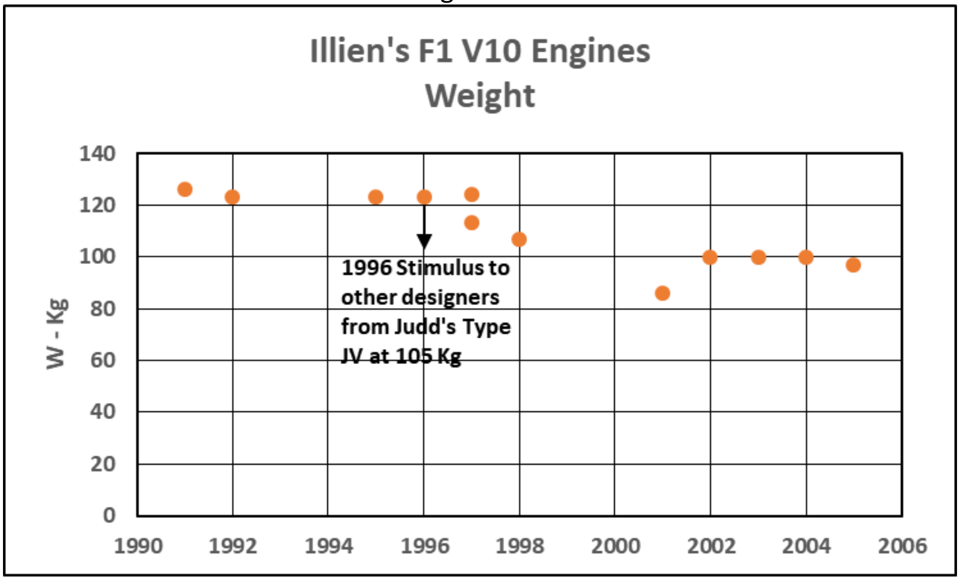
Fig. 4



. Whether MPSP was controlled by reducing Stroke is unknown. This RPM increase process was terminated by permissible stresses after 2003 by FIA -mandated life extensions, first near-doubling and then tripling the life demanded.

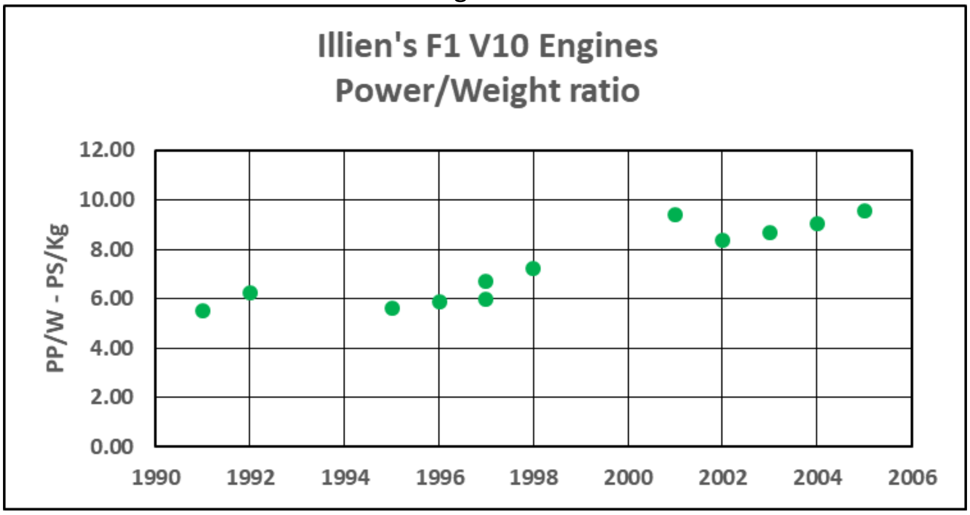
A major influence on engine design was the 1996 re-introduction by John Judd in his Type JV of screwed-in cylinder liners, reducing weight to 105 kg. This was 15% lower than the contemporary FO110D (see Fig. 5

Fig. 5



. Stimulated by this, though without adopting the same construction, Illien managed to get his weight down to a reliable 97 kg in the 2005 FO110R. This final V10, before the formula changed the following year to a prescribed 90V8 2.4L at a mandatory minimum weight of 95 kg, had PP/W = 9.57 PS/kg (9.44 BHP/kg) (see Fig. 6 on P. 47).

Fig. 6



Comparison with Eg. 82

Although the power figure in Eg. 82 was supposed to be official, this may have been *dis*-information. Comparing the 3NA figures with the new data:-

	1998 FO110G	
	Eg. 82 DASO 559	DASO 1202
PP BHP	750	764
@ NP RPM	17,000	16,250
BMPP Bar	13.17	14.04

Actually, the DASO 1202 RPM looks rather low, and therefore the BMPP rather high, in the new series.

The 2005 season

In the article, Norbert Haug of Mercedes claimed that, at the end of the 10 cylinder era,:-

"*We were the benchmark – in 2005 only we had 10 wins*".

In the 19 races, Renault had 8 wins, Ferrari (who were in tyre trouble and despite Michael Schumacher with 7 Drivers' Championships already) only 1. Nevertheless, on points Renault won the Constructors' Championship and their driver, Ferdinand Alonso, the Drivers'.

CORRECTIONS & ADDITIONS

3 October 2018

CORRECTION

Appendix 5 and Illustrations for App. 5 Part 1 p.7 ERA

Information in DASO 838 (see Refs. below), was overlooked previously, regarding the ERA power curve supplied to Rolls-Royce by BRM when they were designing the supercharging system for the BRM T15 (DASO 448). The data was NOT for the E-type engine, which was assumed for App. 5 and Illustrations. It was for the 1½ litre build of Raymond Mays' R4D engine, serial no. 5018, i.e. basically a C-type but with somewhat higher boost pressure from a larger Zoller supercharger.

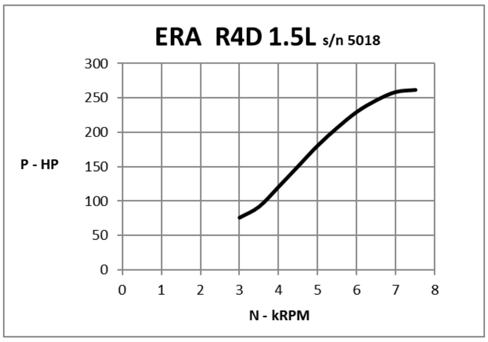
The power curve analysis has therefore been re-worked to C-type B x S and is given on P.48.

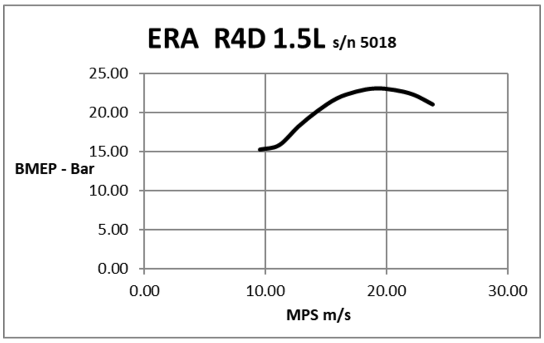
POWER CURVES

PEP	448
DASO	448
YEAR	1939
Make	ERA
Model	R4D s/n 5018
Vcc	1487
Ind. System	PC
Confign.	IL6
Bmm	57.547
Smm	95.25

N	P	MPS	BMEP
kRPM	HP	m/s	Bar
3	76	9.53	15.25
3.5	92	11.11	15.82
4	121	12.70	18.20
4.5	151	14.29	20.19
5	181	15.88	21.79
5.5	207	17.46	22.65
6	230	19.05	23.07
6.5	247	20.64	22.87
7	259	22.23	22.27
7.5	262	23.81	21.02

This curve was supplied to Rolls-Royce to assist in the estimation of the power of the BRM T15.





The MPSP of nearly 24 m/s (nearly 4,700 ft/min) was remarkable for a 3-bearing crank (Hyatt roller centre), carried over with improvements by Murray Jamieson from the 1932 racing Riley.

The E-type 1½ Litre, having a 2 Litre Bore with Stroke reduced from the standard, should in theory have produced at the same BMPP and MPSP higher power in inverse proportion to the strokes i.e. 95.25/80.160 = 1.188. This would have been 311 HP @ 8,900 RPM. In fact, from several data sources, it appears to have given no more power than s/n 5018. It seems probable that this was because the Riley-type push-rod valve gear was already at its limit (see C & A at P. 19) and so RPM could not be increased from 7,500. Nevertheless, the 16% reduction in MPSP *should* have raised the Mechanical Efficiency and given extra power.

At Rheims in July 1939, although in practice Arthur Dobson in GP1 was timed to reach 172 MPH down the N31 straight to Thillois hairpin, his lap speed of 101.8 MPH was equalled by B. Bira in Chula's R12B/C. The high speed on the straight was made possible by a reduction in frontal area from the 13½ sq. ft. of the A – D cars to 9 (-33%). The speed around the rest of the circuit was probably spoilt by bad handling due to chassis deficiencies. ERA, in copying the Mercedes-Benz de Dion rear suspension, had omitted the necessary bearing in the de Dion tube to prevent it becoming a very-stiff torsion bar on roll or 1-wheel bump, causing oversteer. The steering gear and track-rod layout were also poorly designed. The poor handling in immediately post-WW2 races was noted in DASO 779. Much later, when Duncan Ricketts became the owner of GP1 he detected these faults and put them right (Ref. *Motor Sport* www archive Feb. 2004). In his hands the car had achieved its very first win at a VSCC Silverstone race in August 2000.

References

- DASO 448 Supercharging the BRM G. Wilde & F. Allen MIMechE Nov. 64
- DASO 779 1949 Racing Car Review D. Jenkinson Grenville.
- DASO 838 BRM Vol. 1 D. Nye MRP 1994.

CORRECTIONS & ADDITIONS

4 October 2018

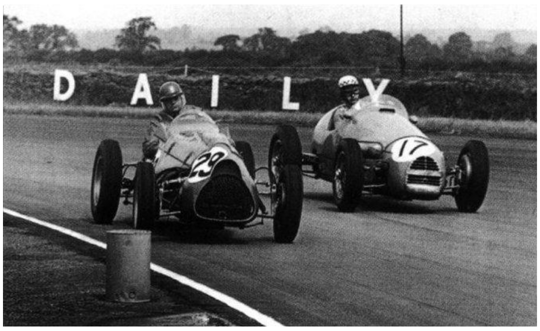
Appendix 5 and Illustrations for App. 5 Part 1 P.14. Bristol

Some further details of Bob Gerard's developed Cooper-Bristol T23 engine were given in *Motor Racing* August 1957. This was additional to the improvement of the chassis road-holding produced by adding transverse torsion bars to each end to reduce the excessive Cooper roll (see Note 66 at Fig.N66A) plus larger-section rear tyres.

In 1955 (possibly done in 1954) the engine was enlarged by removing the dry cylinder liners (used in the later production engines) to increase the bores from 66 mm to 68.7 and the swept volume to 2,135 cc with the 96 mm crank. On methanol fuel this gave 174 HP @ 6,250 RPM (11.7 Bar @ 20 m/s). It was raced with nitro-methane additive once, but this raised so many problems that it was not used again.

Bristol then offered him a special engine they had built before deciding to stop racing their type 450 sports cars after1955 Le Mans (where they had won their class for the 2nd year in succession). This was 68.7 mm with a Laystall crank of 99.64 mm, giving 2,216 cc. With its works special 6-port cylinder head and 3 twin-choke Solex carburetters (which had Al-alloy bodies to save top-weight especially) this produced on methanol 193 HP @ 6,250 RPM (12.5 Bar @ 20.8 m/s; presumably the 7% higher BMPP was due to de-siamesing the inlet ports).

Gerard's driving and this very-special T23 gave 1½ Litre supercharged BRMs a run-for-their money on several occasions in short British races. The best result was actually in August 1954 with his 1954 car, when he beat Ron Flockhart in a Mk II at Castle Combe.



pinterest.com

1956 International Trophy at Silverstone.
Bob Gerard (29, Cooper-Bristol special T23) racing with Hermano da Silva Ramos (17, Gordini type 16).
. Gerard finished 4th, Ramos 5th.
Note that the visible anti-roll bars added by Gerard have reduced the roll compared to Note 66 Fig. N66A.

This entry is a tribute dedicated to remarkable privateer.

CORRECTIONS & ADDITIONS

9 October 2018

ADDITION

Illustrations for Appendix 8:- Aero engines 1914 - 1945

Mainly about constructional features

Fig. 1. 1914 Renault 80 CV. This had cast-iron (CI) 4-cylinder blocks with separate CI heads (an unusual feature at that date). Crankcase was Al-alloy (this can be taken as standard for all engines in the Illustrations, without further mention. Al-alloy, although of much lower strength than later, was employed for piston engine crankcases from early in the 20th century).
CI pistons.

Fig. 2. 1917 Hispano-Suiza 220 CV. Designed originally in late 1914 to give 150 CV by Marc Birkigt at the Spanish factory as a private venture. Note that Birkigt, as a Swiss, was neutral in the war which had just broken out and so was Spain where the prototype engine was built (this calls to mind that the most formidable fighters built in Germany were designed by a neutral Dutchman, Antony Fokker!).

The multi-cylinder Al-alloy block with steel liners construction was a novel contribution by Birkigt and, with various improvements (to be described below) set the pattern for all subsequent liquid-cooled aero engines post-WW1.

At that date in casting technology the Al-alloy was porous and the blocks had to be enamelled to make them water-tight. Initially the dry liners were a press fit but this did not give a satisfactory heat transfer to the cooling water so screwed liners were introduced. Then, to enable the liners to be screwed tight they had to be lubricated with something which did not spoil heat transfer. A lead oxide/glycerine mixture was the answer.

Al-alloy pistons – also a novelty in 1914.

In a version of his V8 fitted with a simple crank-speed reduction spur-gear, at the suggestion of Guynemer, Birkigt introduced the "*moteur canon*". This was a 37 mm weapon firing through the hollow gearwheel and propeller hub. It was an available gun which had to be re-loaded after each shot and generated a lot of smoke, momentarily blinding the pilot. Although some success was obtained, the installation was dropped after a while.

His experience with this may have later led Birkigt to design the 20 mm cannon which was adopted, with development, as the RAF's post-1940 WW2 fighter gun, but wing-mounted.

Fig. 3. 1916 Austro-Daimler 200 PS. Following the pattern established by Daimler in 1912 with their DF80 entry in the Kaiserpreis aero engine competition (see Illustrations for Appendix 5 Part 1 at Fig. 2), this had separate forged-steel cylinders with integral heads with welded-on pressed-steel water jackets (single in the A-D; the DF80 were twinned). As noted in the caption, the 1916 A-D had adopted the Al-alloy pistons discovered in captured Allied engines.

Fig. 5. 1917 Daimler "*Mercedes*" DIVa. Naturally this followed the DF80 construction. An example may be seen in the Rolls-Royce Heritage Trust collection in Derby.

Fig. 6. 1917 Daimler "*Mercedes*" F1468. Its DIII cylinders were as the DF80. The crank speed reduction gear was an unusual feature for a German WW1 aero engine. An example is also included in the R-RHT collection, on loan from the IWM at Duxford.

Fig. 7. 1917 Rolls-Royce *Eagle* Series VIII. As described in DASO 1097, Rolls-Royce had bought in July 1914 a 1913 "*Mercedes*" racing car fitted with a DF80 aero engine, because it was the basis of the Daimler firm's new 28/95 sports car and they wished to evaluate the competition. After war was declared in August 1914 and Henry Royce decided to design a V12 aero engine, he adopted the "*Mercedes*" cylinder construction to save time. The 7-bearing bottom end was derived from his 40/50 "*Silver Ghost*", as Royce did not think much of the DF80 6-cylinder 4-bearing crank (it broke on overload test at Derby).

Fig. 8. 1918 Bentley BR2. The cylinder head was CI.

Fig. 9. 1918 Maybach 300 PS. The separate cylinder construction of this engine was novel for a German WW1 aero engine. A steel barrel had a CI head complete with ports (2 inlet, 2 exhaust) screwed onto the top (this was similar to the 1914 Daimler "*Mercedes*" Grand Prix engine). The water jackets were machined from steel forgings and screwed onto the head with a seal at the bottom.

Fig. 10. 1923 Curtiss D12. As stated in the caption, this engine was inspired originally by the Al-alloy *monobloc* Hispano-Suiza V8, but included the first novel departure from that engine by having mostly-wet steel closed-end cylinder liners.

As described, the 1927 Rolls-Royce "F" then went the next step with its *open-ended* liners in an Al-alloy 6-cylinder monoblock + integral head.

This was the first time that a cast Al-alloy head had been trusted to withstand combustion temperature and pressure successfully. The Rolls-Royce laboratory at that date were in the forefront of material development, especially of light alloys.

Fig. 11. 1924 Bristol *Jupiter* V. This engine had steel forged cylinders with a CI head. The latter was replaced later with a cast Al-alloy head, which *may* have anticipated the Rolls-Royce "F", but the rejection rate of the castings was too high and a change to a forged head was made in 1929.

Fig. 12. 1927 Napier *Lion* VIIA. As an original 1917 design this engine had separate closed-end steel cylinders with welded-on steel water jackets, but the heads with the valve gear were 4-cylinder CI blocks, retained to the cylinders by screwed-in valve seats.

With the high compression ratio of 10, burning fuel 75% petrol, 25% benzole + 0.22% TEL, the ungeared NA VIIA had a Thermal Efficiency of 33.3% (DASO 225).

The 1927 engine was fitted subsequently in successful World Land Speed Record (WLSR) cars driven by Malcom Campbell and Henry Segrave.

Fig. 13. Ref. the supercharged Napier *Lion* VIID, although Gloster VI problems prevented it from racing as intended in the 1929 Schneider Trophy, it gained fame later as the engine(s) in the later WLSR cars of Campbell and John Cobb.

Various "R"-type engines were also used over 1930-1939 to take Water and Land World Speed records in boats and cars driven by Segrave, Kaye Don, Campbell and George Eyston.

Fig. 16. Daimler-Benz DB601E. The 1917 Birkigt *moteur canon* was revived in the Bf109E3 with a 20 mm gun fitted in the engine vee, firing through the crank-speed reduction gear and hollow propeller hub. However, vibration and overheating affected the weapon, it was not popular and sometimes removed.

Fig. 18. The "Meredith Effect". This was a method for cooling aero engines with minimised drag proposed by F. W. Meredith in an Aeronautical Research Committee report R&M 1683 in 1926. Air taken in by a scoop at flight velocity was carefully diffused in a duct to reduce its speed and raise its pressure, then passed through the radiator and, being heated there, was then accelerated aft through a nozzle. The energy supplied could produce a jet which gave thrust sufficient to cancel the radiator drag, if the duct proportions were right. This was actually the case for the P-51 *Mustang* according to Lee Atwood, one of the P-51 design team (ref. www.historicracer.com).

CORRECTIONS & ADDITIONS

20 October 2018

ADDITION

Note 47, re Ferrari 250 Testa Rossa power.

In a comprehensive review of Ferrari V12 development from the original Colombo design of 1947, *Autocar* 9 January 1959 (DASO 138) published the power of the latest unit, the 3 Litre 250 Testa Rossa. Note 47 compared this with the known 270 BHP of the Aston Martin DBR1 which beat the 250TR to the 1959 World's Sports Car Championship and suggested that the claim for the Ferrari was perhaps 10% optimistic.

Correspondent Paul Leclercq has recently told the author of a report published in a classic car magazine some years ago which is relevant to this. An ex-Jaguar engineer described how, when his firm were contemplating racing the new E-type in the new GT-category for production sports cars (which would have been in 1961) they were able to test the engine of a 250GT, likely to be a rival. It developed 297 BHP. [Assuming that this was at 7,400 RPM, it represented BMPP of 12.16 Bar on petrol @ MPS of 14.50 m/s.] A picture of the rivals racing is shown on P.52.

E-type versus 250GT at a Silverstone Classic meeting

1961 prices	E-type £2,196	250GT $12,600, @ $2.8/£1 = £4,500
Average current auction values	£200,000	$15.7 m, @ $1.3/£1 = £12 m!

CORRECTIONS & ADDITIONS

20 October 2018

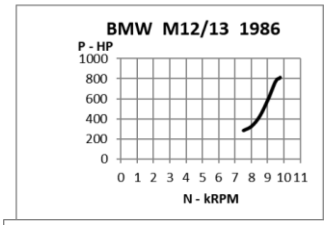
ADDITION

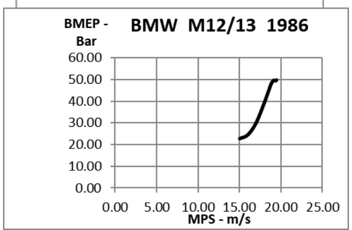
Eg. 64: BMW M12/13

Correspondent Ron Rex has pointed the author to a power curve produced in Australia for a BMW IL4 1.5 Litre TurboCharged M12/13 of 1986 type from a Benetton B186 (ref. www. gurneyflap.com/bmwturbof1engine)(DASO 1204). This data has been replotted in standard format and is given below.

POWER CURVES

PEP	
DASO	1204
YEAR	1986
Make	BMW
Model	M12/13
Vcc	1499.8
Ind. System	NA
Confign.	IL4
Bmm	89.2
Smm	60





N kRPM	P HP	MPS m/s	BMEP Bar
7.5	286	15.00	22.75
8	329	16.00	24.54
8.5	427	17.00	29.97
9	591	18.00	39.18
9.2	668	18.40	43.32
9.4	749	18.80	47.54
9.5	779	19.00	48.93
9.6	798	19.20	49.60
9.7	802	19.40	49.33
9.75	812	19.50	49.69

The shape of the power curve is completely different from any other, for no known reason. Other centrifugally-pressure-charged engines do not show a concave shape.

CORRECTIONS & ADDITIONS

28 November 2018

ADDITION

Appendix 6 Ferrari 250GTO

Two contrasting Racing-Sports engines

Corrections & Additions at P. 51 (20 October 2018) described how Jaguar in 1962 were able to test a Ferrari 3 Litre 250GTO engine to satisfy themselves on the genuine power output. The report prepared by the Experimental Department, as published in DASO1205 (see Refs. Below) has since been seen by courtesy of correspondent Ron Rex. It compared the 250GTO with their own 3 Litre racing engine, which had been built for the prototype E2A car entered by Briggs Cunningham for the 1960 Le Mans (see Fig. 1 on P. 54). This report not only gave the respective power curves but also (much rarer) the Specific Fuel Consumptions (SFC). Uniquely, this permits a thorough analysis of two completely different Racing-Sports engine designs of the same capacity tested in the same way by one firm, as shown below.

Make	Jaguar	Ferrari	
Model	E2A	250GTO	
Capacity class Litres	3	3	
Configuration	**IL6**	**60^0V12**	
Induction System	Both Naturally-Aspirated:- fuel, petrol 100 Octane.		
	Lucas Port injection	6 x 2-choke Weber 38DCN carburetters.	
	Both had **Individual** & **Tuned** inlet tracts.		
Bore (B) mm	85	73	
Stroke (S) mm	88	58.8	
B/S	0.966	1.241	+28.5%
Swept Volume (V) cc	2,996.1	2,953.2	
Compression ratio (R)	10	9.57*	
No. of valves/cyl.	2	2	
Valve Included Angle (VIA)	75^0	60^0	
Inlet Valve head Diameter (IVD) mm	53.2	36	
Inlet Valve max. Lift (IVL) mm	11.1	9.8	
IVL/IVD	0.209	0.272	
Inlet Valve Area/Piston Area (IVA/PA	0.392	0.243	
Valve operating system	DOHC	SOHC	
	CVRS	CVRS?**	
Valve Timing			
IN early/late//EX early/late deg.	35/55//55/35	43/75//70/43	
IN. Open Duration (IOD) deg.	270	298	
Overlap (OL) deg.	70	86	
Spark plugs/cyl.	1 central	1 deeply recessed at side See Fig. 2 on P.55.	
Con. Rod Length (CRL) mm	Not given	110	
			Ferrari rel to Jaguar
Peak Power (PP) BHP	293.5	288	-1.9%
@ RPM (NP)	6,750	7,750	+14.8%
BMEP @ PP Bar (BMPP)	12.99	11.26	-13.3%
@ MPSP m/s	19.80	15.19	-23.3%
Peak Torque (TP) Lb. Ft.	236	203.5	-13.8%
@ RPM (NT)	6,500	7,000	+7.7%
BMEP @ TP Bar (BMTP)	13.42	11.74	-12.5%
@ MPST m/s	19.07	13.72	-28.0%

See Fig. 3 on P.55

(NP – NT)/NP	3.7%	9.7%	+6% points

*Figures in red are from DASO 138

**The report refers to *coil springs*. The Colombo V12 developments retained hairpin springs up to 1958 (HVRS), ref. DASO 138.

	Jaguar	Ferrari	Ferrari rel to Jaguar
Mean Gas Velocity @ PP (MGVP) m/s	50.55	62.46	+23.6%
Mean Valve Speed @ PP (MVSP) m/s	3.33	3.06	-8.1%

In the 250GTO valve bounce began at 7,800 RPM, at which MVS was 3.08.
If this had not intervened the power might perhaps have been 1 BHP higher

	Jaguar	Ferrari	Ferrari rel to Jaguar
Max. Piston Deceleration @ PP (MPDP) g	n.k.	2,501	
At *nominal* CRL/S = 2	2,801		

Estimated Mechanical Efficiency (EEM), using predicted Friction-&-Pumping MEP from Note 99;

	Jaguar	Ferrari	Ferrari rel to Jaguar
	80.6%	82.7%	+2.1% points

Δ from Peak Power RPM predicted from Speed Correlation Factor (SCF) described in Note 12;

	Jaguar	Ferrari	Ferrari rel to Jaguar
	+0.1%	-9%	

ECOM (=EV x EC x EM) as defined in 1st Naturally-Aspirated Era (1NA) Addendum

	Jaguar	Ferrari	Ferrari rel to Jaguar
	56.8%	49.8%	

Specific Fuel Consumption (SFC) @ PP Lb/BHP.Hr:- fuel, petrol 100 Octane; 19,135 BTU/Lb

	Jaguar	Ferrari	Ferrari rel to Jaguar
	0.447	0.594	+32.9%

Brake Thermal Efficiency (BThE), as derived in Note 37:-

	Jaguar	Ferrari	Ferrari rel to Jaguar
	29.7%	22.4%	-7.3% points

Volumetric Efficiency (EV), as derived in Note 37:-

	Jaguar	Ferrari	Ferrari rel to Jaguar
	114.9%	132.4%	+17.5%points
Weight	Not given	Not Given	
$(MPSP)^2$ $(m/s)^2$	392.0	230.7	-41.1%

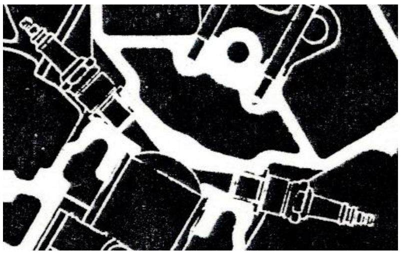
Fig. 1
Jaguar prototype E2A

Slotcartoday

The 3 Litre engine of the E2A was derived from the 1956 port-fuel-injected XK120D, with B x S changed from 83 x 106 mm = 3,441 cc, to 85 mm x 88 = 2,996 cc, with an Al-alloy block and Ti-alloy con. rods. The chassis had independent rear suspension, a first for Jaguar, and inboard rear brakes cooled by ducts behind the cockpit. It was built for the 1960 Le Mans but ran into fuel system trouble which ultimately led to either piston or head gasket failure (reports differ).

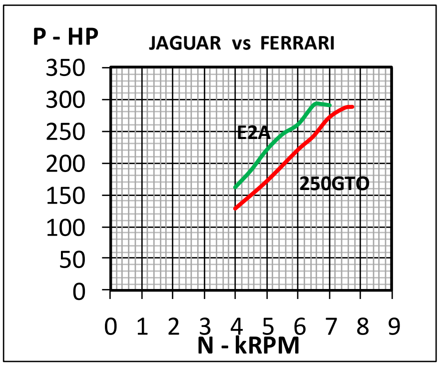
Fig. 2

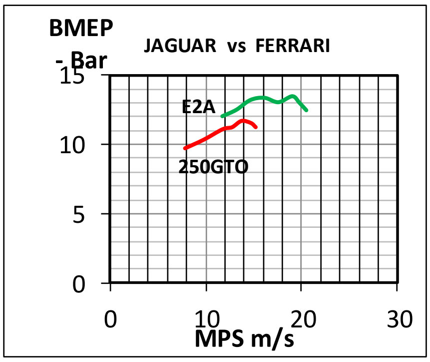
This is a section of the 1956 Ferrari type 290MM/130S which had 2 plugs/cyl. The inside plug was the original Colombo position for 1 plug/cyl. This was suppressed for the 1958 250 Testa Rossa to provide space for the new 6 x 2-choke Weber carburetters, ignition then being by adopting the outside location, still 1 plug/cyl..



DASO 8

Fig. 3





The Jaguar report is incorrect in Ferrari BMEP, 5.4% too low.

Discussion

[The figure for Ferrari 250GTO Power, at 288 BHP, corrects the figure in C&A at P.51 20 October 2018, which was 297 BHP].

1. The Jaguar was "Bottom-end-limited" by its MPSP. The Ferrari, with B/S greater by 28%, was "Top-end-limited" by its valve gear. Valve-bounce set in at 7,800 RPM.
2. The Jaguar Brake Thermal Efficiency was as good as any petrol engine, at nearly 30%. The Ferrari was much less efficient, at about 22%, due to its higher B/S spoiling Combustion Efficiency (EC) by its combustion chambers having higher Surface Area/Volume ratio; the deeply recessed sparking plugs would also have reduced EC.
3. Both engines, with Individual and Tuned inlet tracts had very high Volumetric efficiency at Peak Power. The shape of the BMEP curves showed how the RPM "tuned in" to the tracts near Peak Power.
4. The Jaguar report, in a round-about way, drew attention to the much lower stresses in the Ferrari. Piston stress is proportional to (Mean Piston Speed)^2 ,and that parameter in the 250GTO was 41% less than the Jaguar.

References

DASO 8 "FERRARI" H.Tanner Foulis 1974 Edition.
DASO 138 *Autocar* 9 January 1959.
DASO 1205 "JAGUAR Sports-Racing and works competition cars from 1954"..A Whyte Foulis 1987.

CORRECTIONS & ADDITIONS

30 November 2018

ADDITION

2nd Pressure-Charged Era (2PC) Egs. 69, 70, 71.

Eg. 71 Honda RA168E

DASO 1206 (see Ref. below), published in June 2018, has provided extra details of the Honda RA168E 80^0V6 1.5L Turbo-Charged engine which powered the McLaren MP4/4 car to Ayrton Senna's 1st Drivers' Championship and McLaren to their 4th Constructors' title.

This engine was analysed in Eg. 71, based mainly on SAE890877 (DASO 20). The additional data, seen by courtesy of correspondent Ron Rex, comes from an interview with Michio Kawamoto, lead designer of the engine and a co-author with Osamu Goto of SAE890877. The following comments therefore expand on Eg. 71.

- Although the basic configuration of the RA168E remained as for the first Honda TC engine of 1984 and the Bore/Stroke as settled in 1986 at 79 mm/50.8 = 1.555 for 1,494 cc, in fact "*perhaps 99%"* of the parts were re-drawn. This reflected the 28 mm lowered crank and the lower stresses for the reduced power.
- The specification was up-dated for every race; significant changes received a suffix, from -XE1 for the original units to -XE5 at the end of the season.
- The -XE2 spec. from the 3rd race (Imola) removed the system of 6 throttles downstream of the FIA pop-off valve to 2 throttles ahead of it. This overcame an un-wanted charge dump, as described in Eg. 71..
- Large changes were made for the 4th race, in Mexico City at 7,400 ft (2,240 m) altitude, because of the 24% drop in ambient pressure, from 14.7 psi to 11.2 psi. The FIA-supplied pop-off valve which controlled the charge inlet pressure to 2.5 Bar* absolute, 36.25 psi, at sea-level worked on pressure-difference of 21.6si. In Mexico City it would therefore open at 11.2 + 21.6 = 32.8 psi, 2.26 Bar absolute. To restore some of the *approx*. 10% power loss, Honda in the -XE3 engine used the time-honoured approach of raising the Bore/Stroke ratio to 82 mm/a *deduced* 47.2 mm = 1.737 for 1,496 cc. This was a reversion to the RA165E dimensions of mid-1985. Some parts of that engine may have been useable, otherwise it needed a new cylinder head with pro rata larger valves as well as new cylinder liners, pistons and crank and possibly new con. rods No power details were quoted, but *if* BMPP and MPSP were the same as for the "79 Bore" engine then, at sea level and Q rating the output would have risen by $(82/79)^2$ = 1.077, i.e. from 676 HP to 728. Peak RPM would have been about 1,000 higher at 13,500. Honda accepted that the higher B/S would reduce the Combustion Efficiency because of higher Surface Area/Volume ratio, but fuel consumption was not a problem at the altitude power achieved

  This -XE3 engine was sometimes used for qualification at later races, Monza (12th race) being mentioned.
- .The -XE4 spec., first used at mid-season, using the "Standard" 79 mm bore, had compression raised from the "Standard" 9.4 to 9.6.
- The -XE5 was special for the Japanese home race at the Honda-owned Suzuka circuit (the 15th), but the only detail given is that the Turbo-Chargers had the ceramic (silicon-carbide) turbines to reduce inertia; - also used at Monaco (the 3rd race).
- Three different volumes of TC turbine inlet scroll were used, a choice being made according to circuit shape and whether Q or R rating was required.
- The Shell fuel used (contrary to SAE 890877 which listed *Elf* supply) was raised from the "Standard" 84% Toluene + 16% n-Heptane to 90% Toluene for Qualification.

An illustration of the RA168E is given on P. 57, showing the intercooler arrangement.

A general point about this new data compared to SAE890877 is that the latter did not give any variation of quoted power for the changes listed in DASO1206, but they would probably been small except for the "Big-bore" engine, as estimated here. It is emphasised that the numbers here are according to the author's understanding of how the FIA pop-off valve worked. Correction by a knowledgeable reader would be welcomed.

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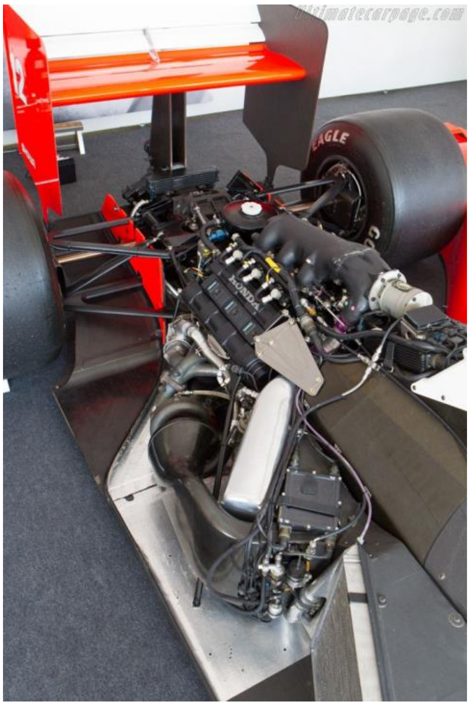
*1 Bar = 10^5 Newtons/m^2 . = 14.5 psi. 1 Atmosphere (1 AT) = 14.7 psi.

<u>General remarks</u>

DASO 1206 emphasises that, to achieve the success in 1988 which, with the Mclaren MP4/4 chassis and the skills of the "Super-drivers" Senna and Prost, totalled 15 wins from 16 races (94%), Honda were prepared to spend extremely large sums of money for just one season, not only before but *during* the season. Nowadays the FIA has ruled that engine makers are not allowed to decide for themselves what they think success is worth. They have to follow extremely-prescriptive initial design rules and are permitted very little development from that. As a result, the first maker who <u>did</u> actually outflank the official desire to produce identical power outputs – Mercedes-made-in England – has virtually been handed the Championships ever since 2014. The FIA would probably say that these seasons were much more competitive than 1988.

Re-visiting the Honda glory days of 1988 with the 80^0 V6 1.5L TC engine does highlight the unhappy fact that their 90^0 V6 1.6L TC engine of 2015 – 2018 has come nowhere near that level of achievement. This despite the continuing success of their MotoGP bike, which has just mounted Marc Marquez to his 3rd successive Riders' Championship!



Honda RA168E
At and from the 9th (German) race the air inlet to the TC was taken from inside the side pod intake by the black carbon fibre (CF) trunking. The pressurised air was fed into the bottom of the intercooler (shows white) and exits to the engine from the top towards the CF inlet manifold. The FIA-supplied pop-off valve is the white fitting on the end of the manifold.

pinterest.com

<u>Reference</u>

DASO 1206 McLAREN MP4/4 OWNERS' WORKSHOP MANUAL S Rendle Haynes 2018.

CORRECTIONS & ADDITIONS

16 FEBRUARY 2019

ADDITION

Hispano-Suiza Voiturettes, 1909 – 1910

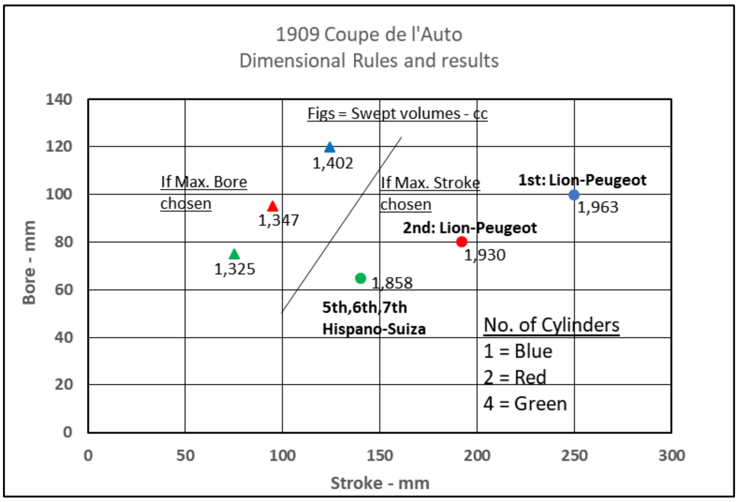
Over 1906 – 1913 the races run in France for "Voiturettes", sponsored by the magazine *l'Auto,* and therefore usually known as La Coupe de l'Auto (C de l'A), were the premier annual competitions for this class of cars (from 1912 described as "Voitures Legeres").

Note 35 has explained the reasoning of the rule-makers for this race series over 1906 -1908 which led to control of only Piston Area (PA) and Number of Cylinders (CN); how this approach was outflanked ("outstroked") by Maurice Sizaire; and how, after his 1906 1-cylinder C de l'A win he produced further 1-cylinder winners in 1907 and 1908, the latter being a particularly grotesque design with Bore (B)/Stroke (S) of 100 mm/250 = 0.4 (S/B = 2.5). An illustration is shown in Significant Other Eg. SO3.

In 1909 the King of Spain, Alfonso XIII, a keen early motorist, persuaded the fairly-new Barcelona car firm Hispano-Suiza to enter Voiturette racing to promote their marque. The King had the previous year already sponsored a new race for this class in his kingdom, the Copa Catalunya, as a supplement to the C de l'A.

The 1909 Voiturette racing rules

The 1909 rules for the C de l'A differed from the "PA & CN - only" format of the preceding races. The B, S and CN configurations permitted are best shown diagrammatically below. There was also a 600 Kg minimum weight limit.



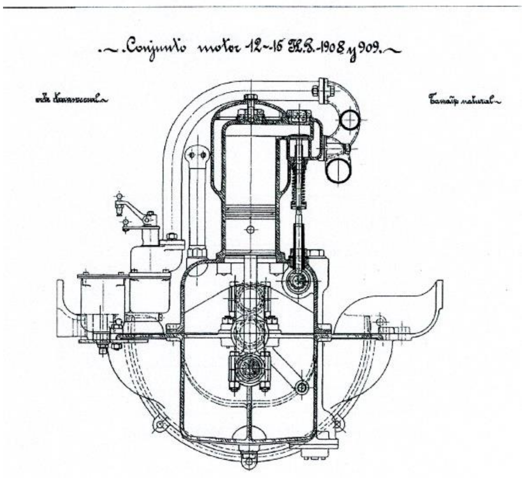
Makers could choose between Max B or Max S and since, as shown, the latter allowed more Swept Volume (V), all the major contestants chose that option.

The 1909 Hispano-Suiza racing engine

The decision by Hispano-Suiza to enter Voiturette racing would have been taken by the company board under its Chairman, Damien Mateu. To give effect to this their Technical Director, Marc Birkigt, decided to race with a 4-cylinder engine as a "civilised" solution, compared to previous pure-racing

1-cylinder winners, derived from his latest production designs and capable of becoming themselves a saleable series. This meant a Bore of 65 mm. Naturally, the first entry was for the 1909 II Copa Catalunya. This race actually permitted a stroke greater than the C de l'A rules and Birkigt chose 180 mm instead of 140 mm for the first racers. B/S was therefore 0.361 (S/B = 2.769) and Swept Volume 2,389 cc. No section drawing or photo of this engine is available. In a recent book (DASO 1210 – see refs. on P.63), Manuel Lage, after studying the Hispano-Suiza archives, concluded that the first voiturette engine was L-head, *not* the T-head used by Birkigt for production engines from (continued on P.59)

1904 to 1908 and assumed by Kent Karslake in DASO 259. An L-head had been adopted by Birkigt in 1908 for a production engine to save a camshaft and its drive, because of economic pressure to give a lower price. A section of this engine is shown below



Note the placing of the carburetter on the far side from the exhaust, as was done by Louis Renault for his L-head 1906 Grand Prix engine (see the 1st Naturally-Aspirated Era at PP.1 &2). This may have been done to obtain cooler inlet air (at the cost of a "Tortuous" manifold) or to avoid the possibility of a petrol leak onto the exhaust, or perhaps both reasons. Also like the Renault, the carburetter was low down. Assuming that the voiturette engine designed at the same date followed the same configuration, the fact that photographs show the 1909 car's bonnet had an aperture for air inlet near this position is a factor in concluding that the engine *was* L-head, because the known T-head redesign in 1910 (see later) had an aperture next to that unit's high-mounted carburetter.

The 1909 engine was typed as 12Cr (Cr = Carreras, Spanish for "Racing").

<u>The first Hispano-Suiza race.</u> (statistics for races are from DASO 1211).

The first appearance of the Hispano-Suiza Voiturette team was in the II Copa Catalunya on 20 May 1909. This was run on the 28.2 km Sitges circuit, 44 km SW along the coast from Barcelona, over 13 laps to total 366 km.

The team drivers were:- Paolo Zuccarelli (a qualified engineer); Louis Pilleverdier (development and road tester); and Leon Derny.

While testing the day before the race, Pilleverdier's car broke its crankshaft (DASO 1208). Derny's car broke its crank on the 6th lap and Zuccarelli's crank broke on the 7th lap (same source) after leading for 3 laps. Pilleverdier finished in 4th place, but 97 minutes behind the winning 1-cylinder Lion-Peugeot (see illustration below) driven by Jules Goux; 20% slower than the winner's 58.1 kph! Clearly this car had a new crank, but probably Pilleverdier was told at a pit-stop to go slowly to finish and in any case he had disarranged steering after hitting a kerb.

This was a poor start for Hispano, although with some promise. Whether the failures were of design (crank size, or in the pressure lubrication system with a drilled crank); or incorrect machining; or faulty material, is not known, although DASO 1210 thinks the latter.

Marc Birkigt's grandson, Bernard Heurteux, has told the author that he had a motto that "*Today's mistakes, if recognised, are tomorrow's knowledge".* These failures might well have been the prompting of that thought!

<u>The 1909 Coupe de l'Auto</u>

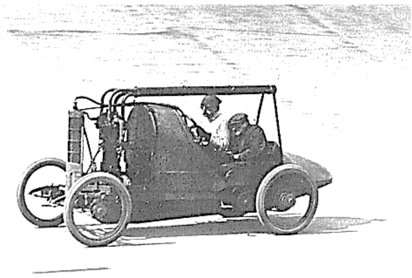
The Hispano voiturette engines necessarily had to have new cranks for their next race, the 1909 IV Coupe des Voiturettes (also known by the name of its sponsoring magazine) because the regulations had to be met with a stroke of 140 mm, for a swept volume of 1,858 cc. DASO 1210 believes the power was 28 metric HP @ 1,750 RPM (15.1 CV/litre @ 8.2 m/s). The race was run on 20 June on a new 37.9 km circuit outside Boulogne over 12 laps for a distance of 454 km.

The same drivers participated and the results were more encouraging. The winner was again a 1-cylinder Lion-Peugeot, driven this time by Giosue Guippone, at 76.4 kph. The Hispano team finished in 5th, 6th and 7th places in the order Pilleverdier, who was 8% slower than Guippone, followed by Zuccarelli and Derny.

Possibly the drivers were controlled to achieve a full team finish

This was the last major 1909 race for the Hispano Voiturettes. In September there were class wins at the Mont Ventoux hill-climb and at a San Sebastian event, Derny driving in each case.

The 1909 Lion-Peugeot competition



imgur.com

This shows the grotesque form of the 1909 Lion-Peugeot with its 1-cylinder 100 mm bore and 250 mm stroke engine, S/B = 2.5, swept volume 1,963 cc.
The picture is of the car which took records at Brooklands in November 1909, driven by Georges Boillot, achieving 68.4 miles in one hour (110.1 kph).
(The pointed tail of this car is rather amusing, considering the huge bluff body shielding the crew!).
The miniscule radiator is also noteworthy.

1910

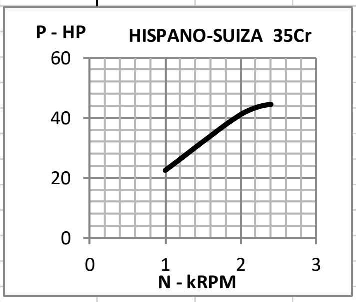
_ Once again, no drawings are known for the 1910 engine, but photos show that Marc Birkigt reverted to his favourite T-head. Compared to the L-head this could provide a larger inlet valve with the charge not heated by an adjacent exhaust port. The 1910 35Cr voiturette engine, as it was identified, can be represented by the given section of the production unit which was derived from the racer in 1911, the 45 HP “Alfonso XIII”. This is shown and described in an Appendix on P.63.

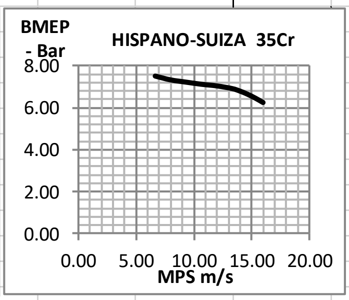
The Coupe de l’Auto Voiturette regulations were changed in 1910 to permit longer Strokes, and Birkigt took advantage of this to increase it from 140 mm to 200, for a swept volume of 2,655 cc, B/S = 0.325 (S/B = 3.08). Very unusually for a pre-World War One engine, the power curve for this engine is known, producing a peak of 45 metric HP @ 2,400 RPM (16.9 CV/litre @ 11.2 m/s; a 12% increase in volume-specific-power). Identified as 35Cr, an analysis is shown at RHS (DASO 1209)..

POWER CURVES

PEP		N	P	MPS	BMEP
DASO	Htx	kRPM	HP	m/s	Bar
YEAR	1910	1	22.3	6.67	7.52
Make	Hispano-Suiza	1.2	26.1	8.00	7.33
Model	35Cr	1.4	30	9.33	7.22
		1.6	33.8	10.67	7.12
Vcc	2655	1.8	37.6	12.00	7.04
Ind. Syster	NA	2	41	13.33	6.91
Confign.	IL4	2.1	42.3	14.00	6.79
Bmm	65	2.2	43.3	14.67	6.63
Smm	200	2.3	44	15.33	6.45
		2.4	44.4	16.00	6.24

Power was given in metric HP and has been divided by 1.014 to show BHP





The 1910 III Copa Catalunya

In 1910 the III Copa Catalunya was held on 29 May on a new 15.00 km circuit near Mataro, 34 km NE along the coast from Barcelona, over 22 laps for 330 km.

The Hispano team for this race was Zuccarelli, Pilleverdier and a newcomer, Jean Chassagne on the re-designed works cars (which once again used 180 mm cranks for this race) plus “Carreras” on a 1909 140 mm stroke car (“Carreras” is thought by this author to be a pseudonym). Once again Goux was the winner, apparently driving a 1909 1-cylinder Lion-Peugeot, at 78.4 kph. Carreras was 3rd, 7% slower than Goux, and Chassagne 4th. Zuccarelli retired with lubrication trouble – he *did* lead the first 9 laps - and Pilleverdier also DNF. DASO 1210 prints an immediate Board request that there must be more severe testing in future. This had an effect, although not until after competing in August at Mont Ventoux with the 180 mm spec. engines only resulted in a 2nd (Chassagne) and 4th (Pilleverdier) class places.

The first victory

Hispano-Suiza this year entered the II Coupe d'Ostende, run on 4 September on a 33.33 km circuit over 12 laps totalling 400 km. This was with the 200 mm stroke engines for the first time.

The result was the first circuit race victory for a Hispano-Suiza Voiturette, Zuccarelli beating Georges Boillot's Lion-Peugeot by just 0.7%, with 84.3 kph. Pilliverdier was 3^{rd} but Chassagne DNF.

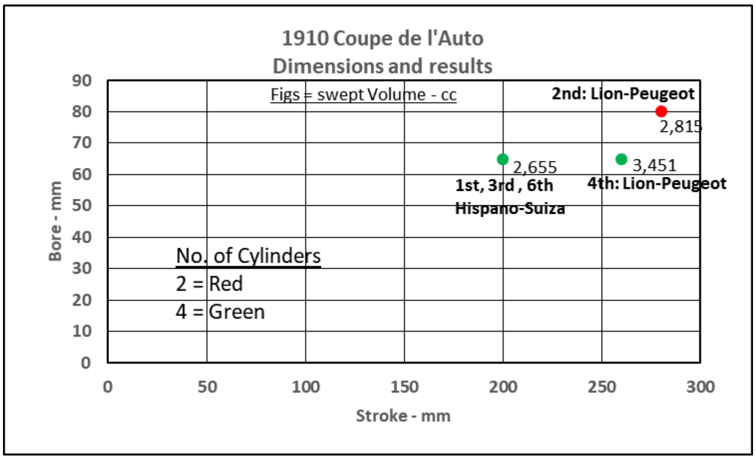
The final triumph

Just a fortnight after the first win, on 18 September, the Hispano team raced again in the Coupe de l'Auto (V Coupe des Voiturettes), the same circuit at Boulogne and the same distance as in 1909.

This produced their final triumph. Zuccarelli beat Goux on a 16^0 V2 80 mm/280 (2,815 cc) Lion-Peugeot by 5.8%, with 89.5 kph. Chassagne was 3^{rd} and Pilleverdier 6^{th}. Reports suggested that the smoothness of the IL4 35Cr was a factor in this victory, as the V2, although it made the fastest lap, was harsher on its tyres. The higher centre of gravity of the Peugeot, having 280 mm stroke plus overhead valve gear (see the SO4 link photo below) versus the Hispano's 200 mm stroke with a T-head, giving more roll on corners, must have been a factor in the Peugeot tyre problems. The 1910 Hispano also had had the petrol tank moved under the chassis to lower the C of G. Both teams were on Michelins.

The diagram below shows the dimensions of the contestants.

The 4^{th} place Lion-Peugeot, driven by Boillot (who, of course went on to fame as winner of the Grand Prix de l'ACF in 1912 and 1913, driving Henri-designed Peugeots) was an all-time record breaker in the matter of Stroke/Bore ratio, being
20^0 (?) V4 65 mm/ 260 = 0.25 (S/B= 4)!
It suffered from over-heating.



Illustrations

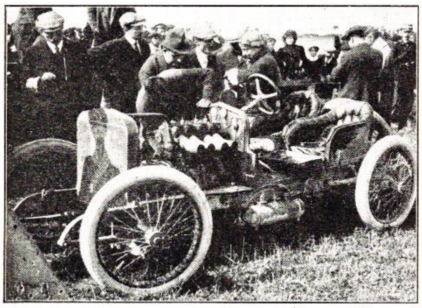
A. Paolo Zuccarelli on the winning car. The radiator size is noteworthy.

B. Showing the stub exhausts of the 1910 C de l'Auto engine. These would probably have been banned if starts had been in grid formation, instead of at timed intervals.

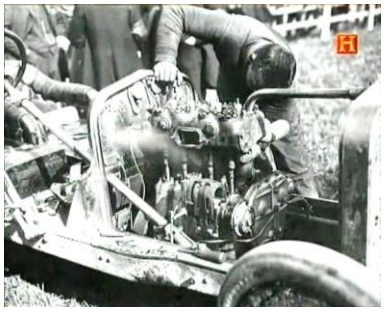
C. In this picture the high-mounted Claudel racing carburetter and ignition leads are not fitted.

For an illustration of the 2^{nd} place Lion-Peugeot 2-cylinder engine see Significant Other Eg. SO4.

firstsuperspeedway
A.



Motor Sport May 1950
B.



IMCDb.org
C.

With the victory in the 1910 Coupe de l'Auto with the first "civilised" Voiturette and the production of the 15/45 HP "Alfonso XIII" derived from the winning car, often said to be the first true sports car, Hispano-Suiza and Marc Birkigt joined the front ranks of the world's motor industry.

After 1910

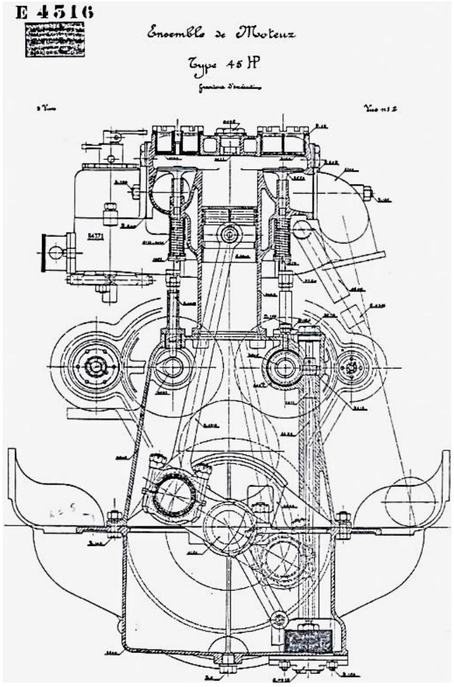
Hispano-Suiza did not defend their Coupe de l'Auto in 1911, ostensibly because they were pre-occupied in opening an additional plant in the Paris suburb of Levallois. In 1912 Marc Birkigt made secretly a *supercharged* modified T-head engine for the new 3 litre rules. This gave 100 CV, but it could not be made *au point* reliably in time for the race. Sunbeam made a clean sweep, 1st, 2nd and 3rd at Dieppe with 74 BHP L-Head engines. When Birkigt's secret was revealed by the journalist W.F.Bradley, the authorities then banned pressure-charging for future Voiturette racing.

By 1912 Marc Birkigt had recognised the limitations of his T-head engines, which he had used since 1904, because of the tortuous porting (which reduced Volumetric Efficiency) and the high ratio of surface area to compression volume (which reduced Combustion Efficiency). He designed the T20 engine, IL4 80 mm/130 = 0.615, V = 2,614 cc, having *inclined, opposed overhead valves* (OHV) with an included angle of 40^0, operated by a single overhead camshaft (SOHC) via rockers. This was used by a number of amateur drivers in small races. In 1914 he simplified the design for the T30, IL4 85 mm/130 = 0.654, V = 2,951 cc, with *vertical* OHV operated directly by SOHC. There *was* a "last hurrah" for the T-head, the 1915 T26, IL4 90 mm/180 = 0.5, V = 4,580 cc for the XIII chassis, which had *4 valves* per cylinder (not quite unique: the 1908 Hutton-Napier which won that year's Tourist Trophy had the same configuration).

The T30 head design was used by Marc Birkigt for his 1914 T31 V8 light-alloy-block aero engine for the Allies in the Great War, which was so successful that it was made in tens of thousands.

APPENDIX, describing the "Alfonso XIII", is on P.63

APPENDIX
The Hispano-Suiza 1910/1911 15/45 HP "Alfonso XIII"



The engine was produced initially
at B 80 mm/S 170 = 0.471, V = 3,418 cc,
but was then revised to 80/180 = 0.444, V = 3,619 cc,
i.e. with the stroke of the original 1909 Voiturette.
This section is with the later Stroke, and therefore is a good representative of the 1910 racing engine as regards vertical height.
Rated @ 40 HP (metric = 39.5 BHP) @ 1,500 RPM
(DASO 1213)
BMEP = 6.51 Bar @ MPS = 9.00 m/s.
A Power Curve is shown on P.64, compared with the 35Cr.

Cast iron fixed-T-head block, the valves inserted through ports closed by brass caps.
Al-alloy crankcase and sump, 3 plain 67* mm main bearings.
Flat crank, without counterweights. Plain 49* mm bearings.
Steel pistons machined from Derihon BND,
(% composition:- C 0.24; Mn 1.27; Cr 0.38; Ni 4.33; Fe 93.78).
Piston pins 22* mm.
Tubular con.-rods, 24 mm OD*, Length/Stroke = 2.11*.
Single carburetter feeding internal manifold.

DASO 1207

conceptcarz.com

Compression Ratio = 4.48 (DASO 1213)
*Dimensions scaled from enlarged drawing:-
IVA/PA = $(60\ mm/80\ mm)^2$ = 0.56
IVL/IVD = (10 mm/60 mm) = 0.17
IOD = 185.7^0 (DASO 1213)
MGVP = 16.00 m/s
ECOM (= EV x EC x EM) = 38%

Engine weight not given.

wallpaperup.com

References

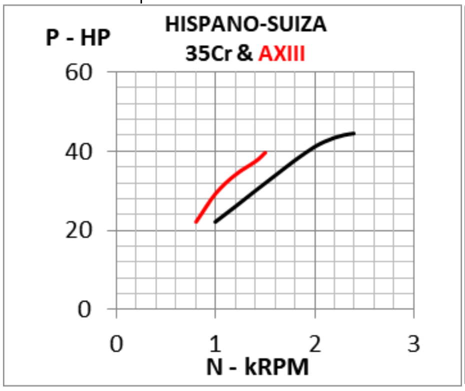
DASO 259. Racing Voiturettes. K. Karslake. MRP. 1950.
DASO 1207. The Hispano-Suiza Car Book. M. Houssais..To be published.
DASO 1208. Information by courtesy of Bernard Heurteux, E-mail 14 March 2018.
DASO 1209. " " " " 3 April 2018.
DASO 1210. La Hispano Suiza, a pioneer company. M.Lage. Ministry of Economics and Business. 2018.
DASO 1211. www.teamdan.com.
DASO 1212. Information by courtesy of Bernard Heurteux, E-mail 3 January 2019.
DASO 1213. Los Manuscristos de Domingo Anguera. Ed. M.Lage. 2019.
Advised by courtesy of Bernard Heurteux, E-mail 8 February 2019.

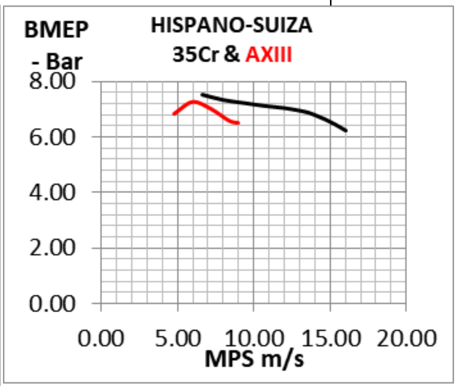
Note that the power is "Rated" at 1,500 RPM. Analysis by Note 12 suggests that the true Peak Power would have been at 1,800 RPM.

POWER CURVES

PEP		N	P	MPS	BMEP
DASO	**DASO 1213**	kRPM	HP	m/s	Bar
YEAR	1910	0.8	22.1	4.80	6.83
Make	**Hispano-Suiza**	1	29.3	6.00	7.25
Model	AXIII	1.2	34	7.20	7.01
		1.4	37.3	8.40	6.59
Vcc	3619	1.5	39.5	9.00	6.51
Ind. System	NA				
Confign.	IL4				
Bmm	80				
Smm	180				

Power was given in metric HP and has been divided by 1.014 to show BHP





The Specific Fuel Consumption is given by DASO 1213 as "around" 300g/CV.Hr, without specifying the corresponding RPM. It can be taken as at the bottom of the curve and is equivalent to a Brake Thermal Efficiency of 20%.

DASO 1210 tables a power for the 45Cr version of the Alfonso XIII,(80 mm/180 mm), as 56CV (55.2 BHP) @ 2,000RPM, where the curve from DASO 1213 above shows 40 CV @1,500 RPM. It may be that this higher output was for the tuned-up racing engine, used by private owners. It represents 6.83 Bar @ 12 m/s.

CORRECTIONS &ADDITIONS

10 May 2019

1st Pressure-Charged Era (1PC) Part 1

Eg. 11 1925 Delage 2LCV
Eg. 13 1927 Delage 15-S-8
A Century of Grand Prix Engine Weights
Corrections & Additions P. 43

By courtesy of a former colleague, Bernard Heurteux, new data has been obtained for the two CoY Delage engines given above from DASO 1214 (see Refs. below). For the first time engine weights have been quoted and the doubts about RPM and Power expressed in Note 5 have been justified.

Contd. on P. 65

1925 Delage 2 Litre 2LCV 60V12 B 51.4/S 80 mm = 0.643

An internet review of DASO 1214 explains the derivation of the designation of this car:-

"2 Litres de Course en Vee".

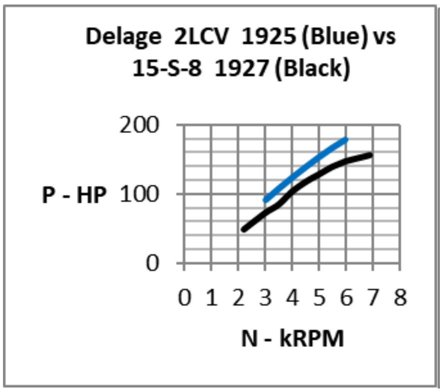
DASO 1214 is concerned principally with the Delage 15-S-8, but an original test chart in facsimile gives a comparative estimate of the 2 litre unit with the 1.5 litre by pro-rating its Torque x ¾ versus the latter's test results (this was actually done on the basis of what the tester who prepared the chart named as "*Couple*" in kg, which was the weight on the brake arm before multiplying this quantity by the arm length to get kg.m. It has been deduced by data on other charts that this arm length was 0.55m.)

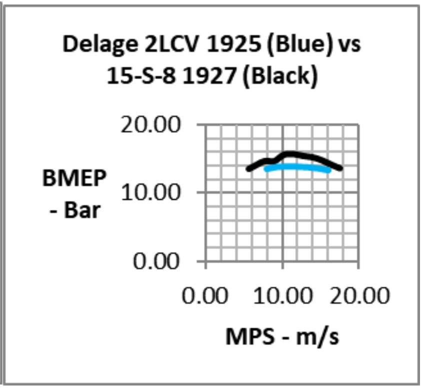
Taking the figures for the 2LCV shown before factoring enables the Power Curve to be calculated and plotted, as shown below. It is given with the best curve obtained later with the 1927 15-S-8 (see later).

POWER CURVES

Eg.				
DASO	1214			
YEAR	1925			
Make	Delage			
Model	2LCV			
Vcc	1992			
Ind. System	MSC			
Confign.	60V12			
Bmm	51.4			
Smm	80			
	N	P	MPS	BMEP
	kRPM	HP	m/s	Bar
	3	90.4	8.00	13.54
	3.5	107.4	9.33	13.79
	4	123.3	10.67	13.85
	4.5	138.4	12.00	13.82
	5	153	13.33	13.75
	5.5	166.6	14.67	13.61
	6	178.6	16.00	13.37

2LCV derived from Torque curve





The highest rated power for the 2LCV was 181 CV (178.6 BHP) @ 6,000 RPM. This compares with the suspect 190 CV @ 7,000 RPM published elsewhere. As explained in Note 5, the higher figure *may* have been a "flash" reading with a cold engine, not sustainable.

Contd. on P. 66

The Weight of the 2LCV engine + gearbox is given in DASO1214 as 230 kg. The 1925 'box was 5 forward speeds (a first in Grand Prix racing), with an overdrive top ratio to reduce steady RPM.

A modern 5-speed 'box (the 1995-design Getrag 221, designed for 200+ HP, and fitted in the Jaguar S-type and the BMW 5-Series) weighed 33 kg. (Internet quote). This could differ from the 1925 design by being (a) lighter by reason of 70 years improvement to stronger materials; (b) heavier by having synchromesh cones on all gears, where the 1925 design would have been simple sliding gears. It is reasonable to offset one difference against the other and take 33 kg for the 1925 Delage. It is confirmed by Eddie Berrisford that the 1925 'box had an Al-alloy case.

The deduced weight for the 2LCV engine was therefore 197 kg*. The Weight Function (WF), as defined in "A Century of Grand Prix Engine Weights", was 10.4 kg/cm. This is plotted and discussed below, in the 15-S-8 section.

An illustration of the original 1923 Planchon-designed NA V12 is given here

conceptcarz.com

*The usual caveat about engine weight applies that, without a detailed specification, what is included is not certain.

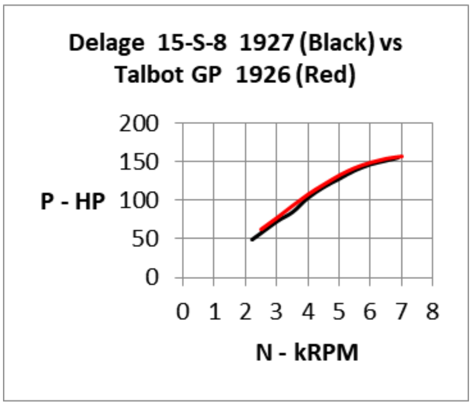
1927 Delage 1.5 litre 15-S-8 IL8 B 55.4/S 76 mm = 0.734

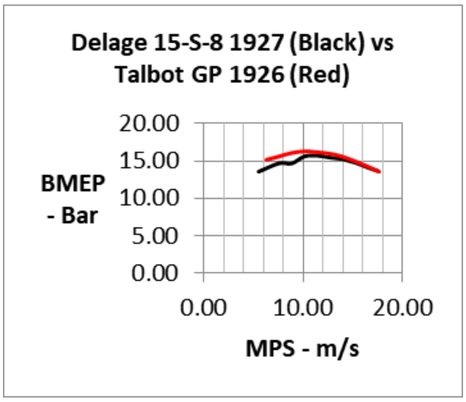
The highest Power given on the original test charts for the 1927 15-S-8 reproduced in facsimile in DASO 1214 was for January 1927:- 158 CV@6,900 RPM. A Power Curve for this test is given below (charts on P.67).

POWER CURVES

Eg.				
DASO	1214			
YEAR	1927			
Make	Delage			
Model	15-S-8			
Vcc	1487			
Ind. System	MSC			
Confign.	IL8			
Bmm	55.8			
Smm	76			
	N	P	MPS	BMEP
	kRPM	HP	m/s	Bar
	2.2	49.3	5.57	13.49
	3	73	7.60	14.65
	3.5	85	8.87	14.62
	4	103.6	10.13	15.59
	4.5	117.4	11.40	15.70
	5	128.2	12.67	15.43
	5.5	139.1	13.93	15.22
	6	147	15.20	14.75
	6.5	151.9	16.47	14.07
	6.9	155.8	17.48	13.59

Power was given in CV and has been divided by 1.014 to show BHP





The 1927 15-S-8 curve is compared with that for the 1926 Talbot T700 GP 1.5 litre IL8 B 56/S 75.5 mm = 0.742, designed by Vincenzo Bertarione and Walter Becchia. The similarity of dimensions and output is remarkable! The Talbot engine would have been lighter because its construction was the Mercedes/FIAT type of fabricated steel block + head instead of cast-iron. Regarding performance, the two teams first met in the 1926 British Grand Prix at Brooklands. As told in Eg. 13, the 1926 version of the 15-S-8 cooked its drivers' legs but Robert Benoist won the race for Delage because the Talbots suffered problems arising from severe brake judder (see Note 5 P.S.). Henry Segrave did make the Fastest Lap in a T700.

The teams met only once more, at Montlhéry in the 1927 GP de l'ACF. Talbot unreliability then could not prevent the re-designed Delage from taking the first 3 places, led again by Benoist.

The January 1927 15-S-8 test is believed to have been run on the 1926 fuel, comprising 40% Petrol, 40% Benzole and 20% Ethyl alcohol (see Appendix 2 No. 7). Reports subsequently quoted the use of "Elcosine" (DASO 294) in which the alcohol content was increased to 44%, deleting petrol (Appendix 2 No. 5). This could have raised the power to 170 CV.

The data used previously for the 15-S-8 was from Pomeroy (DASO 4) and this was incorrect in 3 important ways:-

- Peak Power was given as 170 HP; [regarded as suspect in Note 5]
- Peak RPM (NP) was given as 8,000; [" " " " "]
- Supercharger boost was given as 7.5 psi, whereas the test chart shows it as 1.27 kg/sq.cm. = 18 psi

When the data from DASO 4 was used to calculate the Speed Correlation Function (SCF), NP/SCF was 31.8% above the statistical average for Tortuous inlet/exhaust systems of 38.6 (see Note 12). With the test figures, this is corrected to 7.7%, within the statistical scatter.

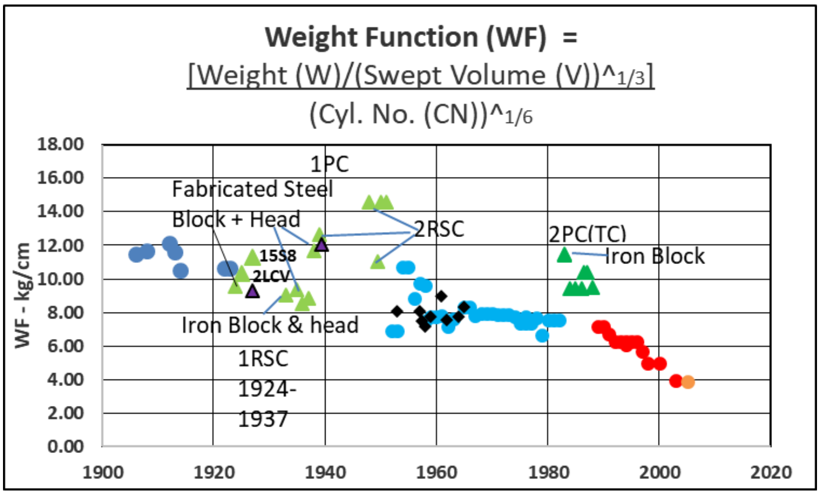
The Weight of the engine and gearbox of the 1926 15-0S-8 is given by DASO 1214 as 215 kg. The 'box was the same 5-speed unit as for the 2LCV. With the same reasoning as for the 2LCV ,above, the engine weight is therefore deduced as 215 – 33 = 182 kg. For 1927 the two 110mm rotor length Roots-type superchargers of the 1926 engine were replaced by a single 220 mm blower. It is assumed that the weight would be the same as before, 182 kg.

Weight Functions for the two Delages

In the website the chapter "A Century of Grand Prix Engine Weights" at Fig.5 presents the Weight Function (WF) for Pressure-Charged (PC) engines superimposed on the data for Naturally Aspirated (NA) units. This chart can now be updated with WF for the CoY Delage engines, as follows (V in cc):-

1925 2LCV = 10.4; 1927 15-S-8 = 11.3; Kg/cm.

It is a little disappointing that the two WF are 9% apart, since they were designed in the same office and built in the same workshop, because, as shown in "A Century...." for the Mercedes M163/M165 and the BMW 1985/potential 1986 pairs, the WF can be within 6%. Perhaps the difference arises between Planchon and Lory as Chief Designers. The chart is shown on P. 68.



Two comments apply to this up-dated chart:-

- The 2LCV was cast-iron Block + Head with 2 Roots-type superchargers in parallel, so would be expected to have a higher WF than the Alfa Romeo P2 2 litre IL8 at 1924/9.6 with fabricated steel Block + Head and a single blower;
- Comparing the 15-S-8 with the Miller 1.5 litre IL8 at 1927/9.3 (Significant Other SO9) (purple triangle), they were both cast-iron Block +Head but the former was all roller & ball bearings where the latter had lighter (and cheaper) plain bearings. Also the US engine had a centrifugal supercharger, lighter than the Delage Roots.

References
DASO 4 THE GRAND PRIX CAR, Volume 1 Laurence Pomeroy MRP 1954.
DASO 1214 DELAGE; CHAMPION DU MONDE D.Gabart & C. Pund OREP 2017.

CORRECTIONS & ADDITIONS

17 May 2019

Appendix 5 and Illustrations for Appendix 5 (Fig. 14)

1936 Austin 750

Although many and various sources were consulted for this entry on the Austin DOHC 750 cc engine, a recent internet review has discovered a source with new information on the power output. This is DASO 1215, which was from an interview in about 1957 with W. (“Bill”) Appleby, who assisted Murray Jamieson with the design. It extends some points made from that interview in DASO 197, already used in Appendix 5.

Power output

Appendix 5 gave what was believed to be the “Sprint” rating for the engine, at 120 HP @ 10,000 RPM. DASO 1215 amplifies and corrects the figures obtained from the engine:-

- On “Long-distance” fuel (which would have been mostly petrol), giving 7.5 miles-per-gallon (MPG):- 90 BHP @ 7.600 RPM.
  Supercharger gearing and pressure would have been appropriate for that fuel Octane rating;
- On “Sprint” fuel (specified in Appendix 5 Illustrations as 10% water, 15% Ethanol and 75% Methanol), giving 3.5 MPG:- 116 BHP @ 9,000 RPM.
  This with a Roots blower boost of 22 psi (IVP = 2.5 ATA).

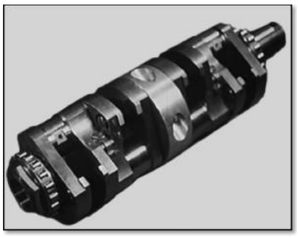
The best result on “Long-distance” fuel was by Charlie Dodson in winning the 1938 handicap British Empire Trophy at Donington at a speed 93% of the 2nd-place car, the B-type ERA of “B.Bira” with twice the power (admittedly not driven flat-out because the ERA was on its 2nd race without overhaul).

Probably the best on “Sprint” fuel was Bert Hadley’s September 1938 climb of Shelsley Walsh in 40.05 seconds, 2nd FTD and just under6% slower than a new record by Raymond Mays with a 2 litre ERA.

Unusual crank design

A detail of the Austin DOHC 750 cc engine revealed by a photo in DASO 1215 was that the 3-bearing crankshaft, with roller bearings at each end, had a centre bearing of sufficient diameter to be inserted end-on into a full-circle plain journal (see the illustration below).

Given this photo, the plain bearing is apparent in the Fig. 14 section.



Murray Jamieson was the designer in 1933 of the new 6-cylinder 3-bearing crankshaft for the 1.5 litre "White Riley", inspired by Raymond Mays, which became the prototype for the 1934 ERA. He had introduced in that shaft a full-diameter centre-bearing equipped with Hyatt rollers (see Note 128). Although this was – and still is!- successful, he must have had 2nd thoughts to use the same approach but with a plain bearing instead of rollers.

The "disappointing" Naturally-Aspirated test

DASO 1215 confirms a peculiar test result, reported elsewhere, that before the Roots supercharger was ready the engine was run Naturally-Aspirated (NA). The power was a "disappointing" 22 BHP. The results supercharged were much more satisfactory, as given above – 121 BHP/Litre on "Long-distance" fuel, as good as the B-type ERA on 76% Methanol mixture. The explanation of the poor NA figure is contained in Note 35 – far too low Mean Gas Velocity (MGV) of the inlet charge, giving poor mixing of fuel and air and consequential low Combustion Efficiency. At 7,600 RPM the MGV would have been only 41 m/s. When supercharged the blower, after the carburetter, would have provided the necessary mixing.

CORRECTIONS & ADDITIONS

22 May 2019

Analysis Part 1

1932 Eg. 18 Alfa Romeo B (P3)

In giving this as the 1st *Grand Prix* engine with all-Al-alloy static structure, the author failed to identify the *first* engine to have this feature. It was the aero engine designed by Marc Birkigt in 1914, his Type 31 V8. Post WW1, this became the standard for all aero engines, superseding the previously-common Mercedes-type fabricated-steel construction.

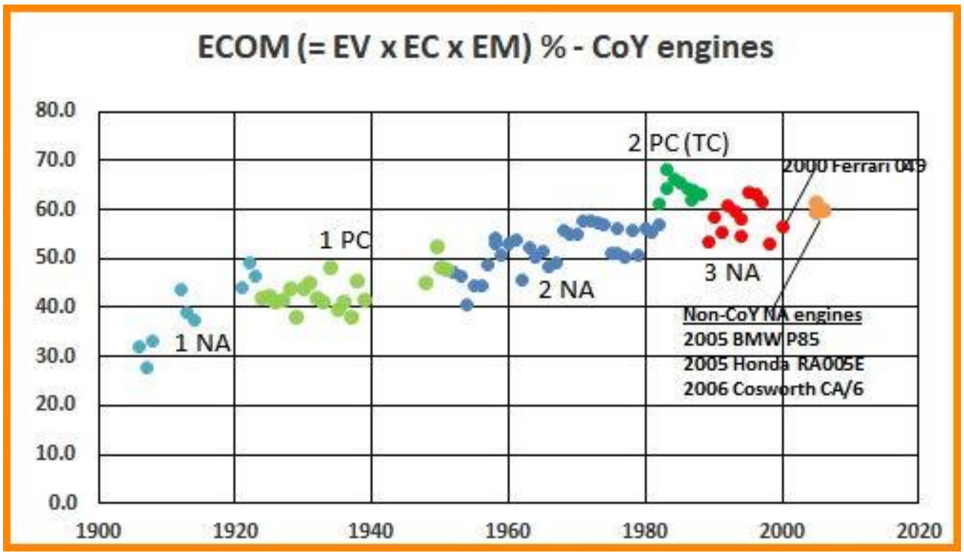
CORRECTIONS & ADDITIONS

24 MAY 2019

3rd Naturally-Aspirated Era (3NA) Part 1 and Part 2

- Egs. 75, 76 and 77 -81 Renault RS series 1992 – 1997.
- C & A at P.25
- Analysis

Renault have released some details of the powers of the above CoY group in a 2017 website "*Renault: 40 years of F1* " (DASO 1216). Appendix 1 has been up-dated to this new data (adjusted from CV to BHP. Two powers have had to be interpolated – entries are stippled). While the powers are not much different from those given previously, the RPMs are significantly lower. It may be the earlier sources were providing Maximum "Red-line" numbers, not Power Peak. Consequently, BMPP and ECOM are now higher. The updated chart for ECOM v. date is shown below on P. 70 and has been revised also in Analysis and on the website Contents page.



Apart from the 1992 RS4 (see C & A at P. 25, 26 September 2016, based on DASO 1184) Renault have still refused to provide Bore and Stroke of the ref. engines.

However, with the new NP RPM the relation of the RS4 value of NP/SCF has improved from 16% excess above the statistical average of 47.4 for "*Individual & Tuned Inlet and Exhaust systems*" to only 6%.

2001 RS21 101^0 V10 3 litre

DASO 1216 also gives the power of the 2001 RS21 with which Renault re-entered the F1 arena with works engines, having retired from that role after 1997. The Vee bank angle of the mandatory V10 F1 engines had been reduced since that date, to lower the Centre of Gravity, reduce weight transfer on corners in particular and so improve cornering 'g'. Ferrari led the way, viz:-
1997 type 046 75^0 ; 1998 047 80^0 ;2000 049 90^0 . Renault Sport, led by Patrick Faure, decided to go to a step beyond that with a 101^0 V10 (it was often reported in the media as 111 or 112 degrees). Jean-Jacques His then developed this engine. DASO 1216 quotes almost 789 Hp @ 17,200 RPM for the 2001 engine, i.e. 5% above the 1997 RS9. It was possibly lighter, but as fitted in the Benetton B201 chassis the engine did not provide sufficient stiffness and first the chassis and then the engine had to be strengthened. Apparently, there was also a vibration problem. Renault persevered with the configuration for 2002 (RS22) and 2003 (RS23), during which years Renault had fully taken over the former Benetton team, claiming well over 800 HP and maximum revs of 18,000. Only one win was secured, in 2003.

\-

2002 RS22.

f1technical.net

Without officially admitting the technical problems with the 101^0 configuration, in 2004 Renault abandoned it and adopted for the first time the "natural" 72^0 Vee angle (2 x 180^0/10) for a new V10 engine, RS24. Perhaps not entirely coincidentally, His left Renault. After a year's development, the succeeding RS25 enabled Fernando Alonso to secure the first all-Renault Championship titles. For the last, deciding, race a special unit was produced giving over 900 CV (888 BHP). Ironically, the Mercedes Ilmor FO110R which the Renault beat was a 90^0 V10!

2006 – 2013 Limited development era with 90^0 V8 2.4 litre NA engines

Renault was the most successful engine maker in this 8-year period, when the configuration above and many details were prescribed by the FIA; maximum bore 98 mm, minimum weight 95 kg; rev limits imposed (19,000 RPM in 2007; 18,000 in 2009); development restricted to very limited areas; and life required without penalty extended (from 1,600 km at the period start to 2,000 km in 2009).

The 2006 RS26, which was first put on the test bed in September 2005, provided Renault and Alonso with a consecutive Championship double. A total of 8 wins were secured (1 by Giancarlo Fisichello). At the season end it gave 800 CV (789 HP) with Maximum revs approaching 20,000.

With the limit imposed of 19,000 RPM for 2007, makers were allowed to re-optimise the engines within strict limits. Rob White, Deputy Renault Sport Technical Managing Director said that, whereas in previous years over 95% of engine parts might be re-designed between one season and the next, for 2007 the changes for the RS27 were only 10%. With even less allowed for subsequent seasons the designation of the engine remained as RS 27 until the formula ended after 2013.

Red Bull adopted the RS27 in 2007 and the history of their combined efforts, greatly influenced by Adrian Newey's aerodynamics, was as follows:-

	Year	2007	2008	2009	2010	2011	2012	2013	Total
	Wins	0	2	6	9	12	8*	14*	51
Championships					Both	Both	Both	Both	

Sebastian Vettel was the Champion Driver.

*Includes a win in each season by Kimi Raikkonen driving a Lotus.

Essentially the same engine had therefore amassed a total of 59 wins in the 8 year life of the 2.4 L NA formula, 40% of the possible 147.

2012 RS2
The shape of the exhaust system is wonderful to behold!

123.com

Abortive work on the 2013 regulation engine

DASO 1216 records how Renault were forced by an FIA (World Motor Sports Council) change of mind into wasted work. In December 2010 the regulatory authority issued the engine rules for the next F1 racing formula, to begin in 2013. It was to be a petrol-electric Hybrid with the Internal Combustion Engine (ICE) an IL4 of 1.6 litres Turbo-charged. Renault, who favoured the formula as relevant to their production strategy, began at once to work on this configuration. However, after 5 months of this, it was made abortive. Ferrari, who thought that the formula was inconsistent with *their* complex and expensive image, employed a secret agreement with the FIA* to get the ICE changed to 90^0 V6, still 1.6 litres. The FIA, although noting that 5 engine makers were already working on the IL4 configuration, managed to get this change rubber-stamped by 4 of them in June 2011 by setting back the introduction to 2014. This change was, of course, contrary to the oft-stated FIA aim to reduce F1 costs.

Adrian Newey in his autobiography "How to build a car", P.71, states "...in 2015...it emerged that Ferrari did...have a secret contract with the FIA that allowed them to veto any regulation changes...*". He probably was linking this to the V6 change.

This wasted effort by Renault therefore joined other major projects aborted by late FIA decisions before there could be any return on the investment (contd. on P.72):-

- The banning of the Williams Continuously-Variable-Transmission in late 1993 (see Note 33);
- The Ilmor Bishop rotary-valve engine banned by a late 2004 rule for the 2.4 litre engines to start in 2006 permitting only poppet valves (see "How many valves per cylinder");
- The BMW P85 engine built and intended for 2005 but cancelled because it could not meet a late FIA change of life required from 1 weekend to 2 (see Note 112).

Renault ill-fortune with Turbo-Charging

Renault introduced Turbo-Charging (TC) to the Grand Prix scene in 1977 and secured its first win with that system of Pressure-Charging (PC) in 1979. It was then copied by every other engine maker, but never gained a Championship with its TC engines either in its own chassis or that of any other constructor.

In the post TC period, 1989 to 2013, Renault Naturally-Aspirated (NA) engines powered 11 Drivers' and 12 Constructors' Championships (two in its own chassis).

However, when the racing formula returned to PC/TC in 2014, Renault's ill-fortune with this system returned. Up to the time of writing (May 2019), 5 years have passed with no further Championships.