THE

GRAND PRIX CAR

by

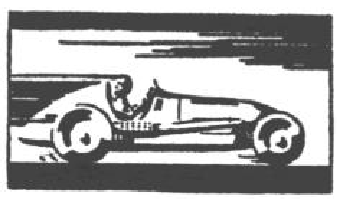
LAURENCE POMEROY

F.R.S.A., M.S.A.E.

Illustrated by

L. C. CRESSWELL

VOLUME ONE



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FOREWORD TO VOLUME ONE

THE work now presented succeeds THE GRAND PRIX CAR 1906-39 which was based upon a series of articles in *The Motor*. These were called " Milestones of Speed " and they appeared during the war-time years, the first, dealing with the 1908 Itala, appearing on 5th June, 1940, and the last, describing the 1939 3-litre Mercedes-Benz, being printed on 27th December, 1947. In the ensuing twelve months the author wrote additional matter, consisting of a survey of motor racing up until 1939 and a technical review of progress in the same period. Thus, as published in 1949, the GRAND PRIX CAR 1906-39 consisted of Part One, Grand Prix Racing ; Part Two, Examples of the Grand Prix Car ; and Part Three, Analysis and Synthesis. With appendices, there was a total of some 420 text pages.

At the time of publication, the later cars described were not remote in time and for most people the words " Grand Prix Car " summoned an image of a 3-litre Mercedes-Benz or Auto-Union. In other words, the information contained in the work was virtually contemporary. The first printing sold out during the two years 1949-50 and when the reissue of the volume had to be considered, it was obviously desirable to bring information about Grand Prix racing and Grand Prix cars up to date.

A logical stage for making a review was the end of 1953, when Formula 1, which was initiated in 1947, expired. But it eventually became obvious that the additional information available would result in a single volume of inordinate size and cost, and it was therefore decided to split the work into two volumes, of which this book is the first.

As a consequence, Volume One contains a history of racing up till 1939 and detailed descriptions of the principal racing cars which were built up to that time. It is not simply a reprint of the same matter contained in THE GRAND PRIX CAR 1906-39, for in both sections there is, as a result of the researches made in the past five years, a considerable amount of new information.

In this connection the author would like to take this opportunity of paying particular tribute to Monsieur Henri Petiet, who has provided a wealth of data concerning motor racing in the pre-1914 period ; to Mr. C. Posthumus, who has cleared up a number of obscure passages in the 1920-30 era, and also to Messrs. George Monkhouse, Harry Knox and P. S. De Beaumont, who contributed special information on various subjects.

The Fiat Motor Company and Dr. Giacosa have given full co-operation in providing new information and drawings regarding Fiat racing cars and Jules Goux, a some-time member of the Peugeot racing team, has made it possible accurately to assess the influence of 1908-10 small racing cars on subsequent Grand Prix cars.

It is intended that Volume Two shall provide a summary of racing in the 1947-53 period ; a description of the principal cars which appeared therein ; and the story of the technical evolution of the Grand Prix car from the earliest times up to the end of 1953. It is hoped, therefore, that the two volumes together will make it possible to study the complete chain of events in Grand Prix racing during the first half of the twentieth century.

In conclusion, the author would like to thank the many correspondents who have so generously given their time in suggesting improvements upon, and corrections to the text of the original work. Mr. R. Shepherd has been particularly helpful and although it is almost impossible entirely to avoid inaccuracies and omissions in a book of this magnitude, it is hoped that there are relatively few textual or statistical errors now remaining. Attention is, however, drawn to a note below on some comments and corrections which are relevant to this volume.

The author would like to renew his thanks to the Directors of Temple Press Limited, for their permission to engage in the additional work involved in the preparation of this book in its new form.

LAURENCE POMEROY, F.R.S.A., M.S.A.E.

London
November, 1953.

Comments and Corrections

Some corrected speeds were worked out after the text of Volume One had been printed, but fortunately before the Appendix giving the principal race results had gone to press. The speeds quoted in the latter should therefore be taken as definitive, and where discrepancies exist between the final tables and the earlier text, the former are marked with an asterisk. The races in error are : 1906 Ardennes ; European G.P. 1926 ; French G.P. 1913, 1914 and 1923 ; German G.P. 1934; Italian G.P. 1935 ; Monaco 1930; and Swiss G.P. 1937. Some textual corrections should also be noted as follows :

A. The stroke of the 1903 Mors car was 175 mm. and not 170 mm. as stated in the table on page 19.

B. The introduction of a live rear axle by Panhard was delayed until 1904 (not 1902 as stated on page 20) and in 1904 Clement Bayard also discarded chain drive, which they did not use in the Grand Prix of 1906.

C. As stated on page 23, the 1906 Grand Prix was run anti-clockwise ; not clockwise as inadvertently written on page 27.

D. In the 1908 Grand Prix the performance of the Renault was slightly better than stated on page 27. The car driven by Dimitri rose from eleventh place on the eighth lap to tenth on the ninth lap and eighth on the tenth and last lap. The Mercedes and Mors cars had H.T. ignition.

E. To clarify the poorly punctuated sentence on page 32, it should be made clear that entrants for the 3-litre race organised by the A.C.F. in 1912 had a choice of a Stroke : Bore ratio lying between 1 : 1 and 2 : 1.

F. In the 1916 Indianapolis race a fourth Peugeot started, retiring on the sixty-ninth lap. (Page 40.)

G. In the 1919 Indianapolis race the Peugeot driven by Goux finished third. (Page 43.)

H. In the 1921 Indianapolis race the Duesenbergs finished second, third, sixth and eighth, with only three retirements. (Page 45.)

I. In the I924 Indianapolis race the Mercedes driven by Werner finished eleventh. Lautenschlager ran subsequently in the 1924 Targa Florio in which he finished second in the 2-litre class and tenth in General Classification. (Page 51.)

J. In the middle of the right-hand column of page 125 the classification " Ignition " should read " Transmission ".

K. The 1913 Peugeot S : B ratio was 2.0 : 1. (Page 135.)

L. On page 146 the Crank Shaft specification should read " 4 piece built up ".

M. The 1927 Delage had a piston area of 30.4 sq. in. and developed 5.6 h.p./sq. in. (Page 180.)

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Part One

GRAND PRIX RACING

A Summary of Results

" Sunt quos curricula pulverem Olympictan
Collegisse iuvat, metaque fervidis
Evitata rotis palmaque nobilis
Terrarum dominos evehit ad deos ;"

HORACE.

" Man is a noble animal, splendid in ashes and pompous in the grave, nor omitting ceremonies of bravery in the infamy of his nature."

SIR THOMAS BROWNE.

" The firm which is building the high speed engine is adding to its knowledge of the durability of materials and of the effect of detail alterations at a rate which is incredible to those without similar experience."

L. H. POMEROY.

"The Führer has spoken. The 1934 G.P. formula shall and must be a measuring stick for German knowledge and German ability. So one thing leads to the other ; first the Führer's overpowering energy, then the formula, a great international problem to which Europe's best devote themselves, and finally action in the design and construction of new racing cars."

MANNSCHAFT UND MEISTERSCHAFT

CHAPTER ONE

Incentives and Restrictions

THE purpose of this work is to narrate the technical progress of the automobile as exemplified by Grand Prix racing cars, and this development cannot be properly understood without reference to the conditions imposed upon the designer by external forces.

Five principal factors have combined in the maintenance of motor racing over the past fifty years. They are the challenge to personal courage, the appeal of pageantry, the desire to use extreme competitive conditions as a forcing ground for technical improvements, the opportunity to advertise by demonstration that the products of one Company were superior to all rivals, and last, but by no means least, the means of providing political propaganda to prove the engineering supremacy of one particular nation and the implied supremacy of that nation in all walks of life.

These widely differing incentives have been largely co-existent but their relative order of importance has constantly changed. It is probable that the earliest races were based mainly on personal competition between various drivers and this element has persisted throughout the years becoming, however, more and more a feature of minor races supported by amateurs. In the Grandes Epreuves the accent quickly shifted firstly to a struggle between makes of cars and then, quite early on, to the theme of national rivalry.

In 1899 Mr. James Gordon Bennett offered the Automobile Club de France a trophy to be competed for by the automobile clubs of the various countries, each country to enter one, two or three cars, each of which had to be entirely constructed, including component parts, in the country which the cars represented. The total distance specified was between 342 and 404 miles.

The first Gordon Bennett race was held in 1900 with entries from France and the U.S.A., and may be considered the precursor of Grand Prix racing. By 1905, after two consecutive French wins, the Automobile Club de France considered that the regulations imposed an unfair handicap upon their own constructors, for France was at this time much the largest producer of cars, both in respect of total quantity and number of manufacturers, and the latter thought the limitation of three cars per nation stipulated by Gordon Bennett to be intolerable. Hence, in 1906 the A.C.F. organised the first of the Grand Prix races with which this volume is concerned. Entries at £200 per car were confined to manufacturers, but there was no limit to the number of makers from any given country who could participate and no restrictions concerning the nationality of component parts. The first Grand Prix race was nevertheless an almost undisguised effort to sustain French supremacy and was thus a logical continuation of the Gordon Bennett evaluation of motor racing victories in relation to country of origin. Later the overriding motives were those of technical development and advertising for the marque, and trade and politics apart, motor racing gave invaluable assistance in improving the breed of the normal motor car both in the " early days " of 1906-14 and for the first few years after the 1914-18 war.

For a few years after 1924 engineers felt, to some extent rightly, that the design of the racing car had become so specialised in conception, so costly in execution, that it could not be justified in relation to the ordinary motor car. Simultaneously the offer of motoring to the masses throughout the world reduced the commercial value of a win in racing, for the potential market was no longer composed mainly of well-to-do men of the world but of those middle people of moderate means who had small knowledge of, and less interest in, motoring sport.

Over a period of nearly ten years we therefore witness a decline in Grand Prix racing, followed by an extraordinary revival in which first Fascist Italy and, subsequently, the Germany of the Third Reich used the spectacle of motor racing to excite emotions of superiority in the breasts of their own nationals, and to further the prestige of their general engineering industry in the minds of the world at large.

It will be observed that the pendulum swings from nationalism to individualism and back, and it was in this last period between 1934 and 1939 when companies like Auto-Union and Mercedes-Benz were encouraged by the German Führer and Reich Chancellor to spend hundreds of thousands of pounds per annum in motor racing that we see the most fantastic progress in power and speed.

Apart from these indirect influences on the design of racing cars there has been, as before mentioned, a direct control on Grand Prix cars in the shape of internationally agreed regulations, for only in the years 1929-33 has it been possible to race cars of any size or type. Thus it is essential to interpret the technical history of the Grand Prix car in relation to the regulations with which it has had to conform. A summary of these is, therefore, set out :-

1906 Maximum weight 1,000 Kg. (2,204 lb.).

1907 Fuel limited to 30 litres per 100 kilometres (9.4 m.p.g.).

1908 Maximum piston area 117 sq. in. Minimum weight 1,150 Kg. (2,534 lb.).

1912 Maximum width of car not to exceed 175 centimetres (69 ins.).

1913 Fuel limited to 20 litres per 100 kilometres (14.2 m.p.g.), contained in a bolster-type rear tank to standard dimensions, streamlined tails behind this tank being forbidden. Minimum weight without fuel 800 Kg. (1,760 lb.).
Maximum weight 1,100 Kg. (2,425 lb.).

1914 Maximum engine capacity 4.5 litres, superchargers and doped fuel forbidden, weight limits as 1913.

1921 Maximum capacity three litres. Minimum weight empty 800 Kg. (1,763 lb.).

1922, 1923, 1924 } Maximum engine capacity 2.0 litres.
Minimum weight empty 650 Kg. (1,433 lb.).

End of tail not more than 150 centimetres behind rear wheel centre.
Note.-In all the foregoing years it was obligatory to carry two occupants with aggregate weight not less than 120 Kg. (264 lb.) or equivalent weight in ballast.

1925 Maximum engine capacity 2.0 litres.
Minimum weight empty 650 Kg. (1,430 lb.).
Two-seater bodies. Minimum width 80 centimetres (31.5 ins.).. Driver only for this and all following years.

1926 Maximum cylinder capacity 1.5 litres.
Minimum weight 600 Kg. (1,322 lb.).
Two-seater bodies. Minimum width 80 centimetres.

1927 Maximum engine capacity 1.5 litres.
Minimum weight 700 Kg. (1,543 lb.).
One or two-seater body.
Minimum width 85 centimetres (33.5 ins.).

1928 Minimum weight 550 Kg. (1,212 lb.). Maximum weight 750 Kg. (1,653 lb.). Minimum distance 600 kilometres. (Only used for Italian Grand Prix.)

1929 Minimum weight 900 Kg. (1,980 lb.). Minimum body width 100 cm. (39.3 ins.). Pump fuel. Maximum consumption fuel plus oil 14 Kg. (30.8 lb.) per 100 kilometres (62.1 miles) (14.5 m.p.g. approx.). (Only used for French and Spanish Grands Prix.)

1930 As 1929 but 30 per cent added Benzol permitted. (Only used for French and Belgian Grands Prix.)

1931 Minimum duration 10 hours. Any type of car.

1932 As 1931. Duration 5 to 10 hours.

1933 As 1931-32. Duration 500 kilometres.

1934, 1935, 1936, 1937 Maximum weight 750 Kgs. (1,653 lb.). Minimum body width 85 cm. (33½ in.).

1938, 1939 Sliding scale relationship between weight and engine capacity, the latter limited to 3 litres supercharged, 4½ litres unsupercharged. Minimum weight for cars with engines of either of these sizes 850 Kgs. (1,873 lb.).

(The A.I.A.C.R. definition of weight is for a car with oil and four wheels, without water, fuel, tyres, tools, spares and spare wheel, except for the five years 1934-39 during which time oil and wheels were also excluded.)

It will be observed that the favoured rule has been a limitation on cylinder capacity, which naturally had the effect of forcing the pace in the development of small high-output engines. Considerable technical advances have, however, taken place in the periods when restriction by weight was imposed. Despite the many theoretical arguments in favour of a fuel consumption rating, proposals on these lines have normally been out-voted or ignored.

It is interesting to observe that entrants have never welcomed complete freedom in the construction of racing cars. There has perhaps been a feeling that such liberty produces too many variables and makes an investment into a given design an unduly hazardous proposition.

To conclude this chapter it may not be out of place to observe that whilst motor racing may to some extent have influenced national affairs, national characteristics have exercised equally a profound influence on motor racing. In Great Britain the ideal of the amateur has always held a high place in every sport. Racing in this country has, therefore, tended towards a competition between moneyed young men, events have been organised to agree with their needs and International Racing has received little support. Austin and Weigel ran in 1908, Vauxhall in 1914, Aston Martin in 1922; and Alvis entered in 1926 and 1927, but only Sunbeam consistently supported Grand Prix racing from this country, with teams of three cars entered in 1912, '13, '14, '21, '22, '23, '24 and '25. In other words, support for Grand

Prix racing so far as England is concerned has rested with the Sunbeam Company with occasional intervention from others.

By contrast, Grand Prix racing has always been regarded by Continental nations as one of the highest exercises of professional skill in design, construction and driving. Large numbers of companies have exerted immense efforts and spent vast sums, drivers have been retained at high fees, and have driven under strict team orders - not, it may be mentioned, always obeyed.

From the public viewpoint Grand Prix racing has been perhaps the most popular form of sport in Europe. The names of the great drivers and the merits of their differing styles have been a source of discussion for the common man, and in the peak years immediately before World War II crowds of over a quarter of a million persons were not exceptional. Any effort to estimate the importance of Grand Prix racing must, in consequence, take account of the violent contrast in outlook existing on the opposite sides of the English channel, but this is an aspect of racing with which we are not immediately concerned.

To evaluate the merits of various designs it is, however, essential to have some knowledge of their performance on the road. The first part of this book is, therefore, devoted to a brief and purely factual account of Grand Prix racing which may perhaps serve as a basis for a full scale work on this theme from a writer skilled in the art of dramatic narrative.

CHAPTER TWO

Before 1906

THE first real motor race was over 732 miles from Paris to Bordeaux and back, and was won by Levassor, who drove for 48 hours 48 minutes on a Panhard and averaged 15 m.p.h. The date was June 11th to 13th 1895.

The history of ensuing events is particularly well documented in *A Record of Motor Racing,** by Gerald Rose and, thus, in this volume no more than a résumé of his work need be given This shows that in the first five years average speeds rose steeply, the highest winning speeds in any given year between 1895 and 1900 being :–

Year	*M.P.H.*	*Winning Car*	*Route or Circuit*	*Total Mileage*
1895	15	Panhard	Paris-Bordeaux-Paris	732
1896	15.1	Panhard	Paris-Marseilles-Paris	1,062
1897	25.2	Panhard	Paris-Trouville	107.7
1898	26.9	Panhard	Paris-Amsterdam-Paris	889
1899	37	Mors	Bordeaux-Biarritz	163
1900	43.8	Panhard	Circuit Sud Ouest	209
1900	40.2	Mors	Paris-Toulouse	837

From the first year of the twentieth century forward we can also reliably estimate the maximum speed of road racing cars by consulting the record book Cars built especially for the flying kilometre record were not made before 1905, and before 1902 the highest speed achieved was with steam or electric cars, but within the three years mentioned we observe the following performances with petrol-driven cars :–

M.P.H.	*Drivers*	*Car*	*Cyl.*	*Date*	*Time*	*Place*	*A.I.*
76.09	W. K. Vanderbilt	Mors	4	5/8/02	29.4	Ablis-St. Arnoult	12.R
76.60	H. Fournier	Mors	4	5/11/02	29.2	Dourdan	12.R
77.14	Augieres	Mors	4	17/1 1/02	29.0	Dourdan	12.R
83.47	Rigolly	Gobron-Brilié	4	17/ 7/03	26.8	Ostend	12.R
84.73	Duray	Gobron-Brillié	4	5/11/03	26.4	Dourdan	12.R
94.78	Rigolly	Gobron-Brillié	4	31/ 3/04	23.6	Nice	12.R
97.26	P. De Caters	Mercedes	4	-/ 5/04	23.0	Nieuport-Ostend	12.R
103.56	Rigolly	Gobron-Brillié	4	21/ 7/04	21.6	Nieuport-Ostend	12.R
104.53	P. Baras	Darracq	4	13/11/04	21.4	Nieupoti-Ostend	12.R

* Published by MOTOR RACING PUBLICATIONS LTD. 42s.

Translating into winning average speeds on the road we find that some cars were capable of sustaining over 70 m.p.h. for long distances, the speed increments in the five years 1900-05 being as follows :–

Year	*M.P.H.*	*Winning Car*	*Route or Circuit*	*Total Mileage*
1901	*53*	Mors	Paris-Bordeaux	327
1902	54.5	Panhard	Ardennes Circuit	318
1903	65.3	Mors	Paris-Bordeaux (Madrid)	342
1904	72	Fiat	Florio Circuit (Bologna)	231
1905	65.1	Itala	Florio Circuit (Bologna)	311

Yet another change came over the racing scene in the first five years of the twentieth century. In the late 90's Panhard had dominated the scene, the number of victories each year before 1900 being :-

1895 Panhard (1).
1896 Panhard (1).
1897 De Dion (Stea) .(2), Panhard (1).
1898 Panhard (4), Bollée (1).
1899 Panhard (4), Peugeot (l), Mors (1).

In sum, out of sixteen races, Panhard won 11, De Dion 2, and Peugeot, Bollée and Mors one race each.

From 1900 onwards the table is :-

1900 Panhard (4), Mors (2).
1901 Panhard (l), Mercedes (l), Mors (2).
1902 Panhard (3), Napier (1).
1903 Mors (l), Panhard (l), Mercedes (1).
1904 Richard Brasier (l), Panhard (I), Fiat (1).
1905 Richard Brasier (l), Darracq (l), Itala (1).

So in twenty-two races Panhard won 9, Mors 5, R-Brasier and Mercedes 2 races each, and Napier, Fiat, Itala and Darracq one race each. It is of particular interest that although Panhards retained numerical supremacy in the 1900-05 period they secured only two firsts in the three seasons 1903-05, in which years no fewer than seven other makes achieved victory.

The decline and fall of Panhard was due to their inability to keep in the forefront of technical progress. The earliest cars used for racing, as we have previously observed, were normal vehicles as sold later to the public. The Panhard is fully described in *Motor Vehicles and Motors,* by W. Worby Beaumont, as are a number of other pre-1900 vehicles. Many of these (including Panhard) used engines built under licence from Daimler and thus in a sense emanating from what was to become the Mercedes and later the Mercedes-Benz factory.

A cross section of the 1899 engine is typical of all these earlier power units ; it has a laterally located exhaust valve and an overhead automatically operated inlet valve. A passage is drilled from a chamber beneath the inlet valve into a burner containing a platinum tube, this forming a primitive ignition arrangement on these early types. The maximum engine speed was limited by a governor giving interrupter action on the exhaust valves, and this normally maintained the engine at 700 r.p.m. However, a lever on the dashboard of the car could be moved so as to fix the engine speed at any required r.p.m., and an accelerator control made it possible to frustrate the governor entirely, the engine speed then increasing to some 1,200 r.p.m.

A drawing of the car shows an outrigged rear seat, but this was supplementary and not carried when the car was racing (Plate I).

Another incidental feature of interest is the low mounting of the cooler which consisted of a 55 ft. pipe of ½ in. diameter carrying thin light alloy fins. Mounting at the rear was presumably dictated by considerations of space. This was the type of Panhard used by De Knyff to win the Paris-Bordeaux race, and by Charron in the Paris-Amsterdam-Paris race at average speeds of 22.1 and 26.9 m.p.h. respectively.

The first developments in engine design were mainly confined to enlargements of capacity. Output, measured either per litre or by square inch of piston area, changed very little for the first four years, during which time, however, swept volume increased from 1.2 litres to 4.4 litres. By 1901, however, Mors were using 10 litre engines and Panhard replied in 1902 with the famous " 70 " of 13.7 litres. Engine design had in fact began to get under way and progress can perhaps best be analysed in a table :–

Year	*Make*	*Bore and Stroke M/M*	*Cyl. No.*	*Capacity Litres*	*B.H.P.*	*H.P./Litre*	*H.P./Sq. Ins*
1895	Panhard	80 x 120	2	1.2	4	3.3	0.26
1896	Panhard	80 x 120	4	2.4	8	3.3	0.26
1899	Panhard	90 x 130	4	3.3	12	3.65	0.32
1899	Panhard	100 x 140	4	4.4	16	3.65	0.33
1900	Panhard	110 x 140	4	5.3	24	4.5	0.40
1901	Mors	130 x 190	4	10.1	60	6	0.73
1902	Panhard	160 x 170	4	13.7	70	5.1	0.56
1903	Mors	145 x 170	4	11.2	70	6.25	0.70
1904	Brasier	150 x 140	4	9.9	80	8.1	0.73

It may also be interesting to consider certain figures for engine size and output just prior to the Grand Prix era. Manufacturers in the early days of motoring quite freely quoted their h.p. figures and there is reason to believe that they were not unduly optimistic in their claims. Accurate published statistics are hard to come by so it is, therefore, interesting to look up the trials made by the A.C.F. in 1906, when they were searching for some rating rule. It may not be generally known that the British

R.A.C. formula and the corresponding S.A.E. formula in the U.S.A. were based on these trials in which ninety-six engines were bench-tested by an independent authority. In the published results these engines are referred to by number only, but by looking through the cylinder dimensions it is possible to identify, with some reasonable probability, a number of relevant types. These can be set out in a table thus :–

Make	*Year*	*No. of Cyls.*	Cyl. *Dimensions M/M*	Cyl. *Capacity Litres*	*B.H.P.*	*R.P.M.*	*Ft./ Min.*	*M.E.P*	*H.P./ Litre*	*H.P./Sq. Ins.*
Panhard	1903	4	160 x 170	13.7	90	1,260	1,400	69.5	6.55	0.74
Mors	1904	4	170 x 150	13.6	100	1,200	1,200	80	7.35	0.72
Mercedes	1904	4	165 x 140	12	105	1,380	1,270	82.5	8.75	0.80
Fiat	1905	4	180 x 160	16.2	120	1,100	1,040	88.0	7.4	0.67
Richard Brasier	1905	4	160 x 140	11.3	101	1,350	1,240	86.5	9.1	0.84

The high m.e.p. of the Fiat is particularly noteworthy and it is obvious that breathing of engines was being materially improved.

So far as chassis design is concerned a major development was the change (*circa* 1897) from tiller to wheel steering, Panhard adopting the latter in 1898, in which year also this Company used aluminium for a number of components, particularly carburetter and gearbox.

In 1900 the honeycomb radiator had made its first appearance but chassis were made from wood reinforced with metal plates. In the next year or two, however, the all-steel channel frame came to be common and 1902 is notable for the introduction by Mors of dampers to the springs.

The Gordon Bennett rules prescribed a maximum weight of 1,000 kg. (2,204 lb.), and in view of the size of the engines that were being used it was remarkable that a complete car could be held to this figure. As it'was, margins of mechanical safety were sometimes cut too fine although great ingenuity was shown in various methods of genuine weight saving. For example, the separate cylinders of the Panhard engine had copper water jackets only 1 mm. thick. This engine weighed under 700 lb. and gave 90 h.p. on the brake. The specific weight, therefore, was 7.8 lb. : B.H.P. The majority of these early cars had low tension ignition and from 1902 onwards the automatically operated inlet valve gave way to the mechanical type although it was still not infrequent for the camshafts themselves to be exposed. Daimler, with their Mercedes model, pioneered the use of the throttle valve in 1901, the speed of the previous cars having been controlled by various governing arrangements, in some cases hit and miss on the ignition and in others by changing the lift of valves. In 1902 almost all the larger cars retained chain drive, but Renault and Panhard had already changed to the live rear axle.

By 1905 France, after a decade of supremacy, was on the verge of being challenged, and not only do we see a shaft-driven Itala amongst the winning makes, but also Fiat, the latter with a remarkable car with 16.2 litre engine capacity, which had push-rod operated valves mounted in the head at an included angle of 90 degrees. Only ill-luck prevented the victory of these cars in two major races.

The last of the Gordon Bennett series of races was held in 1905 with competition between two Richard Brasiers and one De Dietrich car for France, three Fiats for Italy, three Mercedes for Germany, two Wolseleys and one Napier for England, two Pope Toledos and one Locomobile for the U.S.A.

There were very wide variations in the type and size of car. Lancia on a Fiat proved to be easily the fastest driver, putting in a record lap at 52.6 m.p.h. on a mountainous circuit 85 miles long. Later, he had radiator trouble and the race was eventually won by Théry on a Richard Brasier, who had a comfortable margin over Nazzaro, whose Fiat was runner-up.

The speed of these immediately pre-Grand Prix cars is indicated by the speed made by Lancia (again driving a Fiat) in the Vanderbilt cup race held in the United States on October 14th, 1905. Although again he failed to finish-this time due to an accident-he put in a lap at 72 m.p.h. However, it will perhaps be best (in virtue of its Gordon Bennett win) to take the Richard Brasier as a typical example of design.

In 1905 we find it had a capacity of 11.3 litres and developed slightly over 100 h.p. Two valves per cylinder were mechanically operated and the leather cone clutch drove to a three-speed gearbox with a countershaft and chain drive. Cooling was by pump through a tubular finned radiator and a channel pressing was used for the frame. This car, of course, had brakes on the rear only, but was a thoroughly soundly constructed vehicle which ran with considerable speed and regularity. The weight was only 994 kg.

The 1905 Hotchkiss is also worthy of mention, as on this car a live rear axle was located by semi-elliptic springs which were also used to drive the car-an arrangement copied by Hola and Peugeot, and which has since been widely followed on racing cars and has become almost universal on production models.

In sum, before the first Grand Prix race was held, racing cars had developed to a high standard of effectiveness, if not perhaps of efficiency in the terms of power for a given size of engine. What is more, with light axles the ratio of sprung to unsprung weight was good despite the low all-up weight. Hence, the road holding, particularly on those cars fitted with shock absorbers, was very much better than many people have imagined, and this standard of control was achieved without using excessively stiff springs, so that the driver had a more comfortable ride than he did on later models.

The striking increases in speed in the period 1900-05 had, however, been realised almost entirely by enlarging engine size. The first Grand Prix races showed little change in this respect and, from a technical point of view, the events of 1906, '07, and '08, may be considered a continuation of the Gordon Bennett era.

Perhaps with this in mind the Automobile Club de France have retrospectively added eight pre-1906 races to their list of French Grands Prix so that on this reckoning the first event actually to be organised with this title now counts as " Le IXeme Grand Prix de l'A.C.F." The preceding events in this score are : Paris-Bordeaux-Paris, 1895 ; Paris-Marseilles-Paris, 1896 ;. Paris-Amsterdam, 1898 ; Tour de France, 1899 ; Paris-Toulouse-Paris, 1900 ; Paris-Berlin, 1901 ; Paris-Vienna, 1902 ; Paris-Madrid (stopped at Bordeaux), 1903.

CHAPTER THREE

The Age of Monsters

RACING STATISTICS 1906-08

Date	*Event*	Course	*Driver*	*Car*	*Winning Speed m.p.h.*	*Lap Speed (Rec'd *)*
26/6/06	French G.P.	Le Mans	Szisz	Renault	63	
26/6/06	,,	,,	P. Baras	R. Brasier	—	73.3*
13/8/06	Ardennes Prize	Ardennes Circuit	L. Duray	De Dietrich	65.5	—
13/8/06	,, ,,	,, ,,	L. Wagner	Darracq	—	70*
14/6/07	Kaiser Prize	Taunus Mountains	F. Nazzaro	Fiat	52.5	—
2/7/07	French G.P.	Dieppe	F. Nazzaro	Fiat	70.5	—
2/7/07	,,	,,	A. Duray	De Dietrich	—	75.4*
25/7/07	Ardennes Prize (8-litre class)	Ardennes Circuit	J. T. C. MooreBrabazon	Minerva	59.5	—
25/7/07	,, I,	,, ,,	A. Lee Guinness	Minerva	—	67
25/7/07	,, ,, (G.P. Class)	,, ,,	Baron de Caters	Mercedes	57.3	—
25/7/07	,, ,, (G.P. Class)	,, ,,	C. Jenatzy	Mercedes	—	66.6
7/7/08	French G.P.	Dieppe	C. Lautenschlager	Mercedes	69	—
7/7/08	,,	,,	0. Salzer	Mercedes	—	78.5*
6/9/08	Coppa Florio	Bologna	F. Nazzaro	Fiat	74.1	—
6/9/08	,,	,,	V. Lancia	Fiat	—	*82.3**

THE 1906 Grand Prix, held on June 26th and 27th, was not only technically but also politically a continuation of the Gordon Bennett series. The organisers, the Automobile Club de France, were activated largely by the desire to have a French win, and by opening the race to an unlimited number of cars from each country they did much to ensure one as France in those days was the dominant producer of automobiles.

The formula limiting the design of the cars was the same as that imposed previously at Gordon Bennett events, a maximum weight of 1,000 Kg. (2,204 lb.) with a supplement of 7 Kg. to cover a magneto or dynamo driven from the engine and used for ignition. A change was, however, made in respect of the number of helpers who were permitted to work on the car. In the Gordon Bennett races no limit was placed, but for the Grand Prix event it was stipulated that all repairs, including tyre changes, must be effected by driver and mechanic working alone.

The course was a triangular circuit near Le Mans, 65 miles in length, and this had to be covered six times on two consecutive days, an interesting feature being the construction of a wooden by-pass road to avoid St. Calais. This scheme was adopted as an alternative to the arrangement in the Gordon Bennett series in which competitors had been forced to slow down and observe a no passing rule when traversing town limits.

It is interesting that in the original regulations and maps of the course the cars were to run clockwise, but in the end it was decided to retain the tradition dating back to the days of the Roman chariot race, and to run anti-clockwise. The grandstands were placed on the inside of the course and the replenishment depot opposite-an arrangement which enabled the cars to draw up at their " pits " (which were in fact areas marked out at road level) without leaving the right-hand side of the road but which made access to the stands during the race somewhat difficult.

The entries comprised ten teams from French constructors, two from Italy and one from Germany, and with three exceptions every maker entered three cars. There were, therefore, twenty-six French cars competing against six Italian and three German.

Technically the vehicles showed little change from those which had been running for the past two or three years. The Gobron-Brillié was, in fact, of 1903 construction, whilst the Brasiers were very similar to the winning Gordon Bennett cars of 1904 and 1905, but slightly lowered. All had four-cylinder engines, and all serious competitors had an engine capacity of 12 litres or more, Panhard having the largest with 18 litres.

There was a marked division of opinion in the matter of transmission. R-Brasier, Cl. Bayard, F.I.A.T., Gobron-Brillié and Mercedes had chain drive, the rest propeller shaft and live axle. Magnetos were used by everyone for ignition purposes, but only Gobron, Panhard and Renault used high tension ignition ; the rest had low tension systems with contact points inside the cylinder:

The one technical novelty of the race was the use by the Brasier, F.I.A.T., Itala and Renault teams of detachable rims. These were of considerable benefit under the new ruling which prohibited external assistance, an arrangement which had put a premium on a well-trained team who could slash off worn covers with knives and quickly force new tyres on to the rim. The 1906 rules restricted this work to tired drivers and mechanics, who necessarily lost a tremendous amount of time when replacements were needed.

The first Grand Prix of all started at 6 a.m., when Gabriel was despatched on one of the De Dietrich cars, carrying the number 1A, but actually it was number 2A, Lancia on a Fiat, who made history by crossing the line first as Gabriel stalled on the line ; car followed car at 90 second intervals until finally Teste got under way on a Panhard, number 10C, at 6.50 a.m. Fabry made the fastest start, his Itala being timed over the first standing kilometre in 43.4 secs., which equals 52.4 m.p.h., but Baras on a Richard Brasier was first on the opening lap at an average of 73.3 m.p.h. This speed proved to be the fastest recorded in the race, despite the standing start, but the great length of the circuit made the time lost when leaving the line a negligible factor.

Baras retained his position for a second circuit before dropping down to third on the third lap, fourth on the fourth lap, and thirteenth on the fifth lap, and also the sixth, which terminated the day's racing. A Hungarian driver in the Renault team, Szisz, made a slower start but a better finish, coming up from third on the first lap and fourth on the second to first on the third, from which position he was not displaced during the remainder of the first day, at the end of which positions were :–

Car	*Driver*	*Total Time*	*Average Speed*
Renault	Szisz	5 hrs. 45 mins. 30.4 secs.	66.8 m.p.h.
ClCment Bayard .	A. Clément	6 hrs. 11 mins. 40.6 secs.	62.2 m.p.h.
Fiat	F. Nazzaro	6 hrs. 26 mins. 53.0 secs.	59.6 m.p.h.

The position of the Cl. Bayard was notable, as its team had to bear the burden of fixed wheels, whereas both Renault and F.I.A.T. had the advantage of the detachable rims, which enabled driver and mechanic to fit an inflated tyre at the rate of two minutes per wheel.

The second day's start was not, as on the previous morning, in the order of numbers, but in the order of finishing the previous evening. Two extra mechanics were allowed to re-start the engine of each car, and Szisz immediately drove to his depot and spent twelve minutes re-fuelling and fitting new tyres. Clement got going inside five minutes, and Nazzaro went straight off into the race. It will thus be observed that the Cl. Bayard started only nineteen minutes behind the leader and F.I.A.T. twenty-nine minutes behind.

When Szisz finished his first lap, eleven cars were still waiting to be sent off, four being held on the starting line when he had completed his second lap. He was, in fact, so far ahead that he could take the whole of the race comparatively easily and still lead throughout the whole of the day. A De Dietrich, driven by Rougier, made the fastest lap at an average of 72.1 m.p.h., and as Clement made up a few minutes (in spite of his gain at the start), the F.I.A.T. and Cl. Bayard positions became reversed, and at the end of the second day, after 769.9 miles of racing, the results were :–

Car	*Driver*	*Final Time*	*Average Speed*
Renault	Szisz	12 hrs. 14 mins. .07 secs.	63 m.p.h.
Fiat	F. Nazzaro	12 hrs. 46 mins. 26 secs.	60.4 m.p.h.
Clément Bayard	A. Clément	12 hrs. 49 mins. 46t secs.	60.1 m.p.h.

Only eleven cars out of thirty-two starters finished this severe race, and although Fiat was second and fifth, the French could justly congratulate themselves on having seven finishers.

The winner ran an extremely regular race, and although on neither day did he feel it necessary to put up the quickest lap, he was the fastest car to be timed over a flying kilometre, reaching a speed of 92.2 m.p.h. Nazzaro was timed at 87.2 m.p.h.

Another race of importance in 1906 was held on the Ardennes Circuit on August 13th, run over 371 miles. Renault rested on their Grand Prix laurels, but De Dietrich, Darracq, Richard Brasier, Cl. Bayard and Mercedes all entered teams, a Darracq making the fastestrlap at 70 m.p.h., and a De Dietrich winning at 65.5 m.p.h., Duray being the driver.

The success of the 1906 Grand Prix had two consequences, to move the A.C.F. to an early decision to renew the event for 1907, and to spur the Germans into organising a race of comparable importance, but held under regulations more acceptable to German constructors. The result was a race for the Kaiser Prize on June 13th and 14th of 1907, followed by the French Grand Prix on July 2nd.

A circuit in the Taunus Mountains, 73 miles long, was chosen for the German event and the maximum capacity was limited to 8 litres, thus encouraging the normal production type of motor car, and specifically excluding the high-powered racer.

The support of manufacturers was almost overwhelming. An entry of ninety-two cars was received, and this meant that with competitors leaving at one-minute intervals the first man round would come round to the start when a number of cars were still awaiting despatch. To avoid this the race was run in two eliminating events on the 13th June, bringing the racing on the 14th June down to forty cars. Fiats were first in both the eliminating events, and also in the race itself, which was won by Nazzaro at 52.5 m.p.h., followed by a Pipe, two Opels and two more Fiats.

The French Grand Prix was run on a new course and under new regulations, limiting fuel consumption. A circuit was chosen near Dieppe, flat, triangular in shape and 47.74 miles round. It had to be covered ten times on one day.

Anti-clockwise rotation was again used and, reviving a practice established in the Gordon Bennett races, it was obligatory upon the entrants to paint their cars in recognised national colours, viz. English, green ; French, blue ; German, white ; U.S.A., white and red ; Belgian, yellow ; Italian, red ; Swiss, red and yellow. In the previous year manufacturers had been at liberty in this respect, and the winning French car had been painted red.

Eleven teams of cars entered under the French colours and one each representing Belgium, Italy, Germany, Great Britain, and the U.S.A. There was a total of thirty-eight starters, all of which had four cylinders except Dufaux, Porthos and Weigel cars, which used straight-eight engines.

The cars again showed little change compared with the previous year's models ; in fact Renault, having sold their team of cars the previous year, constructed virtual replicas thereof. With other makers the similarity in engine dimension is an indication that the new regulations had brought little change in design.

Lancia started at 6 a.m., on a Fiat, the remaining cars followed at minute intervals, and the Renault-Fiat duel of the previous year was at once renewed, with De Dietrich intervening.

Wagner on a Fiat led for the first three laps at an average speed of 72.1 m.p.h., and was then forced to retire. Duray, on a De Dietrich then moved up from second position and held the lead at an average of 70.6 m.p.h., but after a record lap at 75.4 m.p.h. with two laps to go, with Nazzaro on a Fiat lying second and Szisz on a Renault third, Duray retired with a seized gearbox. The elimination of the De Dietrich raised both cars one place in the order, but the Italian had an unshakeable lead. The finishing order was :–

Car	*Driver*	*Final Time*	*Average Speed*
Fiat	F. Nazzaro	6 hrs. 46 mins. 33 secs.	70.5 m.p.h.
Renault	Szisz	6 hrs. 53 mins. 10.6 secs.	69.4 m.p.h.
Richard Brasier	Baras	7 hrs. 05 mins. 05.6 secs.	67.4 m.p.h.

The Fiat team put up an outstanding performance. Wagner was fastest on the first and second laps and Nazzaro on the sixth, seventh, ninth and tenth laps. But Jenatzy, on a Mercedes, was fastest on the fifth lap, this being one of the very few in which he did not have trouble. Whether the spectators realised this as the omen it was may be doubted.

Seventeen cars, twelve of them French, finished out of thirty-seven starters, and, although losing first place, the French were by no means outclassed. It is indeed arguable that a mistake on the part of the Renault équipe had markedly affected the race, for Nazzaro finished with less than 2½ gallons of petrol, whilst Szisz finished with over 6½. On the other hand, Nazzaro with his greater speed consumed 95 per cent of his fuel allowance, which was certainly running things very fine indeed.

Two races over the Ardennes Circuit were run on July 25th and 27th and these proved highly significant from a technical point of view. On the first day, racing was confined to cars conforming with the under 8-litre Kaiser Prize regulations, and Minervas finished first, second and third, the winner, J. T. C. Moore-Brabazon (now Lord Brabazon of Tara), averaging 59.5 m.p.h., and another Englishman, A. Lee Guinness (now Sir Algernon Guinness), putting up the fastest lap at 67 m.p.h. Only a very small entry was received for the Grand Prix category, which was won by Baron de Caters on a Mercedes at 57.3 m.p.h., the fastest lap being made by Jenatzy, also on a Mercedes, who averaged 66.6 m.p.h., both less than the " small " car speeds. Even more interesting, A. Lee Guinness, who came in second, took 49 minutes 56 seconds to lap on his 13.6-litre Grand Prix Darracq, whereas he needed only 49 minutes 40 seconds on the 8-litre Minerva.

There had been a steady increase in engine capacity for some ten years, and at the time of the first two Grand Prix races, the fastest cars had engines of between 13- and 18-litres swept volume. The Ardennes Race indicated that this tendency towards huge engines had gone too far (a view strongly supported by the Germans) and led to the 1908 French Grand Prix being run for cars with a maximum piston area of 117 sq. in., the equivalent of a cylinder bore of 155 mm. for four-cylinder engines, or 127 mm. for six-cylinder types. The minimum weight was 1,150 Kg.

The entry list for the 1908 race shows a notable diminution of the French entry. Cars of this nationality maintained their majority position but comprised only eight teams compared to three from Gerrnany, two from Italy, two from Great Britain and one each from Belgium and U.S.A. Only two makers failed to put in a team of three, so that there were forty-eight cars entered, all having four cylinders, except Austin and Porthos, who used six-cylinder engines. All the entries were of entirely new design embodying features of considerable technical interest. Richard Brasier, Dietrich, Fiat, Itala, Mercedes and Mors retained low tension magnetos ; all the other entries employed high-tension ignition. The honeycomb radiator introduced on the first Mercedes of 1901 had now won almost complete acceptance, only Brasier and Mors using the gilled tube type and Renault a variation thereof. Four speeds were also preponderant, being used by all except Brasier, Germain, Mors, Porthos, Renault and Weigel. Opinion was divided in the matter of final drive. Chains were employed by Benz, Dietrich, Fiat, Germain, Mercedes, Mors, Motobloc, Panhard and Porthos, the case of Panhard being particularly interesting, in that it was a reversion from propeller shaft and live axle after five years of racing.

It was, however, in engine design that the major changes were made. Valves inclined at 45 degrees were used by Fiat, Dietrich, Benz, Clement Bayard and Weigel, the last two also having an overhead camshaft. A notable reduction in engine capacity was also to be observed, the largest car having less than 14-litres swept volume and the most popular size being 155 x 170 mm., giving a capacity of 12.83-litres.

A further point of considerable technical significance was to be found in the organisation of the race. The circuit was the same as on the previous year, but for the first time in racing history a replenishment area was marked out, and trenches or " pits " were dug at the side of the road in which spares, fuel and tyres were lodged. Fuel under pressure was supplied from large drums; quick lift jacks were employed, Mercedes even having pneumatic jacks available.

It will be recalled that the last-minute decision to run the 1906 Grand Prix on a clockwise circuit made it necessary to put the grandstands on the inside of the course, as the replenishment depots had to be on the right-hand and, in this case, outside of the course. The practical disadvantages of this arrangement are evident, and therefore in the following year both replenishment depots and grandstands were placed on the right-hand side of the course, making it essential for the former to be put below ground level in order that the spectators in the lower seats of the grandstand could retain their view of the passing cars.

In 1908 the replenishment area was for the first time set back from the main course so that the effective use of the road for racing was not diminished by a stationary car which was being worked upon. This also has, of course, been followed in subsequent prominent circuits such as Monza, Montlhéry, Nurburg, Rheims, and the like, although in subsequent races run anti-clockwise it has perhaps been more normal to put the replenishment area opposite the grandstand and to keep supplies at road level.

The race was a disaster for French, a triumph for German, cars. Renault were using a new type of detachable rim, which caused them great trouble, and at no time were they better than eleventh. Panhard never secured better than fifth place, Cl. Bayard at first were right out of the picture (ninth), and Motobloc were never higher than eleventh, leaving the only effective competition to come from Richard Brasier and De Dietrich. A car from the latter équipe reached sixth place on the second lap and then disappeared from effective competition, but at the end of the first lap the Brasiers of Bablot and Théry were second and third, Bablot being a bare nine seconds behind the leader. After this he ran into trouble but Théry held fourth place from the fourth to the ninth lap, at the end of which he was forced to retire having averaged 64.4 m.p.h. up to that point.

A Mercedes was first on the opening lap, and again put up a record from a standing start, the speed being 78.5 m.p.h. This car then broke down, putting first Nazzaro and then Wagner on Fiats into the lead on the second and third laps. They both retired on the fourth lap, having averaged 73.7 m.p.h. up to this time, which left Hemery in the lead on a Benz, with Mercedes (Lautenschlager) running second. These positions were reversed in the sixth lap, and unchanged thereafter, the final positions being :–

Car	*Driver*	*Total Time*	*Average Speed*
Mercedes	Lautenschlager	6 hrs. 55 mins. 43.8 secs.	69 m.p.h.
Benz	Hemery	7 hrs. 04 mins. 24 secs.	67.5 m.p.h.
Benz	Hanriot	7 hrs. 05 mins. 13 secs.	67.4 m.p.h.

The roads were not in such good condition as they had been the previous year, and even driving with the utmost care, the winner had to stop nine times for tyre renewals. But Rigal, on a Cl. Bayard, stopped nineteen times, despite which fact he finished 4th and first of the French cars, averaging 63.6 m.p.h. It is established that Cl. Bayard was the fastest make in the race (*vide* page 262), which was remarkable for the fact that over twenty of the forty-eight entries exceeded 100 m.p.h. over a timed flying kilometre.

These figures represent a marked advance in technique, an advance further proved by the results in the Coppa Florio of 1908, held at Bologna in September. Fiat, De Dietrich, Itala, Mors, Cl. Bayard and Motobloc all entered teams of Grand Prix cars, and Fiat showed a remarkable supremacy, Nazzaro winning at 74.1 m.p.h; for 328 miles. Fastest time for the 32.8 mile circuit was achieved by Lancia on another Fiat at 82.3 m.p.h.

Politically, and from the French point of view, the results of the A.C.F. Grand Prix races had been by no means encouraging. In the first three races, run under regulations specifically beneficial to French manufacturers, they had only provided the winner once. Italy had won once and so had Germany. A legend has since grown that the Automobile Club de France abandoned the Grand Prix series in order to avoid further humiliation for French constructors, but this is not true. The International Commission met on October 19th, 1908, and decided to run a 1909 Grand Prix race on a circuit in the Anjou district, for cars having four-cylinder engines of not more than 130 mm. bore, and weighing not less than 900 Kg. But simultaneously both French and German manufacturers, who had found motor racing an increasing burden, decided by a large majority vote to abstain from all long-distance events; in consequence, by December 31st, 1908, only three teams had been entered for the A.C.F. Grand Prix, wherein forty cars constituted a quorum, and the event was abandoned.

In 1909 proposals for a 1910 Grand Prix race were brought forward but were negatived by the racing committee of the Automobile Club, a decision which, however, reflected not international, but inter-company rivalry. The victories of Fiat in 1907 and Mercedes in 1908 were unfortunate, but although " foreigners " they were world famous firms who had entered the industry right at its beginnings. What the older constructors who dominated the Automobile Club de France could not stomach was the thought that a 1910 Grand Prix might be won by a newcomer such as Delage or Hispano Suiza, already conspicuous in Voiturette racing. At the same time, they felt that further Grand Prix victories could not benefit the well established companies.

Neither the public appetite for automobile racing, nor the desire of the younger and progressive companies to benefit therefrom, could however be stemmed by the autocratic action of the senior members of the Automobile Club de France.

As far back as 1905 the French paper, *L'Auto,* had put up a cup for the best performance in an event for cars with engines of less than one-litre capacity and running in touring trim. The full history of the subsequent competitive events organised by this enterprising paper (and others) in the next eight years is set out in *Racing Voiturettes* * by Kent Karslake, and it is sufficient to record in this work that in 1908 the Grand Prix race was preceded by an event run over 286 miles of the same circuit for cars with engines having pistons not more than 65, 80 or 100 mm. diameter with four, two or single cylinders respectively.

The winning Delage had a single-cylinder engine and averaged 49.8 m.p.h. on total distance but the fastest lap was put up at 54.3 m.p.h. by a 1.96-litre single-cylinder Sizaire-Naudin. The events of the next three years on the Boulogne circuit affected powerfully subsequent Grand Prix racing and are recorded in the next chapter.

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CHAPTER FOUR

Peugeot Supremacy and The German Challenge

RACING STATISTICS 1911-14

Date	*Event*	*Course*	*Driver*	*Car*	*Winning Speed m.p.h.*	*Lap Speed (Rec'd **
30/11/11	American G.P.	Savannah	D. Bruce Brown	Fiat	74.75	—
23/7/11	G.P. de France	Le Mans	V. Hemery	Fiat	56.71	67.75*
25/6/12	French G.P.	Dieppe Circuit	G. Boillot	Peugeot	68.45	—
25/6/12	,,	,,	D. Bruce Brown	Fiat	—	76.8
9/9/12	G.P. de France	Le Mans	J. Goux	Peugeot	74.56	—
9/9/12	,,	,,	G. Boillot	Peugeot	—	80*
12/7/13	French G.P.	Amiens	G. Boillot	Peugeot	71.65	—
12/7/13	,,	,,	P. Bablot	Delage	—	76.6*
5/8/13	G.P. de France	Le Mans	P. Bablot	Delage	76.8	82.5*
21/9/13	Coupe de l'Auto	Boulogne	G. Boillot	Peugeot	63.15	—
21/9/13	,,	,,	J. Goux	Peugeot	—	65.5*
30/5/13	500 Mile Sweepstake	Indianapolis	J. Goux	Peugeot	75.92	—
30/5/13	,,	,,	P. Zuccarelli	Peugeot	—	93.5*
30/5/14	500MileSweepstake	Indianapolis	R. Thomas	Delage	82.47	—
3015114	,,	,,	G. Boillot	Peugeot	—	99.5*
10/6/14	R.A.C., T.T.	Isle of Man	K. Lee Guinness	Sunbeam	56.44	59.3*
5/7/14	French G.P.	Lyons	C. Lautenschlager	Mercedes	65.5	—
517114	,,	,,	M. Sailer	Mercedes	—	69.95

DURING the three racing seasons 1909, 1910 and 1911, during which Grand Prix racing was in abeyance, development took place along the lines which were relevant to the subsequent history of the Grand Prix car. In the first place, although the overwhelming majority of the established manufacturers of Europe voted against further participation in racing after 1908, a minority party, formed by Fiat and others, although not strong enough to keep Grand Prix racing itself alive, were nevertheless continuously active in competition work. Fiat, in particular, built a number of special hill climb and record-breaking cars developed from their 1908 type, with bore and stroke successively increased until in 1910 they produced their 300 h.p. Grand Prix record-breaking model with four cylinders and a bore and stroke of 190 x 250 mm. equal to a swept volume of 28.4 litres. They also continued to produce road racing types of more modest dimensions and with these competed both in America and in various European hill climbs and club competitions. In 1910, for example, Nazzaro broke the lap record in the American Grand Prize race before being forced to retire with a broken chain, and in the following year a Fiat car won this event after averaging 74.75 m.p.h. for 411 miles.

In Europe, circuit racing as such was confined to Voiturettes and the success of the race for small cars which had preceded the 1908 Grand Prix encouraged the proprietors of L'Auto to organise a race in 1909 over a 23½-mile circuit on the outskirts of Boulogne.

We are, fortunately, in a position directly to assess the effects of this competition, for it happened that at the end of 1908 a Sizaire-Naudin, of the type which had put up the fastest Voiturette lap speed at Dieppe, established class records at Brooklands track in which, with remarkable consistency, it covered 65.43 miles in an hour with a timed speed of 66.48 m.p.h. over the half-mile.

The regulations for the 1909 event are dealt with in the third section of this book and it will suffice now to remark that they led to engines with exaggerated stroke/bore ratios. This tendency had already been witnessed in 1908 in which the single-cylinder Sizaire-Naudin had a bore and stroke of 100 x 250 mm. and a crankshaft speed of 2,400 r.p.m. and the Lion-Peugeot Co. adopted the same proportions for their single-cylinder engine in the following year. This model was supplemented by a two-cylinder having axes with an included angle of 16 deg. and bore and stroke of 80 x 192 mm.

A variation on the same theme was the four-cylinder engine designed by Birkigt for Hispano-Suiza which had a bore and stroke of 65 x 140 mm. Thus, when the race was run on 20th June, 1909, there were single-, two-, and four-cylinder cars in competition, all with stroke/bore ratios of between 2.15 and 2.5 : 1, with crank speeds running up to little over 2,000 r.p.m. and piston speeds reaching up to 3,500 ft./min. In the event a single-cylinder Lion-Peugeot made the fastest lap of the circuit at 55 m.p.h., but due to a pit stop the winner was a two-cylinder type of the same general design. The four-cylinder Hispano-Suizas were all substantially slower and a subsequent event makes it safe for us to conclude that at this time the single-cylinder Lion-Peugeot was the fastest example of this type of racing car. This was the arrival of Boillot on a single-cylinder Lion-Peugeot at Brooklands track in November, 1909, successfully to attack the existing Sizaire-Naudin records by covering 68.39 miles in an hour and a half-mile at an average of 72.3 m.p.h. This proves beyond question that cars of 1909 were substantially faster than their 1908 Dieppe predecessors and shows that although the lap speed rose by only 0.7 m.p.h. this must have been because the Boulogne circuit was far more difficult than the prior Grand Prix course.

The 1909 successes of the Lion-Peugeot cars were not confined to the Boulogne circuit for they also won races in Spain and Sicily. In 1910 they repeated their successes, firstly on the famous Madonie circuit and then in Spain at Sitges. They were then using their 1909 type cars, the only serious competition to which came from the Hispano-Suizas which retained four cylinders with a bore of 65 mm. and a stroke enlarged to 180 mm. The 1910 Coupe de l'Auto race had exceptional interest and was once more run on the Boulogne circuit. For this the Lion-Peugeot designer, Monsieur Michaux, discarded the single-cylinder engine and increased the stroke of the 16 deg.

V-twin to 180 mm., thus providing 2.8 litres swept volume with a stroke/bore ratio of no less than 3.5 : 1. This was supplemented by a 3.44-litre V-four engine which by regulations was restricted to a bore of 65 mm. and which with a stroke of 260 mm. reached the record stroke/bore ratio of 4 : 1. On the four-cylinder Hispano-Suizas, Birkigt was influenced by manufacturing convenience to choose a 3 : 1 ratio, giving the dimensions of 65 x 200 mm. and a capacity of 2.65 litres. Partly owing to tyre and chassis troubles which beset the two-cylinder Peugeot, the four-cylinder Hispano-Suiza driven by Zuccarelli won this event and had a best lap of 58 m.p.h. The two-cylinder Lion-Peugeot actually put up the record lap of 59 m.p.h., which represents the very substantial gain of 7.3 per cent. over the previous year.

The four-cylinder Peugeot was a failure, but once again the two-cylinder model was brought to Brooklands, and in the autumn of 1910, despite the handicap of an exhaust system imposed by final regulations, covered 75.25 miles in one hour, the half-mile speed, owing to a head wind, being somewhat slower than this.

For 1911 the regulations for the Coupe de l'Auto were substantially revised, mudguards being demanded and the engine capacity limited to 3 litres with varying combinations of bore and stroke up to 2.0 : 1. The result in the case of the Lion-Peugeot was to produce another Michaux design following the V-four formula with bore and stroke 78 x 156 mm. the two principal drivers Goux and Boillot now being assisted by Zuccarelli. Birkigt withdrew from racing after his 1910 success, but the loss of Hispano-Suiza was balanced by the return of Delage with a four-cylinder engine 80 x 149 mm. with horizontal valves and a five-speed gearbox with direct drive on fourth. This type of car proved the winner on a lengthened circuit which was lapped at 59.7 m.p.h.. by Boillot's Peugeot which finished second, Goux of this team retiring with mechanical trouble and Zuccarelli overturning on the first lap.

Whilst all these road racing activities continued on the Continent, parallel developments in small car engines were taking place in Great Britain where, since 1907, the steeply-banked 2.7-mile Brooklands track had proved a real forcing ground for high-speed development. In the 3-litre category Vauxhall and Sunbeam were the principal contenders, the latter running supreme in class for engines with less than 31 sq. in. of piston area and the former almost monopolising the class for cars with up to 39 sq. in. of piston area. Whereas, however, Louis Coatalen of Sunbeam followed the long-stroke theory with 80 x 149 mm. engines, Laurence H. Pomeroy upheld the short-stroke argument for Vauxhall with 90 x 120 mm. engines, there being negligible difference in their swept volumes. In the end Sunbeams proved to be slightly faster. They put up their first record in October, 1910, with 71.95 m.p.h., over the half-mile, raised this to 86.16 m.p.h. in April, 1911, and then to no less than 101.87 m.p.h. in October, 1912. Vauxhall, on the other hand, were faster in December, 1909, with a speed of 88.618 m.p.h. than were Sunbeam two years later. Moreover in October, 1910, they put up speeds of 97.15 m.p.h., 98.109 m.p.h., and finally 100.083 and thus became the first 3-litre cars to reach three figures. The final speed of this model was 101.24 m.p.h., made in November, 1912, in an unsuccessful effort to beat the Sunbeam maximum.

The speed of both cars was noticeably assisted by very narrow low-drag bodies, but the enormous disproportion between the 75 m.p.h. of the Peugeot and the 100 m.p.h. of the Vauxhall in 1910 was also due to a very real superiority in engine design expressed as h.p. per litre. Both Vauxhall and Sunbeam reaped the benefits of

Brooklands in 1912 road racing. In that year the Coupe de l'Auto race for 3-litre cars was run conjointly with a Grand Prix organised by the Automobile Club de France. This had been preceded in 1911 by an event called The Grand Prix of France, approved by the Automobile Club de France but actually organised by the Automobile Club de la Sarthe. It was run over a 33¾-mile circuit adjacent to Le Mans, but over entirely different roads to those used in 1906, and owing to continued opposition to racing by the Automobile Manufacturers' Association in France there was a very poor entry, victory going to a 10-litre Fiat which is described as Example No. 2 in this volume.

Out of these tentative beginnings of a revival the Automobile Club de France were emboldened to stage a full-scale Grand Prix Race in 1912. They chose the Dieppe Circuit used in 1907 and 1908, and went back to the precedent of 1906 in making the race a two-day affair, 477.4 miles being covered on each day. The only limitation placed on entries was the somewhat odd one of a maximum width of 1.75 metres (5 ft. 9 in.), but concurrently they had a section for cars with engines of under three litres capacity, having a stroke not less, nor greater than, twice the bore and not fewer than four cylinders. These cars had to weigh a minimum of 800 Kg. (1,763 lb.), and as they were thought to have no chance of beating the larger entrants, they were offered a special cup put up by the proprietors of the French paper, *l'Auto.* This class proved extremely popular, and of the fifty-six total entries received, forty-two were competitors for the Coupe de l'Auto. Seven of them, comprising the Sunbeam team of four cars and the Vauxhall team of three, actively intervened in the struggle for the Grand Prix itself. In the big car class teams were entered by three French manufacturers, Lorraine-Dietrich, Peugeot and Rolland-Pilain, and one each from Belgium and Italy, Excelsior and Fiat respectively.

It will be observed that Fiat and Lorraine-Dietrich, were the only companies with prior experience of Grand Prix racing and it is, therefore, not a coincidence that they had by far the largest engines in the race with a swept volume of 15 litres, for they were continuing the tradition built up by competition in the Gordon Bennett, and early Grand Prix series. Both cars also retained chain drive, and Fiat held to wooden wheels with detachable rims, although detachable wire wheels had been tried before the race. Fiats, however, were not wholly wrapped in the mist of antiquity, for they embodied the overhead camshaft type of engine which they had been developing during the past two racing seasons.

Peugeot entered for their first Grand Prix with some 7.6-litre cars of startling technical novelty. Nominally designed by the Chief Engineer, they were in reality the work of a young Swiss designer, Henri, who designed them in co-operation with two of the drivers, Zuccarelli and Georges Boillot. The engine used a phenomenally high piston speed with a completely novel valve gear design, utilising for the first time inclined valves with two overhead camshafts and four valves per cylinder.

The Sunbeams and Vauxhalls both had four-cylinder side valve engines, which had been intensely developed in competition at Brooklands.

It is difficult to compare the small and large cars on an h.p. basis, as designers were apt to over-estimate power output somewhat for reasons of propaganda, but 200 b.h.p. was claimed for the Fiat, 175 b.h.p. for Peugeot, and 80 h.p. at 2,800 r.p.m. for Sunbeam. The last-named figure, equivalent to a b.m.e.p. of 124 lb. per sq. in., seems very high, and it would perhaps be safer to rewrite the above figures as more like 160 b.h.p., 135 and 65 respectively.

The race disclosed that the Fiats were undoubtedly the fastest cars entered and, once again, we find the curious feature of many early Grands Prix, that the first (standing) lap was the fastest of the day. This was achieved by Bruce-Brown on a Fiat, at 76.8 m.p.h., that is to say, faster than the 1907 Fiat (75.4 m.p.h.), but slower than the 1908 Mercedes (78.5 m.p.h.). Later Boillot's Peugeot lapped at 75 m.p.h.

The 1912 race was twice the length of these prior events, which may have held down the speed and Bruce-Brown maintained his lead with complete regularity during the ten laps of the first day to average 72.4 m.p.h. Following him with almost equal precision was Boillot on one of the Peugeots (71.2 m.p.h.), the other two of the team speedily developing trouble with faulty petrol lines. Wagner kept a Fiat steadily in the third position (68.3 m.p.h.), the third Fiat being out, also with a broken fuel line. No other " unlimited " cars were in the picture at all, fourth, fifth and sixth positions being held throughout by the 3-litre Sunbeams and Vauxhalls. Hancock on one of the latter led the class (and was fourth in the race) on laps six, seven and eight, but at the end of the day's run was third in the Coupe de l'Auto behind the Sunbeams of Resta and Rigal, and sixth in general classification.

During the second day, the incredible infection of broken fuel pipes spread to the leading Fiat, which ran out of petrol, leaving Boillot sufficiently ahead of Wagner to stave off competition. These cars ran first and second over the last six laps, and the collapse of all the other large cars brought Rigal's Sunbeam into third place in the Grand Prix race. The Hancock Vauxhall retired on the fifteenth lap, so Sunbeams had no difficulty in finishing first, second, and third in the Coupe de l'Auto, and third, fourth and fifth in the Grand Prix. The final speeds were :–

Peugeot	Boillot	68.45 m.p.h.
Fiat	Wagner	67.32 m.p.h.
Sunbeam	Rigal	65.29 m.p.h.

The winning speed was slower than that recorded by both the previous winners over this course, and whereas in 1908 over twenty cars were timed to exceed 100 m.p.h., in 1912 the maximum speeds recorded by the most prominent makes were :–

Fiat	Bruce-Brown ..	101.67 m.p.h.
Peugeot	Boillot	99.86 m.p.h.
Sunbeam	Resta	84.73 m.p.h.
Vauxhall	Hancock	78.76 m.p.h.

The Grand Prix de France (in contradistinction to the Grand Prix de l'Automobile Club de France) was again run in 1912 by the Sarthe Club over the 33¾-mile course used in 1911. It was sub-divided into a race for cars of up to 3-litre capacity, and unlimited engine size, the events being run concurrently. Only Peugeot, with two of their Grand Prix models, were serious contenders in the larger section in which Boillot put up the fastest lap in 25 mins. 9 secs. (approximately 80 m.p.h.) from a standing start away from the pits. Goux won on the sister car at an average speed for twelve laps of 74.56 m.p.h., both figures showing a great improvement on anything hitherto recorded on this course.

The large entries for the 1912 Grand Prix gave the A.C.F. great encouragement when preparing the 1913 event. A new circuit was chosen, measuring 19.52 miles, near

Amiens and twenty-nine laps had to be covered in one day, making the total distance 566 miles. A maximum fuel consumption formula was revived, but with the permitted amount reduced by one-third compared to 1907, and for the first time the intentions of the A.C.F. in 1906 were put into effect, and the race run clockwise. This led to what is now the common practice of having the grandstand on the outside of the course so as to give free access, but the pits being placed on the inside so that cars could continue to pull in without endangering other competitors. A tunnel was dug beneath the track to permit people to cross between the pits and the stand.

The short lap was designed to provoke spectator interest by virtue of more frequent passing, but for the first time the faster cars might be running a lap ahead of the slower ones, a source of confusion which has continued in practically all subsequent Grand Prix events.

The severe limitation on fuel rendered new designs essential. The organisers must, therefore, have been relieved to obtain an entry of twenty cars, comprising three French, two German manufacturers and one each from Belgium, Italy and Great Britain.

All cars had live rear axles and detachable wheels, and on the Rudge Whitworth type used by Peugeot the now traditional " ears " appeared on the locking rings, so that for the first time these could be removed by a hammer without the use of a special spanner. Itala used rotary valves, Opel and Peugeot inclined o.h.v. with two and four valves per cylinder respectively. Delage also used four valves placed horizontally in the head, the remainder of the entries having L-headed engines. All had four cylinders except Sunbeam and Excelsior, who used six.

An entry of Mercedes cars by the Belgian agent, Pilette, was refused, and the race was won fairly easily by Peugeot. Boillot led from the seventeenth to the twenty-ninth lap and averaged 71.65 m.p.h. ; Goux ran second at 71.29 m.p.h., and a Sunbeam was third at 69.81 m.p.h.

All the leading cars finished with plenty of petrol in hand, Boillot with six and Goux with nearly five gallons left in the tank, out of their total allocation of 40.5 gallons.

A Delage made the fastest lap at 76.6 m.p.h., and another of these cars actually led from the tenth to the sixteenth lap, losing the position on the seventeenth by a strange incident when Guyot's mechanic jumped too soon before a tyre stop and was run over. This caused a loss-of about 30 minutes.

Despite the Delage fastest lap, Peugeot put up the best speed over a timed flying kilometre, the figures recorded by the three fastest makes being :–

Peugeot	Boillot	97.26 m.p.h.
Delage	Bablot	92.21 m.p.h.
Sunbeam	Resta	88.77 m.p;h.

The growing gap between modified production models as typified by Sunbeam, and pure racing designs, is well exemplified in the above figures, whilst the entry list of the 1913 event reflects the change that was going on in the French automobile industry. All the historic grandes marques of France-Panhard, Mors, Clement Bayard, Renault, Richard Brasier, and so on-had dropped out of racing. The standard was now held by the younger concerns, who, although prominent in races for small cars in the 1909-11 period, were relative newcomers to the Grande Epreuve. Few, even of the latter, supported the 1913 Sarthe Club Grand Prix, run on the previous course, but reduced in distance to ten laps. There were Schneiders and Excelsiors which had run in mediocre fashion at Amiens, the much more formidable Grand Prix Delages, and the " Pilette " Mercedes which had been excluded from the previous event. The latter were of great technical interest, for although Fiat retired from racing for 1913, in order to develop new designs, Mercedes decided to make some practical experiments with different types of cars. In the Sarthe race they ran two 7.5-litre six-cylinder cars (105 x 140 mm.), a 9.25-litre four-cylinder (140 x 150 mm.) and another, 8.9-litre, four-cylinder of 130 x 170 mm. All the cars had chain drive, and (although a 1912 Grand Prix Lorraine Dietrich, driven by Szisz, won the 1914 Anjou Race at 65.9 m.p.h. with three passengers) this was the last appearance of chains in Grand Prix racing.

The smaller of the four-cylinder engines had Knight double sleeve valves but the power units of the other models were virtually replicas of the 75-85 h.p. aero engines developed by the company during 1912. They had a single overhead camshaft operating two inclined valves per cylinder, the latter being made in pairs with welded steel water jackets. Although not so fast as the Delage cars in this race the Mercedes team constantly threatened them and after holding 3rd, 4th and 5th positions at half distance Pilette was lying second on the penultimate lap, with his colleagues 4th, 5th and 7th. On the last lap, however, Pilette was forced to yield a place by reason of a tyre failure so that the Delages came home in 1st and 2nd positions.

The winner, Bablot, averaged 76.8 m.p.h. for ten laps, aggregating 337.5 miles. He also put up the record lap of 82.5 m.p.h. (once more from a standing start, after a pit stop). Both speeds were road racing records, which show the 1913 Delage cars were faster than the Peugeots of the previous year.

The rapid rate of technical development from 1910 onwards was even more strongly marked in the 3-litre cars which ran in the 1913 Coupe de l'Auto over the same circuit at Boulogne that had been employed in 1911, and for this event Vauxhall and Sunbeam used cars very similar to the models which had put up such sensational performances at Dieppe in 1912. An unsuccessful contender in that race had been a Henri-designed 78 x 156 mm. car with the typical four inclined valves per cylinder operated from two overhead camshafts, but this engine placed in a modified chassis put up an absolutely sensational performance on the 1913 Boulogne circuit. The winner, Boillot, had a winning time of 6 hrs. 7 min. 40 secs., including two pit stops, whereas Sunbeams, who were the fastest rival make, took third place, the driver, K. Lee Guiness, taking 6 hrs. 18 min. 50 secs. for a non-stop run. In respect of lap speeds, the Peugeot put in a circuit at 66 m.p.h., whereas Sunbeams could do no better than 61 m.p.h. Peugeots then confirmed their ascendancy in this class by achieving 105.81 m.p.h. at Brooklands using a single-seater body, the previous fastest speed with this size of engine being 101.87 standing to the credit of Sunbeams.

The 3-litre cars came into direct competition with Grand Prix models in the 500-mile Sweepstake race held at Indianapolis on May 30th, 1914. The previous year Peugeot had been the first European car to win this event, using one of their 1912 7.6-litre Grand Prix cars which (Goux driving) averaged 75.92 m.p.h. Prior to the race three laps were covered at an average of 93.5 m.p.h. In 1914, Peugeot and Delage used their 1913 Grand Prix cars, and to them was added, as a private entry, a 3-litre

Coupe de l'Auto Peugeot, which had been sold following that race. Boillot on the big Peugeot averaged nearly 100 m.p.h. on a practice lap, but René Thomas, on one of the Delages, led from the 40th to the 100th mile, and (with a brief intermission) from the 200th to the 500th mile, to finish first at an average of 82.47 m.p.h. The 3-litre Peugeot finished second, averaging 80.89 m.p.h., and the best of the works team was Goux, who after many troubles finished fourth at 79.49 m.p.h.

The Peugeot performance was a complete vindication of those who believed in the technical development of the small capacity, high power per litre, prime mover. Organising clubs, in addition to engineers, were impressed by this theme, and the two major races in Europe in 1914 were both run under a restriction of engine swept volume, the first time such a rule had been operative since the 1907 Kaiser Prize event. Whereas, however, the size in that year had been the substantial one of 8 litres, in the 1914 races the cars were limited to engines of 190 cubic inches (3,310 c.c.) for the Tourist Trophy and 4½ litres for the Grand Prix.

The race for the smaller cars was organised by the Royal Automobile Club and run in the Isle of Man on the 10th and 11 th June over an aggregate of 600 miles. It was won easily at an average speed of 56.44 m.p.h., by K. Lee Guinness on a Sunbeam, who also broke the lap record at 59.3 m.p.h. The Sunbeam is of technical interest, in that the engine was an interchangeable replica (except for an enlargement of bore by 3 mm. and stroke by 4 mm.) of the 1913 Coupe de l'Auto Peugeot, all the parts being copied from one of these cars purchased in France some months before the race. Humber and Vauxhall also ran cars which reflected Peugeot influence in having two overhead camshafts, but they were otherwise of original design. Their promise was, in neither case, fulfilled.

Vauxhall and Sunbeam also entered for the 1914 A.C.F. race, which has been termed " The Greatest Grand Prix." The organising club chose a 23.3-mile circuit on the outskirts of Lyons, which had to be covered twenty times, making up a distance of 466 miles and the entry, both in quantity and quality, had not been bettered previously and has never been equalled since. With the exception of the U.S.A., all the motor manufacturing countries of the world were represented, and an entry of fourteen teams, making a total of forty-one cars, was received.

These reflected the immense change in thought which had been wrought by the success of the Peugeot designs. Apart from the sleeve-valve Piccard Pictets, every car in the race was of the overhead camshaft type, Delage, Peugeot, Sunbeam, Vauxhall and Nagant having double camshafts, and all except Fiat and Aquila Italiana four valves per cylinder. Delage and Nagant went so far as to have a mechanical arrangement for closing the valves. Non-detachable cylinder heads were used without exception, and only Mercedes departed from the practice of casting the cylinders in one block. In this German design, however, separate cylinders made from steel forgings with welded up valve ports and water jackets were used, a continuation of the 1913 practice which was to be followed by Mercedes for the ensuing twenty-five years and to be extensively used by other makers.

Even more important than any engine development was the use by Delage, Peugeot, Fiat and Piccard Pictet of brakes on all four wheels. This scheme had been used on touring cars from 1909 onwards and by the Isotta Fraschini racing cars which ran at Indianapolis in 1913 and in the Vanderbilt Cup race run in California in February,

1914. Despite these anticipations, the Lyons event is the true turning-point in racing car history, for no subsequent Grand Prix has been won by a car braked only upon the rear wheels.

Survey of the entries shows that two of the great names in racing, Fiat and Mercedes, had returned to the fray after a retirement lasting twelve months and six years respectively. Mercedes, in particular, made every effort by design, preparation and team control to win the race, although Opel can probably claim to have had their cars completed before anyone, as they were running six months before the event. By contrast, both Sunbeam and Vauxhall were the last to finish their cars, lack of preparation on the latter entirely ruining the chances of a highly promising design.

The race itself was notable for a constant and fierce international and inter-company duel. The cars left in pairs at 30 secs. intervals from 8 a.m. onwards, the three last cars to leave being the Mercedes of Salzer, Wagner and Pilette. Mercedes had five cars entered, and Sailer was dedicated to the task of opening up the race and setting a pace that no one could equal. He led for the first five laps, putting up a record for the course on the fourth lap, at 69.95 m.p.h. He was hotly pursued by the hitherto invincible Peugeot, driven by the rarely beaten Boillot, who, despite going flat out, was nevertheless 2 mins. 44 sets. in arrears at quarter distance. Behind him were Duray on a Delage (third) and Lautenschlager (Mercedes) fourth.

Sailer retired with a broken crankshaft in lap six and thenceforth the drama lay in the struggle between the technical superiority of the Mercedes design and the professional virtuosity of Boillot's driving. From quarter to three-quarter distance the Peugeot star was in the ascendant, Boillot putting in his seventh lap at 68.85 m.p.h., and being only a decimal point slower on his ninth. Both cars made replenishment stops just past half distance (Lautenschlager on the eleventh and Boillot on the twelfth lap), and owing to inferior pit work Lautenschlager lost over two minutes in the process. Already behind he had to work off a deficit of two minutes twenty-four seconds in the last five laps to win. On the sixteenth lap he pulled back 13 seconds and on the seventeenth lap, one minute 51 seconds, due to a pit stop for tyres by Boillot. On the eighteenth lap, Lautenschlager put in his fastest lap of the race at 68.7 m.p.h., which brought him 23 seconds ahead of Boillot, who at this critical point took a minute longer than on his fastest lap. On the nineteenth lap he was even slower, so that when Lautenschlager started on the twentieth circuit he had a lead of 67 seconds. In a last desperate effort, Boillot broke a valve on the Peugeot engine, and was led weeping from his car. He had struggled against a technically superior product for six and a half hours over an exceptionally arduous circuit, in the course of which he had been forced to change tyres eight times compared with the German's four stops for this purpose. The question is asked, did tyres cost Peugeot the race ? The true answer would seem to be that indirectly they were a handicap for reasons which are set out in the next chapter, but one must also consider that Boillot's hard driving may well have made engine failure inevitable.

However one answers these questions, one must agree that as a team the German cars clearly proved their superiority, in that they were able to secure an overwhelming victory, filling the first three positions by playing a waiting game and going ahead into the lead in response to orders from the pit. Lautenschlager averaged 65.83 m.p.h., Wagner ran second at 65.3 m.p.h. (and did a lap at 69.02 m.p.h.), and Salzer was third at 64.8 m.p.h. Goux on a Peugeot finished fourth at 63.94 m.p.h., Resta on a Sunbeam was fifth at 62.46 m.p.h.

Within a month of this German victory, the first world war was declared, and European racing was at an end. The 1914 Grand Prix cars were, however, to renew their competition in subsequent years, during the war in the U.S.A., and immediately thereafter at Brooklands.

CHAPTER FIVE

Wartime Racing and a 1914 Revaluation

RACING STATISTICS 1915-16

Date	Event	Course	Driver	Car	Winning Speed m.p.h.	Lap Speed
30/5/15	500 Mile Sweepstake	Indianapolis	R. de Palma	Mercedes	89.84	98.6
26/6/15	300 Mile Chicago Derby	Chicago Board	D. Resta	Peugeot	97.58	—
7/8/15	100 Mile Race	Chicago Board	D. Resta	Peugeot	101.86	—
30/5/16	300 Mile Sweepstake	Indianapolis	D. Resta	Peugeot	83.26	—
11/6/16	Chicago Derby	Chicago Board	D. Resta	Peugeot	98.61	—
15/7/16	150 Mile Race	Omaha	D. Resta	Peugeot	99.02	—
16/7/16	50 Mile Race	Omaha	R. de Palma	Mercedes	103.45	—
30/9/16	Astor Cup	Sheepshead Bay Tracl	J. Aitken	Peugeot	104.8	—
28/10/16	Harkness Trophy	Sheepshead Bay Tracl	J. Aitken	Peugeot	105.95	—

WITH racing at an end in Europe Peugeot decided to send three, and Sunbeam two, of their 1914 Grand Prix cars across the Atlantic to compete in U.S.A. 1915 events. In the same year the well-known Italian-born U.S. driver, Ralph de Palma, secured one of the victorious 4½-litre Mercedes team and raced it as a private entry.

The year opened with an easy victory for Peugeot, driven by Resta, in the Vanderbilt Cup race held over a very rough circuit at San Francisco, the average speed being only 67.6 m.p.h. In this race only, he drove a 1913 Grand Prix car.

The remainder of the year's racing was on board or brick tracks and commenced with the Chicago Derby for 300 miles over which distance Resta calculated that an average of 98 m.p.h. would suffice to win ; he did in fact secure first position at an average of 97.58 m.p.h., but this speed would have been insufficient if trouble had not overtaken one of the Sunbeams, which led at 40 miles distance with an average of 103 m.p.h. and covered 100 miles at 99.7 m.p.h. Later in the year Resta drove the 1914 Peugeot at an average of 101.86 m.p.h. for the 100 mile race on the same track.

As always, the principal U.S.A. race was the 500 Mile Sweepstake at Indianapolis. De Palma reserved the Mercedes for this event and in practice put up the fastest average of 98.6 m.p.h., Resta doing 98.5 m.p.h. on a Peugeot and Porporato 95.1 m.p.h. on a Sunbeam. Resta led the race for the first 100 miles and was notably faster than the Mercedes on the straights. On the other hand he was slower on the turns, and in the final stages was passed by the Mercedes, which won at 89.84 m.p.h., Resta being second at 88.91 m.p.h. The only other European entry which achieved any prominence was the Sunbeam on which Porporato averaged 91 m.p.h. for the first 50 miles, but at 163 miles he retired with a seized piston. The second Sunbeam, driven by Van Raalte, suffered many delays due to a loose magneto platform and finished tenth, after which both cars were returned to England.

The Peugeot and Mercedes remained in the U.S.A. for 1916 and were joined by four of the 1914 Delage Grand Prix cars, which had proved disappointing at Lyons after very promising practice speeds. In this year the Indianapolis race was the first major event on the calendar, and with de Palma and the Mercedes absent, Peugeots scored another success. Of the three cars entered, one retired on the twenty-seventh lap, another driven by Resta was first at 83.26 m.p.h., and the third car third at 82.6 m.p.h. The Delages were again disappointing, only one finishing, fifth at 79.2 m.p.h. It is worth noting that over the first 25 miles the fastest Peugeot averaged 98.6 m.p.h. and the best Delage 91.2 m.p.h., also that owing to rain making the track dangerous the contest was stopped when the leading car had covered 300 miles.

Twelve days after Indianapolis the Mercedes versus Peugeot battle was re-enacted on the Chicago board track in the 300 Mile Chicago Derby. For nearly three hours the two cars ran bonnet to bonnet, but with only four miles to go a plug failed on the Mercedes when de Palma had a very short lead. He was forced to go into the pits, and as an obvious consequence the Peugeot (again driven by Resta) won at 98.6 m.p.h., the Mercedes coming home 1 min. 54 secs. behind at 97.6 m.p.h. Everyone agreed that this was an unfortunate ending to a closely contested struggle, and a little later a match race, run in three heats, was arranged, On this occasion the Peugeot showed a clear superiority by winning all three heats and over 24 miles averaged 105.1 m.p.h., compared with 104.5 m.p.h. for the Mercedes. The Peugeot also made the best lap at 109.75 m.p.h. This was not the full extent of Resta's victories at the wheel of the Peugeot. He also won the 250 mile " Grand American " at 103.99 m.p.h. on the Chicago track, the Vanderbilt Trophy at a new track in San Francisco at 86.95 m.p.h. and a 150 mile event at Omaha at 99.02 m.p.h. In this last named meeting de Palma declined competition with the Peugeot but ran in an alternative 50 mile race over the same circuit, which he won on the Mercedes at 103.45 m.p.h. This was the sole victory for the German car, but two further Peugeot wins were scored by Aitkin, who won the Astor Cup at Sheepshead Bay at an average of 104.8 m.p.h. and the Harkness Trophy on the same course at 105.95 m.p.h., the distances being 250 miles and 100 miles respectively. The Delages appeared in the former event but their best speed was 95.8 m.p.h., confirming previous evidence that the speed of this make was well below that of the Mercedes, Peugeot and Sunbeam cars. In 1917 the U.S.A. entered in the 1914-18 War and for two years racing was entirely at an end.

With the return of peace a number of 1914 Grand Prix entrants re-appeared, including Vauxhall, who ran two of their Lyons cars at Brooklands during the 1921 season. These are amongst the few entirely British-designed and British-made Grand Prix models, and analysis of their design suggests that they may claim to be amongst the best of the cars which had been sent down to Lyons seven years previously. The Brooklands performances bear this out, for in the course of a highly successful season one driven by E. Swain averaged 101 m.p.h. over 8½ miles from the standing start and put in a lap at a speed of 108.74 m.p.h.

During 1921, also, another car from the winning Mercedes team was being handled by Count L. Zborowski, and in this case the best Brooklands average was 97.75 m.p.h. over 8½ miles and the lap speed 104.19 m.p.h.

At Lyons in 1914 the Mercedes was faster than the Peugeot, but subsequently on the really fast board tracks of the U.S.A. the Peugeot was faster than the Mercedes ; at Indianapolis the speeds were almost equal. These apparent contradictions can be explained by assuming that the Mercedes was superior in engine output and in low speed torque, and that the Peugeot had the better aerodynamic form. Hence, at Lyons, where high speeds were rarely obtained, the former would secure the advantage and on the board tracks running at 100 m.p.h. the Peugeot would be the faster. Indianapolis, where the speed varied between 85 and 110 m.p.h., would be a course where neither car would secure any special benefit from the leading feature in its design and here one would expect an equality of result, as was proved in practice.

An extremely interesting theory was put forward in 1942 by Major Galliot, a close friend of Boillot, who watched the whole of the 1914 Lyons race. According to his evidence the Peugeot team made an unfortunate choice of tyres, and Boillot in particular stopped at his pit on every lap before continuing past the timing box. The failure on his car was caused by a broken exhaust valve in No. 3 cylinder and at least one lap was made on three cylinders in the hope of retaining the lead. At the end of the race Boillot said that his car was 6 m.p.h. faster on the straights and " with my front wheel brakes (the Mercedes had none) I ridiculed them on the short bends on the road."

On this evidence the Peugeot was inherently capable of lapping 23.3 miles in 19 mins. 30 secs. compared with the best Mercedes lap of 20 mins. 7 secs., and these figures, it is interesting to observe, bring the relative performance of the cars at Lyons almost exactly into line with their subsequent times in the U.S.A. But with due respect to an eye-witness, this cannot literally be correct.. At Lyons the timing posts were placed 100 yards behind the starting line, but the Peugeot pits were only 75 yards behind the starting line, so that both on the first and on all subsequent laps Boillot must have been timed before he made a tyre replacement. Jules Goux, one of the Peugeot team drivers, has said that the downfall of the car lay in the streamlined tail which embraced two spare wheels mounted lengthways on in order to reduce wind resistance. In order to keep the height within reasonable bounds, the whole of this mass had to be mounted well behind the rear axle and very poor road holding at high speeds resulted, many of the tyre stops being made to change the type of tread and pressure rather than by reason of the wear or burst covers. This explanation from first-hand certainly fits the known facts and should still a controversy which has lasted for nearly forty years.

The failure of the Vauxhall cars in 1914 is explained by their hurried preparation, which led to minor troubles, but the exceedingly high Brooklands speeds (achieved with an absolutely square tailed body) are an indication of excellent engine design and unusually high power output. This is consistent with a shorter engine stroke and larger piston area than were used on the Continental cars, so that whereas Peugeot and Mercedes represent the apotheosis of the long stroke 2,500 r.p.m. type of engine, Vauxhall was the genesis of the high speed type which has since become universal.

A further increase of engine speeds occurred immediately after the 1914-18 war with the introduction of multi-cylinder engines, as will be disclosed in the following chapter.

CHAPTER SIX

A Post-War Revival

RACING STATISTICS 1919-21

Date	*Event*	*Course*	*Driver*	*Car*	*Winning Average Speed*	*Lap Speed m.p.h.*
30/5/19	500 Mile Sweepstake	Indianapolis	H. Wilcox	Peugeot	87.95	—
,,	,,	,,	R. Thomas	Ballot	—	104.7*
23/11/19	Targa Florio	Madonie	A. Boillot	Peugeot	34.19	—
30/5/20	500 Mile Sweepstake	Indianapolis	G. Chevrolet	Monroe	88.5	—
,,	,,	,,	R. de Palma	Ballot	—	99.15
30/5/21	500 Mile Sweepstake	Indianapolis	T. Milton	Frontenac	89.62	—
,,	,,	,,	R. de Palma	Ballot	—	100.75
26/7/21	French G.P.	Le Mans	J. Murphy	Duesenberg	78.1	84.0*
12/9/21	Italian G.P.	Brescia	J. Goux	Ballot	90.4	—
,,	,,	,,	P. Bordino	Fiat	—	96.31*
22/6/22	Tourist Trophy	I. of M.	J. Chassagne	Sunbeam	55.78	—
,,	,,	,,	H. O. D. Segrave	Sunbeam	—	62.5 (P)
30/5/22	500 Mile Sweepstake	Indianapolis	J. Murphy	Murphy Special	94.48	100.5

NOTE-The 1922 events included above were run under the 1921 formula. * Record

THE armistice between Germany and the Allies was signed on November 11 th, 1918. Shortly afterwards, the R.A.C. in England and the Manufacturers' Association in France decided to withhold their support from racing during 1919 and there were, in consequence, only two races in that year, the 500 Mile Sweepstake at Indianapolis and the Targa Florio. The former was held on the usual date of May 30th under a capacity limit of 300 cubic inches, or 4,917 c.c., and although such a short time had elapsed since the end of hostilities the entries included four entirely new designs by Packard and Duesenberg in the U.S.A., and Sunbeam and Ballot in Europe.

The two six-cylinder Sunbeams had been designed and made in the factory at Wolverhampton during the course of the war under the guise of being experimental aviation work. The subterfuges by which these jobs were " hidden up " when Air Ministry inspectors went round the works is a story in itself, but, alas ! all this effort was in vain, as the cars were withdrawn ; some say because the engines were found to have a capacity of 4,924 c.c. (and were thus over size) ; others because Resta's report on the torsional oscillations in the crank at 2,500 r.p.m. was decisive.

Belief in the latter version is reinforced by measurements made later by Brooklands scrutineers, which gave the capacity as 4,914 c.c. It is unlikely that the pistons and blocks had been changed after the cars came back to England.

The remaining four European cars were the sensation of the race, for they introduced a new name to motor racing-Ballot. They were designed by Ernest Henri, built in the amazingly short time of 101 days, and had eight-cylinder engines, made of two blocks of four, bore and stroke 74 x 140 mm.

M. Ballot was the head of a company which had been making automobile engines for many years and he decided to make an entry on Christmas Eve, 1918. The cars had to leave Paris not later than April 26th, so there remained but 120 days in which to build and test the vehicles. M. Henri was retained as designer and, naturally, the general layout of the cars bore a certain resemblance to the four-cylinder Peugeot he had made from 1912-14. The decision to use a straight-eight layout was undoubtedly the result of his contact, during the war, with a Bugatti-designed straight-eight engine for aviation use. Duesenberg had also been concerned with the manufacture of the Bugatti engine in the U.S.A. and they also entered a straight-eight engine.

The background to this development and the immense formative influence of the Bugatti aero engine on all subsequent racing cars are fully dealt with on other pages. For the moment we are concerned with the immediate effect upon contemporary racing.

During practice the Ballots proved themselves the fastest cars on the track. Unfortunately, they also proved to the team manager's satisfaction that the gear ratio was rather too high and, as they had no spare crown wheels and pinions, the wheels were exchanged for an American type, using straight-sided tyres. This proved a disaster ; trouble started within the first 100 miles and persisted throughout the race. The Duesenberg eight-cylinder proved itself nearly as fast as the Ballot, but none of the new European designs were able to better the speed of either the Packard or the old 1914 Peugeot Grand Prix models.

R. de Palma, driving the Packard (which had a V.12 engine, 60 x 114.5 mm.), covered the first 125 miles at an average of 92.2 m.p.h. and sustained over 92 m.p.h. for the first 150 miles, after which he had to come in for a very long stop during which all four tyres were changed and a new exhaust valve was fitted to No. 1 cylinder of the left bank. He had further trouble with a broken front wheel bearing, and for the whole distance could do no better than 81.05 m.p.h. and sixth position. One of three 4 ½-litre Peugeots, privately entered by an American driver, Wilcox, was third at 125 miles, second at 225 miles and in the lead thereafter to win at 87.95 m.p.h. A second 4½-litre, driven by Goux, another of the same size driven by Klein, both retired, as did a 3-litre 1913 Coupe de I'Auto model driven by Howard, and a 2½-litre designed for the 1914 Coupe de l'Auto, which was never run. This last was driven by Andre Boillot, younger brother of Georges, who had been killed flying on the Western Front.

Only one other race was run in 1919, the Targa Florio, on November 23rd. There were twenty-one entries, technical interest being concentrated on three Fiats (ex-1914 Grand Prix), a Ballot straight-eight, and a 2½-litre Peugeot. The two last named had both run at Indianapolis, and owing to various troubles with the Fiats the race was again between a 1914 and a 1919 Henri design.

Despite having double the cylinder capacity of the small Peugeot, the larger car never managed to get to the lead and on the last lap the Ballot went out with a broken differential. The remaining challenger to the leader was an Itala, and the finish was dramatic in the extreme. Boillot throughout the race had been making up for the small capacity of the Peugeot by the most fantastic exhibition of driving without regard to personal safety. He had been six times off the road ; his refuelling consisted of picking up a can when on the move and filling the tank without stopping and, finally, as he arrived at the finish he found the crowd had overflowed on to the road. He jammed on the brakes, spun the car round, and crashed 10 yards before the finishing line. The excitable Sicilian crowd endeavoured to right the car, ignorant of the fact that they would thus ensure its disqualification. Boillot and his mechanic forcibly defended themselves, drove back 30 yards, turned round, and then won. Utterly exhausted, Boillot cried " *C'est pour la France* " and collapsed over the wheel.

After this event the 2½-litre Peugeot disappears from the racing world, but several of the 5-litre Ballots were brought to Brooklands. In their original form and tune they were able to lap the track at over 112 m.p.h. (Chassagne did 112.17 m.p.h. on September 25th, 1920), and their maximum speed was of the order of 115-118 m.p.h.

In 1920 the European ban on racing was maintained and the only significant race was at Indianapolis, now run under an International 3-litre capacity limit. From a technical point of view interest was concentrated on the entry of three eight-cylinder Ballots, four eight-cylinder Duesenbergs and three four-cylinder Peugeots. The Ballot cylinders measured 65 x 112 mm. ; the Duesenberg 63.5 x 117 mm. ; and the Peugeot 80 x 149 mm.

Ballot had retained Henri in their employ and the new cars were scaled-down versions of the previous year's model, having, typically, the drive to twin overhead camshafts by a train of gears, and, as before, four valves per cylinder. Duesenberg were different, not only in respect of cylinder dimensions, but also by reason of having one camshaft only, driven by a vertical shaft and bevel pinions ; this worked three valves per cylinder, one inlet and two exhaust. The Peugeots had the remarkable number of five valves per cylinder, with two sparking plugs and three camshafts, but despite successful trials in France they were a complete failure in the race, due to cooling problems. This marked the end of Peugeot participation in large-scale racing.

In the preliminary trials, R. de Palma, on one of the 3-litre Ballots, put up the best time, doing nearly 100 m.p.h. ; during the race he led until only 35 miles remained. Unfortunately, his car caught fire and, although he restarted, it ran out of fuel and he could only finish fifth ; R. Thomas on a sister Ballot took second place. The race was won by a Monroe, which had an engine exceedingly like the 3-litre 78 x 156 mm. 1913 Peugeot engine, and thus was another successful follower of the Henri formula. The dimensions had been changed slightly to 79 x 152 mm.

The winning speed was 88.5 m.p.h. -a slight advance on the previous year's time, despite a reduction in engine capacity of 33 per cent.

Of the Duesenbergs, one finished third, despite a broken valve spring and having to change three tyres ; another fourth and another sixth. Of the first half-dozen finishers, one only (admittedly the winner) had a four-cylinder engine-the others were all straight-eights.

In 1921 Grand Prix racing was revived in Europe under the 3-litre capacity limit. But as usual Indianapolis was the first big race of the year and the entry list showed that the lesson of eight-cylinder superiority driven home in the previous year had been well digested.

Four-cylinder engines had powered 78 per cent of the entries in 1919 and 75 per cent in 1920, but in 1921 the straight-eight for the first time gained a clear majority, being used by 56 per cent of the entrants compared to 28 per cent for four-cylinder models. Ballot, Peugeot and " S.T.D." entered from Europe.

The single Ballot was identical with the previous year's cars except for the addition of front brakes. Peugeot were 1913 Coupe de l'Auto cars with much successful racing in America behind them.

The Sunbeams (or Talbot-Darracqs) were highly interesting. They were the first completely post-war racing models, for which Louis Coatalen was responsible, and there was no doubt that his team of designers modelled the engine fairly closely on the successful Ballot. The timing gears and camshaft layout were very similar ; the bore and stroke (65 x 112 mm.) identical. But four carburetters were fitted and owing to the use of plain in place of ball-bearing mains the cylinders were more widely spaced and the engine was longer.

Ballot for the third year in succession proved itself the fastest car on the track, and, for the third year in succession, failed to win. De Palma drove 200 miles at 93.6 m.p.h., easily a record, and broke a connecting rod. An eight-cylinder Frontenac then took the lead, and it was never displaced.

At 350 miles two " S.T.D." cars were lying third and fourth, but various incidents intervened, and eventually the best that could be managed was fifth place, at 84 m.p.h., over 5 m.p.h. slower than the winner's average of 89.62 m.p.h. Seven Duesenbergs similar in design to those running the previous year were entered and finished second, sixth and eighth with four retirements. Again five out of the first six cars had eight in-line engines, which type also contributed 90 per cent of the finishers.

The G.P. of the Automobile Club de France was run in July over a 10.6 miles circuit at Le Mans with a first-class entry of sixteen cars from Ballot, Duesenberg, Fiat, Mathis and the S.T.D. combine.

The Duesenbergs were the first American entries in a European race since 1908, and were identical with the cars which had had two years' running at Indianapolis (with front brakes added) ; in fact two out of the four cars had run in the American event some six weeks previously. The handicap of a three-speed gearbox was offset by remarkably good power output over the whole of the speed range of the engine which, although reaching a power peak at 4,250 r.p.m., could be taken up to 5,000 r.p.m. without damage. The brakes, hydraulically operated for the first time in road racing, were far more powerful and consistent than anything that had previously been known.

Ballot, also with Indianapolis experience, were likewise well advanced in their preparations, but this could not be said of either Fiat or the S.T.D. team. The former did not appear at all and the Coatalen-designed cars were formally withdrawn and then only brought to the line after super-human efforts by drivers and mechanics.

As the Mathis was a four-cylinder sports car of only 1½-litres capacity the race somewhat naturally resolved into a combat between Duesenberg and Ballot. The latter concern had little doubt about the outcome, but by the time the cars had sorted themselves out on the third lap there were two white Duesenbergs first and second, and although on the eighth lap a Ballot, driven by Chassagne, became runner-up, Murphy's Duesenberg kept ahead with a record lap at 84 m.p.h. However, on the tenth lap the leader had a long pit stop as a consequence of which Chassagne led at the halfway mark and remained there until put out by a broken petrol pipe on the seventeenth lap. At this point the two remaining eight-cylinder Ballots were back in fifth and ninth places, so that despite a connecting rod failure on one of the Duesenbergs (on the eighteenth lap) and serious clutch slip on the other American car, Murphy was unchallenged and won at 78.1 m.p.h. De Palma brought home the fastest Ballot second, 15 minutes behind and averaged 73.6 m.p.h., third position being secured by a catalogue type four-cylinder 2-litre Ballot which had a non-stop run to average 71.8 m.p.h.

A second International Grand Prix was held later in the year on a circuit near Brescia. In this race some new Fiats turned up to compete with the Ballots.

The Fiat design had been prepared by a brilliant engineering team and, although featuring the straight-eight motif, it represented a considerable breakaway in constructional features, and differed in almost every material point from the racing cars which were then dominated by the Henri technique. Only two valves per cylinder were employed and the cylinder blocks were not made from iron castings, but from steel forgings welded together and enclosed by a sheet steel jacket.

This construction had been copied from the 1914 Grand Prix Mercedes, for immediately after the race at Lyons in that year the iron cylinder blocks of the 4½-litre Fiats were discarded and a welded-up steel type substituted. These cars were entered for the 1920 and 1921 Targa Florio races, and provided the winner in the latter year.

On the 3-litre car the popular dimensions of 65 x 112 mm. were adopted and a daring detail in design was the use of roller bearings for the main and big ends, coupled with a one-piece crankshaft. This arrangement involved the use of split cages and races for the bearings, an audacious expedient but one which proved entirely satisfactory and has since found a permanent place in engine design, the Fiat example having been followed by such famous concerns as Sunbeam, Delage and Mercedes-Benz.

With engines developing 120 b.h.p. at 4,600 r.p.m., Fiats had probably the fastest 3-litre unblown car which had been known, and one driven by Bordino lapped the Brescia circuit at 96.31 m.p.h., which compares with 93 m.p.h. as the best Ballot lap speed. However, over the full distance of the race Fiat had many minor troubles and could do no better than third place at 86.1 m.p.h., with Ballot first and second, Goux averaging 90.4 m.p.h.

The end of 1921 marks the end of the 3-litre and the beginning of a 2-litre limit for Grand Prix racing. There were, however, two major races for 3-litre cars in 1922, and as these may be considered a carry forward from 1921 they may be appropriately considered in this Chapter.

The Indianapolis organisers adhered to the 3-litre formula and the race was won at 94.48 m.p.h. by Murphy, using a Miller engine in the actual Duesenberg chassis which he had driven at Le Mans in 1921. The 1915 record speed was thus broken after standing for eight years and five races. A Ballot, driven by an American driver, finished third at 93.04 m.p.h.

In Europe the English R.A.C. resurrected the Tourist Trophy race last held in 1914 and ran it over the same course in the Isle of Man. Only nine entries were secured from Bentley, Sunbeam and Vauxhall.

The Bentleys were tuned-up standard productions, the Sunbeams had run in the 1921 French Grand Prix, and only the Vauxhalls were specially built ; they had engines designed by Ricardo. In view of the obviously high costs to the last company of building special cars it may seem odd that they should choose to enter a race under the virtually obsolete 3-litre formula and that they did not wait until the French Grand Prix and run 2-litre models which could have been kept going for some years.

The reason, believe it or not, was simple ignorance. The writer, as a very small schoolboy, remembers vividly the astonishment of the Chief Engineer when he disclosed the truth, for Vauxhall, up to that time, had been quite confident that the R.A.C. were complying with established international practice. As it happens, Vauxhalls did not even receive a reward for their enterprise and could do no better than third, first place being secured by Chassagne on a Sunbeam, and the runner-up being a Bentley. Despite this comparatively poor result in the Isle of Man it can be claimed with justification that these cars had the most efficient unsupercharged engines that have ever been made. They developed 129 b.h.p., the equivalent, therefore, of approximately 40 b.h.p. per litre and 3.7 b.h.p. per sq. in. of piston area. The former figure is not outstanding but the latter indicates that if Dr. Ricardo's skill had been exercised on a six-cylinder 2-litre engine of the same proportions as those used by Continental designers he would have produced an engine developing approximately 120 b.h.p., more than sufficient to win the French Grand Prix given reliability and good chassis design.

It is a real irony of motor racing that Vauxhall Motors Ltd. should have produced one of the three fastest 4½-litre cars to the 1914 formula and one of the two fastest cars of the 3-litre formula, and failed to secure international honours with either of them. That both of these models secured many successes in minor races, such as at Brooklands, in the later years of their lives, was a poor consolation.

CHAPTER SEVEN

The Two Litre Limit

RACING STATISTICS 1922-25

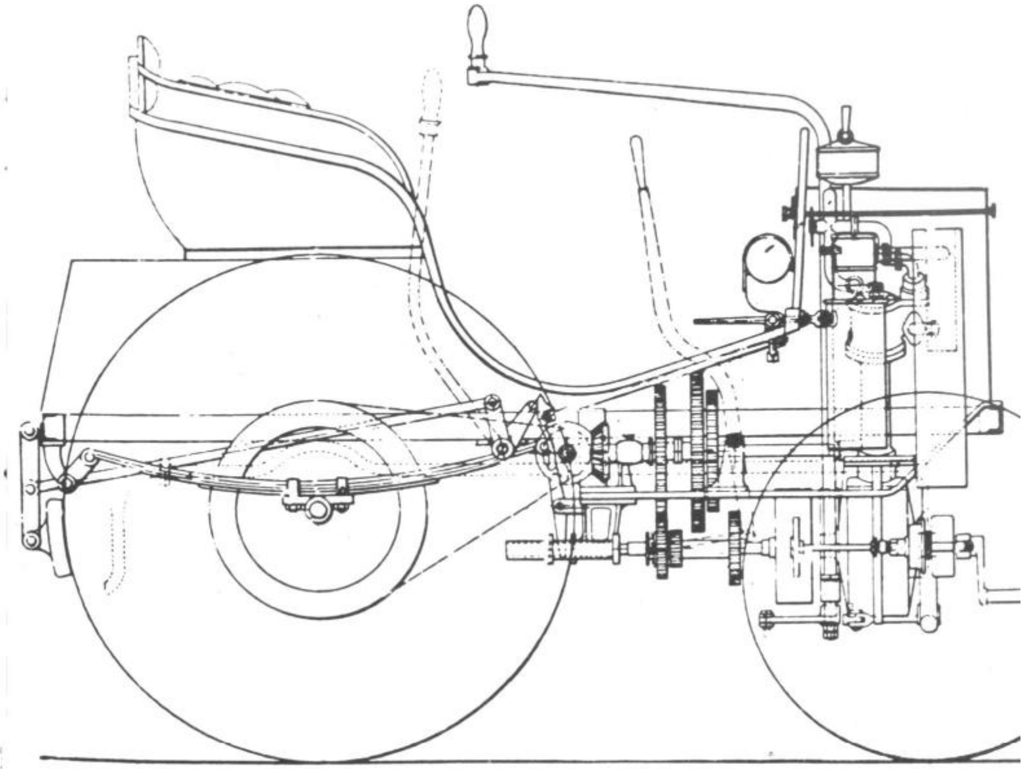
Date	*Event*	*Course*	*Driver*	*Car*	*Winning Average Speed*	*Lap Speed m.p.h.*
16/7/22	French G.P.	Strasbourg	F. Nazzaro	Fiat	79.2	—
16/7/22	,,	,,	P. Bordino	Fiat	—	87.75*
3/9/22	Italian G.P.	Monza	P. Bordino	Fiat	86.89	91.3*
30/5/23	500 Mile Sweep-stake	Indianapolis	T. Milton	H.C.S. Miller	90.95	108.17*
2/6/23	French G.P.	Tours	H. O. D. Segrave	Sunbeam	77.3	—
2/6/23	,,	,,	P. Bordino	Fiat	—	87.75*
9/9/23	European G.P.	Monza	C. Salamano	Fiat	91.06	—
9/9/23	,,	,,	P. Bordino	Fiat	—	99.8*
27/4/24	Targa Florio	Madonie	C. Werner	Mercedes	41.02	42.4
9/6/24	Circuit of Cremona	Cremona	A. Ascari	Alfa Romeo	98.3	100.8*
3/8/24	European G.P.	Lyons	G. Campari	Alfa Romeo	71	—
3/8/24	,,	,,	H. O. D. Segrave	Sunbeam	—	76.7*
25/9/24	Spanish G.P.	San Sebastian	H. O. D. Segrave	Sunbeam	64.12	—
25/9/24	,,	,,	M. Costantini	Bugatti	—	71.7*
19/10/24	Italian G.P.	Monza	A. Ascari	Alfa Romeo	98.76	104.24*
3/5/25	Targa Florio	Short Madonie	M. Costantini	Bugatti	44.5	45.1*
28/6/25	European G.P.	Spa	A. Ascari	Alfa Romeo	74.56	81.5*
26/7/25	French G.P.	Montlhéry	R. Benoist & A. Divo	Delage	69.7	—
26/7/25	,,	,,	A. Divo	Delage	—	80.3*
6/9/25	Italian G.P.	Monza	Count G. Brilli-Peri	Alfa Romeo	94.76	—
6/9/25	,,	,,	P. Kreis	Duesenberg	—	103.21
19/9/25	Spanish G.P.	San Sebastian	A. Divo	Delage	76.4	—
19/9/25	,,	,,	M. Costantini	Bugatti	—	82.75*

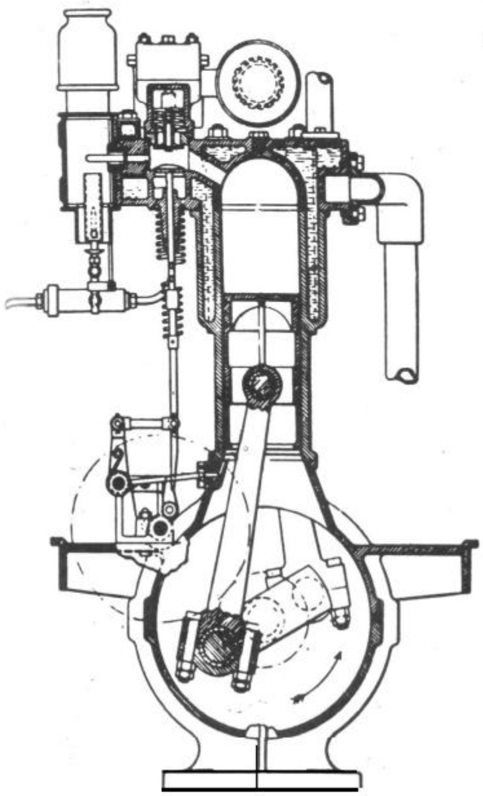
* Record

FROM 1922-25 the principal regulation governing racing cars was that they should have a cylinder volume not exceeding 2-litres. This of necessity led to entirely new designs, the first batch of which appeared on the starting line in the 1922 French Grand Prix held at Strasbourg on July 16th.

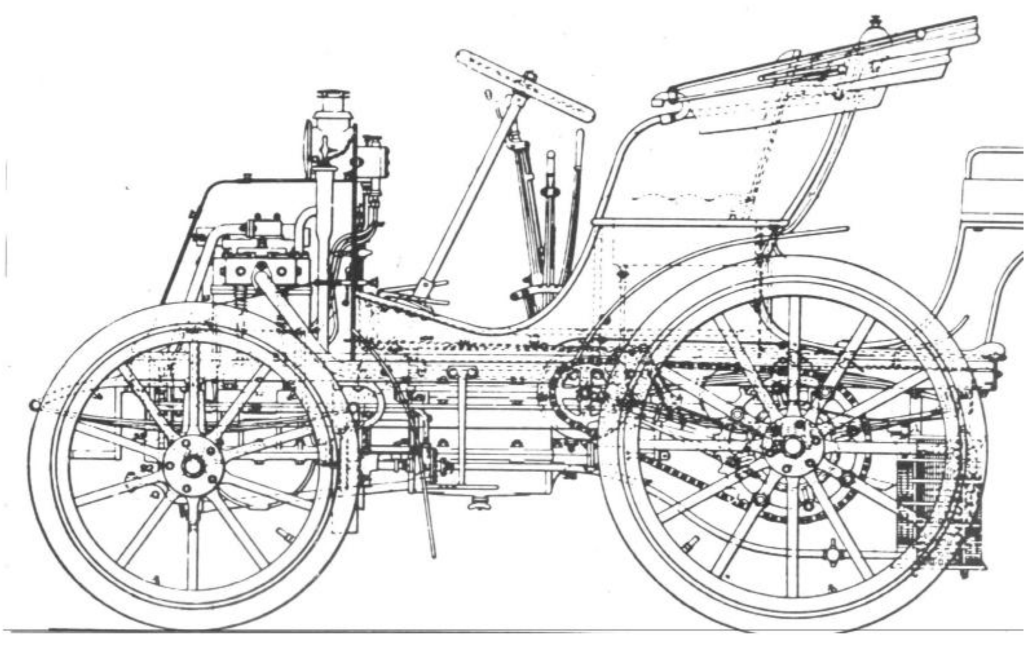
PLATE I

ORIGINAL ENTRY- This drawing to scale 1 : 25 is of the 1894 Panhard and Levassor, which averaged 10.7 m.p.h. from Paris to Rouen on July 23rd, the third highest speed for a petrol driven car. The 1.03-litre V-type engine was built under Daimler (Stuttgart) licence and developed about 3½ h.p. at 750 r.p.m., the gears giving four forward speeds were not enclosed.

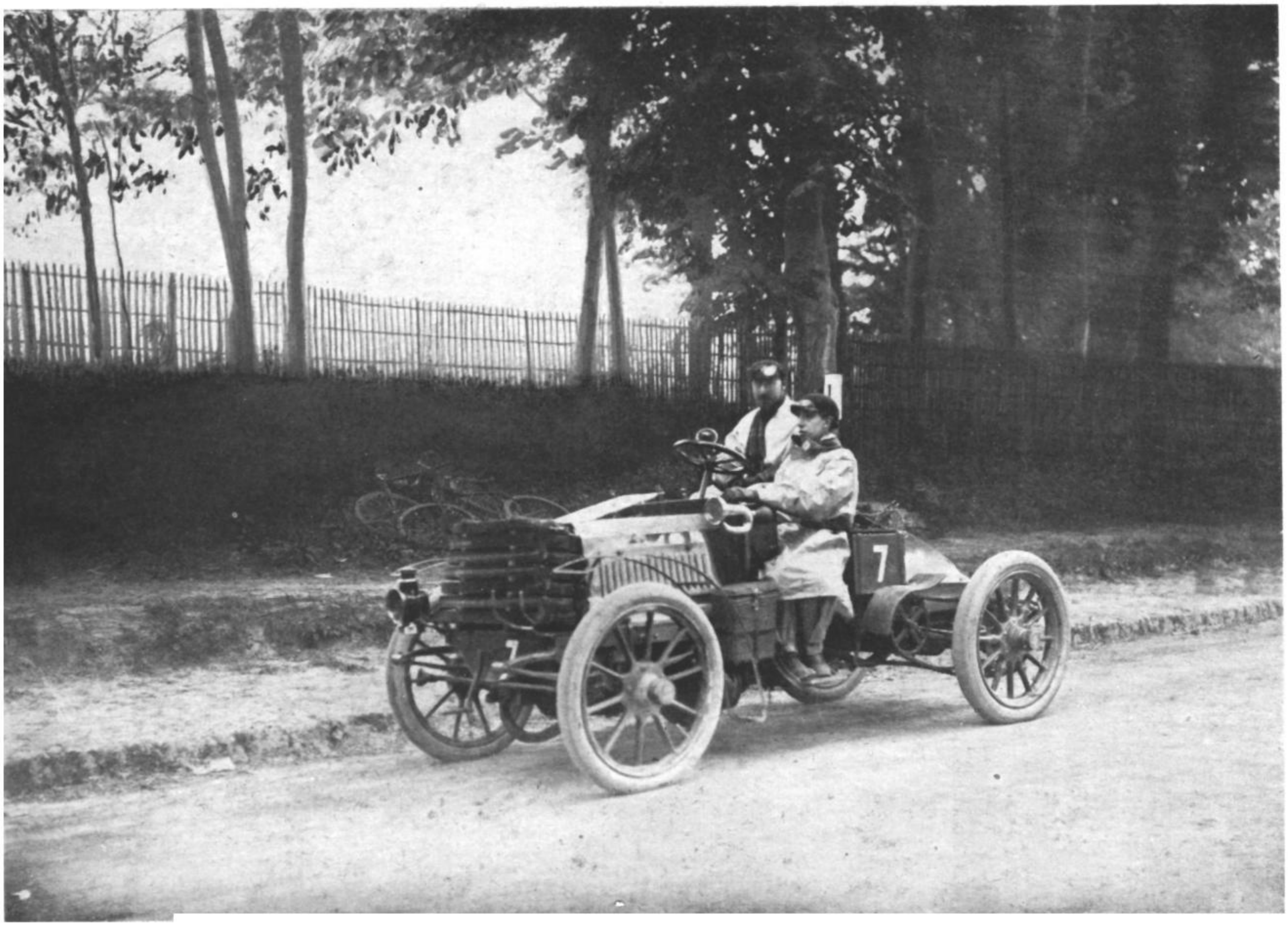




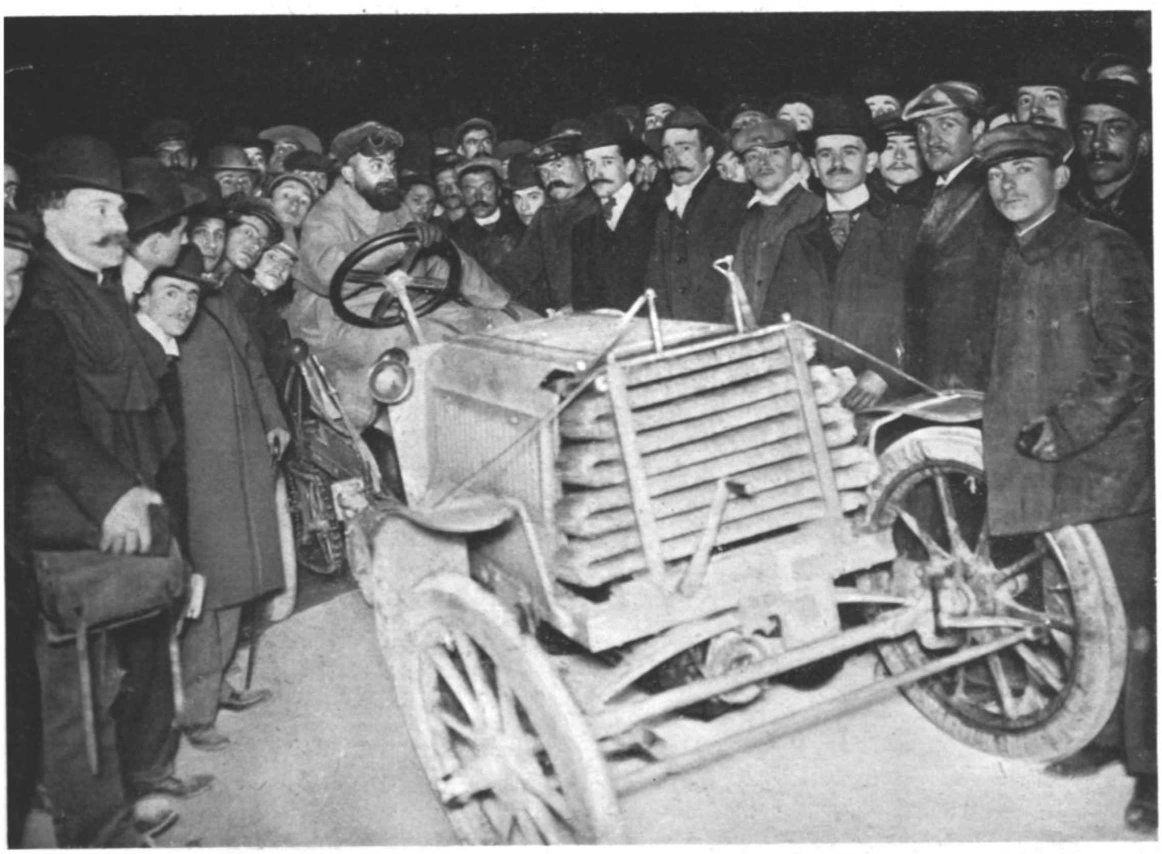
NINETEENTH-CENTURY PRACTICE-This cross section drawing (scale 1:10) shows the Phoenix Panhard engine built under Daimler (Stuttgart) licence in 1899. *The four-cylinder 3.3-litre model developed 12 h.p. and features of particular interest are the platinum tube ignition shown to the extreme left of the drawing, the suction operated overhead inlet valve and the levers between the camshaft and the valve stem which gave an interrupter effect to govern maximum r.p.m.*



FIN DU SIECLE - This-drawing is a side elevation (scale 1 : 25) of the 1899 Panhard and Levassor two-cylinder car. An identical car driven by Charron with a four-cylinder engine won the Paris-Bordeaux race of 351 miles at an average speed of 29.9 m.p.h.



EARLY WINNER-This photograph shows Girardot on his 7.4-litre 40 h.p. Panhard in the 1901 Gordon Bennett race which he won at an average speed of 37 m.p.h. for 372.6 miles.



PACE-MAKER - The Chevalier René de Knyff leaving Paris at 03.36 hours in the 1902 Gordon Bennett race on his 13.6-litre Panhard " 70. " He failed to finish but averaged 54.2 m.p.h. from Paris to Belfort, running on alcohol fuel.

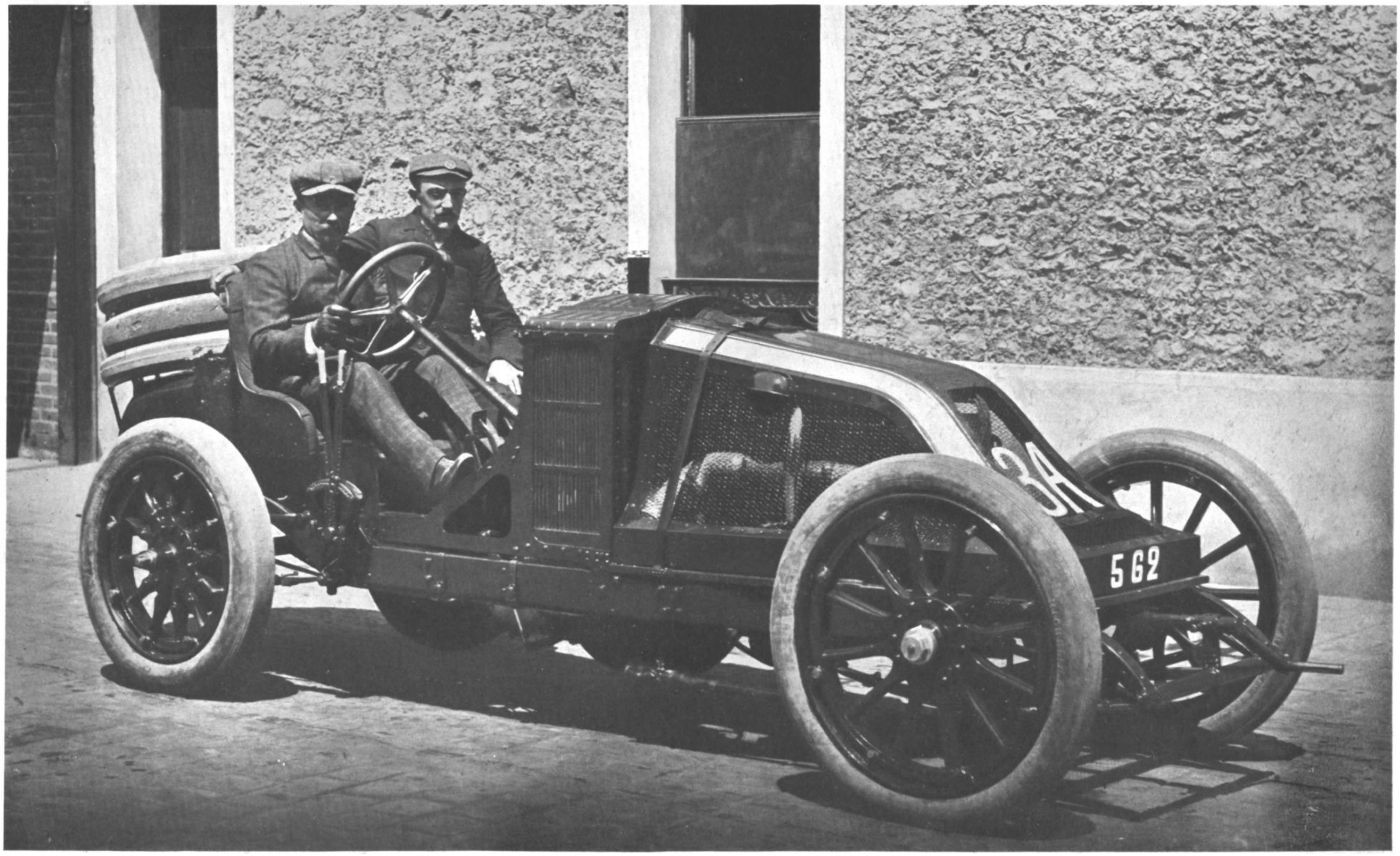


PLATE III

***FIRST GRAND PRIX WINNER-The** Hungarian, Szisz who won the first Grand Prix of the Automobile Club de France on June 26/27 1906, averaging 63 m.p.h. for 769.9 miles on the Sarthe course. He is here shown on the winning car, a 90 h.p. 13-litre, four-cylinder Renault with side valves and shaft drive.*

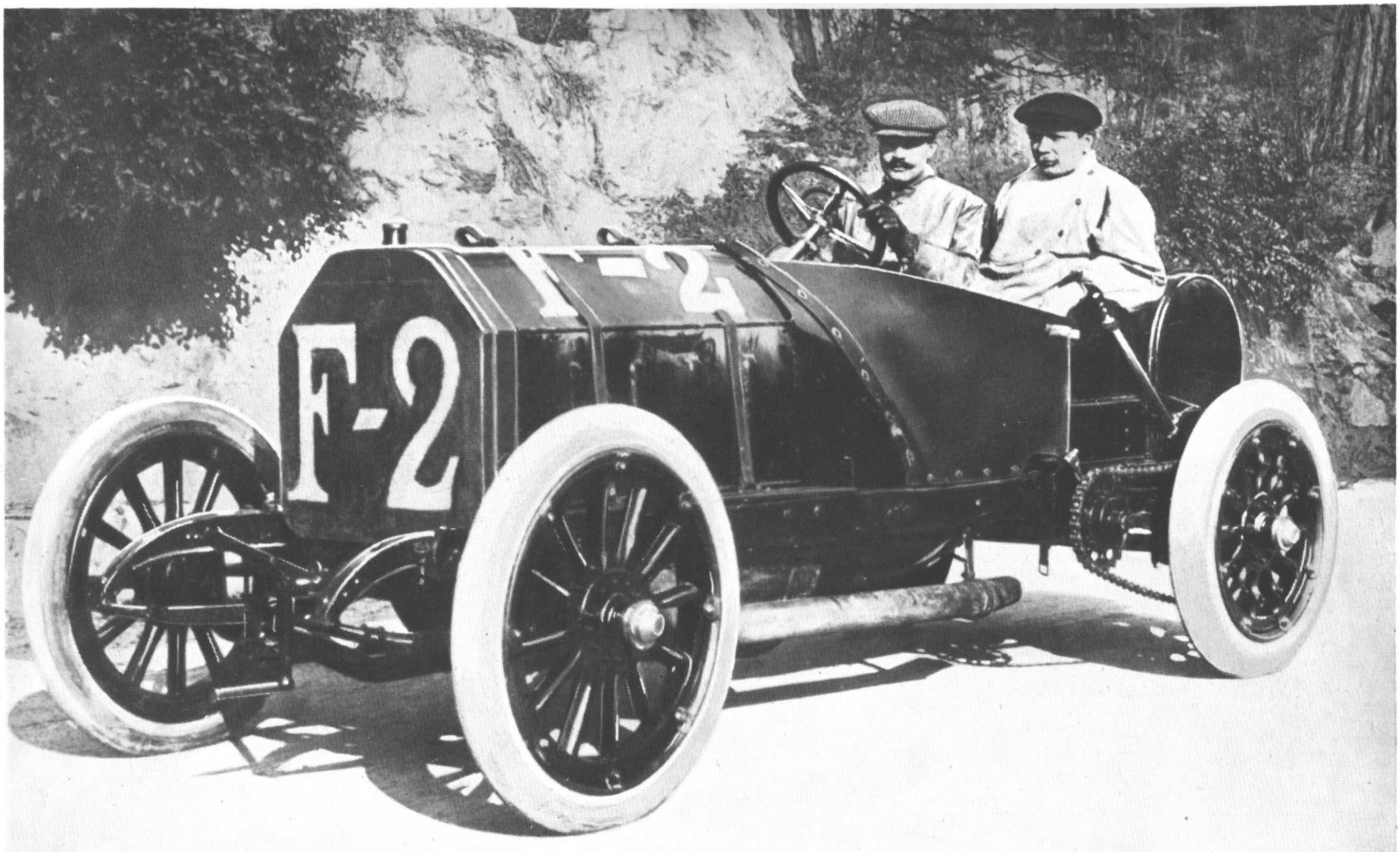


PLATE IV

SECOND GRAND PRIX WINNER-*The second Grand Prix de l'A.C.F. run on July 7th, 1907, over 477.4 miles of the Dieppe Circuit, was won by Felice Nazzaro on a 130 h.p. Fiat car at 70.5 m.p.h. The four-cylinder o.h.v. engine had a capacity of 16 litres with chain drive to the wood wheels.*

PLATE V

***FOUNDING A LINE*—The Grand Prix de l'A.C.F. and the Grand Prix de France in 1912 were won by Georges Boillot and Jules Goux each driving a 7.6-litre Peugeot car, that driven by Goux being shown here. Combining for the first time such features as twin overhead camshqfts, four inclined valves per cylinder, shaft drive and detachable Rudge Whitworth wire wheels, these cars stand first in the line of modern tradition and began a continuous line of design which was consistently successful during the next ten years.**

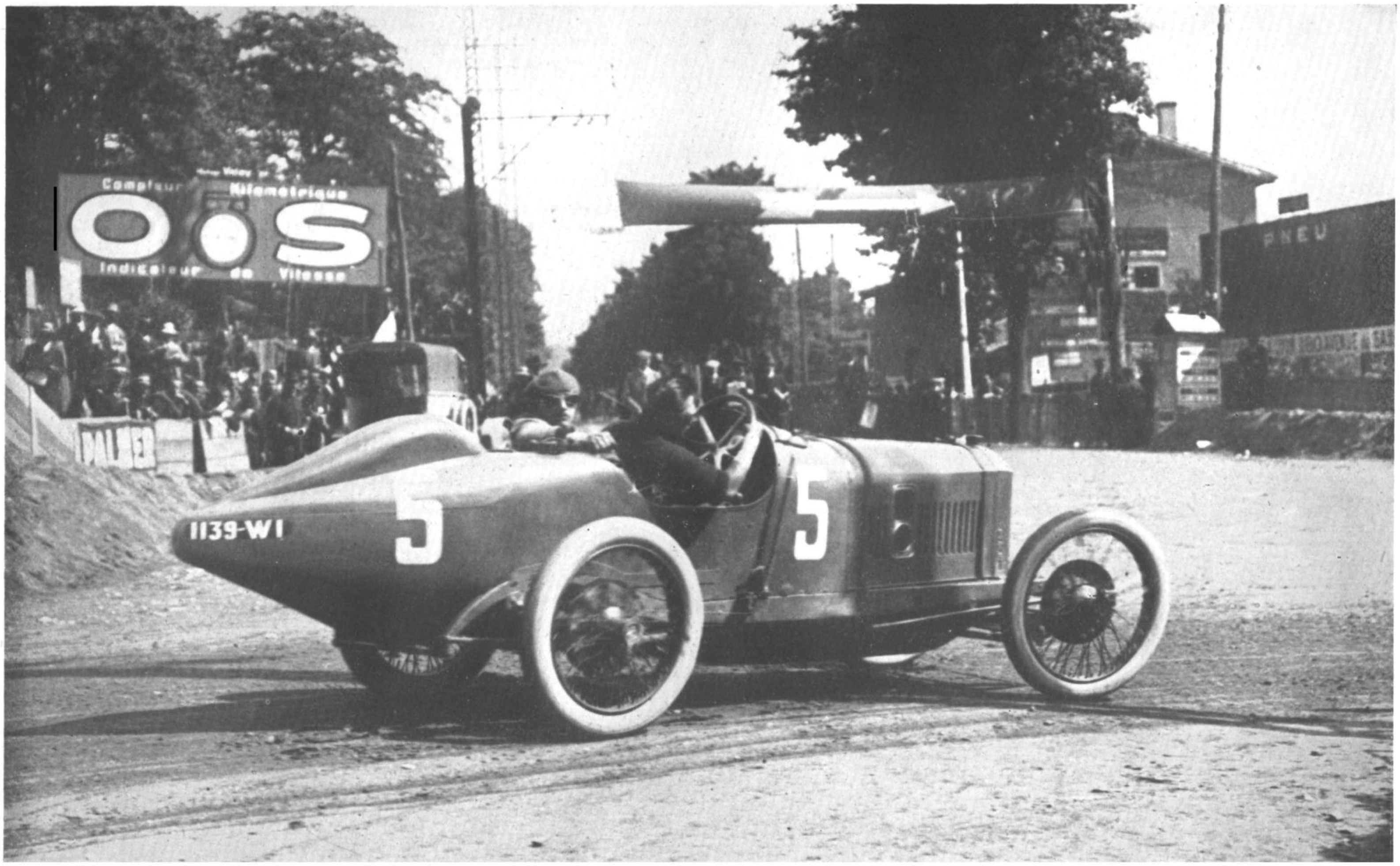


PLATE VI

SUCCESSFUL LOSER - Although Gorges Boillot, shown here in the 1914 4½-litre Peugeot, failed to prevent a 1, 2, 3 Mercedes victory at Lyons in 1914 his car pioneered many features which later became standard practice in racing. In addition to the twin overhead camshaft engine with crankshaft running on roller bearings, features which can he seen in this picture are front wheel brakes and the long streamlined tail. The latter housed two spare wheels, and it was the effect of their mass on the road holding of the car which mainly prevented the car from winning.

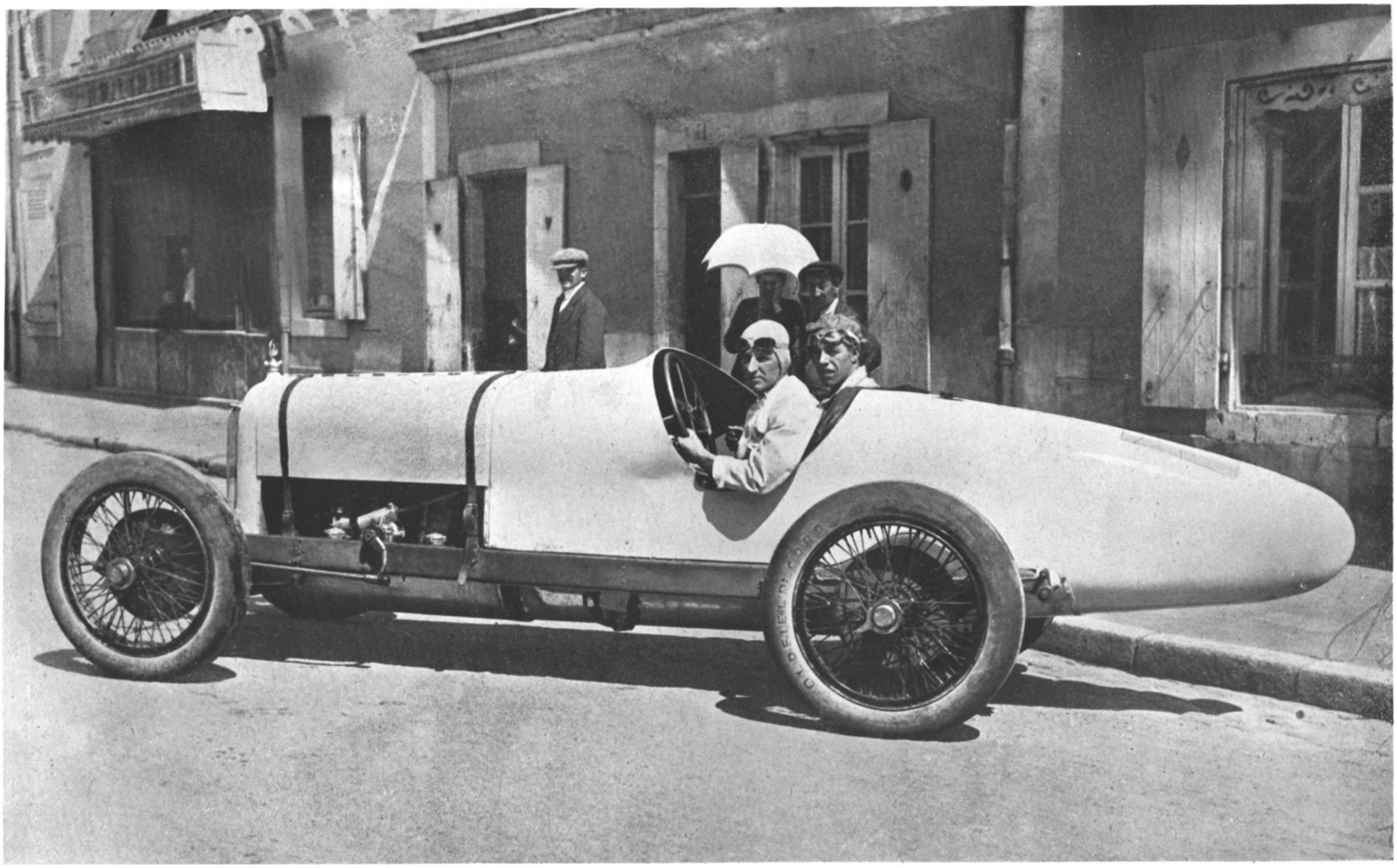


PLATE VII

***FIRST FOR A CLASSIC TYPE** - Since 1920 straight-eight engines have powered the majority of successful racing cars. The first road race to be won with this type was the French Grand Prix of 1921 in which J. Murphy averaged 78.1 m.p.h. for 322 miles at Le Mans. The car was a Duesenberg, with a 3-litre engine giving 115 h.p. The driver in this picture is Joe Boyer.*

PLATE VIII

SETTING A FASHION-F. Nazzaro on the 90 h.p. 2-litre six-cylinder Fiat with which he won the 1922 French Grand Prix at an average of 79.2 m.p.h. over 499 miles at Strasbourg. Both technically and in body form this design set a fashion which lasted for many years.

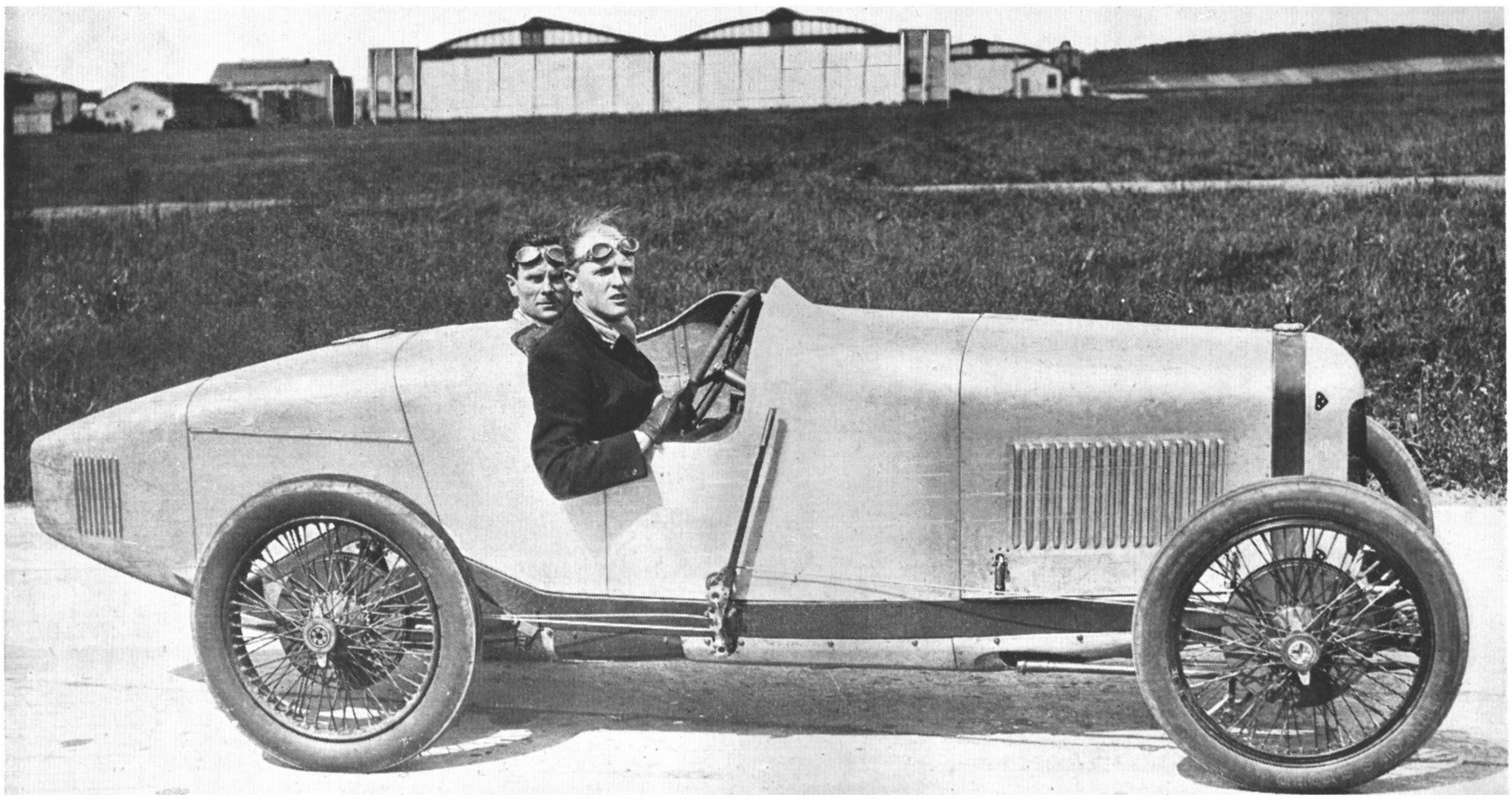


PLATE IX

BRITISH WINNER - Sir Henry Segrave on the six-cylinder 102 h.p. 2-litre Sunbeam photographed at Brooklands before winning 1923 French Grand Prix at an average of 75.3 m.p.h. for 496 miles at Tours.

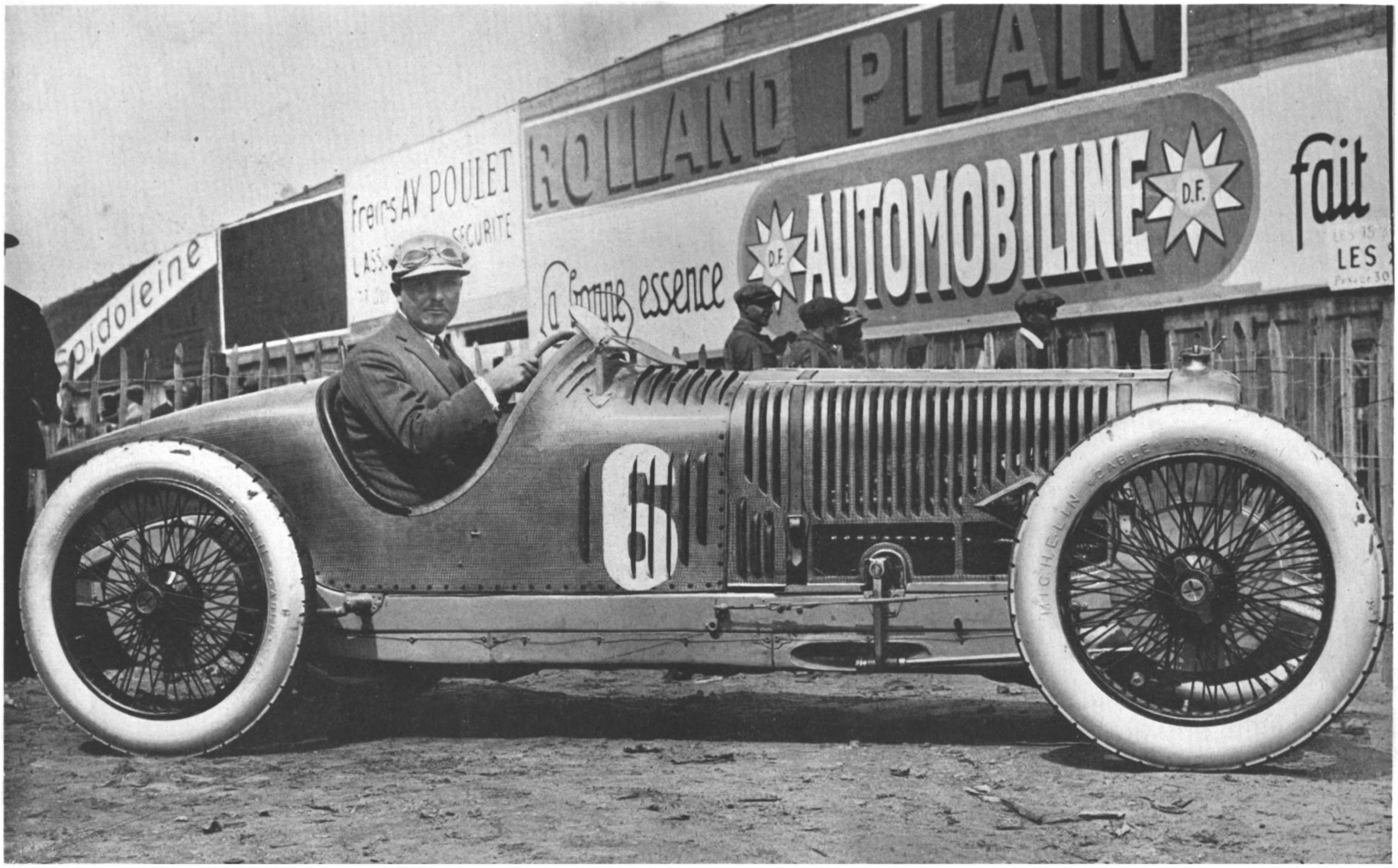


PLATE X

A PINNACLE OF DESIGN - The supercharged twelve-cylinder 2-litre Delage which won the French Grand Prixm at Montlhéry in 1925 at 69.7 m.p.h. for 621 miles. These cars would reach 134 m.p.h. with 190 h.p. available from the engine. At the wheel in this picture is A. Divo, who shared the wheel of the winning car (No. 14) and broke the lap record.

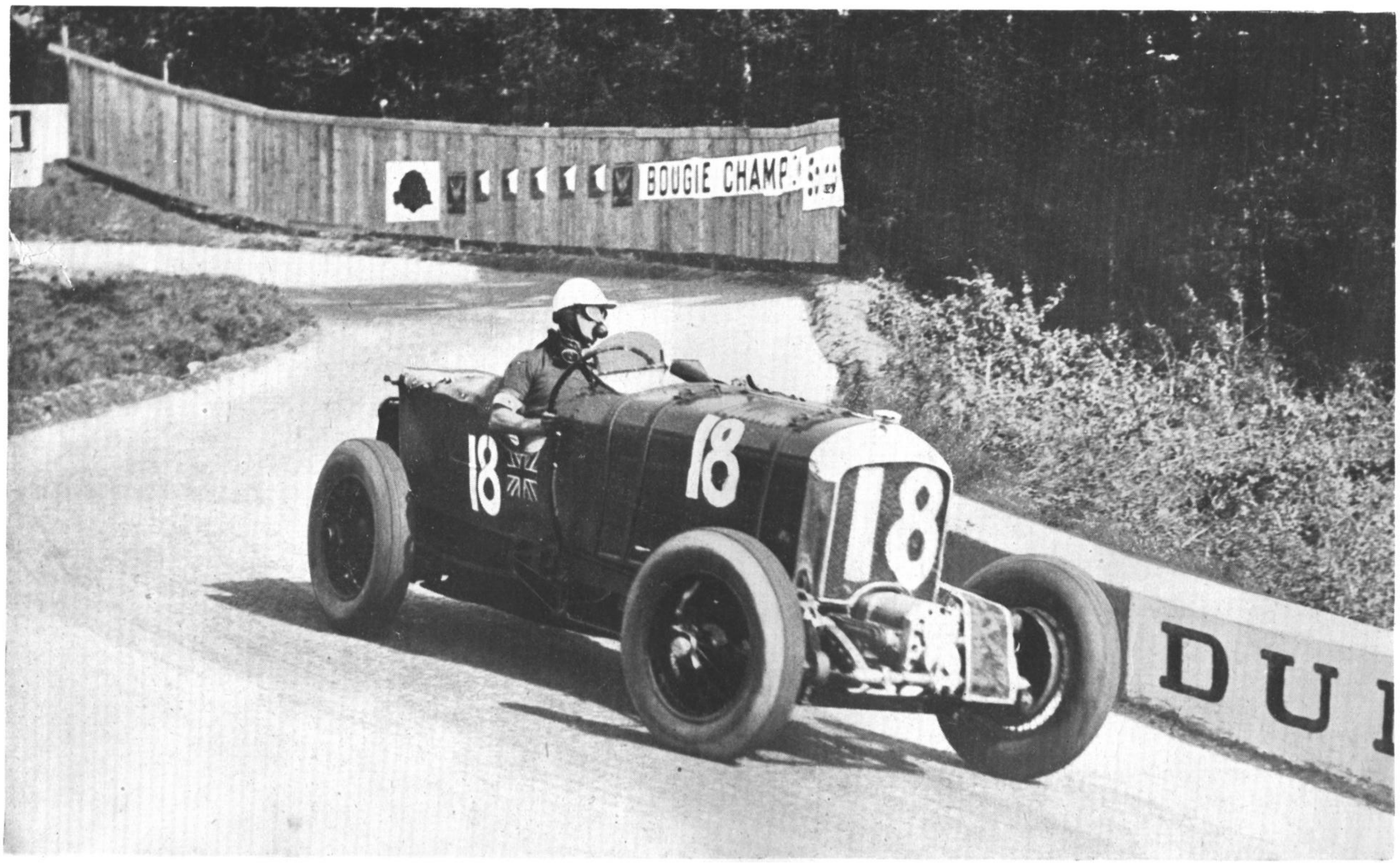


PLATE XI

A MASTER - Sir Henry Birkin, Bt. (refreshing himself with an orange), in the 4½-litre, four-cylinder, 240 h.p. supercharged Bentley, four-seater sports car, weighing two tons, which he drove into second place in the 1930 French Grand Prix at Pau at an average of 88.8 m.p.h. for 247 miles.

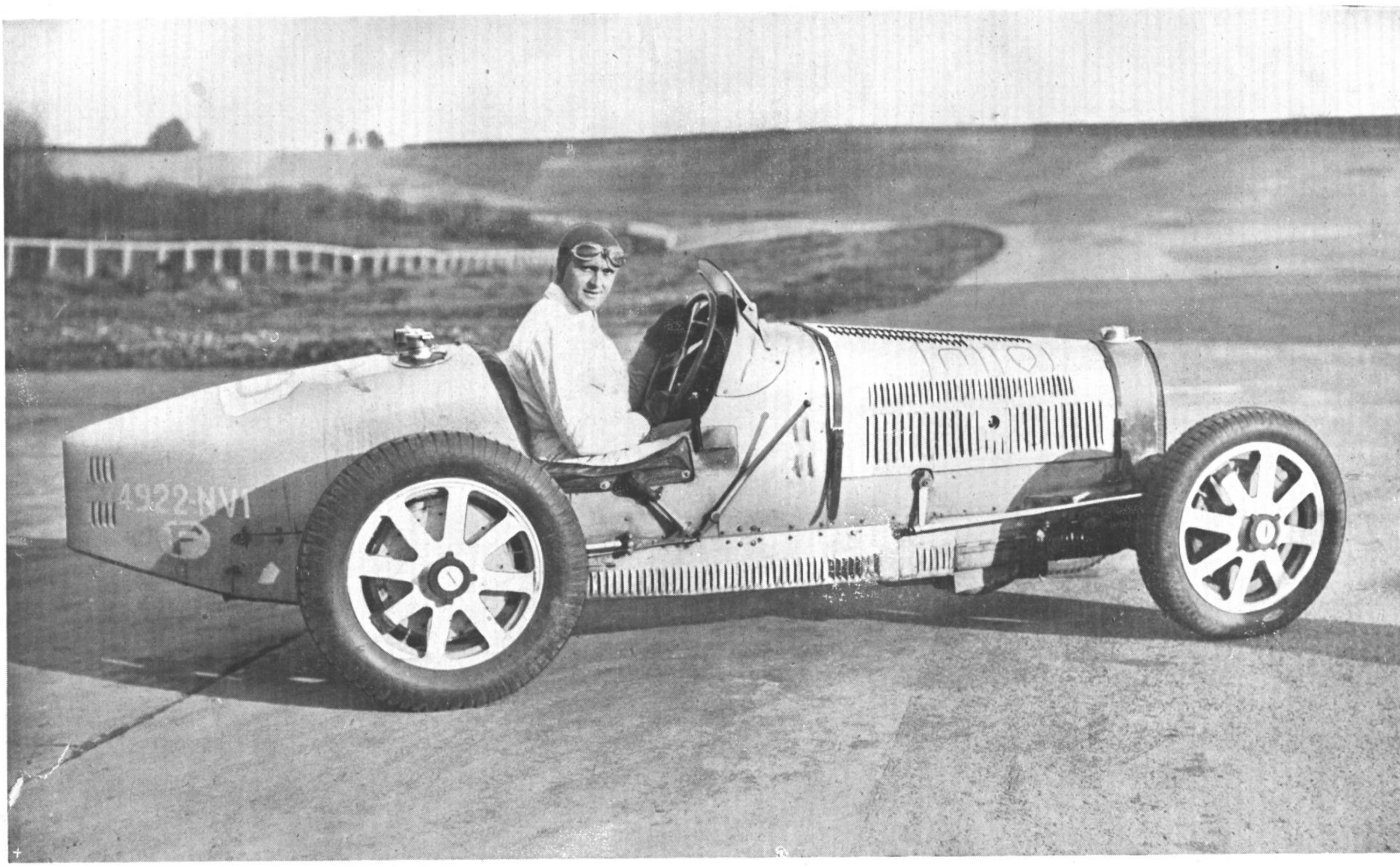


PLATE XII

LE PUR SANG - L. Chiron at the wheel of the Type 51 Bugatti, an eight-cylinder, 2.3-litre, car developing 160 b.h.p., winner of the 1931 ten-hour French Grand Prix at Montlhéry with an average of 78.16 m.p.h. This type of car, and the Type 35 which it closely resembled, won thirty-three major road races in seven years - an unequalled record.

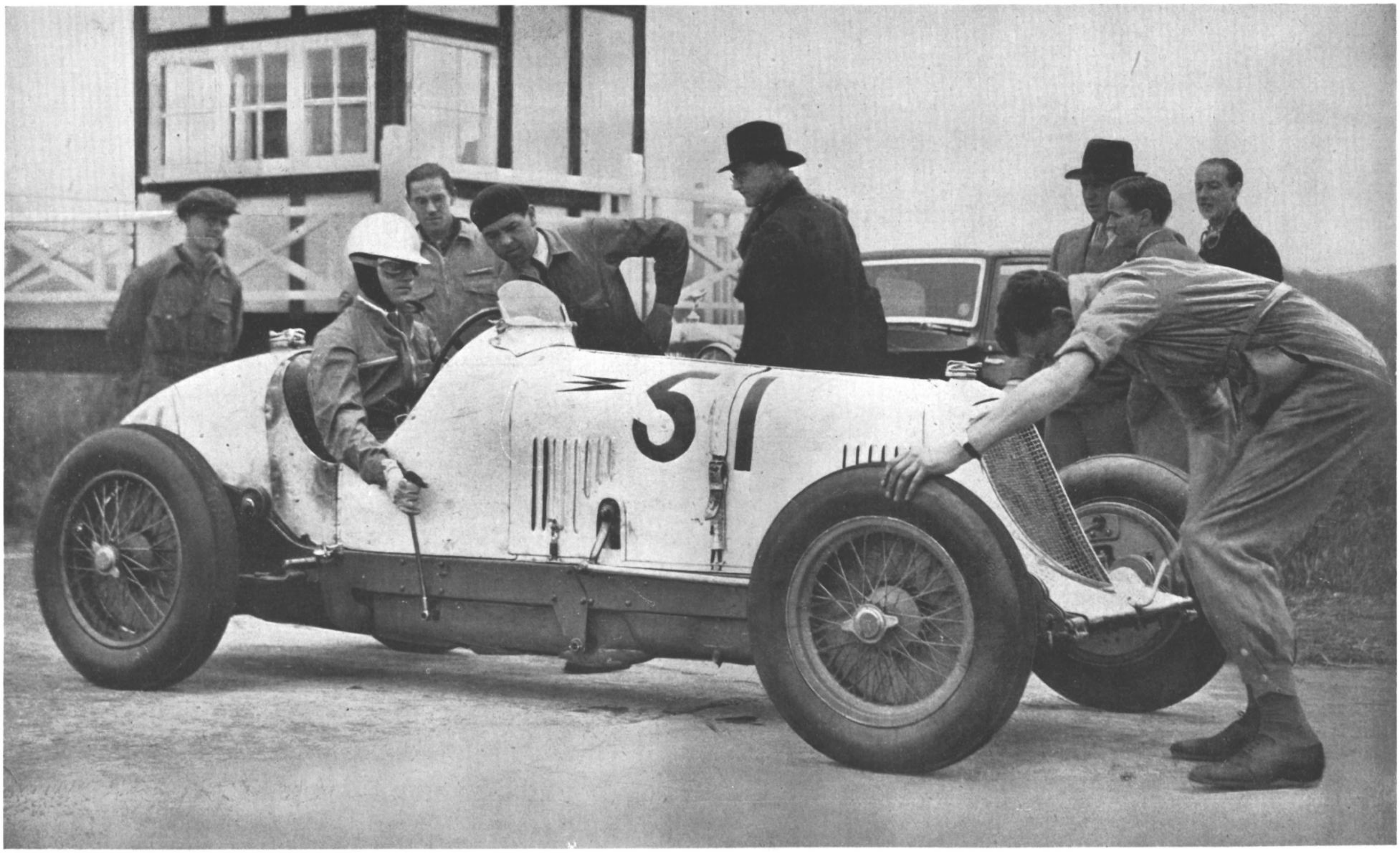


PLATE XIII

***LAST OF THE LINE - The** 1934 single-seater Maserati with 2.9-litre straight-eight engine represented (together with the corresponding Alfa Romeo) the highest development of the orthodox sprung chassis with rigid front and rear axles. The car shown developed 205 b.h.p. and was a direct development of a design initiated in 1930. This picture shows Whitney Straight about to break the International Class D flying kilometre record ot 136.98 m.p.h. in June 1934.*

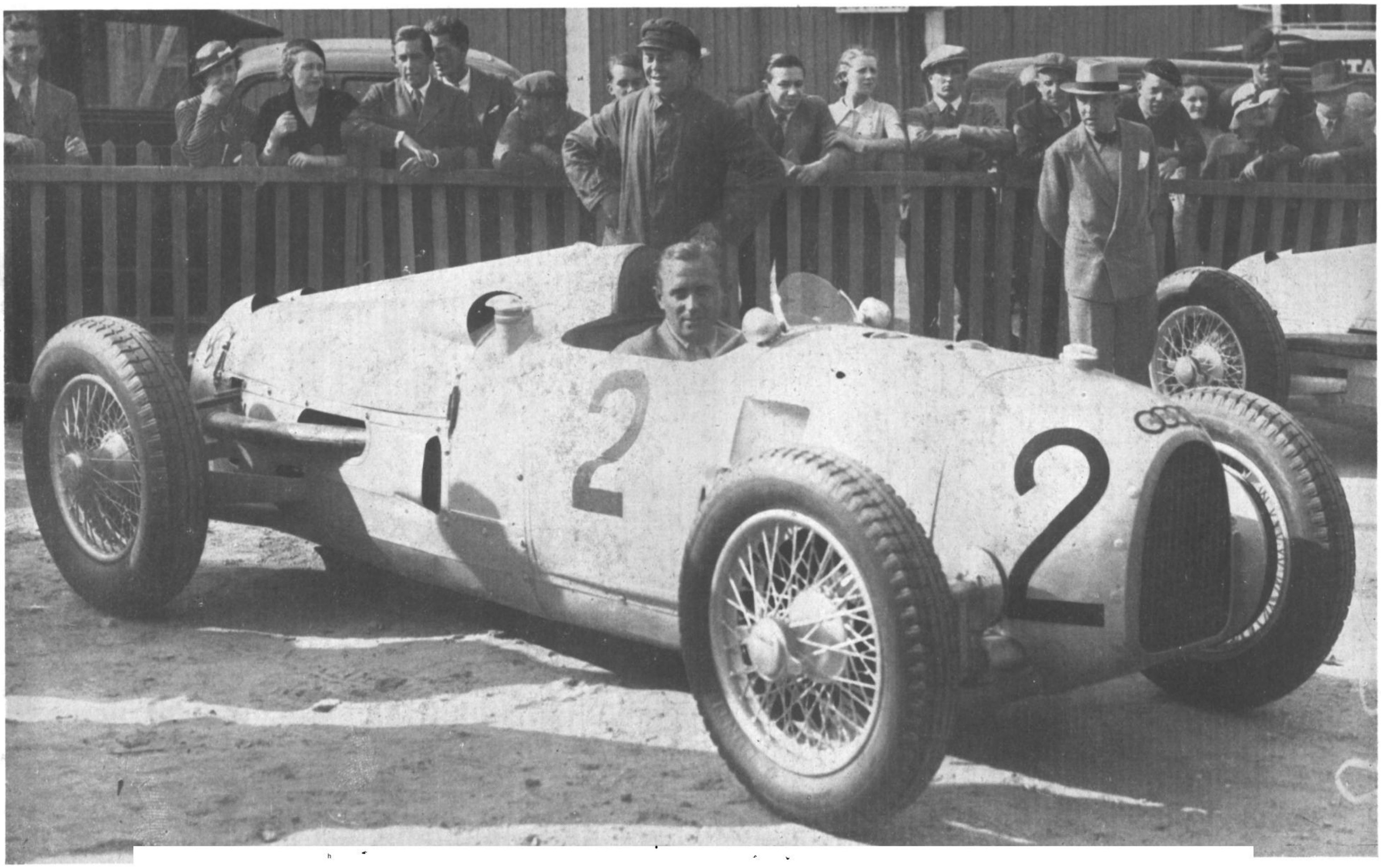


PLATE XIV

A SUCCESSFUL CHALLENGE - The Porsche-designed Auto-Union cars which appeared in 1934 embodied all-independent suspension tubular frame and rear mounting for the 4.36-litre, 295 h.p., V.16-cylinder supercharged engine. The car shown here is that driven by Fagioli in the 1934 Grand Prix de l'A.C.F. and despite many other unorthodox features, this model and the direct descendants thereof secured 17 victories in this and the ensuing three years.

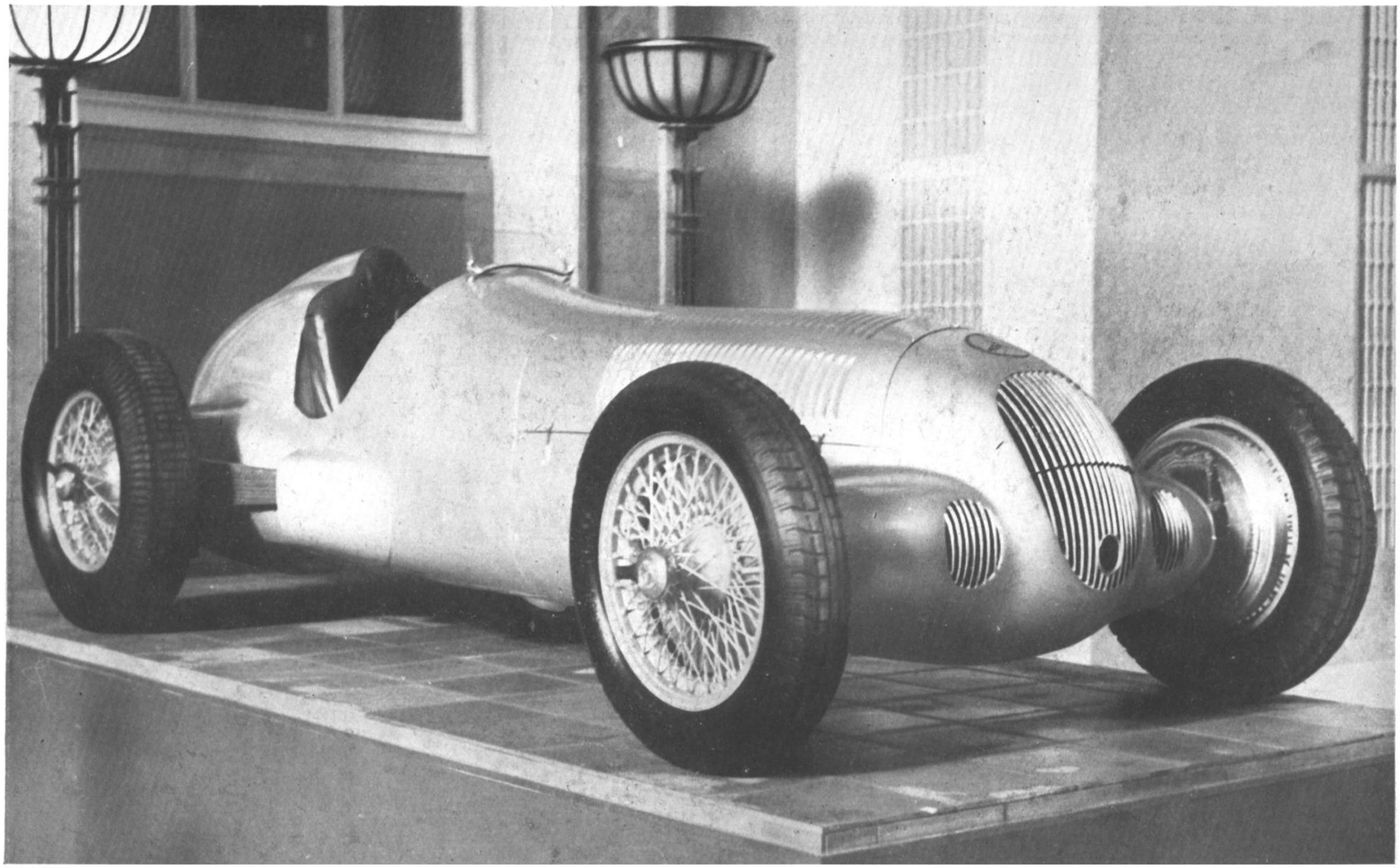


PLATE XV

MAXIMUM POWER - The 1937 Mercedes-Benz built for the last year of the 750 kg. Formula had an eight-cylinder in-line 5.66-litre engine which at the peak of its development developed 646 b.h.p., the highest figure ever available in road racing. The chassis of the car was notable for the first use on a racing car of a de Dion type rear axle, and the tubular chassis frame combined light weight with new standards of stiffness. The lap speeds achieved by this car on the Berne, Brno, Donington, Monaco, Roosevelt and Tripoli circuits have remained unbeaten for 15 years.

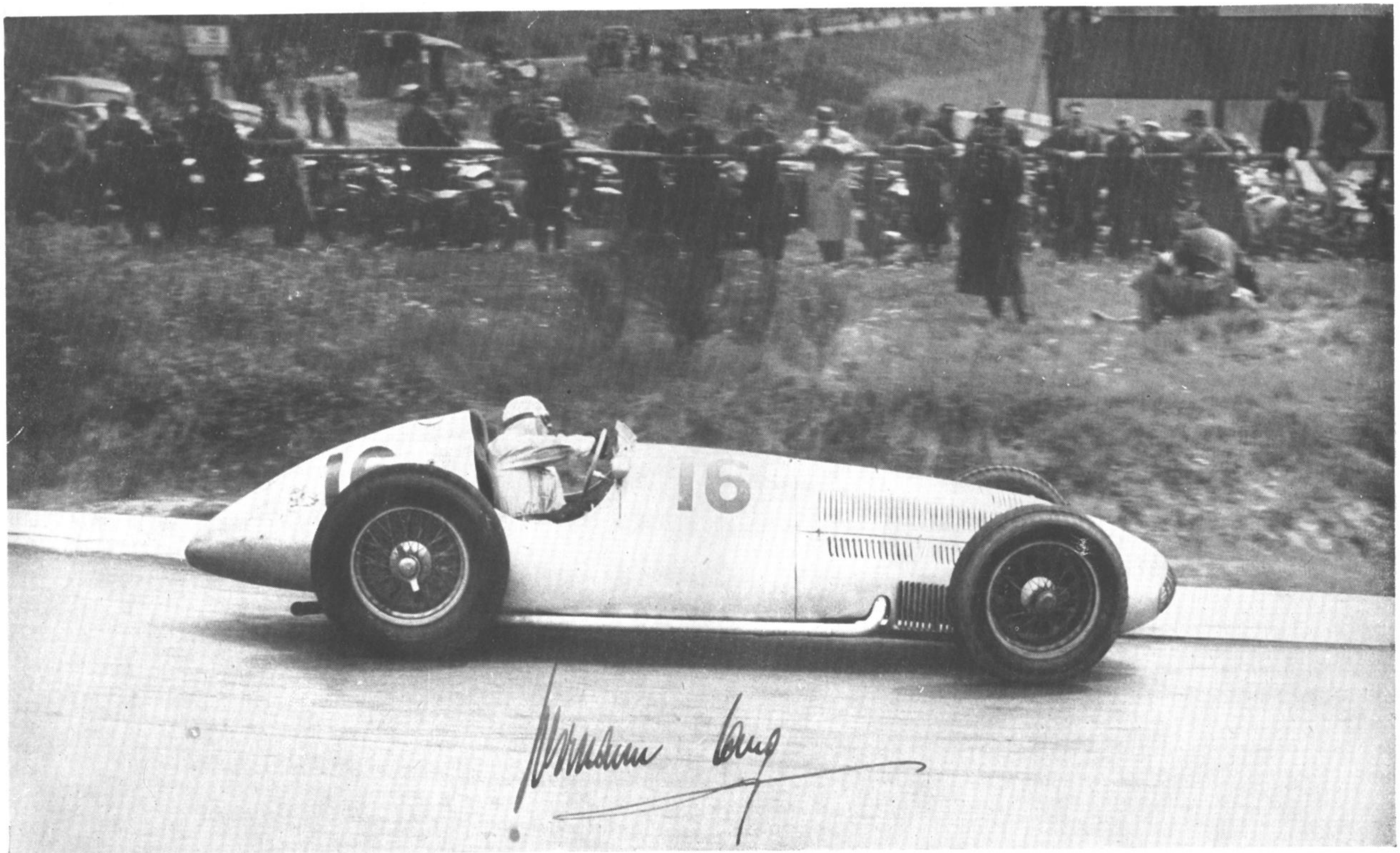


PLATE XVI

SUPREME SPEED - Lang on the twelve-cylinder, 490 h.h.p., 3-litre Mercedes-Benz with which in 1939 he made the fastest timed laps of four Grand Prix circuits with an astonishing peak of 117.5 m.p.h. in practice for the French Grand Prix at Rheims. During this same year he piloted the car to victory in the Belgian and Swiss Grands Prix and in the Eifel Races.

This event marked the second successive breakaway in organisation which had been effected in two years. In 1921 the replenishment depots became pits in name only, all equipment being kept at ground level with manual refuelling from cans or large jugs. In 1922 despatch of competitors in pairs was abandoned and Strasbourg spectators were the first to witness a mass start Grand Prix.

Despite their success in the previous year there were no American competitors amongst the nineteen entries (of which eighteen started), comprising teams from Fiat, Bugatti, Sunbeam, Ballot, Rolland-Pilain and Aston Martin, all of three cars except Bugatti who had four and Aston Martin who had two. The principal non-starter was Delage, who had constructed four-cylinder engines which were obviously deficient in power output, and it is interesting that despite the supremacy of the straight-eight power-unit during the 1921 season only two entries in 1922 embodied this construction -Rolland-Pilain and Bugatti. The former need not long detain us, as it was never a very successful design, although it embodied many ingenious mechanical features. The latter was a forerunner of a range of successful cars during the next decade. The crankshaft ran on three ball bearings, the cylinders were castings of two blocks of four, and a single overhead camshaft operated two inlet and one exhaust valve placed vertically in the cylinder head. Two carburetters were used, and it was claimed that the 60 x 88 mm. engine would give 90 h.p., although this probably was an exaggeration.,

The Ballots were four-cylinder catalogue sports models which had done quite well in the preceding Grand Prix and were, of course, of Henri design.

The Aston Martins also had four-cylinder engines, but had a swept volume of only 1½-litres.

Both the Bugattis and the Ballots were fitted with egg-shaped bodies, and amongst the ingenious features of the former was a scheme for taking the exhaust out through the centre of the body. It was supposed to favour streamlining, but it made the interior of the car extremely hot.

The Fiats had engines which were scaled-down replicas of the 1921 3½-litre eight-cylinder models. The bore remained the same, 65 mm., but the stroke was reduced from 112 to 100 mm., giving a capacity of just under 2 litres. The general specification of the engine, with timing gears at the back, cylinder built from steel forgings with welded-on jackets, wide angle valves, and all-roller-bearing engine, was identical with the previous types, and the choice of six cylinders seems to have been dictated primarily by convenience and not by belief in the superiority of the number as compared to eight cylinders in a line.

As Ballot had decided to rest upon the laurels of the 3-litre " eights " and not to produce pure racing cars to meet the 2½-litre formula, Henri transferred to the Sunbeam Company, where he worked under the patronage of Louis Coatalen in producing an entirely new design. In this model the designer continued on the lines which had hitherto brought him and his followers so much success, but rather surprisingly he abandoned the straight-eight engine in favour of a four-cylinder unit with dimensions of 68 x 136 mm. This had an iron casting as cylinder block with four valves per cylinder inclined at a small angle. The crankshaft ran on ball bearings throughout with plain big-ends ; the two camshafts were driven by a train of timing gears from the front end of the engine ; the gearbox was built in unit and the brakes had mechanical servo action.

By reason of having a small piston area, long stroke and restricted r.p.m., the Sunbeams were beaten before they started, and, in fact, during the race at Strasbourg they were never in the same class as the Fiats. Their highest lap speed was approximately 78 m.p.h., whereas the Bugattis were able to average 80 m.p.h., and the best Fiat speed was 87.75 m.p.h. Nazzaro, driving this make, won easily at an average speed of 79.2 m.p.h. Rear axle troubles affected the other two cars of the team at the last moment and prevented them having a grand slam, and thus two Bugattis finished second and third.

Nine out of the eighteen starters had finished in the 3-litre race of 1921, but only four cars were running at the end of the 1922 race and two-thirds of the entry failed to get past half distance. Furthermore, the superiority of the Fiat cars was so great that Bugatti alone challenged in the other 2½-litre event held during 1922, viz.: the Italian Grand Prix, run on the newly constructed 6¼ miles Monza circuit. This race had in fact a record number of non-starters. Ballot, Benz, Bianchi, Delage, Mercedes, Rolland-Pilain and Talbot Darracq all decided that a Fiat victory was a foregone conclusion and forfeited their entry fees. Moreover, three out of four Bugattis failed to start owing to lack of tyres with the required rolling radius, and two Diattos retired at quarter distance, so that the Fiat team had a very hollow victory, Bordino winning at 86.89 m.p.h., and putting up a record lap of 91.3 m.p.h.

Looking at the season as a whole, one of the principal points of interest was the complete failure of the Henri-designed cars. He had been directly represented in the Sunbeam G.P. models, indirectly through Ballot, but by now the theories which he had successfully advocated for so long had out-lived their usefulness.

The technical features of the Henri period and the reasons for the sudden swing to radically differing types of construction are discussed in detail elsewhere in this book. So far as the story of Grand Prix racing is concerned it is significant to note that the 1922 2½-litre cars with atmospheric induction were amongst the slowest Grand Prix models to be built, for although benefiting by front brakes it is doubtful if they could hold their own with, say, the 1908 cars either in respect of maximum speed or acceleration.

As so often occurs, however, a low level in design and performance was the prelude to a great step forward. Already racing cars had been built and run with supercharged induction systems. The general application of blowing to the Grand Prix car was to effect a dramatic step up in performance during the next five years, and was already foreshadowed by the entry of two 1½-litre four-cylinder supercharged Mercedes cars in the 1922 Targa Florio. Following on this development a team of three blown Mercedes of 2-litre capacity ran in the 1923 Indianapolis race on May 30th and a team of eight-cylinder blown Fiats appeared in the French Grand Prix two months later.

The 500 Mile Sweepstake at Indianapolis was won by an eight-cylinder Miller-designed H.C.S. at 90.95 m.p.h. The race attracted eight European cars, five Bugattis and three Mercedes. The former were similar to the 1922 (Strasbourg) Grand Prix cars, but they were now fitted with very narrow single-seater bodies and provided with first-class drivers. However, they were never at all prominent; the highest position occupied being fifth and the only one to finish took ninth place.

The supercharged Mercedes cars were far more formidable. The design was by no means a simple enlargement of the 1922 1½-litre Targa Florio model but was an entirely new type with a four-cylinder (70 x 129 mm.) engine from which 120 b.h.p. at 4,500 r.p.m. was claimed, maximum speed being estimated at 118 m.p.h. In the U.S.A. these cars were handicapped by poor pit work and inadequate training for the drivers, but, nevertheless, one car driven by Werner was third for many miles, finishing tenth after experiencing valve trouble. Of the other two in the team one came in eighth, and the third, driven by Lautenschlager in his last race, hit the wall at the end of fourteen laps. The driver was uninjured but this was a sad finish to the racing career of a man who had won the French Grand Prix twice in two starts.

The German concerns were debarred from entering the French Grand Prix which was held at Tours in July, but no less than five other constructors prepared entirely new designs for this event, a fact which shows very clearly what a deep impression the new Fiat mode of construction had made on engineers in the previous year. For the third successive year eighteen cars were entered, there being teams from Bugatti, Delage, Fiat, Rolland-Pilain and Voisin. Bugatti and Voisin each entered four cars and Delage one, and all the entrants showed a marked diversity in design, only Rolland-Pilain running cars which had been constructed the previous year.

Bugatti kept the same engine as previously, but had ultra-short wheelbase chassis with tank type streamlined coachwork. Voisin, also, had carefully calculated bodies of good aerodynamic form. Delage returned to racing with a car designed by M. Plancton and built in only four months, orthodox so far as the chassis was concerned, but with a twelve-cylinder engine potentially capable of a very high r.p.m., and road speed, the stroke being only 80 mm. and the bore a mere 51.3 mm.

Between the trials prior to the 1922 French Grand Prix and the Italian Grand Prix in September, the output of the six-cylinder type 404 Fiat was raised from 92 b.h.p. at 4,500 r.p.m. to 112 b.h.p. at 5,000 r.p.m., and there was apparently but small incentive to change a proved design. But on Fornaca's insistence on greater power this engine was discarded in 1923 and replaced by the type 405 designed by Zerbi and Cavelli, this being a straight-eight with bore and stroke of 60 x 87.5 mm. and, most important, with the carburetters fed by pressure air from a displacement type blower. As first built, 130 h.p. was realised at 5,500 r.p.m.

Louis Coatalen followed once again his policy of buying up the best brains from his rivals. During the previous winter he secured the services of Bertarione from Fiat, and it is, therefore, not surprising that the 1923 Sunbeam engines showed a very strong resemblance to the previous Turin products. In point of fact the 1923 Sunbeam engine was almost identical to that of the 1922 Fiat, except that 2 mm. were added to the bore and 6 mm. taken from the stroke (giving dimensions 67 x 94 mm.), whilst the exhaust valve was made larger than the inlet valve. The external appearance of the car was very " Fiat-like" although the chassis was basically the 1922 type designed by Henri.

The contest between these two makes was close, for a Sunbeam was second at five laps, first at ten laps, first at twenty laps, second at thirty laps, and Segrave finally won on the thirty-fifth lap. Fiats, on the other hand, were first at five laps, second at ten laps, first at twenty laps and first at thirty laps. No Fiat finished, all of them going out with various mechanical troubles, including break-up of the rather primitive vane type of blower which is more fully described elsewhere. Sunbeams were also second and fourth, Bugatti running third, twenty-five minutes behind the winner.

The Bugatti drivers were handicapped by the odd proportion of wheelbase and track chosen by their designer, which was 6 ft. 6 in. and 3 ft. 3 in. respectively, and this made them very hard to hold on the straight, although they were quick through the corners.

For the Italian Grand Prix entries were made by Alfa Romeo, Benz, Fiat, Voisin, Rolland Pilains, and Miller. The Alfa Romeo team were withdrawn before the start following an accident in which one of the drivers, Sivocci, was killed. The cars used were supercharged six-cylinder types with the designation P.l. Practice for this event was their first and last in public.

The so-called " Tropfwagen " Benz cars had six-cylinder engines mounted behind the driver and ahead of the rear axle, and were of markedly pear-drop shape with external radiators mounted on struts behind the driver's head. These cars exerted no immediate influence, but, as will be narrated in due course, led directly to the production in 1934 of the Auto-Union " P-wagen."

The Millers were Indianapolis type cars, unsupercharged, and gravely handicapped by inadequate transmission and braking systems.

In the two months that had elapsed since the French Grand Prix the Fiats had been fitted with Roots type blowers and they now showed their quality in no mean fashion. Bordino led up to half distance, a staggering effort for he had broken his arm in practice and had to drive with one hand, the mechanic changing gear. He was forced to retire through physical exhaustion and Salamano and Nazzaro finished first and second, with a Miller, driven by Jimmy Murphy (the 1921 French Grand Prix winner), third, five minutes behind. Benz ran fourth and fifth. The winning speed was 91.06 m.p.h. and Fiat also raised the lap record for the Monza track to 99.8 m.p.h. They were thus 5.6 m.p.h. faster over the race distance and over 7 m.p.h. faster on a lap than the six-cylinder atmospheric induction cars of the previous year.

The Italian Grand Prix of 1923 was the first international race to be won by a supercharged car and from then until 1939 only one event of this status (the 1925 Targa Florio) was won without a blower, except on those occasions when supercharging has been proscribed by the regulations.

The following year Indianapolis was innocent of European entries and from this time forward American and European types of racing car have developed on such widely differing lines that a study of the former steps out of the frame of reference of this work.

In Europe the racing year of 1924 opened with the Targa Florio, which was won by a 2-litre supercharged Mercedes of the type which had run in the previous year's Indianapolis. During the intervening twelve months it had, however, been improved in detail by Dr. Porsche who had just become chief engineer to Mercedes after fifteen highly successful years with the Austro-Daimler Company.

After the withdrawal of the P.l Alfa Romeos at Monza this type was scrapped and an entirely new design developed under the supervision of Jano. This, the P.2 model, had a straight-eight engine with welded steel cylinders in four blocks of two and a bore and stroke of 61 x 85 mm. Both crankshaft and big ends ran on roller bearings and the Roots type supercharger was mounted on the ends of the crankcase and provided with optional gear ratios so that the boost could be changed quickly. A blower supplied pressure air through a finned pipe to a carburetter mounted at the back of the engine. Not only in respect of engine design but also in both body work and general external appearance the car followed the conventions established by Fiat in 1922.

Following the Targa Florio a race was held over a long circuit near Cremona in Italy. The P.2 Alfas were entered for this and won easily at 98.3 m.p.h., one car, driven by Ascari, being timed to cover 10 kilometres at an average speed of 123 m.p.h. This was clear enough proof that the young concern would be a formidable contender for honours in the French Grand Prix run at Lyons on August 3rd, for which twenty-two cars were entered. There were teams from Alfa Romeo, Bugatti, Delage, Fiat, Miller, Sunbeam and Schmidt.

The Alfa Romeo, Delage and Fiat designs all derived from the 1923 types but embodied substantial modifications. Externally, the most notable change was by Bugatti, who used an engine of 1923 dimensions but which was improved in detail and installed in an entirely new chassis remarkable for the use of light alloy wheels which were cast and formed in one with the brake drums. This was the first of the famous Type 35 models. The Delage also used a similar engine to that employed for the previous year but both the chassis and the body had been very extensively redesigned by Lory, resulting in an entirely new appearance. Fiat, on the other hand, were externally similar to 1923 but the engine retained the Roots blower used for the Italian Grand Prix of the previous September and now developed 146 h.p. at 5,500 r.p.m. with a slightly modified cylinder head.

The Miller was a private entry of an Indianapolis type car. The Schmid was a six-cylinder with cuff valves. Sunbeam was the only other car not adhering to the straight-eight principle. This team were using the previous year's engines which, with Roots' blowers added, developed 138 b.h.p. A rather longer and improved chassis included torque tube drive and a four-speed gearbox. They were clearly so superior to any other makes that Alfas, who considered themselves the likely runners-up, approached the Sunbeam team manager with a suggestion that if he would permit Alfas to occupy second and third position they would gladly let Sunbeams take first place without pressing any of the cars too hard.

This " offer " was probably made with a light heart over a mutual glass of wine ; it is certain that Sunbeams went to the line confident of a second successive victory in Grand Prix racing, but this was not to be. The night before the race they were visited by the Bosch Company, who exclaimed upon the burnt contact-breaker covers of the magnetos, which were placed at the rear of the engine facing outwards towards the exhaust pipe. These particular instruments had remained untouched since the previous year, and no doubt the addition of the blower caused the piping to get much hotter and caused the burning to start. Bosch mechanics made a replacement with some magnetos of the latest type that had just arrived from Stuttgart.

During the race the Sunbeams suffered from constant misfiring. Their superior speed was confirmed by unofficial timing during the race, which gave Sunbeam 130 m.p.h., Alfa-Romeo 124 m.p.h., and Delage, running unsupercharged, 114 m.p.h., but nobody could account for the irregular running of the cars which constantly held them back. Sunbeam's ill-luck thus gave Alfa Romeo the rare distinction of winning the French Grand Prix with their first entry for the event at 71.0 m.p.h. Nicola Romeo and Ing. Jano must have felt well satisfied, also Molino, Bazzi, and the young engineers who were largely responsible for this remarkable car. Eight years had to pass before Alfa Romeo won the A.C.F. classic again, although they had great success in other events.

The Bugattis suffered badly from tyre trouble and finished seventh and eighth, whilst the Fiats at the end of the tenth lap were running second, tenth, nineteenth, and twentieth, a sad fall from grace after their predominance in the previous year. When Bordino retired with defective front brakes their four cars ceased to be effective challengers ; for although Nazzaro survived until the twentieth lap, he also went out with brake trouble, he was then lying last.

In the middle of the night following the race the Sunbeam development engineer, Captain Jack Irving, leapt from his couch, rushed to the sheds, put back the old magnetos and the trouble vanished. By such a small incident were the Wolverhampton Company deprived of the rare honour of winning the French Grand Prix for two successive years.

In the Italian Grand Prix at Monza no Fiats were entered, and four Alfa Romeos were so much faster than any other car that when their slowest model finished, the next car, a Schmidt, was flagged off ten laps behind. The winner, Ascari, put up the lap record to 104.24 m.p.h., and had a winning average of 98.76 m.p.h. This means that the P.2 Alfa lap speed was 5.64 m.p.h. better than the supercharged 2-litre Fiat and 12 m.p.h. faster than the 1922 unsupercharged 2-litre Fiat, a remarkable tribute to the rapid progress made in racing car design.

Just previously to this Sunbeams secured compensation for their French Grand Prix disappointment by winning the Spanish Grand Prix, Segrave coming in first at 64.12 m.p.h., a minute and a half ahead of a Bugatti, with a Delage running third, Bugatti put up the best lap at an average of 71.7 m.p.h.

Although still debarred from French and Belgian races, German cars were amongst those invited to compete in Spanish and Italian events, and Mercedes accordingly ran the two 2-litre four-cylinder cars (the re-designed Porsche Indianapolis type) at San Sebastian. At Monza they appeared with two wholly Porsche designed straight-eights with engines developing about 170 b.h.p., but the chassis design of this latter type was so inferior that they had no success, indeed during the Monza race Count Louis Zborowski met his death when driving one of these models.

1925 was the last year for the 2-litre limit cars and during the whole of the season designers were pre-occupied in devising 1½-litre models for the ensuing year. This explains why no new designs were prepared, and, although for the first time in the history of European racing, regulations specified that the cars were to start with only the driver aboard, a two-seater body was still required.

As one might expect, no new constructor came forward with a 2-litre car and only Louis Delage embodied any substantial modifications to the existing 1924 designs. He having previously pinned his faith entirely to the virtues of a large piston area now decided to seek additional b.h.p. with the aid of forced induction and changed the body and bonnet layout for the second time since 1923.

At the beginning of the year Bugatti scored the last win for an unblown type over the Targa Florio circuit. Then, and rather surprisingly early in the year, came the European Grand Prix run by the Automobile Club de Belgique on the Spa Circuit. In this race the new supercharged Delages competed with the now well established P.2 Alfa Romeos, but all retired with a most unusual trouble. The normal blow-off valves on the pressure side of the manifold were not fitted and popping back when accelerating built up large pressures in the inlet system relieved by blowing open the inlet valves. These then fouled the exhaust valves with resultant damage. In consequence Alfas were first and second, Ascari averaging 74.56 m.p.h.

The French Grand Prix represented a notable change with tradition. Since its inception it had always been run on closed road circuits, but this year it was staged on the Montlhéry circuit, one having all the features of a road, but artificially built and without the hazards of the Route Nationale. Entries were received from Alfa Romeo, Bugatti, Delage and Sunbeam.

The Alfa Romeo and Delage cars were run in their Belgian Grand Prix form, but the latter was now fitted with the usual blow-off valves in the inlet manifolding. Both cars were giving between 160 and 190 b.h.p. and were thus much faster than the competing Bugatti and Sunbeams and the three British cars were virtually unchanged from the previous year and were developing not more than 140 to 150 b.h.p., Bugatti clung to the belief that by attention to chassis detail and light weight he could successfully compete with an unsupercharged engine giving around 100 b.h.p.

In the opening laps the P2 Alfa Romeos of Ascari and Campari ran in the first two positions, followed by two Delages. On his eleventh lap Ascari covered the circuit at an average of 80 m.p.h., but shortly after quarter distance his car left the road, overturned and he was killed, and although Campari continued to hold the lead up to half distance (at which point he had averaged 75.5 m.p.h.) his car was withdrawn as a mark of respect. The lead was then taken by the Delage, driven by Benoist and Divo, and they continued to hold it until the end, winning at 69.7 m.p.h., with another Delage second. Divo broke the lap record at 80.3 m.p.h. Sunbeam was third. Bugatti cars tiled fourth, fifth, sixth, seventh and eighth positions with an entry of three works and two privately owned cars.

Following this the Italian Grand Prix was run again at Monza, in which race for some reason Delage decided not to enter. The Alfa Romeos had no serious opposition from two Duesenbergs and a Bugatti, finishing first and second at 94.76 m.p.h. The best Duesenberg came in fourth and showed its speed by putting up fastest lap at 103.2 m.p.h., barely 1 m.p.h. slower than the Alfa record put up the previous year. However, the by now usual U.S.A. troubles of brakes and gears prevented the car from really pushing the winners over the whole distance and this accounts for the reduction in overall average.

1925 ended with the Spanish Grand Prix for which Alfa Romeo did not enter, thus providing Delage with an easy win at 76.4 m.p.h.

It will be noticed that Fiat took no part in the 1925 racing season, but their star driver, Bordino, took a 1924 model to the U.S.A. He ran at Indianapolis but finished last after many pit stops for sparking plugs. Later in the year the car was timed to cover 25 miles on a board track at Culver City at an average speed of 133.7 m.p.h.

These four racing seasons undoubtedly represent the zenith of Italian technical supremacy. They are particularly notable for startling increases in engine power and maximum road speed. Subsequent cars, by virtue of better brakes and improved road holding, improved on the performance of these 2-litre models on some circuits, but so far as maximum speed was concerned, it was ten years before racing cars became much faster.

CHAPTER EIGHT

Cost Versus Result

RACING STATISTICS 1926-27

Date	*Event*	*Course*	*Driver*	*Car*	*Winning Speed m.p.h.*	*Lap Speed*
27/6/26	French G.P.	Miramas	J. Goux	Bugatti	68.2	79.4
18/7/26	European G.P.	San Sebastian	J. Goux	Bugatti	65.5	81.5
7/8/26	English G.P.	Brooklands with Chicanes	R. Senechal L. Wagner	Delage	71.61	—
7/8/26	,,	,,	H. O. D. Segrave	Talbot	—	85
5/9/26	Italian G.P.	Monza	" Sabipa "	Bugatti	85.87	—
5/9/26	,,	,,	M. Costantini	Bugatti	—	98.3
3/7/27	French G.P.	Montlhéry	R. Benoist	Delage	77.24	81.43*
31/7/27	Spanish G.P.	San Sebastian	R. Benoist	Delage	80.52	85.41*
4/9/27	European G.P.	Monza	R. Benoist	Delage	90.04	94.31
4/9/27	Milan G.P.	Monza	P. Bordino	Fiat	94.57	96.59
1/10/27	English G.P.	Brooklands with Chicanes	R. Benoist	Delage	85.59	—

THE " 130 m.p.h. plus " maximum speed of the 1925 2-litre cars taxed the drivers to the uttermost. In an endeavour to limit the possible casualties the A.I.A.C.R. took a notable step when they altered the regulations for 1925 so that a car started with only the driver aboard, although the use of a two-seater body was enforced. The regulations on this point were maintained for 1926, in which year, however, the minimum weight was reduced from 650 Kg. (12.8 cwt.) to 600 Kg. (11.8 cwt.). At the same time with a view to reducing maximum speeds to within the road holding capabilities of the car, engine capacity was brought down to 1½-litres, thus bringing Grand Prix cars on to the level of what had, since 1921, been considered the Voiturette class.

When this combination of capacity and weight was announced in 1925 it was condemned by drivers and constructors alike. Everyone was agreed that the existing 2-litre cars were too lightly constructed and the prospect of a reduction in weight, coupled with a maintenance of speed due to enhanced engine efficiency, led to predictions of dire disaster. Indeed, responsible persons claimed that less than half a dozen drivers could take full advantage of the existing 2-litre cars and they considered that new, and lighter, 1½-litre models would be even more difficult to handle.

These criticisms were based on the assumption that designers would do all in their power to reach the minimum weight figure. In point of fact they did no such thing, practically all the cars scaling between 2 and 3 cwts. over the minimum which, in any event, was raised to 13.76 cwt. in 1927.

Racing car designers were, of course, thoroughly familiar with the problems of 1½-litre models, many of which had been closely related in design to the larger types. It was, therefore, thought that there would be no particular difficulty in providing cars to the new formula, and, as has been seen in the previous chapter, in 1925 manufacturers supported racing in large numbers. Works teams had issued from Alfa Romeo, Bugatti, Delage, Fiat, Rolland-Pilain factories, as well as from Benz, Schmid and Mercedes which had made for exceedingly interesting racing.

In 1926 the promise of a 1½-litre formula was even more satisfactory. Although Alfa Romeo announced their intention of retiring from the field, most of the other companies were probable entrants, and, in addition, new contenders were to be expected from Alvis and Thomas in England, O.M. in Italy, and Sima-Violet in France.

This being so, the A.C.F. looked forward with a pardonable degree of optimism to the running of the French Grand Prix at Miramas at the end of June. Alas for their hopes ! Out of all these possible starters Bugatti alone was ready to race, and he secured a complete walk-over. A unique occasion, one must think, not only because of the absence of other competitors, but because it must have been the only time when Bugatti was ready and the other people were not ! It was, however, not so much design as construction that was at fault, for much earlier in the year there had been full descriptions of a variety of cars in course of development.

Of the newcomers, Alvis had an eight-cylinder front-wheel drive car on the stocks, the Thomas Special utilised the same number of cylinders with conventional rear drive, and the Sima-Violet was a two-stroke design and built by a man who had had a great deal of experience with this type in 750 c.c. events. Fiat also built a supercharged two-stroke on which a great deal of work was done but which never appeared in competition.

The real struggle in the two years reviewed in this chapter was between Bugatti, Talbot and Delage. In 1926 Bugatti ran supercharged versions of 1925 Grand Prix cars with cylinders reduced to 52 mm. to bring the capacity inside the limit. Talbot (given this name quite arbitrarily as a member of the Sunbeam Talbot Darracq group) was an entirely new design. The eight-cylinders were made up in two blocks of four, with the characteristic Bertarione welded-up construction. The crankshaft was also made in two pieces and ran on roller bearings throughout, whilst the whole engine was offset from the centre line of the chassis, enabling the driver to sit really low down on the offside of the car.

The frame was an excellent piece of work, stoutly cross braced and immensely stiff as a beam, being made from a double length of channel with suitable vertical spacing members, each side member being pressed out as one piece ; in other words, it was rather like the Lancia " Lambda " frame on a small scale. The front axle was hollow and in two pieces, with a flanged joint in the centre.

A four-speed gearbox in unit with the engine transmitted power to a double reduction in the rear axle, the propeller shaft thus being exceptionally low. In order to comply with the regulations requiring the possibility of a passenger seat, the driver was markedly offset to the right.

The Delage chassis offered a remarkable contrast. As on the Talbot the engine and gearbox were in one unit, but on the Delage this was of abnormal length and so mounted in the frame that it contributed nothing to the torsional stiffness of the car.

The engine, designed by M. Lory, was a direct development from the twelve cylinder used on the previous year's 2-litre cars. It was a straight-eight, but, nevertheless, the basic design concept was very similar, including the use of an iron casting for the block, the proportion, location and drive of the valves, and the details of the crankshaft and rods. Cylinder dimensions were 57.5 x 75 mm. (as against 51.3 x 80 mm.), and the induction arrangements included two superchargers mounted centrally on the near side of the crankcase. They were driven by a pair of gear wheels like those employed on the Monoposto Alfa Romeo of later time, but mounted on a long shaft which ran forward inside the crankcase to pick up with the timing gears on the front end of the engine. Each blower served four cylinders and the engine was set slightly across the frame, the transmission line extending along this angle so that the crown wheel and pinion were appreciably offset toward the near side of the car. Once again, the purpose was to lower the driver and so reduce the frontal area. A five-speed gearbox was employed, and, unlike the Talbot, the frame was exceedingly light and flexible. The Delage brakes were put on through the medium of a friction servo device driven off the rear end of the gearbox, but the Talbot had self-servo shoes in the brake drums.

The Delage made its first appearance in the European Grand Prix at San Sebastian, in July, and showed itself slightly superior in speed to the Bugattis, fresh from their French Grand Prix victory. This notwithstanding, Bugatti came home first, as at one time and another all the Delage cars were brought to stop for varying periods of time. Owing to the disposition of the superchargers on the near side of the car the exhaust pipe came along the off side, and the offtake pipe of No. 8 cylinder formed a tube of red-hot metal but a few inches from the pedals. The effect, when combined with strong Spanish sun, may well be imagined, and it is certain that this defect cost Delage the race.

The Talbots appeared on the scene in the first of the English Grands Prix which have been run by the R.A.C., and the event showed that they were by no means in a fit state to race. On one of them the front axle broke in the first lap, and although Segrave led for ten laps, and actually made the fastest lap of the day, he eventually went out, probably with valve trouble. The third car also suffered engine trouble before the race was over.

Thus, late in the year it was possible to put Talbot, Delage and Bugatti in an ascending order of reliability and a descending order of speed. One might have hoped for a Grand Finale with every car at its best in the Italian Grand Prix, but this was not to be. Bugatti ran unchallenged, won the race, made fastest lap, and secured the European Championship of 1926.

In 1927, the competitors who had fought out a triangular contest in 1926 were again fighting each other. But whereas the Talbot and Bugatti cars ran with comparatively small changes (albeit the Bugattis had larger radiators and superchargers, new engine dimensions of 60 x 66 mm., and were certainly faster than the 1926 models), Delage incorporated radical " mods " as a result of his unhappy experiences in the previous year's events. The cylinder block was turned back to front, as it were, and the exhaust system shifted to the near side of the car where it was well out of the way. This obviously made it impossible to keep the twin blowers in the centre of the crankcase ; they were therefore deleted and a small plate covered up the hole previously made by the drive. A single supercharger, using the same rotor forms as previously, and therefore of rather abnormal length, was now mounted at the front of the engine, raised rather high so as to give ample clearance for the front axle and the chassis. The steering connections were stiffened up considerably, and over half a hundredweight was added to the weight of the car. With these changes the Delage proved quite invincible, and, in fact, for a decade no one was able to, produce a more powerful engine of this size. It stands to this day as a high-water mark of efficiency if one takes blower pressures into account.

In no event in 1927 did all the cars reach the starting line. For example, at the French Grand Prix, run at Montlhéry on July 3rd, Bugatti was a non-starter, leaving the race virtually as a straight fight between Talbot and Delage. The former cars now had complete new front brake and axle gear, and one driven by Divo led on the first lap, the other member of the team being third with a Delage second. On his fifth lap Williams, driving a Talbot, got very near to the lap record put up by the 2-litre cars by averaging 80.27 m.p.h., and the absolute record was, in fact, broken on the tenth lap by Benoist, who achieved 81.43 m.p.h. on a Delage. By twenty-five laps both the Talbots were experiencing mechanical troubles and from thirty laps onwards Delage were never displaced from the first two positions, holding the first three from the forty-third lap onwards. Benoist secured an easy victory, averaging 77.29 m.p.h. for 263.18 miles, the Talbot driven by Williams, finishing fourth, 39 minutes after the winner had received the checkered flag.

After this failure the Talbot cars made no further appearance as a works sponsored team, but in the Spanish Grand Prix Bugatti returned to the field on a course where the road holding capabilities of his car offered a good offset to deficiency in engine output and enabled Materassi to keep the lead until nine laps from the end. He then ran off the road, leaving his team mate, Chiron, second. With only four laps to go he in turn met with mechanical trouble and this gave Benoist on a Delage a relatively easy win at 80.52 m.p.h.

For some reason Bugatti then decided that he would not compete in the European Grand Prix run at Monza in September, and Delage considered his position so secure that he entered only one car with which Benoist made the fastest lap at 94.31 m.p.h. and averaged 90.04 m.p.h. for fifty laps of the long circuit on a wet track. The only serious competitors were a Duesenberg and two front-drive Millers, entered as Cooper Specials. One of the latter finished third at 77.02 m.p.h., and although they showed speed on occasion the American cars all suffered from poor brakes, inadequate three-speed transmission systems, and the inferior low speed torque characteristic of the centrifugal type of blower. Since their win in the 1921 French Grand Prix, American engineers had concentrated entirely on board and brick track cars designed for flat out running, in which field they were no mean performers. A 1½-litre Miller averaged 116.58 m.p.h. for 200 miles and 123.14 m.p.h. for 120 miles in 1926, and in 1927 a similar car averaged 130.05 m.p.h. on the Atlantic City board track for 200 miles. There can be no doubt that the Coopers running in the Grand Prix were as fast flat out as anything on the circuit, but neither they nor the Delage made the fastest Monza time in 1927. The Milan Grand Prix was run on the same day and over the same circuit as the European Grand Prix and was won by Fiat, making their sole appearance in 1927 (and their last entry in Grand Prix racing) with a remarkable twelve-cylinder car having two geared crankshafts and a bore and stroke of 60 x 63 mm. Bordino driving this car won a heat at 92.88 m.p.h. and then engaged in a great struggle in the final over 50 kilometres with Campari driving a 2-litre " P2 " Alfa Romeo. The latter was unable to reproduce its 1924 form and finished 48 secs. behind the Fiat, which averaged 94.57 m.p.h. for the race and lapped at 96.59 m.p.h. in the rain.

These results make it appear that the Fiat was definitely a faster car than the Delage, but it must be remembered that the former ran over fifty laps and the latter was asked to cover only five. Moreover, the value of these average speed figures in establishing the relative ability of the eight-cylinder Delage and the twelve-cylinder Fiat is dubious since the best lap of both of them was below that of the relatively slow 1926 1½-litre Bugatti on which Costantini had lapped at over 98 m.p.h. on a dry track in the previous year's race.

As, however, the Fiat engine gave between 175 and 187 h.p. at 7,500 to 8,500 r.p.m., it is reasonable to conclude that it was not only the most powerful but also the fastest of all cars built under the 1½-litre formula and it is a great pity that there was no opportunity of confirming this belief in the race held four weeks later.

The second English Grand Prix, held on October 1st, was the last race of the 1927 season and thus the finale of the 1½-litre formula. The Duesenberg which had run at Monza was absent owing to transmission troubles, a Fiat team was scratched owing to the pre-occupation of the works with the Schneider Trophy Seaplane Race, and a front drive eight-cylinder Alvis broke a piston in practice. The only challengers to Bugatti and Delage remaining were two eight-cylinder Thomas cars, but neither of these ran at all well, so that the race became entirely a competition between two French constructors. Competition, however, is too strong a word for this race as the Delage team experienced no difficulty in keeping far ahead of their rivals, Benoist finishing first at 85.59 m.p.h.

It must be conceded that from a competitive viewpoint the 1½-litre formula was a failure. By contrast it was a brilliant technical success, not only in continuing the remarkable progress made in the previous three years in the specific output of engines, but also by developing chassis with low centre of gravity and small frontal area as a consequence of offset single seats. These improvements were, however, only obtained by what was at the time an altogether unwarrantable expense. Competition in the 1914 French Grand Prix, the winning of which by itself made a successful racing season, involved an expenditure of £10,000 to £15,000. By 1925 the cost of maintaining a team of three racing cars through a number of events had risen to at least £40,000 even when full overheads were not charged upon machine-shop work, etc. This figure was undoubtedly exceeded with the 1½-litre cars owing to their far more delicate construction, while, simultaneously, the commercial value of racing declined. The beginning of popular motoring in Europe marked the end of the time when sales to the general public were substantially affected by racing successes. And so after weighing with mounting expenditure on the one hand, and diminishing returns on the other, the manufacturers decided one after another that the time had come to withdraw from the manufacture of special cars and the entry of works teams. Thus, within two years Grand Prix racing fell from one of its recurrent peaks to an absolute rock-bottom.

CHAPTER NINE

Low Water

RACING STATISTICS 1928-30

Date	*Event*	*Course*	*Driver*	*Car*	*Winning Speed m.p.h.*	*Lap Speed (Rc'd*)*
22/4/28	Bordino Prize	Alessandria	T. Nuvolari	Bugatti	63.45	—
"	"	"	E. Materassi	Talbot		64.3*
6/5/28	Targa Florio	Short Madonie	A. Diva	Bugatti	45.65	—
6/5/28	Targa Florio	Short Madonie	L. Chiron	Bugatti	—	46.2
10/6/28	Rome G.P.	Trefontana	L. Chiron	Bugatti	78.55	80.4
24/6/28	Cremona Prize	Cir. of Cremona	L. Arcangeli	Talbot	101.31	—
"	" "	" "	G. Campari	Alfa Romeo	—	108.6*
5/7/28	Marne G.P.	Rheims	L. Chiron	Bugatti	82.5	91.4*
15/7/28	German G.P.	Nürburg	R. Caracciola	Mercedes	64.6	69.34*
28/7/28	San Sebastian G.P.	San Sebastian	L. Chiron	Bugatti	80.58	88.25*
19/8/28	Montenero Prize	Montenero	E. Materassi	Talbot	52.77	—
	"	"	T. Nuvolari	Bugatti	—	53.8*
9/9/28	European G.P.	Monza	L. Chiron	Bugatti	99.4	—
919128	"	"	L. Arcangeli	Talbot	—	103.2
14/4/29	Monaco G.P.	Monaco	W. Williams	Bugatti	50.23	52.7*
21/4/29	Bordino Prize	Alessandria	A. Varzi	Alfa Romeo	68.24	68.6*
5/5/29	Targa Florio	Short Madonie	A. Diva	Bugatti	46.21	—
5/5/29	Targa Florio	Short Madonie	F. Minoia	Bugatti	—	47.3*
26/5/29	Rome G.P.	Trefontana	A. Varzi	Alfa Romeo	80.2	—
30/6/29	French G.P.	Le Mans	W. Williams	Bugatti	82.66	—
1/7/29	Cremona Prize	Cremona	A. Brilli-Peri	Alfa Romeo	114.41	—
	"	"	A. Maserati	Maserati	—	124.4*
14/7/29	Marne G.P.	Rheims	P. Etancelin	Bugatti	85.5	88.6
14/7/29	German G.P.	Nürburg	L. Chiron	Bugatti	66.79	69.97*
21/7/29	Coppa Ciano	Montenero	A. Varzi	Alfa Romeo	54.17	—
"	" "	"	T. Nuvolari	Alfa Romeo	—	55.3*
15/9/29	Monza G.P.	2.8 Mile Circuit of Monza	A. Varzi	Alfa Romeo	116.83	—
"	"	"	A. Maserati	Maserati	—	124.21

Racing Statistics 1928-30 *(continued).*

6/4/30	Monaco G.P.	Monaco	R. Dreyfus	Bugatti	54.63	56.01*
20/4/30	Bordino Prize	Alessandria	A. Varzi	Alfa Romeo	67.7	70.7*
4/5/30	Targa Florio	Short Madonie	A. Varzi	Alfa Romeo	48.48	49.1*
25/5/30	Rome G.P.	Trefontana	L. Arcangeli	Maserati	83.6	—
,,	,, ,,	,,	G. Bouriat	Bugatti	—	86.6*
29/6/30	Marne G.P.	Rheims	R. Dreyfus	Bugatti	88.5	91
20/7/30	European G.P.	Spa	L. Chiron	Bugatti	72.1	—
3/8/30	Coppa Ciano	Montenero	L. Fagioli	Maserati	54.47	—
3/8/30	,,	,,	T. Nuvolari	Alfa Romeo	—	57.2*
17/8/30	Coppa Acerbo	Pescara	A. Varzi	Maserati	75.35	—
17/8/30	,,	,,	L. Fagioli	Maserati		78.3*
7/9/30	Monza G.P.	4.3 Mile Lap Monza	A. Varzi	Maserati	93.55	100.6
21/9/30	French G.P.	Pau	P. Etancelin	Bugatti	90.4	—
4/10/30	Spanish G.P.	San Sebastian	A. Varzi	Maserati	86.82	91.09*

IN 1928 Grand Prix racing fell to a level only previously plumbed between 1908 and 1912. Fiat, Talbot and Delage withdrew factory support, leaving only Bugatti as a regular entrant of a works team, with Alfa Romeo making occasional appearance, and further entries from Maserati, a new Italian constructor. Furthermore, dissatisfaction with the formula proposed by the A.I.A.C.R. was so general amongst constructors, private entrants and organising clubs, that *formule libre* reigned except in the European Grand Prix at Monza on September 9th, run over sixty laps of the 10 kilometre course.

The entries were eleven Bugattis, four 1.7-litre supercharged Maseratis, three eight-cylinder Talbots, two four-cylinder Talbots and a single entry of Delage and Alfa Romeo. Of these only the Maserati cars were of a 1928 design ; the Bugattis were all Type 35 B or C ; the Delage was one of the 1925 twelve-cylinders ; the Alfa Romeo a 1925 P.2 model ; and the three straight-eight Talbots were the works' cars of 1927 now privately sponsored and with cylinders bored out to give a capacity of 1,750 c.c. The four-cylinder Talbots were even older designs which had run in the Voiturette races of 1924 and 1925.

The race soon showed that there was little difference in speed between the eight-cylinder Talbot and Bugatti models, Williams led on one of the Bugattis at the fifth, and Brilli-Peri was first on a Talbot at ten laps. Later Arcangeli on a Talbot lapped at 103.2 m.p.h. compared to the best by Williams of 102.8 m.p.h., both being slower than the 104.24 m.p.h. of the Alfa Romeo in 1924. Varzi did not push the only Alfa Romeo in the first half but came to the front on the fifteenth lap after a disaster in which Materassi's Talbot ran into the crowd, killing twenty-two and injuring twenty, after which the whole of this team was withdrawn. Varzi then handed the wheel to his co-driver Campari, and Chiron on a Bugatti went into the lead which he maintained to win at 99.14 m.p.h., the Alfa Romeo being second at 98.37 m.p.h. The winning speed was a record for a complete race, the previous highest standing to the credit of Ascari, who in 1924 drove a P.2 Alfa at 98.76 m.p.h. for eighty laps.

A number of non-formula races were also held in 1928, chief amongst them were the Targa Florio and the German Grand Prix. There were also San Sebastian, the Grand Prix de la Marne, and the Circuits of Cremona and Montenero, this last used for the Coppa Ciano until 1934.

Of these, the Targa Florio was easily the most important, and deserves extended mention. As early as 1906 Count Florio put up a cup for a race held on an extremely arduous circuit in Sicily, the first winner being Cagno on an Itala at an average speed of 29.18 m.p.h. Reference has been made earlier to the post-war revival of this event in 1919 when it was won by A. Boillot on the Peugeot at 34.19 m.p.h. and it is interesting that not until 1924 did the average speed exceed 40 m.p.h., the winner in this year being Werner, whose 2-litre, four-cylinder supercharged Mercedes averaged 41.02 m.p.h. Starting in 1925 Bugatti secured three successive victories with his Type 35 cars and during these years, when public and manufacturers' interest in Formula Grand Prix racing sharply declined, increasing attention was given throughout the world to the Targa Florio event which retained the atmosphere of the true road races run over long circuits and normal roads 20 years previously. It is not unfair to claim that between 1928 and 1932 the Targa Florio usurped the French Grand Prix as the classic event of the year, although, by its very nature, the number who could witness it at first hand was small.

Alfa Romeo ran a works' team of three cars for the Targa Florio, these being the catalogue 1,750 c.c. blown six-cylinder model used in the various sports car races which were popular at this period. Five straight-eight Maseratis, three of 2-litre and two of 1½-litre capacity, were entered, but the strongest numerical support was from Bugatti. Six Type 35 cars of 2-litre capacity, three of 2.3-litres and two Type 39 1.5-litres, supplemented by eight 1½-litres of unspecified type entered by private owners, made up a total of nineteen entrants for this make alone.

The lead changed on each of the first three laps, passing from Chiron (2-litre Bugatti) to Mme. Junek (2.3-litre Bugatti) on the second lap, and then to Campari on the small Alfa Romeo on the third lap, in which Mme. Junek dropped to second.. In the fifth and last circuit the Alfa Romeo experienced tyre trouble, Mme. Junek dropped back to fifth and Divo on a 2.3-litre Bugatti finished first at 45.65 m.p.h., the Alfa running second at 45.43 m.p.h.

The German Grand Prix was held on the recently opened Nürburg Ring and run over twenty-two laps comprising 316.5 miles. Three supercharged 7-litre Mercedes proved overwhelmingly (and surprisingly) superior to the 2.3-litre Bugattis and finished first, second and third. Caracciola won at 64.6 m.p.h., whereas the best Bugatti (driven by Brilli-Peri, who finished fourth) could only manage 62.2 m.p.h. The Mercedes were almost identical with stock catalogue models and ran with headlamps and mudguards as did the thinly-disguised Type 35 Bugattis, for it should be noted that this was nominally a sports-car race.

Bugatti had, however, won two of the three big races for 1928 and secured many other victories in minor events. Chiron driving a works' car won the Grand Prix de la Marne over the Rheims circuit at 82.5 m.p.h. (and made a record lap of 91.4 m.p.h.), the Rome Grand Prix at 78.55 m.p.h., and the San Sebastian Grand Prix at 80.58 m.p.h. with a record lap of 88.25 m.p.h. Nuvolari, a new Bugatti driver, scored at Alessandria at 63.45 m.p.h. and was second in the circuit of Montenero, which was won by a 1927 Talbot driven by Materassi at an average of 52.77 m.p.h.

On the Cremona circuit race Arcangeli drove a Talbot to win at 101.31 m.p.h., with Nuvolari on a Bugatti again second. The speed was 3 m.p.h. higher than that achieved four years previously by the 2-litre P.2 Alfa Romeo and a sister Talbot was timed over 10 km. at 129 m.p.h.

Talbot also secured fourth position at Alessandria at 59.88 m.p.h., and third in the Rome Grand Prix at 74.84 m.p.h., and were thus far more successful under private ownership than they had been as a works' team in the Grand Prix races of the previous two years.

The fate of the French Grand Prix in 1928 merits extended comment.

Before 1914 the "Grand Prix" was synonymous with the event organised by the Automobile Club de France. With the revival of European road racing in 1921 other countries-Italy, Spain and Belgium, for example-staged international road races, but although these were also termed " Grands Prix," the French event continued supreme in both public prestige and in the number of entries received from manufacturers. There were, for example, eighteen entries in 1921, twenty-two in 1922, eighteen in 1923, twenty-two in 1924, and seventeen in 1925. As already recorded, 1926, with only three starters, was a catastrophe and one from which this historic event never fully recovered. In 1927 there were eighteen entries but only seven starters and in 1928 the organisers waived Grand Prix status and ran a sports car event in conjunction with a handicap race. From this year onwards, therefore, we can no longer use the French Grand Prix alone as a touchstone of racing car success, but have to consider the overall results of many events in the season's racing.

For 1929 the A.I.A.C.R. produced a formula that was even more unpalatable than the one devised for 1928, so that the French and Spanish Grands Prix were the only " approved " international events.

The first named was run at Le Mans and was dominated by eight Type 35 Bugattis, Williams winning at 82.66 m.p.h. In the Spanish race a single Alfa was the only exception to thirteen Type 35 Bugattis, Chiron scoring his second successive win thereon at the modest average of 72.4 m.p.h., 8 m.p.h. slower than his speed of the previous year. This left four large races all of which were run under *formule libre.*

The 1929 Monaco Grand Prix was the first to be held, over a very twisty town circuit, which was later to be the scene of historic struggles, and Bugatti added to his series of victories with the Type 35 cars ; Williams being the winner at 50.23 m.p.h. Alfa Romeo were represented by two six-cylinder sports cars which failed to make any impression, the only rival to Bugatti being Caracciola on a shortened sports type Mercedes-Benz (Type SSK) who was at one time in the lead but was held back by stops for fuel and tyres, and finished 2 mins. 22 secs. behind.

In May the Targa Florio race was run over the usual circuit and was once more a Bugatti versus Alfa affair. Three Italian team cars competed against four works entered Bugattis, supplemented by four private owners ; two Maseratis were entered but were not serious competitors as Bugatti kept a firm grip on first and second places throughout, Divo winning at 46.21 m.p.h., with a sports 1.750 c.c. Alfa a bad third.

The German Grand Prix was run during July and on this occasion Bugatti reversed the verdict of the previous year, Chiron winning at 66.79 m.p.h., another Bugatti second and a privately entered Mercedes third.

From every point of view the most important race of the year was the Monza Grand Prix. This was run as a substitute for the European Grand Prix which had been offered to the Italian club under the official regulations. There were three heats of 62 miles each (over a new short circuit of 2.82 miles per lap) for cars of 1½-litre, 2-litre and unlimited capacity. The only entries in the unlimited class were two privately sponsored sports type Mercedes and a sixteen-cylinder 4-litre Maserati driven by Alfieri Maserati. In an exceedingly close race Momberger on a Mercedes averaged 107.74 m.p.h., beating the Maserati by one-fifth of a second. In the 1½-litre class Arcangeli driving a 1927 type Talbot averaged 111.37 m.p.h., beating Nuvolari on a similar car by two seconds, and in the 2-litre heat Brilli-Peri averaged 114.85 m.p.h., on a P.2 Alfa, a Maserati being second and Varzi on another P.2 third.

The final was a triumph for the old capacity limit cars. Varzi was first on the 1924 P.2, averaging 116.83 m.p.h. Nuvolari was second with a 1927 Talbot at 111.03 m.p.h. and the big Mercedes came in third at 107.68 m.p.h.

The inherently sound design of the pure racing type P.2 Alfa Romeo was demonstrated by many other victories in Italian races. Varzi won the 2-litre class of the Rome Grand Prix at 70.2 m.p.h. (beating Divo on a Bugatti by 10 mins. in a three-hour race), the Bordino Grand Prix at Alessandria at 68.24 m.p.h., and the Coppa Ciano on the Montenero circuit at 54.17 m.p.h. On the Cremona circuit he was second to his team mate Brilli-Peri who averaged 114.4 m.p.h. and was timed at 138.77 m.p.h. over the same stretch of 10 kilometres down which Ascari averaged 123 m.p.h. on the first appearance of the car in 1924.

Concluding the story of the minor races, Bugatti won the Marne Grand Prix on the Rheims Circuit, Etancelin being first at 85.5 m.p.h., with a fastest lap at 88.6 m.p.h.

It will be observed that although Bugatti had won three out of the four big races, the older roller bearing, welded steel-cylindered cars of Talbot and Alfa continued to have a highly successful season, despite the one being three years old, and the other six years. Additionally, a relatively new make, Maserati, had, by its performance at Monza, come into the front rank of racing cars.

The A.I.A.C.R., with almost admirable obstinacy, continued with their complicated and completely unacceptable formula for 1930, allowing, however, a slight modification in that up to 30 per cent benzol could be mixed with pump fuel. These regulations were accepted only by the Belgian and French clubs and as it turned out the former was the only true formula race of the year. Run on the Spa Circuit, which had been used for the Grand Prix of 1925 (and for sports car racing in subsequent years), three Type 35 Bugattis were the only serious racing cars entered and Bouriat obligingly loitered at the end to let Chiron win at 72.1 m.p.h.

The Grand Prix de L'A.C.F. was run at Pau, and following an announcement that it would be run under *formule libre* instead of official regulations there were thirty-seven entrants and twenty-five starters, although neither Italian nor German concerns were present due to the short notice of this change of plan. Fourteen of the starters were Type 35 Bugattis, and for the first time in five years an English car, a supercharged 4½-litre Bentley with four-seater Le Mans type body, entered by Sir Henry Birkin, Bt., was on the starting line. Driving the race of his life, Birkin gave additional proof that at this period a sports car could successfully compete with the pure racing type, for after lying fifth on the fifth lap he climbed to fourth on the tenth and third place on the fifteenth, thence forward retaining second position to average 88.6 m.p.h. for the race. A Type 35C Bugatti, driven by Etancelin, won at 90.4 m.p.h.

Three other events in 1930 may be reasonably entitled major races, the Targa Florio, Monaco Grand Prix and Monza Grand Prix. Since 1925 the Type 35 Bugatti had established a monopoly of success on the Sicilian Circuit with five successive wins and a record average speed of 46.21 m.p.h. The only rivalry had come from Alfa Romeo running sports models of lesser capacity and far lower h.p. In view of the 1929 victories of the P.2 model the works decided to rebuild two of these cars with a larger radiator and other modifications for use as an instrument of victory in the Targa Florio of 1930. However, in " training," chassis and suspension deficiencies presented so alarming a picture that they had no option but to withdraw and revert to the sports type, a decision challenged by Varzi, who was engaged as a works' driver. Reluctantly, he was given permission to start on one of the older models and with it broke the circuit record on his first lap and, never headed thereafter, won at the record average speed of 48.48 m.p.h., a staggering feat of endurance and virtuosity.

The 2.3-litre Type 35 Bugattis had a poor day, and but for trouble experienced by the " little " Alfas might not have finished in the first three. As it was they secured second and third positions.

In the second Monaco Grand Prix Bugatti secured his second successive victory, a private owner, Dreyfus, winning with a Type 35C at 64.63 m.p.h., an advance of nearly 5 m.p.h. on the previous year's speed.

Both these races were on slow circuits in the early part of the season. Held as usual at the end of the year the Monza races were run at extremely high speeds. A new circuit measuring 4.27 miles to the lap was chosen and five preliminary events led to a final over thirty-five laps, equalling 150 miles. The heats were run over 60 miles and Bugatti were first, second, and Maserati third, in the 2-litre class, Etancelin winning at 91.15 m.p.h. In the 3-litre category the new 2.5-litre Maseratis were first and third, Arcangeli winning at 98.4 m.p.h., with a slightly oversize P.2 Alfa Romeo second.

A 4-litre sixteen-cylinder Maserati, driven by the designer, won the unlimited class at 91.4 m.p.h. with a 7.2-litre Mercedes second, and an extra heat brought two further Alfa Romeo P.2's into a final, which was to prove an overwhelming triumph for Maserati.

In the earlier part of the race Nuvolari led on an Alfa P.2, but all three cars of this type suffered tyre trouble and were withdrawn. Towards the end Varzi's 2.5-litre Maserati, which had stopped for plugs, was lying sixth ; the lead held by Arcangeli on the other 2.5-litre car with A. Maserati lying second on his sixteen-cylinder model. By magnificent driving Varzi passed the larger (but older) car on the thirty-second lap and on the thirty-fifth got past Arcangeli to win by one-fifth of a second at 93.55 m.p.h.

As the Maserati was the first successful new design introduced into racing since 1927 it is appropriate to make brief reference to the specification.

The straight-eight engine had dimensions 65 x 94 mm., the cylinder block being formed from a single iron casting with a detachable head, carrying two valves per cylinder inclined at 90 degrees. The crankshaft ran on five bearings, only one of which was of roller type, and the tubular connecting rods also had white metal big ends. A Roots blower driven off the nose of the crankshaft gave a boost pressure of 9 lb., and with a 7:1 compression ratio 175 b.h.p. was claimed for the engine at 6,000 r.p.m. The four-speed gearbox transmitted power to a torque tube drive and it is interesting to note that the gearbox casing, the torque tube, the centre part of the rear axle, brake shoes and brake drums were all made from magnesium alloy.

Monza was by no means the only scene of success of this design. As early as May, Arcangeli won the Rome Grand Prix at 83.6 m.p.h., although (after the withdrawal of Varzi and Nuvolari on the P.2's) Chiron on a Type 35B led until the last yard and put in the best lap at 87.23 m.p.h. Fagioli with a Maserati won the Coppa Ciano at 54.47 m.p.h., and Varzi was first on the same make at San Sebastian, averaging 86.82 m.p.h. and raising the lap record to 91.09 m.p.h., and also at Pescara where Fagioli's Maserati made fastest lap.

Apart from the Targa Florio Alfa wins were confined to the Alessandria Circuit, on which Varzi beat a Bugatti, averaging 67.7 m.p.h.

Bugatti won three major races, also the Marne Grand Prix, in which Dreyfus raised the race record for the Rheims Circuit by finishing first at an average of 88.5 m.p.h., but generally experienced a disappointing year, in which Maserati was clearly the most successful design.

The other constructors now faced problems. Bugatti realised that his Type 35 with an engine design dating back basically to 1922 was under-powered, and Alfa Romeo found that the seven year old P.2 model was suffering from wear and tear, and that springs, brakes and chassis, designed for 120 m.p.h., were inadequate at speeds of 140 m.p.h. Thus, despite the world financial crisis the logic of events forced constructors to produce new racing designs for the 1931 season. In so doing they were much influenced by the growing political importance of racing, Mussolini in particular giving every encouragement to Italian constructors, who were told that motor racing victories were a big contribution to the home and world prestige of Fascist Rule.

CHAPTER TEN

The Turn of the Tide

RACING STATISTICS 1931-33

Date	*Event*	*Course*	*Driver*	*Car*	*Winning Speed m.p.h.*	*Lap Speed (Rc'd*)*
19/ 4/ 31	Monaco G.P.	Monaco	L. Chiron	Bugatti	54.09	56.01
10/5/31	Targa Florio	Long Madonie	T. Nuvolari	Alfa Romeo	40.39	—
10/5/31	Targa Florio	Long Madonie	A. Varzi	Bugatti	—	43.8*
24/5/31	Italian G.P.	Monza	G. Campari & T. Nuvolari	Alfa Romeo	96.17	105*
2/6/31	Eifel Races	Nürburg Ring	R. Caracciola	Mercedes	67.67	—
21/6/31	French G.P.	Montlhéry	L. Chiron & A. Varzi	Bugatti	78.21	—
21/6/31	,,	,,	L. Fagioli	Maserati	—	85.6*
5/7/31	Marne G.P.	Rheims	P. Lehoux	Bugatti	89.49	92.78 *
12/7/31	Belgian G.P.	Spa	W. Williams & Count Conelli	Bugatti	82.04	—
12/7/31	,,	,,	L. Chiron	Bugatti	—	88*
19/7/31	German G.P.	Nürburg Ring	R. Caracciola	Mercedes	67.4	—
19/7/31	,,	,,	A. Varzi	Bugatti	—	72.6*
16/8/31	Coppa Acerbo	Pescara	G. Campari	Alfa Romeo	81.68	—
16/8/31	,,	,,	T. Nuvolari	Alfa Romeo	—	83.4*
6/9/31	Monza G.P.	4.3 Mile Lap Monza	L. Fagioli	Maserati	96.6	—
6/9/31	,,	,,	T. Nuvolari	Alfa Romeo	—	101.23*
27/9/31	Czechoslovak G.P.	Brno	L. Chiron	Bugatti	73.26	75.36*
17/4/32	Monaco G.P.	Monaco	T. Nuvolari	Alfa Romeo	55.81	—
17/4/32	,,		A. Varzi	Bugatti	—	58.3*
8/5/32	Targa Florio	New Short Madonie	T. Nuvolari	Alfa Romeo	49.27	50.7*
29/5/32	Eifel Races	Nürburg Ring	R. Caracciola	Alfa Romeo	70.7	72.8*
5/6/32	Italian G.P.	Monza	T. Nuvolari	Alfa Romeo	104.13	—
5/6/32	Italian G.P.	Monza	L. Fagioli	Maserati	—	112.22*

Racing Statistics 1931-33 (continued).

3/7/32	French G.P.	Rheims	T. Nuvolari	Alfa Romeo	92.26	99.5*
17/7/32	German G.P.	Nürburg Ring	R. Caracciola	Alfa Romeo	74.13	—
17/7/32	,,	,,	T. Nuvolari	Alfa Romeo	—	77.55*
31/7/32	Coppa Ciano	Montenero	T. Nuvolari	Alfa Romeo	53.91	54.5
14/8/32	Coppa Acerbo	Pescara	T. Nuvolari	Alfa Romeo	86.89	—
14/8/32	,,	,,	T. Nuvolari	Alfa Romeo	—	90.3*
4/9/32	Czechoslovak G.P.	Brno	L. Chiron	Bugatti	67.67	73.73
11/9/32	Monza G.P.	Monza	R. Caracciola	Alfa Romeo	110.8	—
11/9/32	,,	,,	T. Nuvolari	Alfa Romeo	—	113.7*
3/4/33	Monaco G.P.	Monaco	A. Varzi	Bugatti	57.04	59.77*
28/5/33	Targa Florio	New Short Madonie	A. Brivio	Alfa Romeo	47.56	—
,,	,, ,,	,,	I. Borzachini	Alfa Romeo	—	49.6*
11/6/33	French G.P.	Montlhéry	G. Campari	Maserati	81.52	86.6*
2/7/33	Marne G.P.	Rheims	P. Etancelin	Alfa Romeo	90.59	—
2/7/33	,,	,,	G. Campari	Maserati	—	96
9/7/33	Belgian G.P.	Spa	T. Nuvolari	Maserati	89.23	92.33*
30/7/33	Coppa Ciano	Montenero	T. Nuvolari	Maserati	54.18	55.38
13/8/33	Coppa Acerbo	Pescara	L. Fagioli	Alfa Romeo	88.03	—
13/8/33	,,	,,	T. Nuvolari	Maserati	—	90.4*
10/9/33	Italian G.P.	Full Monza	L. Fagioli	Alfa Romeo	108.58	115.82*
10/9/33	Monza G.P.	2.8 Miles Lap Monza	M. Lehoux	Bugatti	108.99	—
10/9/33	,,	,,	Count Czaykowski	Bugatti	—	116.81
17/9/33	Czechoslovak G.P.	Brno	L. Chiron	Alfa Romeo	63.57	70.8
24/9/33	Spanish G.P.	San Sebastian	L. Chiron	Alfa Romeo	83.32	—
2419133	,,	,,	T. Nuvolari	Maserati	—	96.59*

BY 1931 the A.I.A.C.R. had failed for three successive years to produce a formula agreeable to either constructors or race organisers. The complex regulations intended to cover the 1931-33 seasons were equally unacceptable and were withdrawn *in toto* leaving a *formule libre* subject to there being no mechanic carried on the car and races lasting ten hours. This time limit involved an immense increase in the distances over which races were run, and led to the use for the first time, in international Grand Prix racing, of two drivers per car, The Targa Florio was the first race of 1931 and stood as usual outside the formula. This notwithstanding, competition was between the two leading makes of Grand Prix car, to wit, Bugatti and Alfa Romeo.

The French constructor now had a re-engined version of the historic Type 35 car, designated the Type 51, in which the principal change was a double overhead camshaft eight-cylinder engine having two valves per cylinder. This gave approximately 160 b.h.p. as compared to the 135 b.h.p. of the older model with twenty-four vertical valves.

Alfa Romeo started the season with an entirely new type which came to be called the " Monza." This was an eight-cylinder racing version of the six-cylinder 1¾-litre supercharged sports car which the Company had been running in suitable events for some time. The bore and stroke of 65 x 88 mm. were identical, and although the engine was a straight-eight like the P.2, it had, unlike that famous model, a cast-iron cylinder block and white metal bearings throughout. The principal novelty lay in the drive to the camshaft and supercharger which was through a train of gears between two separate blocks of cylinders with the crankshaft made in two parts bolted together through the primary gear wheel. A single Roots blower was mounted on the right-hand side of the crankcase. This engine gave 160 h.p. at 5,400 r.p.m., that is some 50 h.p. more than the 1,750 c.c. model and roughly 10 b.h.p. less than the P.2.

The chassis of completely conventional design was a marked improvement on the 1924 Grand Prix type.

The car put up an excellent show in its first race. A landslide necessitated the use of a lengthened circuit in Sicily, and although Varzi on the Bugatti showed himself to have the fastest car a combination of heavy rain-storms with front mudguards on the Alfa permitted Nuvolari to win at 40.3 m.p.h.

The first formula race was the Italian Grand Prix run at Monza on May 24th. Both Alfa Romeo and Bugatti entered full works' teams, to which were added a 2½-litre Maserati and two Talbots and one Delage dating from 1927. The Bugatti works' team all drove the Type 51 model, but the two Monza Alfas were joined by a remarkable twelve-cylinder Monoposto car, the predecessor of the later P.3 model which annexed this designation. The power plant consisted of two six-cylinder sports car engines each with its own clutch and gearbox, giving a total swept volume of 3½ litres and developing well over 200 b.h.p. at 5,000 r.p.m. A spherical universal joint was mounted behind each gearbox and the drive was taken to the rear axle by two propeller shafts, each enclosed in its own pressed-steel torque tube. The back axle contained two separate differential gears in aluminium castings and mounted side by side.

The driver sat in the centre of the car above the two propeller shafts and each gearbox retained a gear lever, these being coupled together so that left- or right-hand changes could be effected. This car had a wheelbase of 9 ft. 6 in. and a track of 4 ft. 9 in. and weighed some 23 cwt.

In the Italian Grand Prix this literal " twin six " was not successful, Nuvolari being third at the end of two hours and then retiring. At this point Varzi was first on a Bugatti and Campari second on a Monza Alfa, but by the end of the fourth hour Bugatti had in turn retired with back axle trouble, after which the Monzas were never displaced from first and second positions. Campari, aided by Nuvolari in the latter part of the race, covered 961.7 miles in ten hours over the full Monza circuit and the 1924 lap record was broken by 0.76 m.p.h.

June saw a non-formula event over the Nürburg Ring which was the beginning of the Eifel series of races on the full length of this course. It was won by a sports type Mercedes-Benz against little opposition.

The French Grand Prix, held at Montlhéry on the 21st June, was a ten-hour formula event. Early on the lap record was raised to 85.6 m.p.h. by Fagioli, driving one of the 2½-litre straight-eight Maseratis which had been so successful in the previous year, but, once again, " the race was not to the swift," for after leading for the first two hours and running second in the third and fourth hours the car was held back with brake trouble. This gave victory to Chiron and Varzi driving a Bugatti Type 51, in which they covered 782.1 miles, second being a Monza Alfa driven by Campari and Borzacchini who covered 755 miles. It is worth noting that in this immensely long race the winning Bugatti had only five pit stops, aggregating 10 mins. 30 secs., whilst the Alfa stops totalled 24 min.

Bugatti was to have a string of successes in 1931 and the victory of the new twin camshaft model at Montlhéry was followed by a win in the lesser Marne Grand Prix run at Rheims. Lehoux beat Dreyfus on a Maserati and in doing so put up a record speed both for the lap and for the whole distance.

Bugatti scored a third success in the formula race run at Spa in mid-July, Alfas being second and third. The race was a very close one, the Englishman, Williams, and the Italian, Count Conelli, jointly covering 820.1 miles, whilst Nuvolari and Borzacchini covered 813.3 miles. The winners made only three stops, aggregating 5 min. 4 sec., and owing to the wheels and brake drums being one casting they were able within this time to change all the brake shoes. The runners-up made four stops lasting 8 min. 45 sec.

Within a week Bugatti and Alfa, together with a Maserati, were running on the Nürburg Ring in the German Grand Prix, and on this very difficult circuit it is of particular interest that Caracciola, driving a modified version of the 7-litre Mercedes-Benz car, was able to beat the smaller models, averaging 67.4 m.p.h. for twenty-two laps. This repeated the lesson of the Eifel races held earlier in the year, but there was stronger opposition in the German Grand Prix and Varzi on a Bugatti made the fastest lap. Neither this event nor the Monza Grand Prix run in September complied with the international formula. The latter was held on a fraction of the full course giving circuit of approximately 4.3 miles per lap and the preliminary heat for cars of up to three litres, run over fourteen laps, had entries from Alfa Romeo, Bugatti and Maserati. The last named had two cars with engines enlarged to 2.8-litres and these led alternately, Fagioli winning with Dreyfus second. The average of 97 m.p.h. was appreciably slower than the speed in the equivalent event of 1930.

The race for cars of unlimited capacity attracted two twelve-cylinder twin-engined Alfa Romeos, the sixteen-cylinder (twin eight) Maserati and Bugatti's newest car, the 86 x 107 mm. 4.9-litre Type 54 which was making its racing debut. Although holding the ten kilometre record at 152.9 m.p.h., the big Maserati was never in the picture at Monza, Varzi winning on a Bugatti at 98.5 m.p.h. and Nuvolari on one of the twelve-cylinder Alfas breaking the lap record for this short circuit at 101.25 m.p.h. The line-up for the final consisted of three Monzas and one twelve-cylinder Alfa, two Type 54 and one

Type 51 Bugatti, and two 2.8litre Maseratis. Fagioli on the Maserati showed himself clearly superior to the opposition, winning at 96.6 m.p.h. despite a tyre stop. Nuvolari was never better than third on the twelve-cylinder Alfa and Borzacchini ran second with the Monza model. Varzi on a Type 54 Bugatti challenged the winner in the early parts of the race but had two burst tyres.

The Type 51 Bugatti scored a victory in the final race of the year which was the second Czechoslovak Grand Prix run over a fast circuit at Brno. The previous year the race had been largely an amateur affair, but it was now supported by Bugatti, by the Austrian, Hans Stuck, and Caracciola (both driving Mercedes-Benz cars) and by works' cars from Alfa Romeo and Maserati. On an early lap Fagioli, driving a Maserati, brought down a bridge crossing the track which led to the withdrawal of his own car, two Alfa Romeos and Caracciola. Chiron then had an easy win from Stuck.

The year was noteworthy for the emergence of three entirely new designs, to wit, the Type 54 Bugatti, the Monza Alfa and the twelve-cylinder Monoposto from the same company. Both the 2.8litre Maserati and the Type 51 Bugatti showed useful improvement in performance over their immediate predecessors and the evidence shows that in 1931, as in 1930, the former was the fastest road racing car.

In 1932 Bugatti decided to continue with his two established designs rather than to tempt fortune in the production of an entirely new car. Maserati had good grounds for confidence and they also continued with their current models. Alfa Romeo took a different line. The Monza, although a reasonably successful type, had little, if any, margin of superiority over competing designs and was incapable of providing the manufacturers with the decisive successes which are sought by all racing engineers. The twelve-cylinder car was promising, but heavy and not too easy to handle. These facts led the company to introduce the celebrated eight-cylinder P.3 car, which may be best described as a blend of the Monza and twelve-cylinder themes.

The P.3 engine, as on the Monza, was an eight-cylinder and had the same bore, but the stroke was increased to 100 mm., giving a capacity of 2.65-litres. The inlet and exhaust sides of the engine were reversed and two superchargers, both connected to the central auxiliary drive, were mounted on the left-hand side of the crankcase. The details of the car are fully revealed on other pages of this book, but it is relevant to note here that although a single gearbox was employed the notion of twin propeller shafts with the driver mounted centrally above them was continued, although the differential mechanism was placed behind the gearbox, instead of in the rear axle housings as it had been on the twelve-cylinder type.

This design was not available for the first two road races of the year, that is the Monaco Grand Prix and Eifel Races, but both were won by the Monza type Alfa, the driver in the first being Nuvolari and in the German event Caracciola. In both races the Type 51 Bugatti put up a stern fight. At Monaco Chiron driving one of these cars was leading for much of the race, when a rare error of judgment caused the car to crash, whilst another Bugatti driven by Varzi made the best lap at 58.3 m.p.h. In the German race Dreyfus on a Type 51 was beaten by only 22 sec. in a race lasting nearly three hours.

Following these initial races the true Grand Prix season began, a notable feature being the widespread acceptance of an A.I.A.C.R. ruling giving *formule libre* except that no mechanic could be carried, that the duration of the race should not be less than five and not more than ten hours, and that no more than four persons, including the driver and spare driver, could work on the car at the pits. The organisers of the Italian Grand Prix, run on the 5th June, decided to limit the race to five hours over the full Monza circuit. Six Alfa Romeo cars, four entered by the works, competed against five Bugattis, three entered by the works, and four Maseratis, two entered by the works. The sixteen-cylinder Maserati now showed what it could do by putting up a lap record of 112.22 m.p.h., an immense advance over anything hitherto recorded on this circuit, but, unfortunately, Fagioli's skill at the wheel was by no means equalled by the rapidity of the Maserati mechanics in the pits. They took no less than 3 mins. 7 secs. to change four tyres and refuel, and this reduced the Maserati to ninth place on the twenty-fifth lap. Although consistently the fastest car on the course it could do no better than finish second, covering 515.6 miles compared to the 520.5 miles achieved by Nuvolari, who won on the new P.3 Alfa. After a lapse of eight years design was really advancing, for the winning average of 104.13 m.p.h. for five hours nearly equalled the 1924 P.2 lap record of 104.24 m.p.h. and was less than 1 m.p.h. slower than the 1931 lap record of 105 m.p.h. put up by the Monza model. Neither the Type 54 nor Type 51 Bugattis could make any impression in this extremely fast race.

The next event was the French Grand Prix, held once more on the road over the Rheims Circuit, which had for some years been used for the Grand Prix de la Marne. Bugatti again entered both Type 54 and 51 cars, Alfa entered three P.3's, to which were added four Monzas. The result was a clear demonstration of P.3 supremacy, only Varzi on a Type 54 making a challenge in the first five laps. Thereafter the P.3's annexed the three leading positions, Nuvolari breaking the lap record for the course at 99.5 m.p.h. and winning at 92.26 m.p.h. At the end of five hours the second P.3 was 400 yds. behind the winner and the third less than one mile in arrear.

The German Grand Prix was even more remarkable, for Bugatti decided to send only one Type 51 and Maserati only one 2.8-litre car. At the end of seven laps the only cars running were the Alfa team of P.3's and a privately owned Bugatti, Caracciola driving for the Italian concern, averaged 74.13 m.p.h. for 354 miles.

The major racing of the year was concluded by the Monza Grand Prix, run as usual in heats and a final, but this year the full circuit was used and in preliminary heats Nuvolari did a lap on a P.3 at 113.7 m.p.h. In the final he was unable to equal this speed and, suffering from carburetter flooding, finished third. Caracciola upheld the honour of the team by finishing first at 110.8 m.p.h., 1 min. 9 sets. ahead of Fagioli on the 4-litre sixteen-cylinder Maserati, who averaged 108.2 m.p.h. after suffering plug trouble.

After the excellent season of 1931 Bugatti had the disappointment of not winning any major races in 1932. But in the Czechoslovak Grand Prix, run as usual on the Brno circuit, he had the distinction of being the only constructor to beat the P.3 Alfa Romeo in fair fight.

This race was run only a week before the Monza Grand Prix and the Alfa Romeo team consisted of only two cars driven by Nuvolari and Borzacchini. These two led the race in the initial stages but Nuvolari had to change a magneto and lost so much time that he finished third. Borzacchini had rear axle trouble and retired, giving Chiron an easy win on a works Type 51 Bugatti. As he also made the best lap he thoroughly deserved his success.

Two P.3's were first and second in the Coppa Ciano over the Montenero circuit, which Nuvolari won at 53.91 m.p.h., a similar statement being true for the Coppa Acerbo where his winning speed was 86.89 m.p.h. Apart from the Brno mishap the only occasion in 1932 when a P.3 was beaten was on the neglected Miramas track, which was used for the Marseille Grand Prix on the 25th September. The Alfa pit made a miscalculation in the lap score and the race was won by an independently entered Monza model.

The regulations effective for the 1933 racing season amended the duration of the racing to 500 kilometres, but a considerable change came over the racing situation following the decision of Alfa Romeo to retire from racing and to put the P.3 model into storage. An organisation headed by Ferrari commenced the season by running a team of Monza cars with engines bored out to 2.55-litres and carrying an offset single-seater body. Both Bugatti and Maserati abandoned their big cars, the former concentrating on the Type 51 and the latter developing a 2.9-litre 69 x 100 mm. straight-eight.

The German Grand Prix was cancelled owing to economic difficulties, so that the five major events of the year were the Grands Prix of Monaco, France, Belgium, Italy and Spain, the latter revived after a lapse. At Monaco, Varzi showed that the Type 51 could match the modified Monza. Driving the French car to its limit he had a tremendous duel with Nuvolari who, on the last lap, broke an oil pipe, his Monza catching fire and being pushed until 200 yds. short of the finishing line. Varzi's winning speed was 57.04 m.p.h., with Borzacchini on a Monza model second.

This race has a special historic significance for it was the first in Europe in which the positions on the starting grid were. determined by the times made in practice. This arrangement had been used at Indianapolis for very many years and it was Faroux who perceived that on the very twisting course at Monte Carlo a fast car which had the ill-luck to draw a back row position by ballot would be most unfairly handicapped, and who suggested the Indianapolis arrangement to the organisers. Starting positions in the 1933 Marne Grand Prix were similarly established but this method did not come into general use until 1935.

Bugatti had planned to run an entirely new 2.8-litre car in the French Grand Prix, held at Montlhéry on the 11th June, but as they were not ready five privately owned Bugattis competed with twelve Monza Alfas and two 2.9-engined Maseratis. Campari driving one of the last named led for practically the entire race, putting the lap record to 86.6 m.p.h., and winning at an average of 81.52 m.p.h. The runner-up was a privately entered Monza, which averaged 81.21 m.p.h., a similar car entered and owned by G. E. T. Eyston finishing third. After the race Nuvolari had a dispute with Ferrari over the preparation of the Alfa cars for the French race and then drove a Maserati in the Belgian Grand Prix at Spa, which he won. Both the Monzas entered by Ferrari retired and Bugatti ran second and third. Varzi finished 3 mins. behind Nuvolari, who averaged 89.23 m.p.h. and broke the lap record at 92.33 m.p.h.

Alfa Romeo continued their successive victories in the Targa Florio by winning the 1933 race at 47.56 m.p.h., but, generally speaking, the events held up to the end of July had shown the modified Monza model inferior to the 2.9-litre Maserati. The latter car won not only the French and Belgian Grands Prix, but also the Coppa Ciano, where Nuvolari beat the Alfa Romeo driven by Brivio by the resounding margin of eight minutes. To offset these defeats the works decided to release the P.3 models to the Ferrari organisation and two of them accordingly re-appeared in, the Coppa Acerbo run on the 13th August. In the early stages of the race they proved slower than the 2.9-litre Maserati of Nuvolari who led Campari's P.3, but the latter broke down and the former had to make a pit stop, and this gave the P.3 driven by Fagioli victory by virtue of making a non-stop run. This event could be considered a rehearsal for the major races for the Italian and Spanish Grands Prix, which in accordance with tradition were held late in the racing season. The Italian Grand Prix was run over fifty laps of the full course of Monza in the morning of September 10th, the afternoon of the same day being reserved for the heats and final of the Monza Grand Prix run on the short circuit used in 1929.

The Italian Grand Prix was notable for a tremendous struggle between Nuvolari, on a 2.9 Maserati, and Fagioli and Chiron both driving P.3 Alfa Romeos. Nuvolari led on the first, sixth, ninth, twelfth, fifteenth, twenty-seventh, forty-first and forty-eighth laps, Chiron on the eighteenth, thirtieth and thirty-fifth laps, Fagioli on the fifth, seventh and last lap. Fagioli's winning speed was 108.58 m.p.h., and he covered the forty-first lap at the record speed of 115.82 m.p.h., but Nuvolari was definitely deprived of victory by a burst tyre on his forty-eighth lap, despite which he finished second at the average of 108.19 m.p.h.

The Monza Grand Prix followed and is known to history on account of a burst tank on one of the competing cars, which led to oil being spread over one of the fast turns. Inefficient cleaning of the track at this point led to accidents, causing the death of Campari, Borzacchini and Count Czaykowski on a Type 54 Bugatti. Before he was killed Czaykowski lapped this short circuit at 116.81 m.p.h., Moll on a Monza Alfa having achieved 115.95 m.p.h. on a preceding lap.

Barely a week later the P.3 Alfa Romeo continued its almost unbroken run of successes by gaining first place in the Czechoslovak Grand Prix, the poor speeds realised being fully explained by the appalling weather conditions in which the race was run.

In the Spanish Grand Prix Bugatti contrived to get his new 2.8-litre cars on to the line, but these, the precursors of the famous 3.3-litre Type 59 model, which rendered an excellent account of themselves the following year, had a far from sensational first appearance. They finished fourth and sixth, Chiron winning on a P.3 Alfa at 83.32 m.p.h. He was fortunate to do so as Nuvolari kept the Maserati comfortably in the lead until three-quarters distance, putting in a record lap at 96.59 m.p.h. and then having the misfortune to leave the road and hit a tree.

Although unsuccessful in major racing, in which they were frequently beaten by Maserati, the Monza type Alfas run by Ferrari were very successful in minor events. The year was, however, chiefly remarkable for the continuing successes of Maserati cars which showed that they could compete on even terms even after the celebrated P.3 Monoposto Alfa Romeos had been released from retirement. Bugatti had a shocking racing season due largely to the difficulties experienced in bringing out his entirely new car.

Speeds over full distances and on the lap had in most cases increased and the faster cars were now capable of over 140 m.p.h. This trend caused some alarm in the international governing body, who hoped that the new formula governing the years 1934-37 would limit speeds and serve to break up the Italian monopoly of racing successes. It was, as we shall see, highly successful in this latter respect.

CHAPTER ELEVEN

The New Order

RACING RESULTS 1934

Date	Event	Course	Driver	Car	Average Speed m.p.h.	Lap Speed m.p.h.
2/ 4/ 34	Monaco G.P.	Monaco	G. Moll	Alfa Romeo	55.86	—
2/ 4/ 34	,,	,,	Count Trossi	Alfa Romeo	—	59.7*
3/ 6/ 34	Eifel Races	Nürburg Ring	M. von Brauchitsch	Mercedes-Benz	76.12	79*
17/ 6/ 34	Penya Rhin	Montjuich	A. Varzi	Alfa Romeo	64.24	—
17/ 6/ 34	,,	,,	L. Chiron	Alfa Romeo	—	66.25*
1/ 7/ 34	French G.P.	Montlhéry	L. Chiron	Alfa Romeo	85.55	91.44*
8/ 7/ 34	Marne G.P.	Rheims	L. Chiron	Alfa Romeo	90.71	—
8/ 7/ 34	,,	,,	A. Varzi	Alfa Romeo	—	97.65
15/ 7/ 34	German G.P.	Nürburg Ring	H. Stuck	Auto-Union	75.14	79.29*
29/ 7/ 34	Belgian G.P.	Spa	R. Dreyfus	Bugatti	86.9	—
29/ 7/ 34	,,	,,	Brivio	Bugatti	—	96.38*
15/ 8/ 34	Coppa Acerbo	Pescara	L. Fagioli	Mercedes-Benz	80.26	—
15/ 8/ 34	,,	,,	G. Mall	Alfa Romeo	—	90.5*
26/ 8/ 34	Swiss G.P.	Berne	H. Stuck	Auto-Union	87.21	—
26/ 8/ 34	Swiss G.P.	Berne	A. Momberger	Auto-Union	—	94.42*
9/ 9/ 34	Italian G.P.	2.68 Miles at Monza	R. Caracciola and L. Fagioli	Mercedes-Benz	65.37	—
9/ 9/ 34	,,	,,	H. Stuck	Auto-Union	—	72.59*
23/ 9/ 34	Spanish G.P.	San Sebastian	L. Fagioli	Mercedes-Benz	97.13	—
23/ 9/ 34	,,	,,	H. Stuck	Auto-Union	—	101.96*
30/ 9/ 34	Czcchoslovak G.P.	Brno	H. Stuck	Auto-Union	79.21	—
30/ 9/ 34	,,	,,	L. Fagioli	Mercedes-Benz	—	81.23*

* Record

SINCE October, 1932, racing car designers had known that in the years 1934, '35, '36, racing was to be governed by a formula wherein cars without driver, fuel, oil and tyres must weigh less than 750 Kg. (14.73 cwt.) and that the body width must be at least 33.5 in.

The winter of 1933 saw the principal adversaries of the past two years working in quiet confidence in their Italian establishments. Alfa Romeo were under contract to deliver to the Ferrari group a set of cars complying with the new regulations, but they were only slightly modified versions of the P.3 model which had been beaten only twice in the past two years. Wheelbase and track were enlarged, bodies were widened to comply with the new regulations, and the weight rose to a little over 14 cwt. The engine capacity was raised to 2.9-litre capacity by opening up the cylinder bores from 65 mm. to 69 mm., the stroke remaining unchanged at 100 mm. These minor modifications took no great time and in January, 1934, a car was tested over the Montenero Circuit which had been the scene of the Coppa Ciano races.

Maserati continued with the 2.9-litre straight-eight car which had made its debut at Tunis in 1932 and with which they had four good wins in 1933, including the French and Belgian Grands Prix. In view of the new body regulations the width between chassis members was increased from 20 in. to 30 in., but, this apart, the car underwent little change.

Bugatti went on with the new 2.8-litre car which he had run at San Sebastian the previous September, a model, which, with its unique wire wheels, plain bearing engine, double reduction drive to the rear axle, and offset driving position, showed a marked change from previous Molsheim models.

Overshadowing all these activities of the established constructors were two new German cars. One of these marked the return of Mercedes-Benz to Grand Prix racing after an interval of ten years, the other the entrance upon the stage of the recently formed Auto-Union combine (Horch, Audi, Wanderer and D.K.W.), who had taken over a design by Dr. Porsche which had originally been a private venture.

The German Government, under Adolf Hitler, had offered a prize of £40,000 to the most successful German racing car of 1934 and Porsche's design, which embraced tubular frame with independent springing to all four wheels and a 4.36-litre sixteen-cylinder rear-mounted engine, was an ambitious and highly original attempt to secure this reward. Although an entirely new concept construction was very well forward, and in December of 1933 one car had a preliminary trial on the Nürburg Ring followed by tests in January, 1934, on the Autostrada between Milan and Varese, speeds of 155 m.p.h. were mentioned, and any doubts concerning the immense potency of this design were set at rest when it broke the one-hour record on the A.V.U.S. Track on March 6th. The speed of 134.608 m.p.h. could be directly compared with the 4.9-litre Bugatti which had averaged 132.87 m.p.h. on the same track in the previous year.

The 1934 Mercedes-Benz had an orthodox 3.3-litre engine of eight cylinders conventionally positioned, but was also notable for using independent suspension to all four wheels. It also was taken during January to the Milan-Varese Autostrada, but it is evident that these tests showed the constructors that the cars were by no means ready for serious racing, for they made no effort to appear in the initial race under the new formula, which was run at Monte Carlo in May.

The Auto-Unions were also non-starters as they were thought unsuitable for this race owing to their long wheelbase, so the old guard, Bugatti, Maserati and Alfa Romeo, were thus left to fight their battles alone.

Bugatti and Alfa Romeo had no difficulty in meeting the weight limitation, but Maserati had to resort to fearful expedients, even draining the rear axle of oil.

In practice Count Trossi, on an Alfa Romeo, equalled the lap record set up on a Type 51 Bugatti the previous year, but the new Bugattis in the hands of Dreyfus, Wimille and Nuvolari proved to be much slower. In the race itself the Alfas remained steadily at the head of affairs, running, however, at a consistently lesser speed than Varzi's Bugatti in 1933, so that in the end Moll won at an average of only 55.86 m.p.h., Chiron following on another Alfa Romeo a minute later at 55.8 m.p.h., and Dreyfus brought home the fastest Bugatti in third place at 55.2 m.p.h.

It seems likely that the Alfa Romeo brakes were not quite adequate to this type of race, whilst the Bugattis had not at this stage such good acceleration as the previous models. One might have thought that these factors would have permitted Maserati to go into the head of affairs, but for some reason they failed to take advantage of the opportunity thus presented and at half distance were in no better than sixth, although they would have gained fourth place if their best car had not retired on the very last lap.

The German constructors chose a *formule libre* event run on the A.V.U.S. track near Berlin on May 27th as the scene of the first trial of strength between the new order of highly unconventional cars produced with lavish expenditure and State encouragement, and the established classic designs in which development had proceeded step by step over a number of years constrained by moderate expenditures of cash and man-hours. In practise for this event one of the Mercedes-Benz cars was timed at 143 m.p.h. for the lap, but the Stuttgart engineering department decided that the cars were not yet fit for a long distance event and they were all withdrawn.

The Auto-Union team remained to compete against the Ferrari-sponsored Alfa Romeos, one of which was given a fully faired body and an enlarged engine of 3.2-litre capacity. This car, driven by Guy Moll, eventually proved the winner at 127.56 m.p.h. after two of the Auto-Unions retired at fifth and twelfth laps respectively. The third, driven by a relatively inexperienced driver, finished in third position at 125 m.p.h.

Both of these events it should be noted were slower than the corresponding races of the previous year, and at this point, therefore, the authors of the new formula seemed to have justified their belief that it would curb average speeds. Such satisfaction was to be very short lived, for within a week the Eifel Races, held on the Nürburg Ring, were to demonstrate the potentialities of the new, and to sound the knell of the established, designs. A Mercedes-Benz, driven by von Brauchitsch, led throughout the race and raised the 1932 lap from 77.55 m.p.h. (R. Caracciola on a P.3 Alfa Romeo) to 79 m.p.h.

At half distance Brauchitsch was followed by his team mate, Fagioli, with Stuck on the Auto-Union third, with Chiron leading the van for Italy but completely outclassed.

Fagioli was later engaged in a remarkable dispute with team orders, for although he could clearly take the lead whenever he wished, he was ordered to remain in second position, to which he responded by stopping his car and walking away. This let the Auto-Union into second position and Chiron's Alfa Romeo into third. The Alfa, however, finished 5 min. 44 sec. behind the Mercedes-Benz and 4 min. 24 sec. behind the Auto-Union. From the technical viewpoint the German win was the more creditable as both the leading cars had to refuel, whereas the Alfa Romeo team were able to run the distance non-stop.

The Penya Rhin Grand Prix was run for the second time on the Montjuich circuit at Barcelona, and the official Alfa team had no significant opposition and filled the first three places.

The stage was now set for an historic struggle for the Grand Prix of the Automobile Club de France in a race to be run at Montlhéry on July 1st. The reliability of the German cars having been apparently established at Nürburg Ring it was generally considered that they would have little difficulty in beating their French and Italian rivals, consisting of three Bugattis with engines now enlarged to 3.3-litres capacity, three Alfa Romeos and three Maseratis, one of which was a non-starter.

In practice the lap record of 86.6 m.p.h., established by Campari on a Maserati the previous year, was beaten, not only by Brauchitsch on a Mercedes-Benz, but also by Chiron on the B Type Alfa Romeo, and it is not uninteresting that the latter were much the lightest cars, weighing in at 14.15 cwt. with both Maserati and Bugatti perilously near the maximum weight limit.

The starting line positions were determined by the ballot, but Chiron made a trick start and led on the first lap followed by Caracciola, Mercedes-Benz ; Fagioli, Mercedes-Benz ; Stuck, Auto-Union ; and Varzi, Alfa Romeo. Bugatti were right out of the picture, running eighth, ninth and twelfth, as were Maserati, who occupied tenth and eleventh positions. The first lap was symbolic of the entire race for it was only between the third and ninth (out of forty laps) that Chiron was overtaken. For this brief period Stuck led on the Auto-Union, but was delayed at a pit stop which brought him down to seventh position on the twelfth lap, finally retiring on the thirty-third lap when running fourth. Of his team mates, Prince Leiningen was a non-starter, and the relatively unskilled Momberger trailed along between tenth and thirteenth positions until he retired at quarter distance with suspension trouble.

Mercedes-Benz, also, were. in bad shape, for Caracciola went out with a cracked gearcase when running third at fifteen laps, Brauchitsch never really got his car going properly and retired on the twelfth lap, leaving Fagioli, the third member of the team, the only one to put up any fight. In the first part of the race he, Stuck and Chiron broke and re-broke the Maserati (Campari) lap record of 5 min. 23 sec. On the second and third laps it was lowered by Stuck to 5 min. 13.2 sec., and 5 min. 9.4 sec., and then by Fagioli on the ninth lap to 5 min. 8.8 sec., tenth lap 5 min. 8.6 sec., eleventh lap 5 min. 6.5 sec., twelfth lap 5 min. 6.4 sec.

For sheer speed Alfa, however, had the last word, for on the fifteenth lap Chiron put in a time of 5 min. .06 sec., or 91.4 m.p.h., which remained unbeaten. At 200 kilometres, on the sixteenth lap, this driver was leading his team mate Varzi by 1 min. 18 sec., and the nearest German car was Stuck, 5 min. 22 sec. behind the best Alfa. All the Mercedes-Benz had retired.

The poor position of Stuck in the face of his lap records was accounted for by numerous and lengthy pit stops. On the eleventh lap he took 2 min. 35 sec. to change the rear wheels and take on fuel and water, his subsequent pit calls being on the twentieth lap, 1 min. 22 sec. for fuel and water alone, and, finally, on the thirty-first lap, 1 min. 11 sec., again for fuel and water. The car was boiling on all of these stops. Caracciola had the rear wheels changed and his Mercedes-Benz refuelled in 1 min. 20 sec. on the fifteenth lap, whilst the best Alfa time was Varzi's on the eighteenth lap in which four wheels were changed and the car refuelled in 1 min. 30 sec.

From half distance onwards Chiron, Varzi and Moll took Alfa Romeo steadily forward to a 1, 2, 3 victory, and when the third car (which had suffered throughout the race from the absence of bottom and third gears) received the checkered flag, Benoist on one of the Bugattis was flagged off with three laps still to go. Thus, exactly twenty years after the dramatic Mercedes victory at Lyons the German cars were decisively beaten in the most famous of all Grand Prix races. The newer designs had been unable, either in reliability or sheer lap speed, to hold their own with the well-tried types.

This race was the zenith of Alfa Romeo fortune ; thereafter they were to secure occasional victories, but never by virtue of superior performance. They were to suffer many defeats at the hands not only of the German cars, but also of Bugatti.

The German Grand Prix, in which Alfa Romeo and Maserati had works' teams competing with Auto-Union and Mercedes-Benz, was an example of future events.

Nuvolari drove for Maserati, and although in the previous race held in 1932 he had gained second place and put up the record lap on a P.3 Alfa Romeo, this year he could do no better than finish fourth at an average of 72.04 m.p.h. His team mates made no serious contribution to the race and Alfa Romeo did little better, only Chiron lasting more than a quarter of the distance, to finish third at 74.21 m.p.h. with a best lap at 77.8 m.p.h., figures only fractionally better than those put up by the P.2 model two years previously. Stuck on an Auto-Union led almost throughout to win at 76.39 m.p.h., putting in a record for the ninth lap at 79.29 m.p.h., Caracciola lapped at 79.23 m.p.h., and came into the lead for the nineteenth lap, only to retire immediately afterwards, and another Mercedes-Benz, driven by Fagioli, finished second, 2 min. 7 sec. behind the Auto-Union, but 6 min. 6 sec. ahead of the best Alfa Romeo.

This was the second victory in succession for German cars on German soil, but they had yet to secure their first away victory, which made their entry for the Belgian Grand Prix all the more interesting.

Unfortunately, both Auto-Union and Mercedes-Benz decided not to start following a demand for heavy customs duty on the special fuel which they wished to bring with the team. Bugatti, however, returned to the field with three cars to compete against two Alfa Romeos. The French cars made a disastrous start, Brivio stopping three times in the first three laps, and losing 5 min. 23 sec., Dreyfus three times in the first three laps, losing 5 min. 22 sec., and Benoist one stop on the second lap which cost him 1 min. 5 sec. It is, therefore, scarcely surprising that at half distance the two Alfa Romeos were more than a lap ahead, shortly after which, however, Chiron got off the road and overturned his car. Varzi was left in an unchallengeable position, but on the twenty-second lap he decided to raise the lap record (standing to the credit of Nuvolari on the Maserati), which he did by the very considerable margin of nearly 4 m.p.h. This proved his undoing as the car then broke a piston letting two Bugattis into first and second places with an even faster lap thrown in for good measure. The Bugattis, however, thoroughly deserved their victory, for apart from the unfortunate stops in the first part of the race they generally proved themselves the faster cars.

All the leading makes were represented at Pescara for the Coppa Acerbo, and the comparatively even running of the cars was shown by the fact that there were five different makes in the five final positions. Unfortunately, the Auto-Union of Stuck had mechanical trouble, Chiron's Alfa Romeo caught fire, Caracciola crashed the fastest Mercedes-Benz, and tragedy overtook Moll, who was killed when his Alfa Romeo crashed after being in the lead at half distance.

After this unhappy affair Fagioli's Mercedes-Benz kept comfortably ahead of Nuvolari's Maserati, with a Bugatti, driven by Brivio, running third.

The first Swiss Grand Prix was run over the Berne circuit and it proved a very fast course, over which an Auto-Union, driven by Stuck, led virtually from start to finish, averaging 87.21 m.p.h. For more than four-fifths of the distance Dreyfus on a Bugatti ran second, but was displaced by Momberger's Auto-Union (which raised the lap record to 94.42 m.p.h.) as a result of having to take on water. Alfa Romeo could do no better than finish fourth and fifth, and Mercedes-Benz suffered from various mechanical disabilities and did even worse.

The Stuttgart team, however, returned to the winning habit in the Italian Grand Prix run over a section of the Monza course with many *chicanes* put in to reduce average speeds. Stuck made the fastest lap at 72.59 m.p.h. and led at half distance. After this he ran into brake trouble and was passed by a Mercedes-Benz, the finish being in this order, with an Alfa Romeo third. Bugatti entered only one car which did not start.

This was a desperately slow race on a highly artificial circuit and contrasted unfavourably with the very high speeds realised in the Spanish Grand Prix run over the roads in the environ of San Sebastian. Nuvolari held the lap record at 95.69 m.p.h. on a Maserati, and at the end of the practice period both he and Dreyfus on 3.3-litre Bugattis had raised this speed to 99.5 m.p.h. During the race the Bugattis pressed hard on the heels of the two Mercedes-Benz, which held the first and second positions, Caracciola keeping the lead and putting the lap record at over three figures. He lost time in refuelling (which took 62 sec. with no wheel changing) and at half distance was 18 sec. behind his team mate Fagioli, but 49 sec. ahead of Wimille on the best Bugatti. The last named then had carburetter trouble, leaving the challenge to Nuvolari, who had made a bad start.

Stuck broke his own car early in the race and took over the Auto-Union of Prince Leiningen, with which he raised the lap speed to nearly 102 m.p.h., but this took place too late to affect the major issue, Caracciola coming in second 53 sec. behind Fagioli and 24 sec. ahead of Nuvolari. Once again Alfa Romeo were completely outclassed.

In the last race of the year neither Bugatti nor Alfa Romeo could keep in sight of the German cars on the fast, but rough, Brno circuit used for the Czechoslovak Grand Prix. Fagioli averaged 82.9 m.p.h. and put in the best lap but was deprived of his position by a pit stop, leaving Stuck the winner at an average speed of 79.11 m.p.h. Nuvolari brought a six-cylinder 3.7-litre Maserati into third position and Varzi was placed fifth in an Alfa Romeo. Practice for this event was notable for the appearance of Nuvolari at the wheel of an Auto-Union, and although he remained faithful to Italian cars for a further three racing seasons he must have realised that the threat of German supremacy was soon to be established as a fact.

Seldom can the fortunes of any make have suffered such an utter change of fortune as Alfa Romeo in 1934. The P.3 models were beaten twice only between their introduction for the Italian Grand Prix early in 1932 and the end of 1933. The positions of the P.3 B type cars are vividly shown in the table set out below in which the best position for any make of car is given for the major races of the year.

1934 RESULTS BY MAKE OF CAR

Event	*Alfa Romeo*	*Bugatti*	*Maserati*	*Auto- Union*	*Mercedes-Benz*
Monaco	First	Third	Second	N.S.	N.S.
Eifel Races	Third	N.S.	N.S.	Second	First
French G.P. ..	First	Fourth	Retired	Retired	Retired
Marne G.P. ..	First	N.S.	Retired	N.S.	N.S.
German G.P. ..	Third	N.S.	Fourth	First	Second
Belgian G.P. ..	Retired	First	N.S.	N.S.	N.S.
Coppa Acerbo ..	Fourth	Third	Second	Fifth	First
Swiss G.P.	Fourth	Third	Eighth	First	Sixth
Italian G.P.	Third	N.S.	Fifth	Second	First
Spanish G.P. ..	Fifth	Third	N.S.	Fourth	First
Czechoslovak G.P.	Fifth	Retired	Third	First	Second

It is immediately apparent that Maserati had a thoroughly bad year and that from the French Grand Prix onwards Bugatti staged something of a come-back. In the last half of the season, however, it is clear that the superior power of the German cars was giving them continuous victories. They were not, in fact, defeated from the 1st July onwards, and only Moll on the Alfa Romeo at Pescara contrived to put up a record lap when the German cars were running.

There was little to choose between the successes of the two rival German manufacturers, and the Nazi prize fund was divided between them. By this time, however, the construction and operation of advanced designs of their kind involved expenses far beyond anything which had previously been thought possible in road racing and the prize fund money was but a tithe of the burden borne by each constructor.

CHAPTER TWELVE

Teutonic Triumphs

RACING STATISTICS 1935-36

Date	*Event*	*Course*	*Driver*	*Car*	*Average Speed m.p.h.*	*Fastest Lap m.p.h.*
22/4/35	Monaco G.P.	Monte Carlo	L. Fagioli	Mercedes-Benz	58.17	60.08*
5/5/35	Tunis G.P.	Carthage	A. Varzi	Auto-Union	101.2	105.17*
10/6/35	Eifel Races	Nürburg Ring	R. Caracciola	Mercedes-Benz	72.8	75.6*
17/6/35	Penya Rhin G.P.	Montjuich	L. Fagioli	Mercedes-Benz	66.99	—
17/6/35	,,	,,	R. Caracciola	Mercedes-Benz	—	68.94*
23/6/35	French G.P.	Montlhéry with chicanes	R. Caracciola	Mercedes-Benz	77.39	—
23/6/35	,,	,,	T. Nuvolari	Alfa Romeo	—	85*
7/7/35	Marne G.P.	Rheims	R. Dreyfus	Alfa Romeo	98.03	102*
14/7/35	Belgian G.P.	Spa	R. Caracciola	Mercedes-Benz	97.8	—
14/7/35	,,	,,	M. von Brauchitsch	Mercedes-Benz	—	103.7*
28/7/35	German G.P.	Nürburg Ring	T. Nuvolari	Alfa Romeo	75.43	—
28/7/35	,,	,,	M. von Brauchitsch	Mercedes-Benz	—	80.73*
4/8/35	Coppa Ciano	Montenero	T. Nuvolari	Alfa Romeo	55.18	56.22
15/8/35	Coppa Acerbo	Pescara	A. Varzi	Auto-Union	86.6	90.9*
25/8/35	Swiss G.P.	Berne	R. Caracciola	Mercedes-Benz	89.95	--
25/8/35	,,	,,	L. Fagioli	Mercedes-Benz	—	99.5*
8/9/35	Italian G.P.	Monza 2.68 Miles	H. Stuck	Auto-Union	86.2	—
8/9/35	,,	,,	T. Nuvolari	Alfa Romeo	—	90.77*
22/9/35	Spanish G.P.	San Sebastian	R. Caracciola	Mercedes-Benz	101.92	—
22/9/35	,,	,,	A. Varzi	Auto-Union	—	108.11*
29/9/35	Czechoslovak G.P.	Brno	B. Rosemeyer	Auto-Union	82.39	—
29/9/35	,,	,,	A. Varzi	Auto-Union	—	85.21*
13/4/36	Monaco G.P.	Monte Carlo	R. Caracciola	Mercedes-Benz	51.69	—
13/4/36	Monaco G.P.	Monte Carlo	H. Stuck	Auto-Union	—	56.01*

Racing Statistics 1935-36 (continued)

17/5/36	Tunis G.P.	Carthage	R. Caracciola	Mercedes-Benz	99.62	—
17/5/36	,,	,,	B. Rosemeyer	Auto-Union	—	103.79*
7/6/36	Penya Rhin G.P.	Montjuich	T. Nuvolari	Alfa Romeo	69.21	71.85*
14/6/36	Eifel Races	Nürburg Ring	B. Rosemeyer	Auto-Union	72.71	74.46
21/6/36	Hungarian G.P.	Budapest	T. Nuvolari	Alfa Romeo	69.1	71.84*
28/6/36	Milan Circuit	Milan	T. Nuvolari	Alfa Romeo	60.02	—
28/6/36	,,	,,	A. Varzi	Auto-Union	—	62.26*
26/7/36	German G.P.	Nürburg Ring	B. Rosemeyer	Auto-Union	81.8	85.52*
2/8/36	Coppa Ciano	Leghorn	T. Nuvolari	Alfa Romeo	74.8	77.05
15/8/36	Coppa Acerbo	Pescara	B. Rosemeyer	Auto-Union	86.48	—
15/8/36	,,	,,	A. Varzi	Auto-Union	—	89.04
23/8/36	Swiss G.P.	Berne	B. Rosemeyer	Auto-Union	100.45	105.42*
13/9/36	Italian G.P.	Monza with chicanes	B. Rosemeyer	Auto-Union	84.59	87.18*
12/10/36	Vanderbilt Trophy	Roosevelt Speedway	T. Nuvolari	Alfa Romeo	65.99	69.92*(P)

Note.-In 1936 Czechoslovak and Spanish G.P. not held ; Belgian, Marne and French G.P. for sports cars.
* Record

THE latter half of 1934 had been an unbroken run of successes for the newly designed German cars with all independent suspension and engines developing 300 b.h.p. or more. The margin by which these victories had been won was nevertheless extremely small and measured either by race averages or fastest lap speeds was of the order of 2 per cent or less.

The companies who were continuing with established designs of cars, that is to say Alfa Romeo, Bugatti and Maserati, had, therefore, to decide whether they should scrap their previous experience and build new types of cars or endeavour to bridge the relatively small gap by improving their existing models. All three adopted the latter course, engineering counsels being doubtless swayed by financial considerations. Alfa Romeo made more detail changes than the others, enlarging their P3 engine to 3.2-litres capacity, changing to independent suspension of the Dubonnet type at the front with reverse quarter-elliptic springs in the Bugatti style at the rear.

Maserati at first confined themselves to the six-cylinder engine of 3.7-litres capacity in their existing chassis, which had gained first places at Modena and Naples, and ran third at Brno in 1934, and Bugatti decided that his best course was to get the 3.3-litre cars going really properly.

Mercedes-Benz also made practically no change in the chassis design of their cars, but towards the end of 1934 they had fitted a power unit in which the swept volume had been increased from 3.7 to 3.99 litres, by changing the bore and stroke from 82 x 88 mm. to 82 x 94.5 mm. The result was to raise the power from 398 to 430 b.h.p. at 5,800 r.p.m., figures comparing very favourably with the 302 b.h.p. which was given by the 78 x 88 mm. engine during its early trials.

Auto-Union introduced more substantial modifications. The bore of the sixteen-cylinder engine was increased from 68 to 72.5 mm., and the stroke remained the same at 75 mm. ; the compression ratio was increased from 7 : 1 to 8.95 : 1 ; maximum engine revolutions were raised from 4,500 to 4,800 r.p.m., and output rose from 295 to 375 b.h.p. There was, therefore, a gain both in swept volume (from 4.36 to 4.95 litres), and output per litre. The chassis design was also changed in one important feature-the transverse rear springs used with the swing axle in 1934 were discarded in favour of links connecting to torsion bars within the tubular frame members. The car was also markedly changed in appearance by modifying the tail of the body and fitting stub exhaust pipes to each cylinder, in place of delivery into a tail pipe on each side.

Neither Auto-Union nor Bugatti entered the opening formula event at Monaco, and although a Mercedes-Benz, driven by Fagioli, won, it was no easy victory. The new six-cylinder Maserati, driven by Etancelin, not only proved faster than the Alfa Romeos, but displaced the Mercedes-Benz driven by Caracciola from second position, and although as a result of fierce driving the Maserati brakes weakened so much that it was only able to finish fourth, Caracciola's car broke down so that in the end an Alfa Romeo ran second.

When the Tunis Grand Prix was run in 1932, a Type 51 Bugatti, driven by Varzi, had won at 90.28, and another in the hands of Chiron had lapped at 93.8 m.p.h. In 1935 Varzi was having his first year with Auto-Union and this company relied solely upon him to repeat his previous victory. In this they took a well-judged risk, for with a 5-litre engine he had no difficulty in beating the 3.3-litre Bugattis, Scuderia Ferrari Alfas and Maseratis. One of the former, driven by Wimille, ran in second place throughout with a Maserati, confined to top gear, third. Comotti was fourth on a team Alfa and various older Alfas driven by relatively inexperienced drivers filled fifth and subsequent positions.

The Eifel Races on the Nürburg Ring were held in June, and as usual the German teams were there in force. Auto-Union had discovered a new star in B. Rosemeyer, an ex-motor-cyclist, who showed his skill by coming home only 2 sec. after the Mercedes-Benz of Caracciola despite finishing on only fourteen cylinders. Caracciola made the fastest (and new record) lap, but Rosemeyer showed that, perhaps, it was no disadvantage to approach the driving problems of unorthodox rear-engined racing cars with a mind unclouded by experience of orthodox types.

An Alfa Romeo finished third in the race with Chiron at the wheel. This make, with Nuvolari driving, also ran third in the Penya Rhin event, which Fagioli was permitted to win for Mercedes-Benz with Caracciola second.

Auto-Unions stood down for the Spanish race as they were busy correcting various troubles which presented themselves in the Eifel event and wished to have the cars perfected before the French Grand Prix at Montlhéry. This course now suffered the indignity of a chicane placed upon the straights so as to reduce average speeds, and in the hopes of repeating their victory of the previous year, Alfa Romeo enlarged the engine capacity of their cars to 3.5 litres. Bugatti also increased the cylinder capacity of his cars to 3.8 litres, but as was so often the case the single entry from this works was one of those assembled too late to become a serious competitor.

The race itself proved clearly that Auto-Unions were still suffering from technical troubles. Varzi, who had put up the fastest practice lap, suffered from continuous plug oiling, Stuck retired after the sixth lap with suspension trouble, Rosemeyer broke his transmission on the sixteenth lap. The first part of the race accordingly resolved itself into an immense struggle between Alfa Romeo and Mercedes-Benz, Nuvolari building up a lead of 8.4 sec. over Caracciola in the first twelve circuits and making the fastest lap of the day. Immediately afterwards the Italian had to retire with piston trouble, allowing the German cars to run first and second two laps ahead of a six-cylinder Maserati.

Mercedes-Benz repeated this victory in the Belgian Grand Prix at Spa, Caracciola again being the winning driver, and Fagioli again at variance with a pit control which asked him to run second when he felt able to move into first position without exceeding the stipulated r.p.m. In protest he handed over his car to von Brauchitsch, who proceeded to break the lap record for the course to finish second despite the time lost in the change-over. Once more an Alfa Romeo, driven by Chiron, finished third, and one of the team of 3.3-litre Bugattis ran fourth.

A week before this event Alfa Romeo had a walk-over at the Marne Grand Prix at Rheims, but no one really expected that they would be serious contenders for the German Grand Prix on the Nürburg Ring. The previous year they had finished no better than third, and although they had been able to repeat this position in the Eifel Races of 1935 it seemed that with both the German teams making every effort to win they were scarcely likely to prove victorious in what was now the most important race of the year. The first five laps confirmed this view of their chances for at this stage one Alfa had retired, Chiron was running fourth, Nuvolari sixth, and no other non-German car better than twelfth. What was to follow was a triumph of man over machinery on a wet road, when driving skill was at a premium. On the sixth lap Nuvolari began to put on speed and between then and the end of the ninth circuit he passed Rosemeyer, Chiron, Brauchitsch, and Fagioli. On the tenth lap he did even better and got past Caracciola, so that on the eleventh (half distance) he was in the lead. He then suffered a grievous misfortune for at his pit stop the hand refuelling pump broke down and an improvised method of replenishing the tank by churns substituted. In consequence he lost 2 min. 14 sec., whereas von Brauchitsch took only 47 sec. On the twelfth lap, therefore, Nuvolari was back in fifth position, but he rose to second on the thirteenth, on which he passed Caracciola, Rosemeyer and Fagioli, and became 1 min. 9 sec. behind von Brauchitsch. The latter pulled away somewhat by making a record average lap of 80.73 m.p.h. on his fourteenth circuit, but then, apparently feeling he had enough time in hand, slowed down to 77.6 m.p.h., 77.5 m.p.h. and 74.9 m.p.h. between the sixteenth and eighteenth laps. Nuvolari, *per contra,* crowded on speed and averaged 78.9 m.p.h., 79.2 m.p.h. and 79.3 m.p.h. for the same laps. He was, however, never able to make up more than 16 sec. a lap on Brauchitsch, and when they started the last circuit was still 35 sec. to the bad. On the face of it a German victory was assured, but the position indicator in front of the grandstand showed that with half a lap to go Nuvolari had got ahead. He crossed the line

2 min. 39 sec. before the Auto-Union, driven by Stuck, who was followed by Caracciola and Rosemeyer. Then, in fifth position, came a weeping Brauchitsch, whose car finished on the rim of the nearside wheel. He had a burst tyre and took 17 min. for his twenty-second lap, but no one could dispute the justice of Nuvolari's victory, for without the misfortune at his pit stop he would not have been out of the lead for the last half of the race.

Nuvolari and Alfa Romeo secured a second successive win at Leghorn in the Coppa Ciano with no other competitors of worth, but in the Coppa Acerbo, on the fast Pescara circuit, Auto-Union competed with a full team. Although a chicane was put on the long straight to reduce maximum speeds the Auto-Unions of Rosemeyer and Varzi were timed over a flying kilometre at 172 and 164.3 m.p.h. respectively, whereas the best speed achieved by Nuvolari was 147.1 m.p.h. This margin was too big to make up, and although Rosemeyer damaged his car in a skid he was able to finish second to Varzi, Alfa Romeos taking third to sixth positions.

This was the second victory of the year for the rear-engined cars, which had yet, however, to beat their German rivals. They met them once more, and were again defeated in the Swiss Grand Prix in which the now almost monotonous result of Caracciola first, Fagioli second, was witnessed, with a lap record by the latter.

Auto-Unions took their revenge in the Italian Grand Prix which was run over an artificial twisty circuit developed by placing five chicanes on the Monza track. At half distance Nuvolari's superb driving skill was paying its usual dividend ; he had made the fastest lap of the day and was in the lead. Unfortunately, his car then broke a piston, and although he took over from his team mate, Dreyfus, who was then lying fourth, he was unable to do more than be runner-up to the Auto-Union of Stuck, whose best lap was 2 min. 50.4 sec., compared to Nuvolari's 2 min. 49.8 sec.

No Mercedes-Benz could better 2 min. 53 sect. ; none of the team of four finished, and only one went more than half distance. Bugatti brought back his 3.3-litre cars but these were quite outclassed, Wimille making the best lap in 2 min. 59.2 sec.

It is worth noting that Nuvolari used an entirely new design of car at Monza, having not only independent springs to the front wheels, but also at the rear with a swing axle and transverse leaf. It had an eight-cylinder engine, 3.8-litre capacity, with one blower and the entire appearance of the car had altered. The P.3 design was now withdrawn from first-class racing.

The Mercedes-Benz disappointment in Italy was compensated by a sweeping one, two, three victory in the Spanish Grand Prix, for although an Auto-Union put in a record lap the highest position occupied by this make in the end was fifth. A 3.3-litre Bugatti driven by Wimille finished fourth, having at one time been as high as third. Nuvolari retired in the eighth lap.

The last race of the year was on the Brno circuit. Mercedes-Benz did not enter it, and Varzi on the Auto-Union gave every appearance of winning, until forced to retire on the twelfth lap. Rosemeyer who had hitherto run second took over the lead and the Alfa Romeo of Nuvolari, which was third, correspondingly went to second place, this being the finishing order, 1935 was definitely a Mercedes-Benz year. They were only beaten twice and only thrice did they fail to make the fastest lap. They were able to achieve this success with 4-litre engines against the opposition of Auto-Union with 4.95-litre power units, but it is true to say that the cornering and road-holding peculiarities of the rear-engined cars were such that no one had yet been able to drive them to full advantage, although Rosemeyer was an obviously promising recruit. Alfa Romeo had relied almost entirely upon Nuvolari, but had secured only one win in races against the German cars.

During 1935 the Italian concern were developing a V.12 4-litre engine and they were confident that with the extra power available from this they would be able to take full advantage of their new independently sprung chassis and reassert in 1936 the supremacy which had been theirs only two seasons before. Maserati also had a V type engine with eight cylinders under development, together with an all independently sprung chassis using torsion bars at the front and semi-elliptic springs at the rear. Bugatti had had a poor year, but confined new projects to a 4.7-litre engine fitted into a modified frame giving a central driving position.

Although more successful than Bugatti, Auto-Union also had a relatively unsuccessful season in 1935, having won only two of the International Grands Prix. For the ensuing year they embarked on considerable design changes without departing from Dr. Porsche's general concept.

It was found possible to increase the bore and stroke to 75 x 85 mm. without displacing the cylinder centres or increasing the overall weight and dimensions of the power unit, and the capacity was thus enlarged to 6.01 litres. With compression ratio, max. r.p.m., and manifold pressure all increased, the output was raised to 520 b.h.p.

The chassis dimensions were also changed slightly, the wheelbase being increased by some 4 in., which was devoted to a larger tank, fitted as before between the front of the cylinder block and the back of the driver's seat. The dry weight remained unchanged (and was, of course, still within the formula limit), and the all-round performance of the car enormously increased.

Mercedes-Benz also increased the capacity and output of their racing cars, bore and stroke for 1936 being 86 x 102 mm., giving a capacity of 4.74 litres with an output of 494 horse-power at 5,800 r.p.m. This larger engine was fitted into a new chassis, in which the wheelbase was shortened by some 11 in., the rear axle being considerably modified to cope with the increased engine torque.

The Mercedes-Benz team of drivers was simultaneously strengthened by the engagement of the vastly experienced Louis Chiron, and the works thus had the services of three drivers in the top flight with which to counter the problem of Nuvolari's special abilities with the Alfa Romeo. Auto-Union continued with Varzi and Stuck as their most experienced drivers, with Bernd Rosemeyer to back them up.

The first formula event of the year was as usual the Monaco Grand Prix, and any comparison with previous events was made impossible by appalling weather conditions and by a multiple crash which eliminated many of the fastest drivers at the outset.

After an early struggle between Nuvolari and Caracciola the latter went into the lead, whilst in the concluding stages Nuvolari was also passed by two Auto-Unions. As might be expected from these conditions the speeds were the slowest since 1930.

Mercedes-Benz then proceeded to contest the Tunis Grand Prix with great success, Caracciola and Chiron being first and second at half distance, to Rosemeyer's third. The Auto-Union driver subsequently speeded up ; then ran into trouble ; so also did Chiron's Mercedes-Benz, and it was the eight-cylinder Alfa Romeo which finished in second position. This race was run in mid-May and from this date forward the Stuttgart firm was to have an unbroken string of failures. Caracciola was beaten by 3 sec. by Nuvolari in the Penya Rhin Grand Prix, and in the Eifel Races, run in June, with shocking weather, Nuvolari and Rosemeyer were first and second well ahead of Brauchitsch and Caracciola at half distance.

During the second half the rain slowly turned to thick mist, so that only Rosemeyer was able to continue at almost undiminished speed and by converting a 9 sec. deficit to a 2 min. 13 sec. lead fully earned the title of *Nebelmeister*. Nuvolari, in second place, was followed by two other Alfa Romeos, Mercedes-Benz being fifth and sixth.

Nuvolari followed this race by beating Mercedes-Benz and Auto-Union at Budapest and Varzi alone at Milan ; the cars were then brought together for the German Grand Prix which was now indisputably the premier event of the year. Mercedes-Benz put in five cars and Auto-Union and Alfa Romeo four each and, interestingly enough, it was to be the youngest drivers of the day who were really to show their worth. Nuvolari could make little headway, and although Caracciola made the fastest lap for Mercedes in 10 min. 4.6 sec., the new-comer Lang ran him close at 10 min. 9.8 sec., and occupied second position from the end of the first to the seventh lap, led on the eighth, and was lying third on the thirteenth, when he retired. But with the exception of the first and the eighth laps (after a refuelling stop), Rosemeyer never moved from the first place. He raised the lap record from 80.73 to 85.52 m.p.h. and the final winning speed from 75.43 to 81.8 m.p.h., a fantastically large margin for a year's development.

Nuvolari drove a twelve-cylinder Alfa at Nürburg, but it was generally thought that it was then not running at its best. It did little better in the next event on the calendar, which was for the Coppa Ciano, run over a new and much faster course outside Leghorn.

On the first lap the latest Alfa had rear axle trouble and the team manager called in an older eight-cylinder car and handed it to Nuvolari, who then passed the whole of the Auto-Union team, which were the same cars which had run a week previously on the Nürburg Ring and were in consequence very tired.

The race has an historic value for it was the last occasion that year when Alfa Romeo finished in front of either Mercedes-Benz or Auto-Union.

The latter had a full team of properly prepared cars available for the Coppa Acerbo on the Pescara Circuit over which two of their cars were clocked at 183 m.p.h. over a kilometre. The 4-litre, twelve-cylinder Alfa Romeo showed a maximum of 152 m.p.h., and in the face of such a tremendous handicap upon the straights the car was doomed to failure. Rosemeyer eventually won by the remarkably large margin of 6 min. from his team-mate Von Delius, and Varzi was third, having suffered a lot of tyre trouble. The latter made the fastest lap, which was a little slower than the speed obtained the previous year.

Rosemeyer won his second race in succession (and three out of four events) at Berne in the Swiss Grand Prix. Mercedes-Benz entered four cars and Bugatti also brought out his new 4.7-litre model with which, however, he had little fortune. Caracciola had made the fastest lap in practice and he kept ahead of Auto-Unions the first eight laps. Nuvolari was also well up, in fact at the end of five laps only fractions of a second separated the leaders. By the tenth lap, however, Rosemeyer was leading Caracciola by 4 sec., Lang in another Mercedes-Benz was third, Varzi in an Auto-Union fourth, Brauchitsch fifth, and Nuvolari sixth, 42 sec. behind. Rosemeyer was taking no chances and broke the lap record on the eleventh and again on the fifteenth circuits, whereas Nuvolari ran into trouble and had to abandon. In the last half of the race all the Mercedes-Benz team had trouble and all three positions were annexed by Auto-Union. Rosemeyer raised the lap record by nearly 5 m.p.h. and the final average speed by 10 m.p.h.

The unorthodox Auto-Union design could only be driven to the limit by a man with altogether abnormally quick reaction times. Rosemeyer proved himself to be such a one and secured his third victory in succession, and the fourth out of five races, in the last European event, held on part of the Monza Circuit. Again he made the fastest lap and again Nuvolari proved a challenger, using the twelve-cylinder Alfa Romeo.

The opening laps were fought out between Stuck on an Auto-Union and Nuvolari, but the former left the road which enabled Rosemeyer to win by a margin of 2 min. 20 sec. from the Alfa.

The last time in which European and U.S.A. cars had run together in Europe was in the 1933 Monza Grand Prix in which Trossi drove a specially constructed 4.43-litre Duesenberg which retired in the first heat. To find any serious competition we have to go back to 1927, in which year two front-drive Millers and a Duesenberg competed in the European Grand Prix at Monza, one of the former coming in a very bad third. But in 1936 Nuvolari had a final, if extra European, win in an unusual race run in the U.S.A. For the first time since the 1914-18 war an international " road " race was run, although on a highly artificial enclosed circuit. It was, in fact, something of a cross between a dirt-track event and a road race in the European understanding of the term, but was dominated by European entries. Nuvolari, to the astonishment of the Americans, scored an exceedingly easy victory at nearly 66 m.p.h. over Wimille on a Bugatti, and also made the fastest lap.

The Vanderbilt Trophy showed how much the road worthiness of U.S.A. racing cars had been neglected, for although in practice Nuvolari lapped 69.92 m.p.h., the fastest of any U.S.A. designed car was at 66.55 m.p.h. No American car finished the race in the first six places, and the highest race average was 60.48 m.p.h.

The years 1935 and '36 had proved fruitful ones for German cars, although it is interesting to observe that in 1935 it was Mercedes-Benz who were virtually all conquering, whereas 1936 was definitely an Auto-Union year, Mercedes-Benz having only two victories at the beginning of the season and ending the year by withdrawing the team which had been entered in the Italian Grand Prix. Maserati and Bugatti virtually disappeared from serious racing during this period, but the combination of Alfa Romeo, plus Nuvolari, was still able to spring surprises ; it is significant that without Rosemeyer's driving for Auto-Union, Alfa Romeo would stand in the records as winners of six out of the thirteen most important races of the year, The value of these two drivers to their particular companies can be shown by taking the best lap in 1936 on a relatively slow course such as the Nürburg Ring and a very fast one such as at Berne and comparing the times they put up with the next best driver on the same make and type of car. Thus :

1936 LAP TIME VARIATIONS

Course	*Cars and Drivers*			
	Alfa Romeo		*Auto-Union*	
	Nuvolari	*Brivio*	*Rosemeyer*	*Stuck*
Nürburg Ring	10 min. 14 sec.	10 min. 28 sec.	9 min. 56.6 sec.	10 min. 22.6 sec.
Swiss G.P.	2 min. 41.5 sec.	2 min. 45.2 sec.	2 min. 34.5 sec.	2 min. 39.5 sec.

These figures also show that in the 1936 stage of automobile design a super excellent driver on a relatively inferior car was more than a match for a first-class driver on a first-class car ; hence, the tradition of motor racing as a battle between men, as well as a struggle between machines, still had limited validity.

CHAPTER THIRTEEN

Year of Titans

RACING STATISTICS 1937

Date	Event	Course	Driver	Car	Average Speed m.p.h.	Lap Speed m.p.h.
6/6/37	Rio de Janeiro G.P.	Gavea	C. Pintacuda	Alfa Romeo	51.5	—
13/6/37	Eifel Races	Nürburg Ring	B. Rosemeyer	Auto-Union	82.56	85.13
20/6/37	Milan G.P.	Milan	T. Nuvolari	Alfa Romeo	64.4	67.8*
5/7/37	Vanderbilt Cup	Roosevelt Field	B. Rosemeyer	Auto-Union	82.95	—
5/7/37	,, ,,	” ”	R. Caracciola	Mercedes-Benz	--	84.5*
11/7/37	Belgian G.P.	Spa	R. Hasse	Auto-Union	104.87	—
11/7/37	,, ,,	Spa	H. Lang	Mercedes-Benz	—	108.8*
25/7/37	German G.P.	Nürburg Ring	R. Caracciola	Mercedes-Benz	82.77	—
25/7/37	,, ,,	,, ”	B. Rosemeyer	Auto-Union	—	85.57*
8/8/37	Monaco G.P.	Monaco	M. von Brauchitsch	Mercedes-Benz	63.25	—
8/8/37	,,	”	R. Caracciola	Mercedes-Benz	—	66.99*
15/8/37	Coppa Acerbo	Pescara	B. Rosemeyer	Auto-Union	87.61	92*
22/8/37	Swiss G.P.	Berne	R. Caracciola	Mercedes-Benz	97.42	107.14(P)
12/9/37	Italian G.P.	Leghorn	R. Caracciola	Mercedes-Benz	81.59	84.5*
26/9/37	Czechoslovak G.P.	Brno	R. Caracciola	Mercedes-Benz	85.97	94.89*
2/10/37	Donington G.P.	Donington	B. Rosemeyer	Auto-Union	82.86	85.62
2/10/37	Donington G.P.	Donington	M. von Brauchitsch	Mercedes-Benz		85

* Record

WHILST the races of 1936 were being contested the terms for a future formula were being argued.

Under the terms agreed in October, 1932, the 750 Kg. maximum weight formula expired at the end of 1936, but. although discussions began on the subject of future rulings in the winter of 1935-36, no decision was agreed until September, 1936. It was by then impossible for constructors to build new cars and have them ready for the ensuing season, and the maximum weight regulations were, therefore, given a further lease of life and remained in force for 1937. During this year, however, design teams were concentrating on 1938 models and there was every temptation to make do with unchanged types for the current year. Mercedes-Benz were an exception in this respect for their 1936 model had proved so disappointing that they were well ahead with a replacement which had an entirely new design of frame and front and rear suspension systems. They were able to graft an eight-cylinder engine of 5.6-litre capacity into this chassis without exceeding the weight limit and hence, for the first time since the beginning of 1934, they were competing with Auto-Union on an equal footing in respect of engine capacity. Both of these cars were now powered with engines developing over 500 b.h.p. and were capable of some 200 m.p.h. Grand Prix racing in 1937 was, indeed, a struggle between Titans, and it is improbable that racing cars with piston engines will ever again have such incredibly high performance factors, nor make such stringent demands on the skill, the nerve, and, above all, the discretion of the drivers. Of the latter Varzi retired from the Auto-Union team and was replaced by Fagioli, who left Mercedes-Benz. The latter Company added Zehender and Richard Seaman to their number, and with Lang had, therefore, five drivers plus Kautz in reserve.

Alfa Romeo had V12 4-litre cars with independent suspension all round, but as these were giving not more than 400 h.p. they were obviously handicapped on fast circuits. On twisty roads with comparatively low race averages they thought that the skill of Nuvolari would offset the deficiency in engine power, but somewhat ironically, on the first occasion during the year when an Alfa Romeo came into first place it was their second string, Carlo Pintacuda, who was the driver. This was in a race run outside Rio de Janeiro and the Italians beat Stuck on an Auto-Union by a narrow margin of 4 sec., and at the very low average speed of 51.5 m.p.h. Then as late as mid-June, Nuvolari beat a lone Auto-Union, driven by Hasse, on the Milan circuit, the Alfas of Farina and Ruesch being second and third.

Formula racing in Europe started with the Eifel Races on June 13th, run as usual on the Nürburg Ring. On the first lap the new Mercedes-Benz was first, third and fourth, Rosemeyer on the Auto-Union being 5 sec. behind Caracciola who led ; subsequently Rosemeyer went into, and held, the lead and although Mercedes-Benz finished second and third they all experienced fuel pump trouble.

This was Rosemeyer's third successive win on this famous circuit and on this occasion the Alfa Romeo-Nuvolari combination could achieve no better than fifth place.

Auto-Union, Mercedes-Benz and Alfa Romeo each sent two cars to the U.S.A. for the second race of the Vanderbilt Trophy on the Roosevelt Speedway. The organisers had acted upon the criticisms of the track made the previous year and had considerably revised it so as to reduce the number of corners. At the start Caracciola led Rosemeyer, and an American driver, Rex Mays, ran third, driving a 3.8 Alfa Romeo which had been modified by its owner-driver by the addition of a centrifugal supercharger. He held third position for practically the entire race, keeping comfortably ahead of the two official Alfa Romeo entries, but was overwhelmed by Rosemeyer, who won fairly easily at 82.56 m.p.h. Caracciola retired after twenty-two laps, and although Seaman made a brave struggle and finished second, he was as yet too new in this class of racing to cope with his highly experienced rivals. The first American car finished seventh at 67.6 m.p.h., the results thus confirming the technical lessons of the previous year.

There being no transatlantic passenger air service in 1937, participation in the U.S.A. event automatically excluded the cars and drivers running therein from the Belgian Grand Prix run the week following. Nevertheless, remarkable speeds were achieved. The lap record had been set up in 1935 by Brauchitsch on the 4-litre Mercedes-

Benz at 103.7 and was now raised by this same driver on the new 5.66-litre model to 105.6 m.p.h. Stuck, however, on the 6-litre Auto-Union was even faster, doing 107.7 m.p.h. and was timed over a flying kilometre at 175 m.p.h. Fastest of all was the relatively new-comer Lang who put in the eighteenth lap at an average of 108.8 m.p.h. and whose Mercedes-Benz was timed over the kilometre at the astonishing speed of 193 m.p.h. None of these three, however, was destined to be the winner. Stuck had a long stop at quarter distance which dropped him to fifth position after which he recovered to second, von Brauchitsch retired on the eighteenth lap and Lang had a number of stops and finished third. In consequence, it was the relatively unknown Hasse on an Auto-Union who led for almost all the last half of the race to finish at the highest average speed yet realised on this extremely fast and dangerous circuit.

The now all-important German Grand Prix was staged on the Nürburg Ring at the end of July. It is significant that whereas Mercedes-Benz and Auto-Union each entered teams of five cars Alfa Romeo ran only two works' models and no other concern troubled to make a direct entry.

In practice there was intense competition to make the fastest lap, this being eventually achieved by Rosemeyer who, taking abnormal risks, made a circuit at 87 m.p.h. Lang on a Mercedes-Benz took 6 sec. longer and averaged 86.2 m.p.h., whilst the best Alfa Romeo's time was 22.2 sec. longer than the Auto-Unions, the average being 83.9 m.p.h. As usual the best practice lap was not equalled in the race, fastest being Rosemeyer's second at 85.57 m.p.h., Caracciola doing best for Mercedes-Benz at 85.4 m.p.h., and Nuvolari improving slightly to 84.4 m.p.h. Rosemeyer was frustrated in his ambition to secure four successive wins on this track for Auto-Union, as on his fourth lap he hit the side of the road with such violence that he damaged not only a wheel but the hub cap. A stop of 2 min. 28 sec. whilst the wheel was changed dropped him to tenth position and with further stops for tyres on the eleventh and seventeenth laps he could do no better than finish third 61 sec. behind Caracciola, who drove a steady race, never being lower than second from the third lap onwards. Lang led at the start but towards the end damaged a tyre a long way from the pits and dropped to seventh position. This allowed Brauchitsch to finish second, Seaman having been eliminated by a collision with the Auto-Union driver, von Delius, on the sixth lap. Auto-Union secured fifth position with Hasse, but Stuck retired on the seventh lap when running eleventh. Although unable to finish in the first three Nuvolari came in fourth, 4 min. 4 sec. after the winner, and the Alfa Romeo averaged 80 m.p.h., which would have sufficed to bring it into second position the previous year, and a speed better than the lap record of 1934.

Mercedes-Benz had won the Monaco Grand Prix two successive years and they achieved the hat trick with a decisive win in 1937. Nuvolari was absent testing out a new and much lower twelve-cylinder Alfa Romeo. From start to finish the race was the scene of a fantastic duel between two of the new Mercedes-Benz cars driven by Caracciola and von Brauchitsch. In defiance of team orders the latter forced his leader to travel flat out in order to hold a lead of 27 sec. at the end of forty laps ; Brauchitsch then went by, and at the end of sixty laps led by 34 sec. Caracciola then really decided to show what he could do and raised the lap record to 64.98 m.p.h., and shortly afterwards to 66.99 m.p.h. This effort gave him a lead of 26 sec. in the eightieth lap but led to a pit stop during the course of which Brauchitsch passed to win at 63.25 m.p.h., that is to say over 3 m.p.h. faster than the previous record for one lap only. Auto-Union had a poor race, Rosemeyer retiring when third and then taking over Stuck's car to finish fourth. He made his fastest lap at 65.2 m.p.h. with Farina doing the best for Alfa Romeo.

Auto-Union supremacy at Pescara in the race for the Coppa Acerbo was now as traditional as a Mercedes-Benz victory at Monaco. In 1937 practice both Rosemeyer and Stuck put up extremely fast times, as did Caracciola, and by the time the race settled down Rosemeyer was in the lead to the accompaniment of a record second lap at 92 m.p.h. and Caracciola was second. Both the leaders had stops for tyres in the eighth lap. Caracciola's car had trouble with its camshaft bearings and was handed over to Seaman who had the engine on fire and eventually finished fifth. Rosemeyer then won at a record speed and Brauchitsch finished second.

The performance of the new Alfa Romeo was a great disappointment, it retired early in the event, and was withdrawn from participation in the Swiss Grand Prix at Berne the following week. This race was run over wet roads and the remarkable speeds put up by the Auto-Unions the previous year remained unequalled, although in practice both the Mercedes-Benz and the Auto-Union broke the existing lap record with speeds of 107.14 and 106.8 m.p.h. respectively, the drivers being Caracciola and Rosemeyer. In the race the former led throughout and the latter had to be content with making the fastest lap average of 104.7 m.p.h. after he had run off the road and ditched his car in the first lap and had taken over from Nuvolari on the eighth lap. The Italian had practised on one of these rear-engined cars before the 1934 Czechoslovak Grand Prix at Brno. In the Swiss Grand Prix he made no effort to do more than familiarise himself with the cars and after losing No. 6 on the entry list he took over No. 4 from Fagioli, and finished seventh. Alfa Romeo were in a sorry plight without him, and were placed never better than sixth with their fastest car flagged off three laps in arrear at the end of the race. The best lap of these cars (both twelve-cylinder models) was 100 m.p.h.

The German and Swiss Grands Prix offer examples of races run consistently on one course. The Italian Grand Prix on the other hand, after many years on the full length of the Monza circuit had, since the inception of the 750 Kg. formula, been run on varying sections of it with chicanes. In 1937, tradition was even more strongly violated as the event was run over the Leghorn Circuit which had been used for the Coppa Ciano in the previous year. On this occasion Auto-Union had been slighted by Alfa Romeo as a consequence of poor maintenance and Nuvolari had scored one of his frequent personal triumphs. Twelve months afterwards his Alfa Romeo finished seventh and last, and both Caracciola and Lang got their Mercedes-Benz cars round at 84.5 m.p.h., the former winning under team orders at a speed substantially in excess of Nuvolari's prior lap record. Rosemeyer was fastest for Auto-Union, but since the beginning of the season the Mercedes-Benz Engineering Department had increased the output of their straight-eight 5.66-litre engine by over 75 b.h.p., and this in conjunction with their new stiff frame, soft springing and De Dion type rear axle made them virtually invincible, and Auto-Unions relied upon Rosemeyer producing super-human driving skill in every race. In the Czechoslovak Grand Prix he did this very thing. During the first eight laps Lang ran his Mercedes-Benz off the road trying to keep up with him and even a record lap by Caracciola at 94.89 m.p.h. was insufficient to put him into first position, although Rosemeyer did no better than 92.8 m.p.h. The leader then over-steered his car into the kerb and bent the wheels so badly that he could no longer continue, but after walking 1½ miles to the pits he took over the only other car in the team that was running and passed Seaman to finish third. Caracciola had no difficulty in finishing first.

The last formula race for 1937 and *ipso facto* the last of the 750 Kg. formula was run in England over the road circuit in Donington Park. Auto-Union ran three and Mercedes-Benz four cars, which were the only modern types on the course. Von Brauchitsch, indicated that Mercedes-Benz were the fastest cars by putting in a practise lap at 86.01 m.p.h., the best Auto-Union doing 85.36 m.p.h. with Rosemeyer at the wheel. It is a matter of interest that a Maserati which had raced under the same formula in 1934 lapped at 77.59 m.p.h. In the beginning part of the race two Mercedes-Benz, driven by Lang and Brauchitsch ran first and second with Rosemeyer third, but the former had trouble with his front suspension system and withdrew, so that at half distance, when all the leading cars had made stops for tyres and petrol, Brauchitsch led Rosemeyer by 24 sec. In the second part of the race Brauchitsch was the first of the two leaders to make a routine pit stop and he refuelled and changed both rear tyres in 31 sec. on the fifty-second lap. Rosemeyer delayed his stop until the sixty-second lap and took 32.8 secs. for the same operation, but on the previous circuit the whole aspect of the race had been changed when Brauchitsch lost the tread from a front tyre and had to cover over half a mile at reduced speed as well as losing 28 sec. for the unexpected wheel change. Following this he could win only by making up a deficit of 31 sec. in the last seventeen laps. That is in less than 45 miles. So far from so doing he actually finished 37.8 sec. behind the Auto-Union with Caracciola third. The latter had a no-trouble. trip, but appeared to misjudge the pace at which the race would be run. His steadier driving took him through with only one pit stop, but the advantage he so gained was insufficient in the face of the brilliance of his two young rivals, who tied for fastest lap during the race.

The 1937 results show that Mercedes-Benz reasserted their technical superiority. They were sufficiently enterprising to develop an entirely new eight-cylinder engine for this season alone and with it they had a gross power output much exceeding the larger Auto-Unions with their V-type, rear-mounted power units. The combination of 20 per cent more power with a stiff frame and De Dion rear suspension gave them a superior performance on corners coupled with equal or greater speed on the straight.

In the Monaco and Swiss Grands Prix Mercedes-Benz filled the first three positions, in the German, Italian and Czechoslovak Grands Prix they ran first and second. Auto-Unions, on the other hand, had only one race, the Belgian Grand Prix, in which they filled the first two positions, all their other victories being single-handed efforts by the prodigy, Bernd Rosemeyer.

It will be clear from this brief summary that Alfa Romeo were by now completely out of the picture. In European races they had to be content with fourth in the German Grand Prix and fifth in the Czechoslovak and Belgian Grands Prix. The temporary collapse of Mercedes-Benz in 1936 had, in fact, resulted in an over-estimation of Italian merit, and during 1937 so far from narrowing the gap, Alfa Romeo fell farther behind. This was only to be expected in view of the immense difference in the resources available as between the German constructors and the rest of the world. By 1937 the German teams travelled with imperial pomp accompanied by a great cavalcade of mobile workshops, spare cars, engines, tyre technicians, carburetter experts and so on. At the factory resources equivalent to a good sized works were constantly available for the racing teams alone, and both companies could draw on the exclusive services of 300 skilled men at any time if they so desired. The cost amounted to approximately £¼mil. in the case of each company and was justified not only by the direct technical and advertising benefits accruing to the companies themselves but also by the immense value as propaganda for the German industry and the Nazi way of life.

The four racing seasons of the 750 Kg. formula had started as a struggle between Auto-Union and Mercedes-Benz ; Alfa Romeo and Maserati ; and Bugatti. By 1936 only three cars counted, the two German makes and Alfa Romeo. 1937 saw the virtual elimination of the last named as a serious competitor and the stage was now set for a 3-litre formula which was to be a demonstration of absolute German superiority.

CHAPTER FOURTEEN

Absolute Supremacy

RACING STATISTICS 1938-39

Date	*Event*	*Course*	*Driver*	*Car*	*Winning Speed m.p.h.*	*Fastest Lap m.p.h.*
10/4/38	Pau G.P.	Pau	R. Dreyfus	Delahaye	54.64	—
10/4/38	,,	,,	R. Caracciola	Mercedes-Benz	—	57.86*
23/4/38	Cork G.P.	Carrigrohane	R. Dreyfus	Delahaye	92.5	95.71*
3/7/38	French G.P.	Rheims	M. von Brauchitsch	Mercedes-Benz,	101.3	—
3/7/38	,,	,,	H. Lang	Mercedes-Benz	—	105.87*
24/7/38	German G.P.	Nürburg Ring	R. Seaman	Mercedes-Benz	80.75	83.76
31/7/38	Coppa Ciano	Leghorn	H. Lang	Mercedes-Benz	85.94	89.17*
31/7/38	,,	,,	M. von Brauchitsch	Mercedes-Benz	—	89.17*
14/8/38	Coppa Acerbo	Pescara	R. Caracciola	Mercedes-Benz	83.69	—
14/8/38	,,	,,	L. Villoresi	Maserati	—	87.79
21/8/38	Swiss G.P.	Berne	R. Caracciola	Mercedes-Benz	89.44	—
21/8/38	,,	,,	R. Seaman	Mercedes-Benz	-	103(P)
11/9/38	Italian G.P.	Monza with chicane	T. Nuvolari	Auto-Union	96.7	—
11/9/38	,,	,,	H. Lang	Mercedes-Benz	—	101.38*
22/10/38	Donington G.P.	Donington Park	T. Nuvolari	Auto-Union	80.49	83.71
2/4/39	Pau G.P.	Pau	H. Lang	Mercedes-Benz	56.09	—
2/4/39	,,	,,	M. von Brauchitsch	Mercedes-Benz	—	57.83
21/5/39	Eifel Races	Nürburg Ring	H. Lang	Mercedes-Benz	84.14	86*
26/6/39	Belgian G.P.	Spa	H. Lang	Mercedes-Benz	94.39	109.12
9/7/39	French G.P.	Rheims	H. Müller	Auto-Union	105.25	—
9/7/39	,,	,,	H. Lang	Mercedes-Benz	—	114.87*
23/7/39	German. G.P.	Nürburg Ring	R. Caracciola	Mercedes-Benz	75.12	81.66
20/8/39	Swiss G.P.	Berne	H. Lang	Mercedes-Benz	96.02	—
20/8/39	,,	,,	R. Carraciola	Mercedes-Benz	—	104.32
3/9/39	Yugoslav G.P.	Belgrade	T. Nuvolari	Auto-Union	81.21	83.9*
3/9/39	,,	,,	M. von Brauchitsch	Mercedes-Benz	—	83.9*

* Record

THE formula (agreed in September, 1936) to have effect in 1938, '39 and '40 was based on a sliding scale relationship between engine c.c. and minimum weight and assumed the equivalent capacity of a supercharged engine to be two-thirds that of an unblown type. The minimum engine size permitted was 666 c.c. supercharged, the maximum 4½-litre unsupercharged, but as frontal area does not vary in relation to engine size and as the fixed items-drivers, wheels, tyres, etc.-form an increased handicap on the smaller sizes of engine everything indicated that constructors would choose the largest swept volume in one of the two categories. Informed opinion held that a 3-litre supercharged engine would be clearly superior to any possible 4½-litre atmospheric induction competitor and hence no surprise was registered when it became known that Alfa Romeo, Auto-Union and Mercedes-Benz had all fitted superchargers to short stroke, high r.p.m., 3-litre power units.

Alfa Romeo introduced an entirely new car, the type 308, having an eight-cylinder engine with virtually the same dimensions as the celebrated P.3 Type B which they had used in 1934. Over 300 b.h.p. at 6,000 r.p.m. was claimed for this design, which was fitted into the new low chassis with all independent suspension which had housed a V.12 engine in the Coppa Acerbo and Italian Grand Prix of the previous year. Alternative V-type engines with twelve and sixteen cylinders were available, the former having a bore and stroke of 63 x 73 mm. (for which an output of 320 b.h.p. was claimed), and the latter cylinders 58 x 70 mm. which had an estimated 350 b.h.p.

Auto-Unions produced a new rear-engined car similar to those used in the previous four years, but of entirely new design. Dr. Porsche was no longer employed as a consultant so that the new car was designed under the direction of technical director Werner, engineer Fuereisen and developed by Eberan von Eberhorst. The tubular frame and Porsche type trailing link I.F.S. were retained, but the steering geometry improved and a De Dion type suspension system was substituted for swing axle at the rear. The engine was a 90 degree V.12 in place of the 60 degree V. 16, and the greater spread of the cylinders made it impossible to continue the ingenious valve gear layout, using only one camshaft, characteristic of the Porsche model. The new engine had a single camshaft operating the inlet valves in both blocks with separate exhaust camshafts on the outer side of each block. As a result of the shorter engine and as a consequence of replacing the fuel tank behind the driver by a pair placed outside the frame members it was possible to bring the driver's seat a good deal farther back on the frame, a change that did not greatly affect the weight distribution but did give a somewhat more orthodox view of the road which, it was thought, would help the drivers to raise lap speeds.

The Auto-Union driving team suffered a tragic, irreparable, loss in February, 1938, when the brilliant Bernd Rosemeyer was killed in a record attempt on the Frankfurt-Darmstadt Autobahn. This blow was the more serious since Stuck had officially left the team and this threw the whole burden of responsibility on the relatively inexperienced R. Hasse and H. Müller, who were reinforced by C. Kautz, who had had occasional drives for Mercedes-Benz. To meet this situation Stuck was prevailed upon to return, whilst for the German Grand Prix and subsequent races the company had the good fortune to secure the services of the incomparable Nuvolari. The loss of Rosemeyer was, however, a grievous handicap in developing the cars through their early tests.

The Mercedes-Benz picture was by contrast a bright one. They had three top-notch drivers, Caracciola, von Brauchitsch and Lang, with Seaman as a recruit of the highest order. The cars were based on the 1937 chassis, the frame and rear suspension of which were retained unchanged and with only minor modifications to the front suspension and transmission. A V.12 engine was used but this again was no novelty, for in 1936 and 1937 engines of this kind having between 5- and 6-litre capacity had been used for record breaking and non-formula races at A.V.U.S.

Both the German cars had over 400 b.h.p. available.

Bugatti decided to make a limited return to racing with a straight-eight 3-litre engine in the latest type chassis with central driving position, which had had a brief run in the 750 Kg. formula, and in addition two French constructors, Delahaye, with a V.12 engine, and Talbot, with a six-cylinder power unit, decided to demonstrate the possibilities of *circa* 200 b.h.p. from 44 litres without supercharger.

One of these unblown types created something of a sensation by winning the first race of the new formula held over a winding circuit at Pau in April. Auto-Unions were not ready to start in this event and the full Alfa Romeo team of three cars was withdrawn after Nuvolari had found his car on fire, caused by a flexing chassis, which had split the fuel tank. The driver suffered from burns and shock and this was his last appearance for the Italian company. Before this mishap practice had shown that Nuvolari and the 4½-litre twelve-cylinder Delahaye were both equal in speed to the 3-litre, supercharged Mercedes-Benz, two of which were entered. The car driven by Lang, however, had to be withdrawn before the race started, and at half distance Caracciola had gained only 6 sec. from Dreyfus on the Delahaye. The enormous fuel consumption of these new, highly supercharged types now became evident, for within less than ninety miles the German car had to call at the pits to refuel. This took only 50 sec., but was sufficient to let the French car go into the lead, and with Mercedes-Benz experiencing subsequent trouble with the gear change the Delahaye won by a lap.

This was the first French win in a major race since the Belgian Grand Prix of 1934, and it was followed by a second victory for the same marque in the Cork Grand Prix a fortnight later. In this event Bugatti also entered one car, driven by Wimille, and this put up the fastest speed over a measured kilometre at 147.25 m.p.h., Dreyfus doing 145 m.p.h. and Bira on a 1934 Maserati, originally built for the 750 Kg. formula, 138 m.p.h. Dreyfus' Delahaye made the fastest lap and with the Bugatti suffering from misfiring he had no difficulty in keeping ahead of the old Maserati despite slowing down for the last few laps.

Neither of the traditional non-formula A.V.U.S. and Eifel Races was held and it was therefore comparatively late in the year that Auto-Unions and Mercedes-Benz came into competition in the French Grand Prix held on the Rheims circuit, which had for many years been the scene of the Marne Grand Prix. The fastest lap so far recorded had been 101.9 m.p.h. by the P.3 Type B Alfa Romeo, but in 1938 practice this speed was exceeded by four Mercedes-Benz drivers and three Auto-Unions, the best figures being Mercedes-Benz (H. Lang) 109.6 m.p.h., Auto-Union (C. Kautz) 107.4 m.p.h., and then, very much slower on this type of course, a 4½-litre six-cylinder Talbot (R. Carriere) at 98.4 m.p.h. Mercedes-Benz entered only three cars and this led to Seaman standing down, although he had made the second fastest lap in practice.

Auto-Union also entered three cars, but only two started. This team had considerable misfortune in practice, for a fully streamlined car devised for this very fast course was overturned by Hasse, and Müller crashed on one of the more normal types and had to go to hospital. Thus only Kautz and Hasse came to the starting line and both crashed before finishing the first lap. The single Bugatti retired at the pits with a broken oil pipe, and so, from the second lap onward, the race degenerated into a high speed tour with three Mercedes-Benz in the lead by so great a margin of speed over the unblown cars that they could take things easily and yet win by fifty miles. Lang made the fastest lap of the race at 105.84, and von Brauchitsch won at a speed almost equalling the previous lap record.

Much of the Auto-Union trouble at Rheims was due to improper shock-absorber settings, but practice for the German Grand Prix showed that the cars as a whole were still far from ready for serious racing.

Alfa Romeo ran a team, but Nuvolari appeared as senior driver for Auto-Union. It was the third occasion on which he had driven a rear-engined car, but it was apparent that he had not immediately mastered the specialised handling problems involved, for his best lap was at 80.5 m.p.h., whereas von Brauchitsch on a Mercedes-Benz put in a practice lap of 86.6 m.p.h. As in the French race, so in the German, the first lap may be considered decisive for Nuvolari damaged his car in a skid and had to retire on the second circuit. By the third lap all the Alfa Romeo cars were out of the picture and the Mercedes-Benz driven by Lang was experiencing ignition trouble. This left Seaman chasing von Brauchitsch. On lap six the Englishman made the fastest circuit of the day, on the seventh he went into the lead (whilst Brauchitsch had both wheels changed in 44 sec.), and on the eighth came in for his own refuel and tyre change, which was accomplished in 52 sec. This put him back into second position again. The two rivals maintained their relative stations until the sixteenth lap, when they both came in to refuel, which they were doing at intervals of 113 miles on cars which carried 70 gallons of fuel. The pressure pumps were capable of delivering this volume in 60 sec. and the tanks had small windows so that the mechanic could gauge the cut-off point. This was misjudged on Brauchitsch's car and led to a large gallonage overflowing. The car was not pushed clear before restarting and a moment after the portable electric starter was engaged the car was a mass of flames immediately in front of Seaman, who was just about to get away. Seaman was only slightly impeded and after a stop of 68 sec. he took a lead from which he was never displaced. Lang took over Caracciola's car and finished second; Nuvolari took over Müller's Auto-Union and finished fourth. Stuck took third place with his Auto-Union, but was almost nine minutes slower than Seaman.

From the Coppa Ciano Auto-Union stood down and this allowed Mercedes-Benz to win with the greatest of ease from both the eight- and twelve-cylinder Alfa Romeos, Lang and Brauchitsch tying for fastest lap. Lang won after Brauchitsch had gone over the line first only to be disqualified for receiving outside assistance after a slight accident.

The principal feature of the day's racing was the astonishing performance put up by Count Trossi on a new 3-litre straight-eight Maserati with a conventional rigid rear axle. He had made best practice time on each day, and on the fourth lap passed from third to first position. This, however, led to engine trouble and it is likely that the German cars had something in reserve as their best lap in the race was better than anything they achieved during the practice periods.

Auto-Union had taken first position in the Coppa Acerbo in the previous three years and they tried during the interval provided by the Leghorn race to get their cars into full racing condition for this event. But although Nuvolari was clearly mastering his new mount they failed again through mechanical troubles. A Mercedes-Benz finished first and the twelve-cylinder Alfa which had been awarded second place at Leghorn was second again at Pescara. A Maserati made the fastest lap of the day so the Italian crowd was not too ill pleased.

With more than half of the season's races completed it was evident that although the new highly supercharged 3-litre cars were almost equal in speed to their 6-litre predecessors (Caracciola was timed at 170.90 m.p.h. at Pescara), they were by no means equal in reliability, so that often the Germans were achieving victory with only one car running at the finish.

The Swiss Grand Prix showed that the minor troubles of the Mercedes-Benz team were well on the way to being sorted out, but that Auto-Union were still not clear of their problems. Seaman proved that he was worthy of his win in the German Grand Prix by making fastest practice lap at a speed of 103 m.p.h. and Stuck was fastest for Auto-Union at 100.2 m.p.h. The best Alfa Romeo speed was 99.5 m.p.h.

The race was run in heavy rain, Caracciola had long been acknowledged *Regenmeister,* and although Seaman held the lead for many laps and made the fastest circuit of the day he eventually lost to his team leader by 24 sec. Brauchitsch completed the Mercedes-Benz triumph by running third. Stuck and Farina ran fourth and fifth on an Auto-Union and Alfa Romeo respectively, and the rest of the field finished far behind. Clearly, however, Auto-Unions were now rapidly improving and they scored their first 1938 win in the Italian Grand Prix held in mid-September.

After the previous year's excursion to Leghorn the race returned to Monza (on which track an entirely artificial course had been marked out with chicanes) and for once it was Mercedes-Benz who had an exceedingly poor day. Caracciola on his second lap made one of his very rare errors of judgment, hit a chicane and stopped his engine. Although he restarted the car, it suffered during the race from over-heating. On the seventeenth lap Seaman's car caught fire and shortly afterwards Lang and Brauchitsch also retired. At one time it looked as though Auto-Union would be first, second and third, but Stuck ran off the road and two laps from the finish Müller had engine trouble. This left Nuvolari with an easy win over Farina's Alfa Romeo, with Caracciola a poor third, over ten minutes behind the winner. Lang, however, had made the fastest lap and it remained arguable that the Mercedes-Benz was the fastest racing car of the year.

The Donington Grand Prix in England showed the real merit of the 1938 version of the rear-engined car. Auto-Union had won this race the previous year, aided somewhat by an unlucky tyre failure which put Brauchitsch out of the lead. In the 1938 race there were two Auto-Unions and four Mercedes-Benz cars in the best six practice times and one of the latter made absolutely the fastest time. In the race itself, however, Nuvolari made the fastest lap, and either he or Müller held the lead up to the thirty-second lap. Half distance (forty laps) saw Müller first, Lang on a Mercedes-Benz second, and Nuvolari third ; but these places had been decisively affected by an incident on the thirtieth lap when the engine of Hanson's Alta disintegrated and dropped oil over the track, so that on the thirty-first lap a number of drivers lost control and left the road. Seaman, who had been second, became sixth, and Hasse on an Auto-Union retired. After refuelling Lang went into the lead, but suffered from a broken windscreen and was unable to respond to a great spurt made by Nuvolari from the fiftieth lap onwards. At this point Lang was 58 sec. ahead of the Auto-Union, but by the end of the sixty-seventh lap he was 2 sec. behind. Whilst Nuvolari was getting past both Müller and Lang, Seaman's Mercedes-Benz also overtook Müller's Auto-Union and, in fact, although handicapped by his skid, the Englishman actually made up 42 sec. on Nuvolari in the latter half of the race and took third place.

In this last event of 1938 the Auto-Unions proved that they were not only quicker at accelerating away from slow corners (a quality in which they had always excelled), but could also pass the Mercedes-Benz on the straight. During the winter of 1938-39, therefore, the Stuttgart engineers carried out some substantial revisions in design. The appearance of the cars was considerably altered by widening the base of the body so as to enclose all the suspension links, lengthening the nose of the car and placing the radiator farther forward. There was a completely novel type of brake drum and, perhaps most important, a new relation of the two Roots blowers so that instead of supercharging in parallel they compressed the mixture in series thereby reducing the power lost in driving the blowers and raising the engine output from 420 b.h.p. obtained at the beginning of 1938 to over 480 b.h.p. in 1939.

As in 1938 the earliest meeting was at Pau. This was scarcely the type of course on which the cars could show their improvements to the fullest advantage, but this time they made no mistake about winning, although the fastest lap was actually slightly below that put up by the unsuccessful Caracciola in the previous year.

In Eifel Races at Nürburg some astonishing speeds were achieved. In practice Mercedes-Benz made the three fastest times, Lang lapping at 86 m.p.h., and von Brauchitsch and Seaman 85 m.p.h. Nuvolari was fastest for Auto-Union but at the much slower speed of 84 m.p.h., whilst the fastest unsupercharged car, a 4½-litre Talbot put up a speed of 72.6 m.p.h. Mercedes-Benz were never displaced from the lead in the race, which was won by Lang who also repeated his practice lap record and then set up a faster race speed with his 3-litre than had been achieved by any of the 650 b.h.p. 5.6-litre models. Caracciola ran third and Brauchitsch fifth, Seaman failing on the first lap with clutch trouble. All the Mercedes-Benz team had to stop for fuel and tyres, even the steady-driving Caracciola being unable to travel more than 85 miles, although the fuel tanks of the cars had now been enlarged to 88 gallons. Nuvolari had a non-stop race and finished, although slower on lap speeds, only 12 sec. behind the winner.

The Belgian Grand Prix witnessed a second victory for Lang, but tragedy for the Mercedes-Benz team. The race was run under exceptionally difficult conditions with intermittent and local rain showers producing unpredictable slipperiness on the high speed corners which abound on the Spa Circuit. Even Caracciola was caught out and had a minor accident, but worst fate of all befell Richard Seaman who held the lead from the twelfth to the twenty-first laps and then skidded off the wet road surface and damaged the car against a tree. He was temporarily stunned, the large tanks spread fuel on to an inflammable part of the engine and the car burst into flames. An official was unable to release the steering wheel, which had to be detached before the driver could be lifted clear, and by the time he had been dragged out he sustained burns from which he succumbed during the same evening. Before this accident Lang was in second position, after it he won the race and made the best lap speed. Nuvolari also left the road but was not hurt, Müller broke a valve on his car and Hasse finished second. Of the two Alfa Romeos entered one finished fourth, the other retired at half distance.

The vacancy caused by Seaman's death resulted in only three Mercedes-Benz cars appearing for the French Grand Prix, which was again held at Rheims with four entries from Auto-Union, three from Alfa Romeo, three from Talbot, and two from Delahaye. Once more it was Lang who was prominent in practice. He proved the tremendous speed of the 1939 3-litres, for on the very first day he put in a lap at 117.5 m.p.h. to which Nuvolari replied on the second day with 116.6 m.p.h. on a newly introduced Auto-Union with two-stage boost and 485 b.h.p. Of the unblown cars the fastest pre-race speed was by a Talbot driven by Le Begue, who averaged 105 m.p.h.

The rivalry between Lang, now clearly the fastest of the Mercedes-Benz team, and Nuvolari was continued in most stirring fashion in the event itself. Nuvolari got away to a magnificent start and held the lead for the first three laps, raising the circuit record to 113 m.p.h. in the process. However, at five laps Lang passed to lead by one-third of a second, after which he pulled away to lead by 5 sec. at seven laps, with Nuvolari retiring with a broken engine in the eighth lap. Müller was running only 38 sec. behind, Caracciola had run off the road and retired, so although von Brauchitsch held third position Auto-Unions were placed second, fourth (with Stuck) and fifth, with a new driver, George Meier. At seventeen laps von Brauchitsch retired, and just before he refuelled Lang put on a little extra speed and pulled the lap record up to 114.87 m.p.h. There was no change in order as a result of pit stops and Lang had a 90 sec. lead over Müller until, on the thirty-fifth lap, after a continuous smoking from the engine for some time, his car had to be withdrawn with mechanical trouble. This gave Auto-Union the leading three positions with the best unsupercharged cars some three laps behind. Fate now struck at the rest of the Germans, for Stuck had a long stop at forty laps and drove on at touring speed. Müller, however, had only to continue to win, which he did ; Meier finishing second, one lap (5 miles) behind in his first race. It is worth noting that in Rosemeyer, Müller and Meier Auto-Union had successfully enrolled ex-motor-cycling experts.

From a technical point of view the race was interesting in that both Auto-Union and Mercedes-Benz were employing two-stage superchargers, and the enormous margin of superiority held by these cars over their rivals can best be indicated by stating that in a fifty-lap race the winner finished six laps ahead of a 3-litre supercharged Alfa Romeo, and a 4½-litre unsupercharged Delahaye.

The fact that Auto-Unions had lost the Eifel Race to Mercedes-Benz by less than half a mile in a race of 142 miles augured an intense struggle for the German Grand Prix to be run over double the distance on the same course. Lang reaffirmed the speed of his car and his own personal driving skill by taking a Mercedes-Benz round in practice at 87.5 m.p.h. Nuvolari's car was in trouble prior to the race, and the best Auto-Union time was, in consequence, put up by Müller, who averaged 84.7 m.p.h. These speeds were achieved in dry, warm, weather, but on the day of the race a rapid change lowered the temperature, played havoc with carburation, made the course intensely slippery, and turned what should have been an epic struggle into something akin to a farce. Lang and Brauchitsch were in constant trouble with wet mixture which fouled the plugs, the car which was to be driven by Seaman was a non-starter, and it was left, therefore, to Caracciola, to maintain his Company's reputation, which he did by driving steadily if somewhat slowly. He reached first position on the sixth lap and, except for the inevitable drop in position following a pit stop, did not lose it. His winning speed, 75.18 m.p.h., and best lap of 81.65 m.p.h., were, however, but little better than the figures achieved in 1934. Auto-Union were in no better case. Nuvolari also suffered from plug troubles and ran third, until he retired three laps from the end ; Müller finished second, 58 sec. behind the leader, and Meier retired at half distance. Hasse also retired on the twelfth lap ; he was then leading due to Caracciola's pit stop. Perhaps the most remarkable aspect of a sorry spectacle was the fact that on the second lap Pietsch's Maserati was able to challenge the German cars, and eventually finished third. Three Delahayes were the only other cars to finish.

The 1939 Swiss Grand Prix was the last major race of the year and to all intents and purposes the last race in which these cars appeared before a European public. Mercedes-Benz gave their fourth car to a new cadet driver, H. Brendel, but owing to an injury in the Swedish Motor Cycle Grand Prix, Meier was replaced in the Auto-Union team by the more experienced Hasse. It may seem almost redundant to record that once again it was Lang who put up the best practice time with a speed of 106.23 m.p.h., Stuck being the fastest Auto-Union man with an average of 103.3 m.p.h., with Dreyfus (now using a Maserati) achieving 96.5 m.p.h., and Farina on an Alfa Romeo 99.4 m.p.h. The last named figure was particularly remarkable as it was achieved with a new 1½-litre car (Type 158) which, although out-classed in capacity, was run in competition with the full Grand Prix types.

The day's racing consisted of two heats, one confined to 1½-litre cars, the other for full Grand Prix cars, with a final for the twenty-six fastest cars. In the smaller car race Farina won easily at an average speed of 96.4 m.p.h. In the heat for Grand Prix cars only Nuvolari was able to challenge the three regular Mercedes-Benz drivers and he was third at half distance with von Brauchitsch just behind him. The latter then put on speed and passed Nuvolari, whilst Caracciola, running second, made a supreme effort to catch Lang, and failed to do so by a mere 4.8 sec. after making the fastest lap of the day at 104.23 m.p.h. In the final Farina, on the phenomenal Alfa Romeo Type 158, made a valiant and by no means unsuccessful effort to keep up with the larger cars. Averaging 97.5 m.p.h. he was headed only by Lang for the first seven laps. Caracciola then took the matter in hand and started closing up on the leader at the rate of a second a lap, but for the second time he slightly misjudged his timing and finished second, 3.1 sec. in arrear. In the last half of the race the other larger cars also swept by Farina so that von Brauchitsch ran third, with Auto-Union fourth and fifth, and the little Alfa sixth.

Alfa Romeo had developed this smaller car to run in a number of events in which, to avoid a certain German victory, a 1.5-litre limit on engine capacity had taken the place of the International Formula.

In this way the Coppa Acerbo and Coppa Ciano, for example, disappeared from the 1939 international Grand Prix calendar, but one new event appeared on the list-the Yugoslav Grand Prix. On the 3rd September, 1939, three Mercedes-Benz and two Auto-Unions were on the starting line of a twisty course through the streets of Belgrade. This was at 5 p.m., six hours after drivers and the spectators knew that a state of war existed between Germany on the one hand and Great Britain and Poland on the other. Brauchitsch, who had frequently been unlucky, was determined to win what everyone must have realised was to be the last Grand Prix for many months ; perhaps, as it was to prove, for many years.

He got into the lead from the start and although Lang remained very closely behind he could not pass. Additionally, on the seventh lap a stone from the rear wheel of the leading car was thrown up, breaking Lang's goggles, so that, temporarily blinded, he ran off the road. He was able to continue but came round to his pit and announced that he would retire. Brauchitsch, determined to put the matter beyond doubt, cut his times down until on the fifteenth lap he averaged 83.9 m.p.h. and led the Auto-Unions of Müller and Nuvolari by 13.8 and 14.2 sec. respectively. On the sixteenth lap his speed proved his undoing. On a right-hand turn and a 1 in 7 gradient his car swung broadside across the road and only his large lead gave sufficient time to reverse and clear the track for the two Auto-Unions who came past bonnet to tail. Nuvolari showed his subtle driving methods by slowing a little so making it awkward for Brauchitsch to pass him and allowed Müller to go well out into the lead. The latter, however, was forced to stop for tyres and Nuvolari, with the way clear, now equalled Brauchitsch's lap record and was never again to lose first place. Thus, with the victory of an Italian driving a German car in a Balkan country, Grand Prix racing, which had previously been interrupted by a five-year war, was brought to a close. Seven years, in which Germany went down in defeat and ruin, elapsed before racing was resumed before European crowds eager as ever to enjoy the grand spectacle.

CHAPTER FIFTEEN

Out of Bounds

THE main story set out in the preceding chapters has been deliberately confined to real road racing carried on within the limits of the international Grand Prix formulae in force at the time. In order to complete the picture it is desirable to deal with certain other aspects such as the Voiturette races held between 1909 and 1913 and some of the non-formula events held over exceptionally fast circuits in the decade immediately preceding the Second World War. The speeds recorded in these last-named give a distorted picture of the progress and have been excluded from the general calculations which have been made, but as the winning car was in many cases eligible to run under the current Grand Prix formulae and so complete the historic record, the facts, in brief, will now be set out.

The semi-road event was held on the Mellaha circuit in North Africa for the Tripoli Grand Prix. This particular course was established in 1933 and it should be noted that earlier Tripoli Grands Prix were run on an entirely different circuit at much lower average speeds. The 1933 event was notable for the fact that an Englishman, Sir Henry Birkin, driving a 2.8-litre Maserati, held the lead for the first four laps and at half distance was in second position only 10 sec. behind Nuvolari who was handling one of the bored-out 2.6-litre Monza type Alfa Romeos. Unfortunately, Birkin's pit was very poorly organised and his refuelling stop dropped him back to third position from which he was unable to recover. The last half of the race was in consequence a struggle between Nuvolari and Varzi, who was driving a 2.3-litre Type 51 Bugatti. At twenty laps (with ten still to go) the Alfa Romeo was in the lead, but on the twenty-fifth Varzi passed first by a margin of 20 sec. The cars then ran neck and neck, so that on the last lap Varzi won by barely a length, with one-tenth of a second in hand over his rival. This was the last race for one of Britain's finest drivers, for Sir Henry contracted a burn which turned septic and he died within a few weeks of the race being run.

The following year saw the appearance of the 2.9-litre Monoposto Type B Alfa Romeos, against which were ranged two of the new 2.8-litre Bugattis, a team of 2.9~litre Maseratis, a pair of U.S.A.-entered Miller four-wheel drive cars, and (taking advantage of this being a non-formula event) two of the sixteen-cylinder Maseratis, one with 4-and the other with 5-litre engine capacity. Only Taruffi on the last named, with a lap speed of 123 m.p.h., was able effectively to oppose Alfa Romeo, but although second on the fifth lap he later ran off the road. Wimille was able to make a fair show for Bugatti, but he retired on the twenty-fifth lap when running in fourth position and his team mate, Dreyfus, finished sixth at 107.62 m.p.h., with a lap at 116 m.p.h. The two U.S.A. cars could only manage seventh and eighth place at an overall average of little better than 104 m.p.h., so the official Alfa Romeo team annexed all first three positions. They all averaged over 115 m.p.h., and lapped at over 124 m.p.h.

Owing to this race being held in the very early part of the year none of the German cars built to the 750 Kg. formula competed in 1934, but both Auto-Union and Mercedes-Benz appeared on the scene in 1935, the former with two and the latter with three entries. Alfa Romeo opposed them by two extremely interesting double-engined cars, one of 5.8 litres and the other of 6.3 litres capacity, driven by Chiron and Nuvolari respectively. In effect these cars used Type P.3 engines, one being mounted in the tail behind the driver and both being connected to the rear wheels. 510 and 540 b.h.p. respectively was claimed from these pairs of engines, which showed the cars a surplus of some 100 b.h.p. compared to the contemporary German models. Unfortunately, despite using 5.5 x 20 in. rear tyres the power available was too much for the existing state of tyre design and Nuvolari had to change thirteen wheels during the event. Even with this handicap he averaged 116.56 m.p.h., but this gave him no higher than fourth position.

Caracciola won on a Mercedes-Benz at an average of 123.03 m.p.h., and showed his mastery of the course by making the fastest circuit at nearly 137.81 m.p.h. only two laps from the end. Stuck on an Auto-Union achieved the same speed within the second place of decimals, but retired at half distance when in the lead. Varzi then took over the Auto-Union challenge and led the race until four laps from the end, when a pit stop put him back into the second position, in which he eventually finished. A Mercedes-Benz, driven by Fagioli, was third, so that the twelve months old German cars had a complete triumph.

This they repeated in the following year, when Varzi secured his third win on this circuit, again driving for Auto-Union. From half distance onwards he and his team-mate Stuck alternated between first and second places, and with four laps to go Varzi put in a lap at an average of 136.5 m.p.h., which gave him a lead of 15 sec. on Stuck, contrary to team orders. The latter opened up and they commenced the last lap with only a few yards separating them, but at this point Varzi raised the lap record to 141.3 m.p.h., which brought him over the line a quarter of a mile ahead of his team leader. It should be recorded that Mercedes could do no better than 136.42 m.p.h. for a lap (i.e. slower than their best 1935 speed), and although Caracciola improved slightly on the winning average of the previous year by putting up 126.08 m.p.h., this gave him only third place.

Alfa Romeo ran two twelve-cylinder 4-litre cars, but these were outpaced and in addition had serious tyre trouble. The winner stopped three times and took 2 min. 4.2 sec. to change three tyres, but Brivio (who had the fastest Alfa Romeo) finished only seventh, and although he lapped at 134.79 m.p.h. he had five pit stops aggregating 6 min. 38.4 sec. to change ten tyres.

As recorded elsewhere Mercedes-Benz introduced an entirely new design of car for 1937 and at the same time a new young driver, Herman Lang, became a regular team driver, or *Hauptrennfahrer*. The Tripoli event of that year enabled him to show his complete mastery of high speed driving, as he ran through the entire race with only one stop for tyres and averaged 134.42 m.p.h. to win by just under 10 sec. It was, however, left to one of the old guard, Hans Stuck, to make a record lap of the circuit for Auto-Union at 142.45 m.p.h., although in practice Caracciola went even faster and made the best lap for Mercedes-Benz at 143 m.p.h. Generally speaking, the Auto-Unions had the higher speed in this event, but they lacked the excellent pit control shown by Mercedes-Benz and this coupled with loss of time in extra tyre stops was a disadvantage they could not overcome.

In 1938 some reduction in speed, following the introduction of the 3-litre supercharged cars, was inevitable and the practice times showed that only Mercedes-Benz had designed a car with a performance approximating to its larger predecessor. Lang put in a lap at 140 m.p.h., but his speed was very much faster than anything achieved by rival makes and types. The corresponding supercharged 3-litre cars of Alfa Romeo and Maserati averaged 137.2 m.p.h. and 135.7 m.p.h. respectively, and these in turn were much faster than the unsupercharged 4½-litre Delahayes, the best of which averaged 126.5 m.p.h.

Lang repeated his 1937 victory and led almost throughout, but the Alfa Romeo driven by Farina held second and third positions between the first and fifth laps, and Count Trossi's Maserati made a brief appearance in first and second positions in the ninth and tenth laps respectively and, in addition, made the fastest lap of the day at 131.2 m.p.h. This, however, led to the breakdown of the car and to an easy victory for Mercedes-Benz, who finished in the first three positions. The two Alfa Romeos, one with twelve and the other with sixteen cylinders, both retired, allowing an eight-cylinder type to finish fourth, nearly a quarter of an hour behind the winner. In 1939 the race was confined to 1½-litre cars.

The A.V.U.S. races were instituted in 1921 over a section of twin track road leading from Wannsee, a suburb of Berlin, to Potsdam, which had been converted into a toll road for cars only.

The German Grand Prix (not a formula event) was held on this course in 1926 and it was won by a 2-litre Mercedes driven by Caracciola at an average speed of 84.15 m.p.h. This type of car lived up to its reputation of being very difficult to handle and led to a terrible crash by Rosenberger, who hit the timekeepers' box when leading, killing two officials and severely injuring himself. Due to wet weather and slippery surface this was, taken all round, a very dangerous race, and even the skilled veteran Chassagne, driving one of the well proved, four-cylinder 1½-litre Talbots, overturned, as did his team mate, Urban-Emmerich, who was actually in the lead when he crashed.

The first A.V.U.S. Grand Prix was instituted in 1931, Caracciola again being the winner, the car now being a Mercedes-Benz of the well-known SSKL type.

In 1932 a large entry was received, consisting of nine Bugattis, two backed by the works, three Maseratis, two Mercedes-Benz, a Monza Type Alfa Romeo, and a 4-litre V.12 Sunbeam. One of the Maseratis was the celebrated 5-litre sixteen-cylinder model which put the lap record at over 130 m.p.h., only to develop engine trouble at the sixth lap by which time the field had been reduced to ten cars. Caracciola held the lead for some time on the solitary Monza type, but he was passed on the last lap by von Brauchitsch driving a 7-litre SSK Mercedes-Benz with a cumbersome looking, but quite effective, streamlined single-seater body. Brauchitsch won by a mere 4 sec. in 1½ hours racing, with a privately owned Bugatti third.

The race was now well established on the International Calendar and in 1933 entries were received from Ferrari, running three of the modified Monza Alfa Romeo cars, and Bugatti, who was represented by three of his 4.9-litre Type 54 models and three Type 51's. Brauchitsch appeared again and this year was the sole Mercedes-Benz representative, but he had to make five stops for tyres and was only able to gain sixth position at an average of 109.92 m.p.h. Two of the Ferrari Alfas dead-heated in third place at 120.66 m.p.h., but neither could approach the speed of the big Bugattis. The car driven by Count Czaykowski raised the lap record to 137.77 m.p.h. and led until the thirteenth lap, but Varzi on the sister car got past on the fourteenth lap and won on the next circuit by a margin of one-fifth of a second at an average of 128.48 m.p.h.

The 1934 event, which marked the first appearance of the German 750 Kg, formula cars, has been referred to in Chapter Ten. It was notable for a new lap record by Momberger on an Auto-Union and also for the defeat of the German cars by the 3.2-litre Alfa Romeo driven by Moll. This win was reinforced by another Alfa Romeo taking second position.

In 1935, however, the German cars were really running properly and they put everybody else completely out of the picture. In practice Hans Stuck put in a lap for Auto-Union at 161.88 m.p.h., Caracciola lapping at 150 m.p.h. for Mercedes-Benz. Nuvolari achieved 150.5 m.p.h. on a twin-engined Alfa Romeo, but one of the more normal 3.2-litre eight-cylinder cars could do no better than 132.6 m.p.h.

The day's racing of May 26th consisted of two heats and a final. Preliminary events were won by Stuck and Caracciola at 155.53 and 147.87 m.p.h. respectively, the big Alfa Romeos suffering from their usual chronic tyre trouble. One of them, driven by Chiron, was able, nevertheless, to qualify for the final, as did the P.3 model driven by Dreyfus. Two Auto-Unions and four Mercedes-Benz completed the line-up of eight starters in the ten-lap final amounting to 122 miles. At half distance two of the Mercedes-Benz had retired (including Caracciola's), and the third driven by von Brauchitsch was poorly placed due to tyre stops. Stuck also suffered from this malaise and had to call at the pits twice, as did his team-mate Varzi. It thus came about that Fagioli on a Mercedes-Benz and Chiron on an Alfa Romeo took first and second positions by virtue of having non-stop runs.

No race was held in 1936, but in 1937 it was run over a substantially modified course. The loop at the Potsdam end, with a 1 in 9 banking, was left unchanged but at the Berlin end a new corner was laid out in a 300 ft. radius with a banking of 43 degrees and this enabled the cars to continue on this section at full speed.

Taking advantage of the possibilities thus presented of sustained maxima both the German constructors entered specially designed cars and in the face of this competition no other works' entries were received. Auto-Unions made no great changes to their Grand Prix chassis but two cars driven by Rosemeyer and Fagioli were fitted with all enveloping aerodynamic bodies, another pair being standard Grand Prix models. Mercedes-Benz had greater variety. They had five cars entered, three of them driven by Caracciola, Brauchitsch and Lang, with all enveloping aerodynamic bodies and two in the hands of Seaman and Zehender of Grand Prix form. There was, however, a further variation in that the cars driven by Brauchitsch and Zehender, that is one of each type, were fitted with a 5.57-litre V.12 engine (82 x 88 mm.) giving 679 h.p., that is to say 100 b.h.p. more than the straight-eight engine was developing at this time of the year.

The fastest lap in practice was made by Fagioli on an aerodynamic Auto-Union at 174 m.p.h., and owing to Zehender's engine developing mechanical trouble before the race entries were reduced to eight cars, four from each factory.

Starting positions were determined by speeds for a standing lap over the 12 miles circuit and it is interesting to analyse the times as an indication of the effect of engine type and body form. The streamlined Auto-Unions averaged 171.6 m.p.h. and the best Grand Prix type of the same make at 165 m.p.h. The twelve-cylinder 679 h.p. Mercedes-Benz with streamlined body work averaged 170.2 m.p.h., the eight-cylinder 568 h.p.

fully streamlined car 165 m.p.h., and the same engine with the normal Grand Prix body 159.5 m.p.h.

In the first heat Auto-Unions were represented by Rosemeyer and Delius, and Mercedes-Benz by Caracciola and Seaman, the first named in each team with streamlined and the second with G.P. models, and the drivers kept their speed well down. After making the fastest lap of the day at 171.6m.p.h., Rosemeyer had trouble with his oiling system and this let Caracciola win at 155.59 m.p.h. In the second heat Brauchitsch and Lang drove two streamlined Mercedes-Benz, Fagioli drove a similar type of Auto-Union and Hasse a Grand Prix Auto-Union. Fagioli broke up his engine when in the lead, giving first and second places to Brauchitsch and Lang, the winning speed being 160.37 m.p.h.

In the final the aerodynamic Auto-Union of Rosemeyer lost oil pressure and Von Delius and Hasse with ordinary Grand Prix models were unable to make much impression on Lang, who drove carefully, had no tyre stops, and averaged 162.5 m.p.h. Caracciola set the pace from the start but he had to retire on the fourth lap with rear axle trouble after averaging 165 m.p.h. for the first three laps.

The speeds achieved in this event are by far the highest ever recorded in any race, but the type of cars used showed a very marked divergence from practical road racing lines, quite apart from any question of technical compliance with the formula. They were perhaps the inspiration of an Auto-Union of a similar type which was entered for the French Grand Prix at Rheims the following year, but on a road circuit the stability problems of a streamlined car proved insuperable. The car left the course when practising and was seen no more in Grand Prix racing.

As with the A.V.U.S. series of races so with the Targa Florio, there was no restriction on the type or size of car entered nor, moreover, was there any limit to the number of mechanics who could help with repairs or refuelling. Whereas, however, the German track exaggerates the possible average speed of any given car in relation to a normal Grand Prix circuit, the Sicilian event depreciates it to an even greater extent.

The event was first held for a Trophy put up by Count Florio in 1906 and at this time the speed of the winner, Cagno, on an Itala of 29.18 m.p.h. was about half that of the overall average returned by the winner of the French Grand Prix. This was accounted for by the rough mountain roads which abounded in hairpin corners, and even when André Boillot was driving the 2½-litre Peugeot to the utmost in 1919 (vide Chapter VI) his average speed was little more than 34 m.p.h. In 1920 the race was won by Count Masetti driving one of the 1914 Lyon Grand Prix Fiat cars and was notable for the first appearance of a supercharged car in European road racing, in the form of a Mercedes which gained second place in the hands of Max Sailer. In the following year the Count Masetti repeated his win, this time on a 1914 Lyon Grand Prix Mercedes and this marque was the first to put the average speed over 40 m.p.h., when the event was won by Christian Werner driving a four-cylinder 2-litre supercharged car in 1924.

The five races held between 1925 and 1929 were all won by the Type 35 Bugatti, racing unsupercharged in the first year, and supercharged thereafter, and although Peugeots were second and third with sleeve valve engines in 1925 Maserati took third place in 1927 and Alfa Romeo second in 1929. With these exceptions Bugatti took 1st and 2nd or 1 st, 2nd and 3rd positions as the case may be, and with the collapse of Grand

Prix racing in 1926 and 1927 the Targa Florio became the most important pure racing event on the calendar. To keep the history of racing in its proper perspective the overwhelming success of Bugatti in Sicily in these years must therefore be set against their comparative inability to shine against the absolutely faster Talbots and Delages in the 1½-litre Formula events.

The races run between 1928 and 1933 have been referred to in Chapters IX and X and, unfortunately, with the introduction of the 750 kg. Formula, the race ceased to have any technical or " political " significance and was indeed run for the last time over the traditional circuit in 1935. Nevertheless, in order to complete the statistical evidence of road racing the results from 1919 to 1927 and in 1934 and 1935 are set out at the end of this Chapter.

RACING STATISTICS FOR TARGA FLORIO 1920-27 AND 1934-35

Date	*Event*	*Circuit*	*Driver*	*Car*	*Winning Speed m.p.h.*	*Best Lap m.p.h.*
!4/10/20	Targa Florio	Madonie	G. Meregalli	Nazzaro	35.99	—
29/5/20	Targa Florio	Madonie	Count Masetti	Fiat	36.19	37.5 (Sailer, Mercedes)
21/4/22	Targa Florio	Madonie	Count Masetti	Mercedes	39.2	41.3
15/4/23	Targa Florio	Madonie	U. Sivocci	Alfa Romeo	36.69	40.8
27/4/24	Targa Florio	Madonie	C. Werner	Mercedes	41.02	42.4
3/5/25	Targa Florio	Madonie	M. Costantini	Bugatti	44.5	45.1
25/4/26	Targa Florio	Madonie	M. Costantini	Bugatti	45.68	46.8
24/4/27	Targa Florio	Madonie	E. Materassi	Bugatti	44.61	47.2
24/4/27	Targa Florio	Madonie	F. Minoia	Bugatti	—	46.78
20/5/34	Targa Florio	Madonie	A. Varzi	Alfa Romeo	43	—
20/5/34	Targa Florio	Madonie	P. Ghersi	Alfa Romeo	—	45.76
28/4/35	Targa Florio	Madonie	A. Brivio	Alfa Romeo	49.18	49.72

RACING STATISTICS TRIPOLI, 1933-38

Date	*Event*	*Course*	*Driver*	*Car*	*Winning Speed m.p.h.*	*Best Lap m.p.h.*
7/5/33	Tripoli G.P.	Mellaha	A. Varzi	Bugatti	104.7	110*
6/5/34	Tripoli G.P.	Mellaha	A. Varzi	Alfa Romeo	115.67	—
6/5/34	„	„	L. Chiron	Alfa Romeo	—	124.48*
12/5/35	Tripoli G.P.	Mellaha	R. Caracciola	Mercedes-Benz	123.03	136.81*
10/5/36	Tripoli G.P.	Mellaha	A. Varzi	Auto-Union	129.01	141.29*
9/5/37	Tripoli G.P.	Mellaha	H. Lang	Mercedes-Benz	134.42	—
9/5/37	„	„	H. Stuck	Auto-Union	—	142.44*
15/5/38	Tripoli G.P.	Mellaha	H. Lang	Mercedes-Benz	127.4	139.7 (P)
15/5/38	„	„	Count Trossi	Maserati	—	131.2

* Record

RACING STATISTICS A.V.U.S., 1931-38

Date	*Event*	*Circuit*	*Driver*	*Car*	*Winning Speed m.p.h.*	*Best Lap m.p.h.*
2/8/31	Avusrennen	A.V.U.S.	R. Caracciola	Mercedes-Benz!	115.39	121.65*
22/5/32	Avusrennen	A.V.U.S.	M. von Brauchitsch	Mercedes-Benz	120.07	—
22/5/32	Avusrennen	A.V.U.S.	R. Dreyfus	Maserati	—	130.39*
21/5/33	Avusrennen	A.V.U.S.	A. Varzi	Bugatti	128.48	---
21/5/33	Avusrennen	A.V.U.S.	Count Czaykowski	Bugatti	—	137.77*
27/5/34	Avusrennen	A.V.U.S.	G. Moll	Alfa Romeo	127.57	—
27/5/34	Avusrennen	A.V.U.S.	A. Momberger	Auto-Union	—	140.33*
26/5/35	Avusrennen	A.V.U.S.	L. Fagioli	Mercedes-Benz	148.83	---
26/5/35	Avusrennen	A.V.U.S.	H. Stuck	Auto-Union	—	161.88*
1936	Not Run					
30/5/37	Avusrennen	A.V.U.S.	H. Lang	Mercedes-Benz	162.61	—
30/5/37	Avusrennen	A.V.U.S.	B. Rosemeyer	Auto-Union	—	172.75*

* Record

Part Two

EXAMPLES OF THE GRAND PRIX CAR

Technical Descriptions

" How small is the power of word to convey clear notions of visible things, and on the contrary how well fitted for this task is the craft of the limner."

LEONARDO DA VINCI.

"The test of truth in matters of practice is to be found in the results obtained, for it is only in them that supreme authority resides."

ARISTOTLE.

EXAMPLE No. ONE

The 1908 Itala

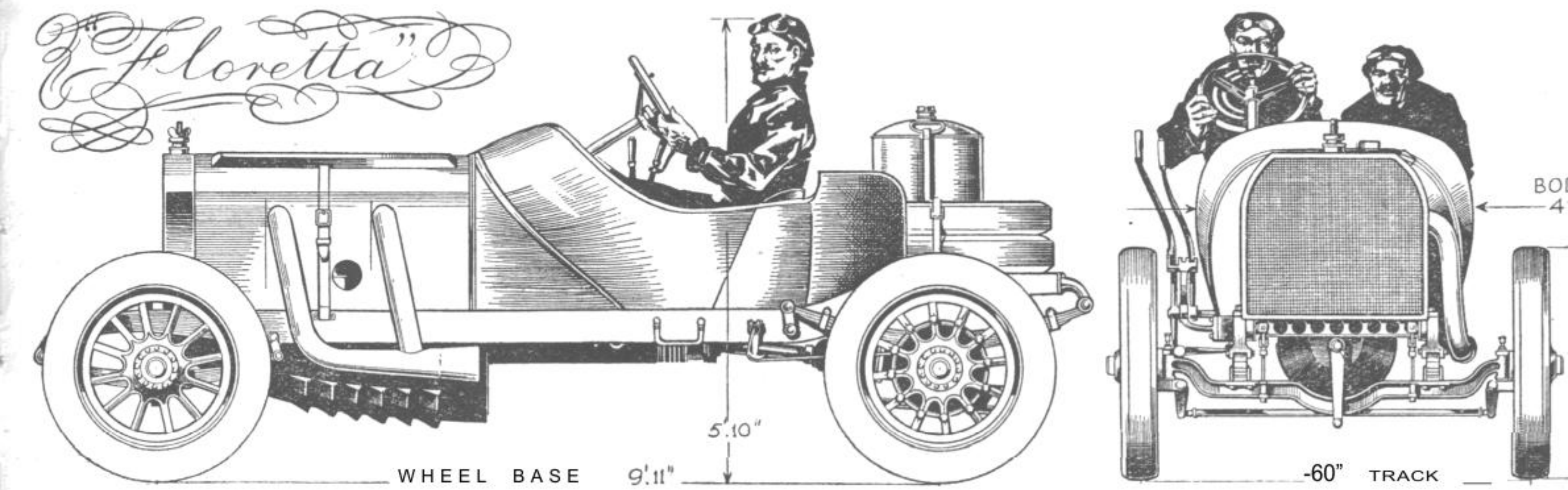
THE regulations for the 1908 races proposed by the Automobile Club de France stipulated that the minimum weight should be not less than 1,150 Kg. (approximately 22.6 cwt.), and that the bore should not exceed 155 mm. for four-cylinder cars, the equivalent of a piston area of 117 sq. ins.

The car constructed by the Itala Company for this race can be considered highly typical of design practice at this time. It embraced a live rear axle, a feature which was perhaps something of an advance, but, on the other hand, retained side exhaust and overhead inlet valves and low tension ignition at a period when overhead valve engines with high tension ignition were by no means unknown.

A team of three cars was entered, and although the highest position gained was eleventh at an average of 57.8 m.p.h., it is worth noting that on the first lap of 48 miles an Itala was only 57 secs. behind the eventual winner, Lautenschlager on a Mercedes.

In 1940 the same car was timed at Brooklands to cover a flying quarter mile at 85 m.p.h. and a standing quarter mile in 20 secs. The car was not in the best of tune when these last-mentioned figures were achieved, and it is fair to assume that in original condition the speed of the car would lie between 95 and 100 m.p.h., the latter representing a probable flat-out speed.

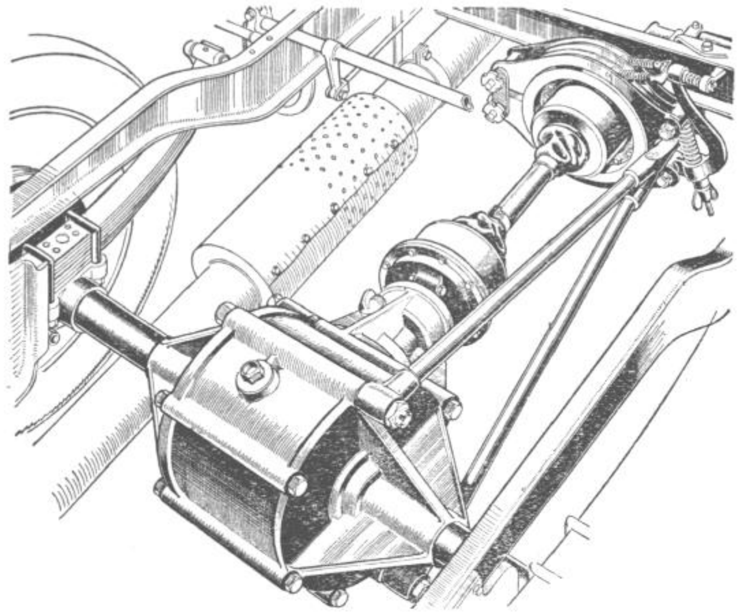
The scale and perspective drawings both indicate the comparatively large size of the car, but it is worth emphasising that there was very little waste space. It is indeed notable that the bonnet fits so closely around the engine that the overhead valve gear projects above the level of the radiator and had to be covered by a protuberant cowling. The height of the driver was also determined largely by the diameter of the wheels and



the method of mounting both front and rear springs above the axle level. The front axle was of normal H section cranked down to give clearance beneath the nose of the engine. Quite straight-forward semi-elliptic springs were attached to straight channel section frame. The rear springs were also of this type and were shackled at the forward end only. The rear end of the frame was splayed slightly outwards and upwards, and gave clearance for the vertical movement of the live rear axle.

Itala were amongst the first to depart from chain drive and on this car the bevel and differential gears were contained in a large, light-alloy casting to which deeply ribbed flanged members were bolted, the latter having steel axle tubes shrunk in them. The drive was taken through the springs but a triangulated arm ran forward to a pivot mounted behind the gearbox so as to relieve the spring leaves from torque.

The open propeller shaft was short and included two Hooke-type universal joints made entirely of case-hardened steel and assembled with a circumferential ring made in two halves bolted together. The foot brake was connected to two external shoes contracting upon a drum on the nose of the propeller shaft, the hand brake expanding shoes in rear wheel drums.



The " live " rear axle was an innovation

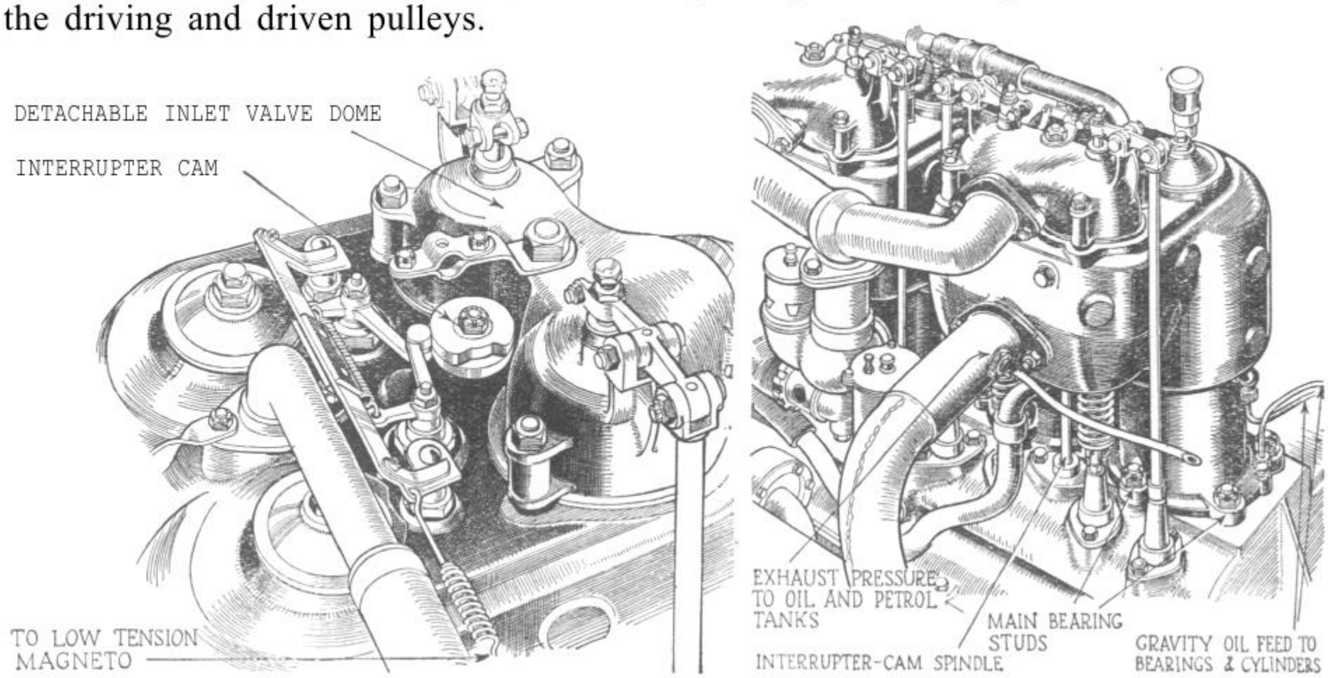
The transmission gears were contained in a light alloy housing mounted on the midpoint of the frame and although all reflect the comparatively low engine speed it will be seen that the actual gaps between them are comparatively wide. Power was transmitted between the engine and the box by clutch containing 72 steel plates each approximately 10½ in. diameter.

The design of the power unit was, of course, strongly influenced by the regulations of the race. The designer chose the maximum permitted bore and cautiously approached the problem of raising the piston speed above the 1,500 r.p.m., which was the then existing standard. Given the opportunities of unlimited stroke, he decided to fix the figure at 160mm., which permitted a maximum engine speed of 1,800 r.p.m. with a piston speed of 1,700 f.p.m. At this speed the car was theoretically capable of 113 m.p.h. so there was a reasonable balance between the factors of b.h.p., r.p.m. and reliability.

The cylinders were formed in pairs from iron castings, the water jacket extending about one-third of the way down the bore. The exhaust valves were situated in laterally located pockets at the near side of the engine, the inlet valves being mounted above them in detachable cages. The exhaust valves, therefore, were operated directly from a side mounted camshaft and the inlet valves through push rods and rockers, the latter mounted in the plane of the crankshaft. The camshaft also drove vertical shafts driving a cam on the top of the cylinder head which impinged on short spring-loaded rockers operating the wipe contacts of the low tension ignition system inside the combustion space. Skew gears were used for driving purposes and enabled the timing to be advanced or retarded by moving the camshaft endwise.

Slightly domed cast-iron pistons gave a compression ratio of approximately 4½ : 1 and the long connecting rods have offset big ends with white metal bronze shells. The crankshaft ran in a similar type of bearing and was approximately 55 mm. diameter, and innocent of counterbalancing.

The three main bearings were bolted to the crank case through intermediate distance pieces and extensions of the bolts were used for turning cylinder blocks on the face of the crank case. A somewhat elaborate lubrication system was used in which an external reserve oil tank, maintained under pressure by exhaust, fed, as required, to a container mounted on the driver's side of the scuttle. This container had a sight level glass facing the driver and contained eight double reciprocating plunger pumps worked by a transverse rocker and driven by a spring-built drive from an external pulley on the end of the camshaft. Each double pump was connected to a separate oil pipe, three connecting directly to the main bearings and four to the cylinder walls with holes for attachment alternatively to the thrust face of the pistons or at 90º thereto. The remaining pump was joined to 12 small-bore open-ended pipes which dropped oil over appropriate parts of the valve gear. It must be emphasised that there was no return of oil from the crank case, the delivery being controlled by the relative size of the driving and driven pulleys.



Engine details

Manifolding consisted, on the exhaust side, of two pipes passing through the bonnet side and connecting to the centre of each pair of cylinders. The inlet manifold was Y shaped, each branch feeding a pair of inlet valves and receiving mixture from a vertical carburetter of Itala design. The diameter of the pipe was 60 mm. and at maximum engine speed the gas velocity was therefore approximately 125 ft. per second. A large water pump was driven from the front of the engine, distributing the coolant through another Y-shaped pipe directly on to the seat of the exhaust valves, thus forming a somewhat striking anticipation of the modern principle of direct water flow.

The 1908 Grand Prix Itala was somewhat overweight and under-powered by comparison with the best designs of the time and for this reason had no great success in Grand Prix racing. It has, however, in later years proved to be an outstandingly reliable design, two cars participating in racing at Brooklands until 1914, one in 1910 averaging 97.5 m.p.h. for 194 miles and lapping at 101.8 m.p.h. This car survived and continues in competition use to-day.

Acknowledgments. -Thanks are due to Messrs. R. Wil-de-Goose, C. Clutton and Dr. G. A. Ewen for assistance in obtaining data on this car,

DETAILS OF CAR

MAKE.-Itala
TYPE.-G.P.
YEAR OF CONSTRUCTION.-1908
YEAR RACED.-1908 by constructors.
DESIGNER.-
WHEELBASE. -9ft. 11 in.
TRACK FRONT. - 5ft.
TRACK REAR. -- 5ft.
HEIGHT TO SCUTTLE. - 56in.
HEIGHT TO DRIVER'S HEAD. - 67in.
FRONTAL AREA. - 18.5 sq. ft.
UNLADEN WEIGHT. - 27.8 Cwt.
ALL-UP STARTING LINE WEIGHT. - 32.3 cwt .
MAXIMUM SPEED. - 100 m.p.h.
SPEED ON INDIRECT GEARS. - 77 m.p.h. in Third
,, ,, ,, ,, 55 m.p.h. on Second
34 m.p.h. on First
H.P. PER SQ. FT. - 5.4
H.P. PER TON UNLADEN. - 72
H.P. PER TON ALL UP. - 62
BORE. - 155 mm.
STROKE. - 160 mm.
S.B. RATIO. - 1.03
No. OF CYLINDERS. - 4
CAPACITY. - 12,000 c.c.
PISTON AREA. - 117 sq. in.
B.H.P. - 100 at 1,600 r.p.m.
H.P./SQ. 1N - 0.85
B.M.E.P. - 68
PISTON SPEED FT./MIN. - 1,700
CYLINDER HEAD. - Integral C.I.
VALVES No. - 2 per cylinder
VALVES ANGLE.-opposed
VALVES AREA INLET. - 41 sq. in.
VALVES AREA EXHAUST. - 48.5
CYLINDER BLOCK. - Cast-iron in Pairs
CARBURETTER. - Itala vertical
FUEL. - Petrol
SUPERCHARGER. - Nil
MANIFOLD PRESSURE. - Atm.
IGNITION. - one low tension magneto
PLUGS. No. - Four low tension contact breakers
PLUGS LOCATION. - Offset in head
CRANKCASE. - Two-piece light alloy
CRANKSHAFT. - One-piece no counter balancing
MAIN BEARING NO. - 3 fixed to cylinder castings
MAIN BEARING TYPE.-White metal
BIG END TYPE. - White metal
LUBRICATION. - Gravity and splash
CAMSHAFT NO. - 1
CAMSHAFT LOCATION. - Inside of crankcase
CAMSHAFT DRIVE. - Gears
CAMSHAFT DRIVE LOCATION. - Front of crank
CLUTCH. - Multi-plate
GEARBOX LOCATION. - Separate from engine.
GEAR RATIOS. - 1.65, 2.4, 3.4, 5.4
TRANSMISSION. - open propeller shaft to live rear axle with triangulated torque arm.
FRAME. - Channel
FRONT SUSPENSION. - Semi-elliptic
REAR SUSPENSION. - Semi-elliptic
SHOCK ABSORBER TYPE. - Friction
BRAKE SYSTEM. - Mechanical pedal to transmission; hand to rear wheels
BRAKE DRUM DIAMETER. - Pedal 6¼ in.
Rear 16¼ in.
BROKE DRUM WIDTH. - Pedal 3 in.
Rear 3 in.
SQ. IN, PER TON LADEN. - 130
STEERING - Worm and wheel. 1 turn lock to lock
WHEELS TYPE. - Fixed wood Dunlop detachable rims
TYRES. - Front and Rear : Dunlop 895 x 135

RACING RECORD OF THE 1908 ITALA

Date	*Event*	*Course*	*Speed*	*Lap Speed*
7/7/08	French G.P.	Dieppe	58.7 m.p.h. (11th)	72.5 m.p.h.

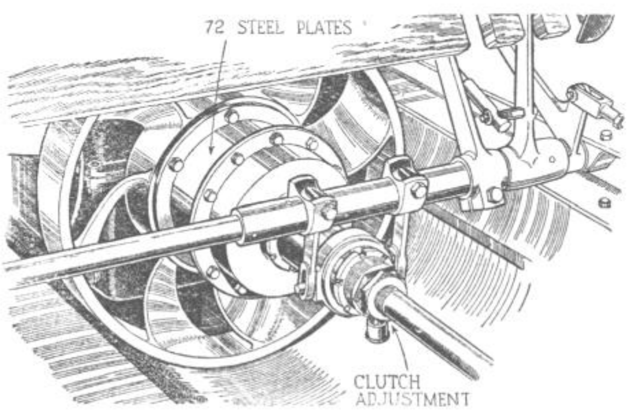
EXAMPLE No. TWO

The 1911 Fiat

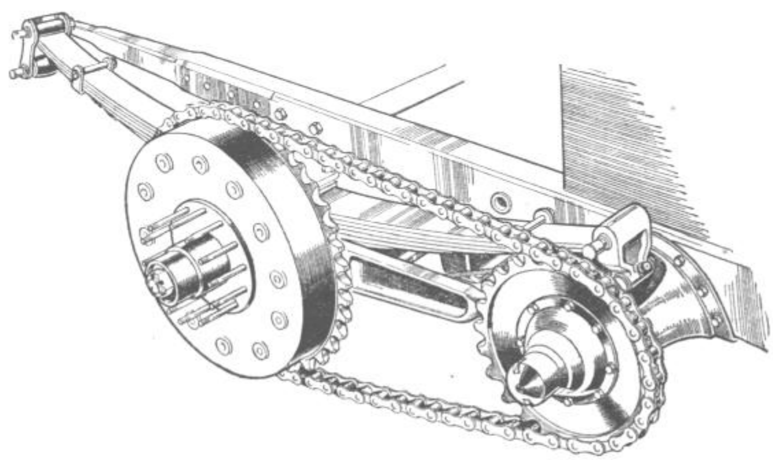
THE Fiat which won the 1911 Grand Prix de France was a catalogue model privately entered. It was a genuine racing type, designed in 1909, but raced in America during 1910 in the Savannah Grand Prize and variously known as the " Savannah G.P. Model " and the " 90 h.p. type." The manufacturers' designation is " Model S.61."

There is reason to believe that the winning car in the French event had been delivered some time previously to a Paris coach-builder in order to fit a closed body to the order of a customer. The latter, it is said, refused to take delivery and after a long delay the car was bought and raced without modification. Such a series of events readily explains the very upright driving position, square dashboard, long wheelbase, high weight and other features which one would not expect on a pure racing car. That it was nevertheless the fastest car on the course is proved by a record fourth lap at 67.75 m.p.h.

Subsequently this type of car was driven at Brooklands with a swept tail ending the two-seater body, and light alloy pistons. In this form it was capable of lapping the track in 1921 at 104.8 m.p.h. These figures are definitely superior to those which would have been obtained in 1911 as the car was then fitted with body having higher drag and running on somewhat worse fuels. It will, however, be safe to assume that in its original form the car could reach 95 m.p.h.



Clutch and flywheel details

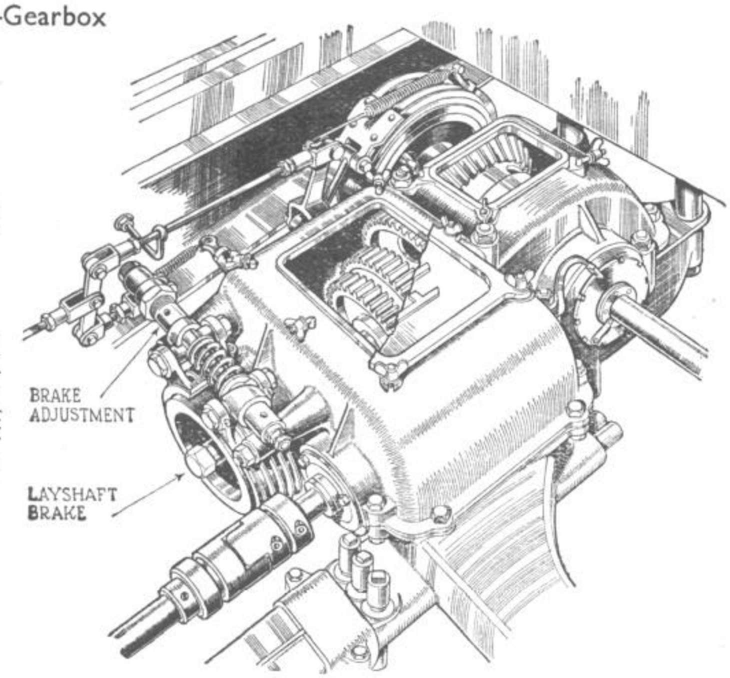


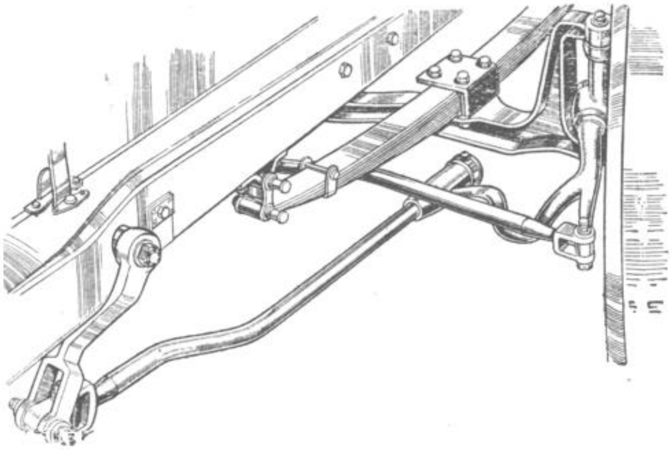
Fiat continued the use of chain final drive

The chassis design was completely in accord with the normal practice of the day, but Fiat were one of the last constructors to abandon chain drive, a system with many good points, some of which have only recently been rediscovered and revised by the more complicated layout of the De Dion type rear axle. With chain drive unsprung weight is reduced to a minimum, the springs are relieved from driving torque and transverse torque is contained within the frame so that there is no tendency for one back wheel to lift off the road when accelerating.

On the Fiat the overall gear ratio could be varied quickly by changing sprockets, and the gear reduction on the bevel drive gave a 1.5: 1 overall ratio when the sprockets were of equal size. The bevelbox was formed in one casting with the gearbox and markedly offset from the centre line, the primary and lay shafts of the box being mounted side by side and the former receiving power direct from an exposed shaft from the clutch.

Right—Gearbox





Front suspension and steering

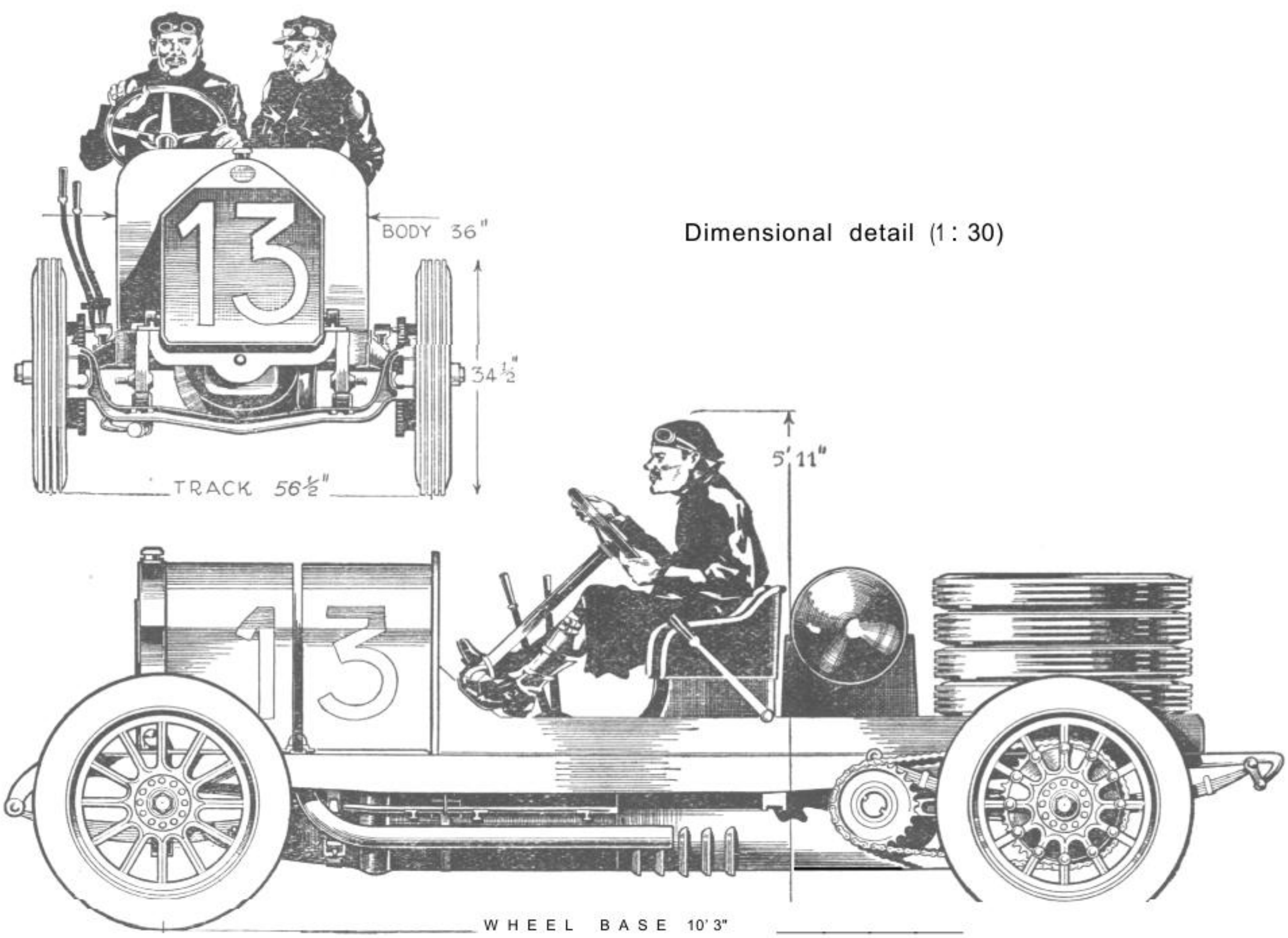
The brake gear embodied some highly ingenious details. In addition to the normal two-shoe internal expanding brakes on the rear wheels there were two external contracting brakes on the transmission system and one of these (7 in. in diameter) was attached to an extension of the gearbox lay shaft and thus imposed reverse loading on the gear and bevel wheel teeth. The other (9 in. in diameter) was mounted on one of the fixed half shafts and therefore imposed loads only on the chains. Both brakes however, were coupled together and linked to the pedal and both were water cooled: A water tank supplied fluid through a control valve set by a trip gear on the brake pedal. When the latter was depressed a stream of water was poured onto the drum, exerting both a cooling and a cleaning effect. When the foot was removed from the pedal the trip mechanism caught up and a valve cut off the water supply,

Brake and clutch pedals were mounted on a cross shaft which also carried the clutch withdrawal mechanism and adjustment. The clutch in itself consisted of seventy-two steel plates enclosed within a flywheel having a 22 in. diameter rim and vane-type spokes designed to extract hot air from the bonnet and pass it beneath the floor of the cowling beneath the frame, the latter being suitably vented to assist the egress of air.

The engine formed the principal feature of interest in this car for it anticipated many features incorporated in later cars.

The drawings show that the cylinder block was formed from two iron castings the heads being cast integral and carrying four vertical valves per bore each held (as shown in a detail sketch) in a detachable cage. They could thus be removed quickly and the valve ground into the cage seating, the whole assembly being rendered gas-tight by pulling down on to a copper asbestos washer.

A single overhead camshaft ran along the centre line of the head, there being one inlet and one exhaust cam per cylinder. Each cam (separately machined and keyed to the shaft) engaged with a roller centrally disposed upon a bridge piece connecting to a pair of valves. The latter were mounted transversely, so that there was an inlet and an exhaust valve on each side of the head, a feature making for simplicity in the



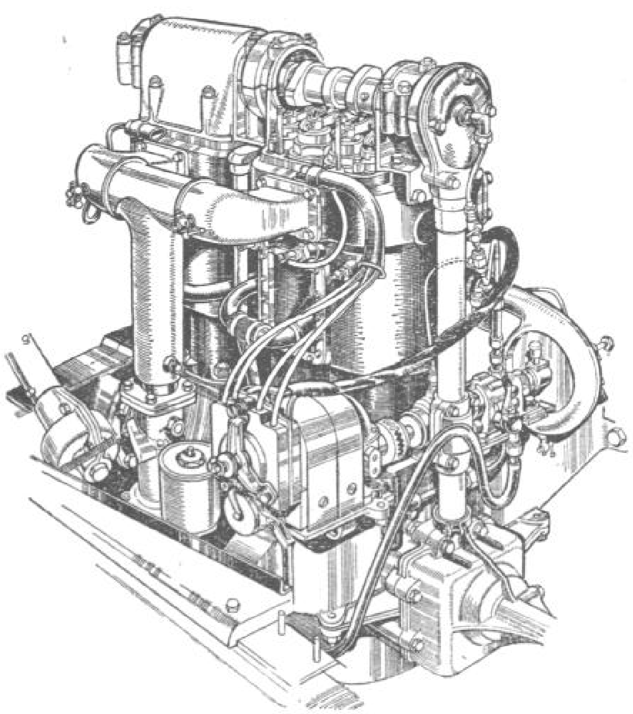
Dimensional detail (1 : 30)

valve gear and a good heat balance across the head, but involving a somewhat complicated porting system for the inlet and exhaust manifolds. These were grouped on opposite sides so that each valve had one port feeding direct from the manifold and another cored through the cylinder head.

The inlet manifolding comprised a vertical type carburetter mounted to a curved riser which ran into the vertical portion of the inlet system and then joined a straightforward T-shaped manifold. The exhaust pipe was of Y formation, designed so that the overlapping exhaust impulses exerted a mutual extractor effect.

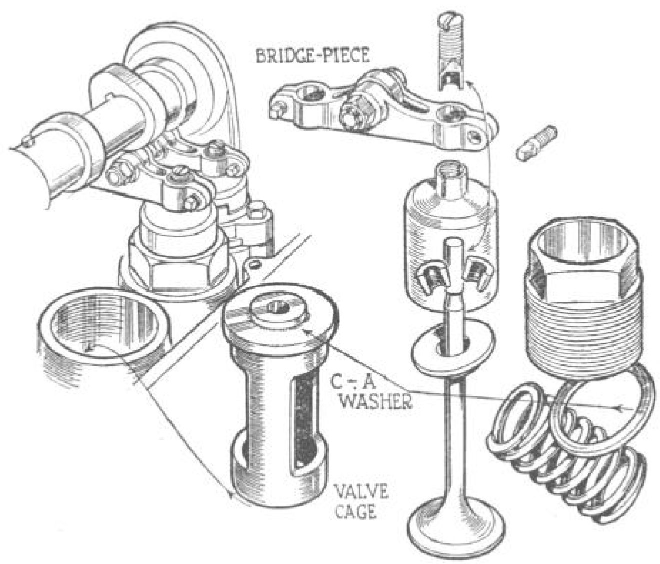
Cooling was by a large diameter water pump which delivered fluid to detachable plates on the inlet manifold side of the engine, although the pump itself was on the exhaust manifold side. It will, however, be remembered that each side of the engine contained an equal number of exhaust and inlet valves, and the circulation was designed so that a cross flow was derived by having two water offtakes at the top of the pump side of the engine.

The pump was driven by a cross shaft which also served the oil pump and magneto, the latter mounted at right angles to the crank axis and on the right-hand side of the car. This shaft was driven by skew gears from the vertical drive provided for the camshaft, which had bevel gears top and bottom. A highly interesting detail feature of this design was the magneto drive which incorporated a quick thread device so that spark timing could be varied without changing the optimum relation between magneto armature under the contact breaker. The high tension magneto (of Bosch manufacture) was fitted with a dual distributor, the engine having plugs horizontally mounted on both sides of the cylinder head. The oil pump, although of comparatively small capacity, gave 25 lb. oil pressure throughout, the engine lubrication being fully forced, including the camshaft and valve gear.



Left-Engine showing camshaft details

Below-Valve details



The cylinders were bolted to a split crankcase with four bearer arms, the crankshaft having three white metal bearings and not counterbalanced. Steel connecting rods and cast-iron pistons were features of the original design, and making comparison with the known performance of the car, one may fairly agree with the declared engine output for the race, which was 120 b.h.p.

In respect of minor details of design, drawings show that the channel frame was connected to the front and rear axles through the normal semi-elliptic springs, the rear springs being shackled at both ends and carried at the back by forged spring horns. Fixed wooden wheels with detachable rims were employed and the steering gear embodied a worm and wheel mechanism giving about 1¼ turns over the full lock. The illustrations are from a car in its long chassis form as run in the Grand Prix de France.

Acknowledgments.-A. S. Heal, Esq., owner of one of these cars, has given great assistance in obtaining details and drawings.

DETAILS OF CAR

MAKE.-Fiat
TYPE.-Model 6
YEAR OF CONSTRUCTION.-1910
YEAR RACED.-1911.
DESIGNER.-
WHEELBASE.-10 ft. 3 in.
TRACK FRONT.-4 ft. 8½ in.
TRACK REAR.-4 ft. 8½ in.
HEIGHT TO SCUTTLE.-51 in.
HEIGHT TO DRIVER'S HEAD.-71 in.
FRONTAL AREA.-18 sq. ft.
UNLADEN WEIGHT.-28 cwt.
ALL-UP STARTING LINE WEIGHT.-33 cwt.
MAXIMUM SPEED.-100 m.p.h.
SPEED ON INDIRECT GEARS.-65 m.p.h. on 3rd
" " " " 45 m.p.h. on 2nd
" 30 m.p.h. on 1st
H.P. PER SQ. FT.-6.8
H.P. PER TON UNLADEN.-85
H.P. PER TON ALL-UP.-71
BORE.-130 mm.
STROKE.-190 mm.
No. OF CYLINDERS.-4
CAPACITY.-10,008 c.c.
PISTON AREA.-83 sq. in.
B.H.P.-120 at
R.P.M.-1,650
H.P. PER SQ. IN.-1.45
B.M.E.P.-78
PISTON SPEED FT./MIN.-2,060
CYLINDER HEAD.-Integral cast-iron
VALVES No.-4
VALVE ANGLE.-Vertical in head
VALVES AREA INLET.-
VALVES AREA EXHAUST.-
CYLINDER BLOCK.-Cast-iron in pairs
FUEL.-Petrol
CARBURETTER.-Fiat vertical
SUPERCHARGER.-Nil
MANIFOLD PRESSURE.-Atm.
IGNITION.-One Bosch high tension magneto
PLUGS NO.-8
PLUGS LOCATION.-Horizontally opposed in head
CRANKCASE.-TWO-piece light alloy split on bearings
CRANKSHAFT.-One-piece no counterbalancing
MAIN BEARING No.-3
MAIN BEARING TYPE.-White metal
BIG END TYPE.-White metal
LUBRICATION.-Fully forced wet sump
CAMSHAFTS No.-1
CAMSHAFT LOCATION.-Central above cylinder head
CAMSHAFT DRIVE.-Shaft and bevel gears
CAMSHAFT DRIVE LOCATION.-Front of crank
CLUTCH.-Multi-plate
GEARBOX LOCATION.-Separate from engine
GEAR RATIOS.-1.7, 2.6, 4.05, 6.25
IGNITION.-By open propeller shaft to gear-bevel box aggregate mounted on frame. Bevels drive to cross shaft and sprockets with final chain drive to rear axle located by radius arms
FRAME.-Channel
FRONT SUSPENSION.-Semi-elliptic
REAR SUSPENSION.-Semi-elliptic
SHOCK ABSORBER TYPE-Nil
BRAKE System.-Mechanical. Pedal to two contracting bands on transmission systems with water cooling. Hand to internal expanding shoes on rear axle.
BRAKE DRUM DIAMETER.-Pedal 9 in. and 7 in.
Hand 16½ in.
BRAKE DRUM WIDTH.-Pedal 3 in. and 2 in.
Hand 3¼ in.
SQ. IN. PER TON LADEN.-290
WHEELS-Michelin fixed wood with detachable rims
TYRES.-Michelin 895 x 835 front and rear

Date	*Event*	*Course*	*Speed*	*Lap Speed*
23/7/11	Grand Prix de France ..	Le Mans	56.5 m.p.h.	67.75 m.p.h.

EXAMPLE No. THREE

The 1912 Peugeot

DURING the early period of motoring, Messrs. Peugeot Freres were entirely concerned with the production of small light cars, so that although they had competed in racing events since 1890 they were not amongst the entrants in the first three Grand Prix. They continued, however, to compete in many Voiturette races, using cars powered by single cylinder or narrow angle V twin engines with exceptional stroke/bore ratios.

In 1911 the Company entered a team for the Grand Prix de France organised by the Sarthe Club, in which event there was a class for cars having four-cylinder engines with a maximum bore and stroke of 110 x 200 mm. In deference to the wishes of the French Manufacturers' Association this project was not completed, but it seems probable that some preliminary design work was carried out during the year which was also remarkable for the advent of Zuccarelli, an engineer who had made his name as a racing driver with Hispano-Suiza.

Zuccarelli made a third with Georges Boillot and Jules Goux and they persuaded Robert Peugeot to let them build a team of cars with 110 x 200 mm. four-cylinder engines for 1912 Grand Prix racing in the Lion-Peugeot works at Belfort. They secured the services of a young Swiss engineer called Henri, who was charged with the task of interpreting their many ingenious ideas on paper and extending them into the realm of working practice, and the result was without doubt the most advanced racing car constructed up to that time, many features of which persisted for more than a decade and some of which had an influence on racing from that day to this. In particular, the general construction embodied in the various sizes of the 1913-14 Peugeots followed directly from the 1912 cars and markedly influenced the 1914 Sunbeam and Humber racing cars, the 1919-22 Ballot designs and the 1921-23 Sunbeams and Talbot Darracqs.

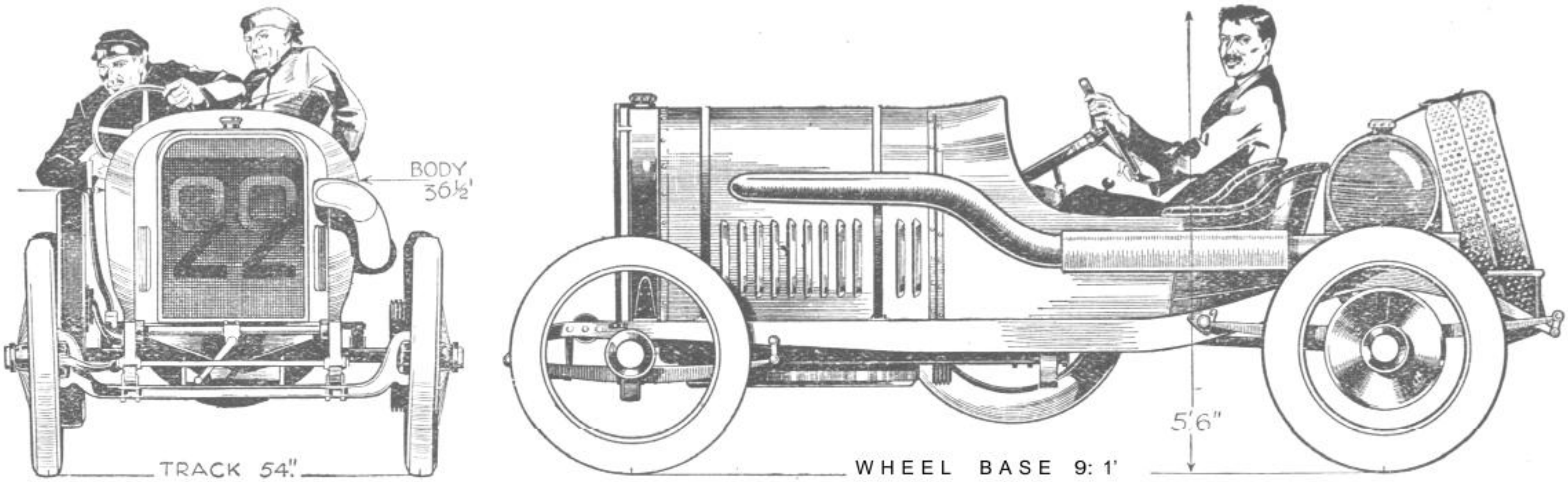
The car now to be described was driven by Boillot to win the 1912 Grand Prix on the Dieppe Circuit at 68.5 m.p.h., and the 1913 Indianapolis race with Goux at the wheel at 75.92 m.p.h.

So far as is known no car survives for inspection and measurement but, fortunately, a search has revealed a number of details and the Peugeot Company have adequate photographic records, although no drawings.

A glance at the perspective drawing accompanying this chapter reveals a characteristically modern feature, viz. : twin camshafts operating four inclined valves per cylinder. Multiple valves, inclined valves and an overhead camshaft had all been used in various combinations prior to 1912, but Henri was the first to combine all the three features just mentioned and a patent was claimed.

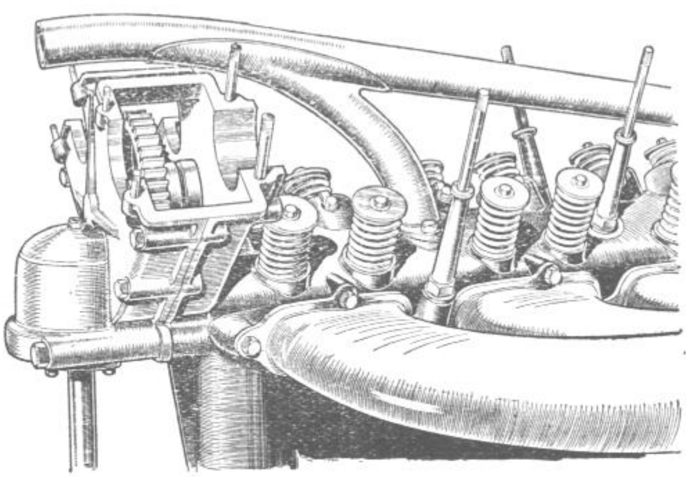
A detail drawing shows that each camshaft was enclosed in an aluminium tunnel split longitudinally and supported from the cylinder head by studs which acted as distance pieces. Projecting from the cover was a tappet running through a bronze guide and forming a complete circle surrounding the cam. This tappet had its own return spring and the entire mechanism was fully enclosed and pressure lubricated.

The valves and valve springs were exposed with the idea of giving good improved cooling and complete immunity from leaks from the cam box down the guide into the cylinder.

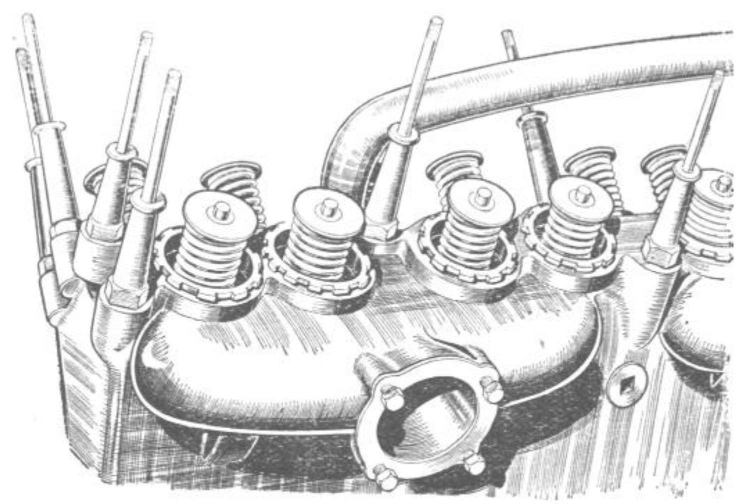


Front and side elevation dimensions (Scale 1 : 30)

The valves themselves were of identical diameter and lift, viz. : 54 mm. and 10 mm. respectively, and although the valve timing is not now available it is known that overlap was employed. The exhaust valves were seated directly in the head, but the inlet valves were carried in detachable cages. The sparking plug was centrally mounted in the cylinder head and all the cylinders and the head formed in one block from an iron casting, both novel features in racing car design at this period.

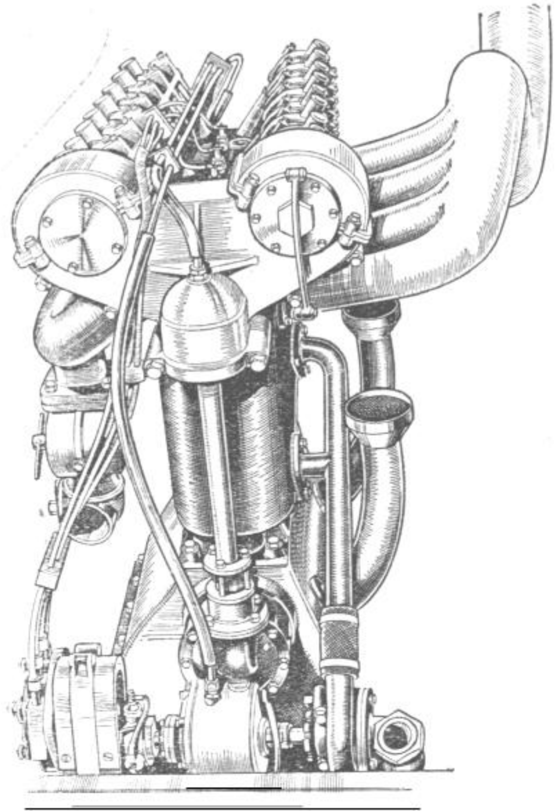


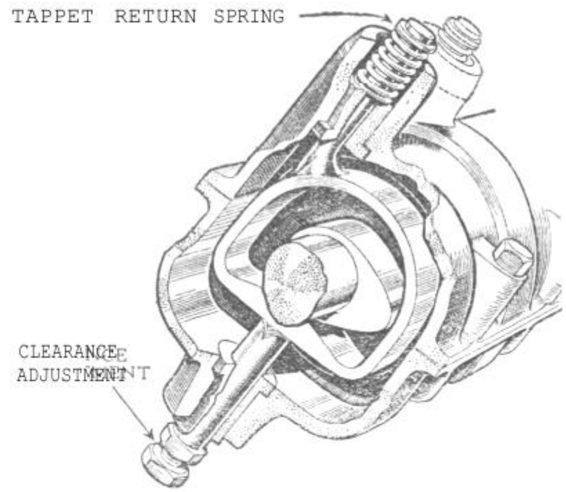
Details of twin-camshaft drive



Rear end and carburetter intake

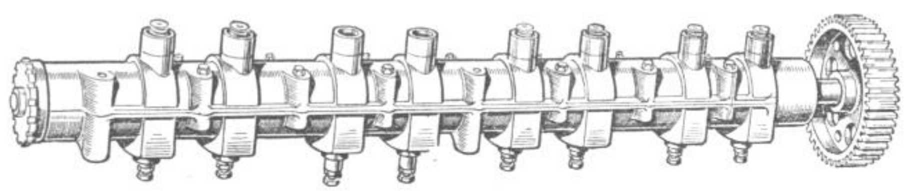
The block was bolted on to a two-piece light alloy crankcase split on the centre line of five plain main bearings. A flat ribbed sump was bolted to these primary castings, the forward part of which contained a conical seating against which a detachable gear type oil pump was pulled up to make an oil-tight joint. This pump was driven from an extension of the auxiliary drives, comprising a bevel gear leading to the vertical cam-shaft drive, a worm gear driving a cross-shaft to the Bosch magneto on the offside of the car, and the water pump on the nearside.





Above-Details of the tappets and their return springs

Left-The engine was pump-cooled by a centrifugal pump driven by a cross-shaft at the front



Right- The camshafts were contained in aluminium tunnels

The cylinder block was mounted markedly *désaxe* in relation to the crankshaft with a view to reducing thrust losses in the pistons, these last being of steel, weighing 32 ounces, and having two narrow rings. The gudgeon pin was locked into the connecting rod boss by a set pin and the connecting rod passed through closely fitting baffles mounted in the top half of the crankcase, which also had detachable inspection plates so that the interior condition of the engine could be quickly examined.

Water circulation was carefully arranged with coolant entering the pump at the base of the block on the exhaust side and emerging through carefully proportioned riser pipes placed on the exhaust side between cylinders Nos. 1 and 2 and 3 and 4. Each pair of exhaust valves discharged into a common port with four ports in all, but a short integral manifold cast in the block served the front and rear pairs of cylinders.

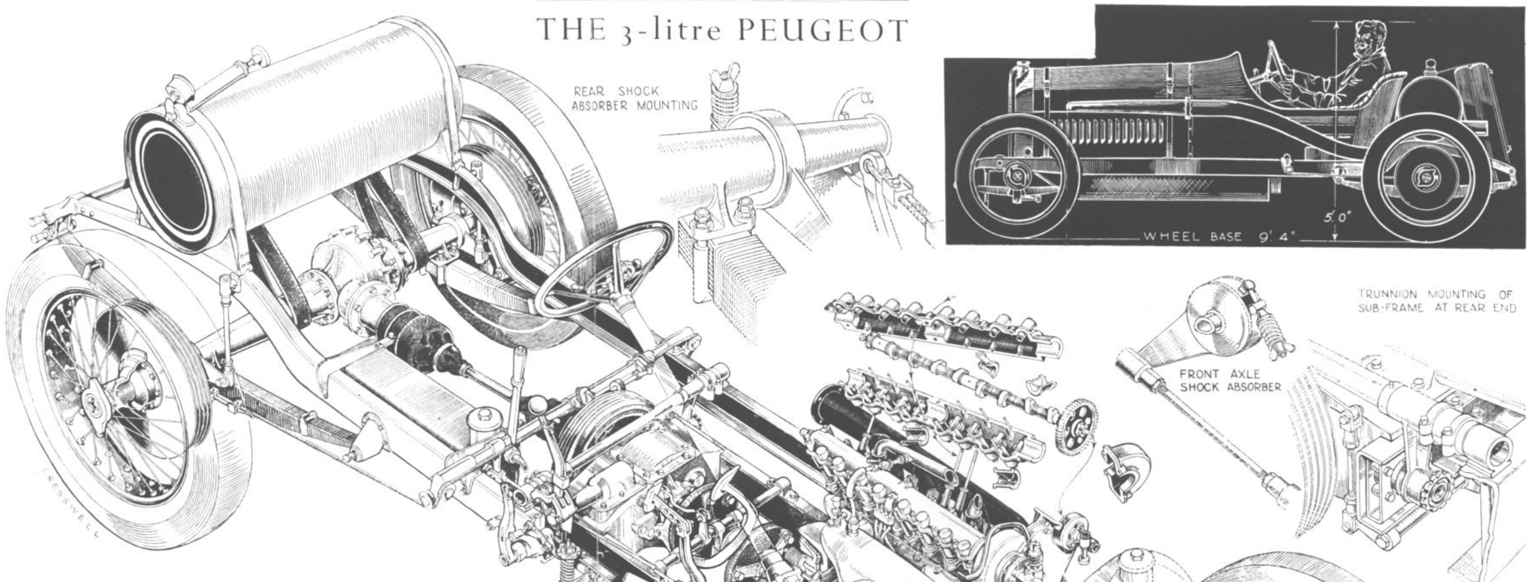
Reliable figures concerning the power output of this engine are hard to find, figures quoted contemporaneously falling between 148 and 175 b.h.p., the latter being the maker's claim. There are good reasons for believing that the lowest of these figures is something of an exaggeration and a reasonable, if conservative, estimate would be 130 b.h.p., that is to say, approximately the same gross output as was obtained on the 1908 Grand Prix cars. Whereas, however, these had been of approximately 12-litres capacity and 120 sq. in. of piston area, Peugeot power was secured with one-third less capacity and half the piston area.

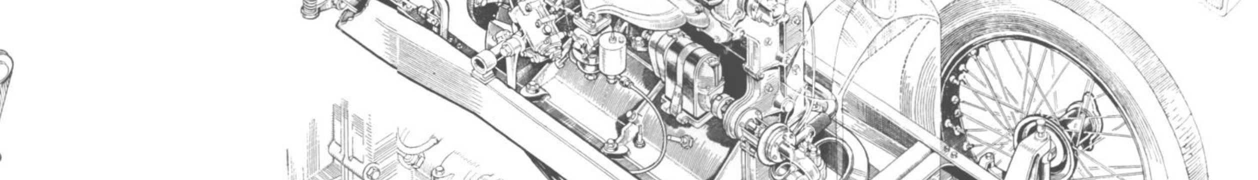
This followed from a big increase in r.p.m. and piston speed, features inevitably tied together by the remarkably high stroke/bore relationship.

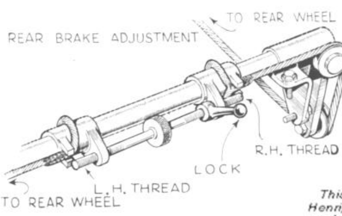
PLATE XVII

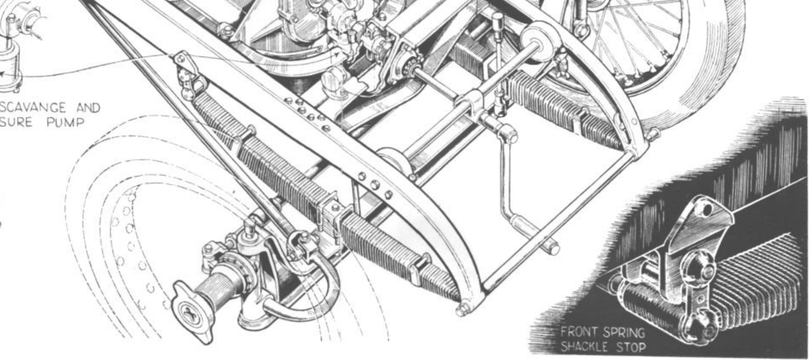
EXAMPLE No. FOUR

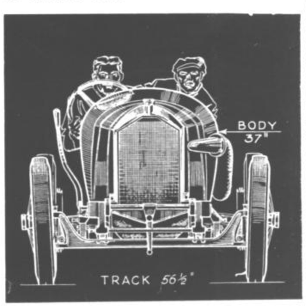
THE 3-litre PEUGEOT











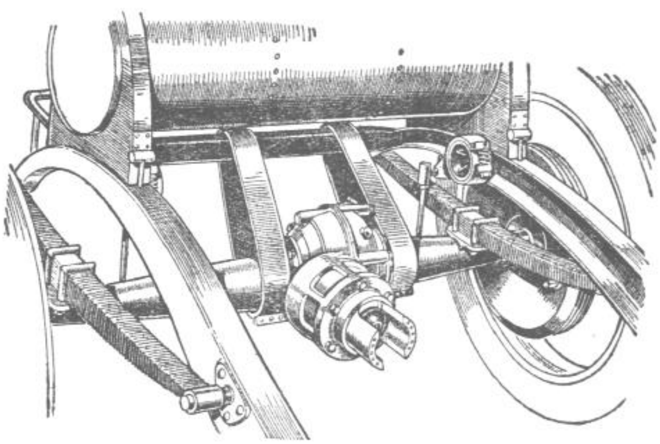
This car, designed by a Swiss engineer, Henri, was easily the most efficient racing model of its time and able successfully to compete with Grand Prix types with double the engine capacity. The engine developed 90 b.h.p. at 2,800 r.p.m., and the car weighed less than one ton in racing trim, so that it had high acceleration and a maximum speed of not far short of 100 m.p.h. On the Indianapolis track it averaged 83 m.p.h. for 200 miles and 80 m.p.h. for 500 miles. Outstanding technical features shown in this drawing include the two overhead camshafts operating four valves per cylinder with exposed valve springs; the single oil pump which sucked oil from the crankcase and circulated it back to the engine through a sealed tank on the driver's side of the chassis and the manner in which the engine was isolated from the effect of chassis distortion by mounting it in a sub-frame which was attached to the main frame through three trunnion bearings. The four-speed gearbox was also attached to the sub-frame and drove the exceedingly light rear axle through a propeller shaft having double universal joints, the torque reaction being taken through the rear springs. The body was designed to be as light as possible and to carry two spare wheels with minimum overhang, as on a 33-mile circuit it was not possible to rely on wheel changing at the pits only.

The success of this car had a great influence on other makes and similar designs were produced between 1914 and 1920 by Sunbeam, Humber, Straker-Squire, the American Monroe, and, to a lesser extent, the Bentley.

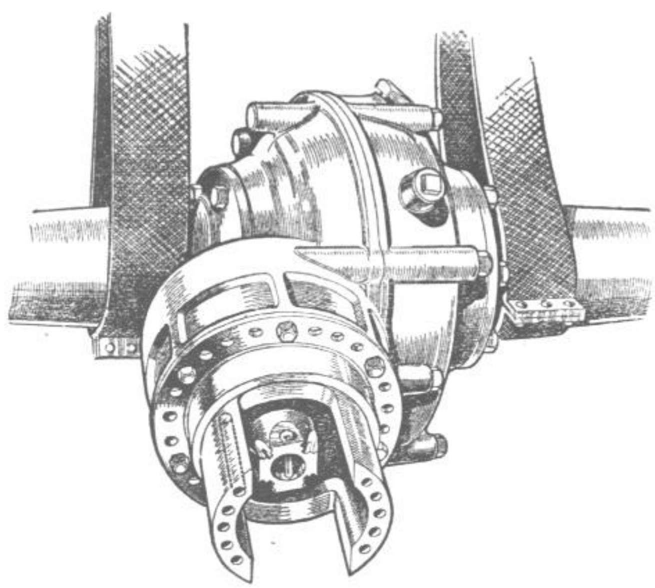
All previous Peugeot racing experience had been with extremely long stroke engines, but there is reason to believe that the 1911 regulations were primarily responsible for the proportions chosen. As an indirect consequence it was possible to provide a compact combustion chamber with a relatively high compression ratio and a high useful swept volume per minute with no excessive r.p.m. or valve openings per minute. The choice of four valves per cylinder was part of an effort to achieve maximum valve area in the face of the comparatively small cylinder diameter.

The engine mounting was in itself unusual, the whole unit being carried in a sub-frame of channel steel shaped in the form of a very elongated U. The opening end was attached to the main frame by ball and socket joints at the back and connected to a cross member beneath the radiator by a trunnion bearing at the front. The engine was thus isolated from any strain imposed by chassis deterioration.

Both frame design and springs were conventional, straight sided channel section being used for the former and semi-elliptic springs fore and aft. The frame was, however, unusually well cross-braced at the front end. The springs, in addition to being exceptionally long and flat were used to transmit the torque from the live rear



The rear axle scaled only 2 cwt. complete and even the rear universal joint was drilled for lightness.



axle. The Peugeot had, in fact, what is known as Hotchkiss drive, whereas all the previous high powered cars had employed either chain drives (for reasons described in the 1911 Fiat) or a live axle in which the torque was transmitted through radius arms or a torque tube. It is now recognised that the Hotchkiss system is a preferred layout in that it produces the minimum of rear-axle steering.

The gearbox, giving four forward speeds, was mounted in the centre of the car and used very short shafts so as to have the minimum deflection. A large ribbed external contracting brake was fitted directly behind the gearbox. The open propeller shaft had pot-type universal joints.

Every endeavour was made to lighten the rear axle as much as possible, and the total weight was only 225 lb. The centre portion consisted of two light alloy castings enclosing the pinion, the crown wheel being rigidly mounted in an extension of the offside housing, as shown in a drawing. Very large diameter internal expanding brake drums were fitted to the rear axle, these being controlled from the hand lever.

Rudge-Whitworth detachable wire wheels were used, this again being an innovation as in all previous Grand Prix races they had been barred by regulations. No attempt was made to streamline the body, and although the engine capacity was moderate compared with preceding cars the extreme dimension for the stroke, plus the height of the valve gear above the cylinder head, imposed a high radiator and bonnet so that there was no possibility of reducing the frontal area.

From the viewpoint of engine output, weight, frontal area and overall performance factors, the Peugeot, indeed, showed little improvement over the cars built four years previous, but the manner of its design created a profound impression amongst European engineers. For example, with three exceptions all subsequent successful road racing cars have embodied the principle of two overhead camshafts operating inclined valves.

DETAILS OF CAR

MAKE.-Peugeot
TYPE.-7.6-litre
YEAR OF CONSTRUCTION.-1911-12
YEARS RACED.-1912-13
DESIGNER.-Henri
WHEELBASE.-9 ft. 1 in.
TRACK FRONT.-4 ft. 6 in.
TRACK REAR.4 ft. 6 in.
HEIGHT TO SCUTTLE.-51 in.
HEIGHT TO DRIVER'S HEAD.-66 in.
FRONTAL AREA.-16 sq. ft.
UNLADEN WEIGHT.-22.5 cwt.
ALL-UP STARTING LINE WEIGHT.-28 cwt.
MAXIMUM SPEED.-100 m.p.h.
SPEED ON INDIRECT GEARS.-90 m.p.h. on Third
,, ,, ,, ,, 66 m.p.h. on Second
,, 50 m.p.h. on First
H.P. PER SQ. FT.-8
H.P. PER TON UNLADEN.-115
H.P. PER TON ALL-up.-93
BORE.-110 mm.
STROKE.-200 mm.
STROKE/BORE RATIO.-1.82 : 1
No. OF CYLINDERS-Four
CAPACITY.-7,600 cc.
PISTON AREA.-58.5 sq. in.
B.H.P.-130 at 2,200 r.p.m.
H.P. PER SQ. IN.-2.43
B.M.E.P.-100
PISTON SPEED FT./MIN.-2,880
CYLINDER HEAD.-Cast-iron integral with block
VALVES No.-Four
VALVES ANGLE.-45 degrees
VALVE AREA INLET.-28.5 sq. in.
VALVE AREA EXHAUST.-28.5 sq. in.
CYLINDERS.-Cast-iron in one block

FUEL.-Petrol
CARBURETTER.-Claudel
SUPERCHARGER.-Nil
MANIFOLD PRESSURE.-Atm.
IGNITION.-BOSCH High Tension Magneto
PLUGS No.-Four
PLUGS LOCATION.-Vertical in head
CRANKSHAFT.-One-piece no counterbalancing
MAIN BEARING No.-Five
MAIN BEARING TYPE.-White Metal
BIG END TYPE.-White Metal
LUBRICATION.-Forced, wet sump
CAMSHAFTS No.-Two
CAMSHAFT LOCATION.-Overhead
CAMSHAFT DRIVE.-Shaft and bevel wheels with final spur wheels
CAMSHAFT DRIVE LOCATION.-Front of crank
CLUTCH.-Multi-plate
GEARBOX LOCATION.-Separate from engine
GEAR RATIOS.-2.3, 2.6, 3.5, 4.7:1
TRANSMISSION.-open propeller shaft, two universal joints, live axle with Hotchkiss drive.
FRAME-Channel
FRONT SUSPENSION.-Semi-elliptic
REAR SUSPENSION.-Semi-elliptic
SHOCK ABSORBERS.-Hartford friction
BRAKE SYSTEM.-Mechanical. Foot : to external contracting band behind gearbox. Hand : to internally expanding shoes on rear wheels
BRAKE DRUM DIAMETER.-18 in. approx.
BRAKE DRUM WIDTH.-No data
SQ. IN. PER TON LADEN.-No data
WHEELS.-Rudge-Whitworth detachable
TYRES-Continental, 895 x 135 Rear, 875 x 120 Front

RACING RECORD OF THE 1912 PEUGEOT

Date	*Event*	*Course*	*Speed*	*Lap Speed*
25/6/12	French G.P.	Dieppe	68.45 m.p.h.	75 m.p.h.
9/9/12	G.P. de France.	Dieppe	71.65 m.p.h.	80 m.p.h.
30/5/13	500 Mile Sweepstake	Indianapolis	75.92 m.p.h.	93.5 m.p.h.

EXAMPLE No. FOUR

The 1913 3-Litre Peugeot

HENRI, once again in association with Messrs. Boillot, Goux and Zuccarelli, designed two Peugeot racing cars for 1913 events. In these he was able to embody all the experience that had been learned with the cars designed for the 1911 Grand Prix, which eventually ran in, and won, the 1912 Grand Prix, as described in Example No. 3.

The larger of these models had a four-cylinder engine with 5.65-litre capacity which won the 1913 French Grand Prix and, in practice, broke the lap record for Indianapolis in 1914 at 99.5 m.p.h., showing that despite the reduction in engine size this car was faster than its predecessor. Even more remarkable from a technical viewpoint was the 3-litre car built for the 1913 Coupe de l'Auto race. This design was not originally designed as a Grand Prix model, but was so efficient that after winning the aforementioned race with great ease it competed with success against full Grand Prix types in later races. For example, in the 1914 Indianapolis race, it was second to a 1913 Grand Prix Delage and beat six cars which had run in that event, including both factory-entered 5.65-litre Peugeots. Additionally, it broke the Class E kilometre and mile records at Brooklands at 105.81 and 105.36 m.p.h., figures which compare very favourably with the speeds achieved on the 1912 7.6-litre Grand Prix Peugeot which did 107.6 and 106.29 m.p.h. respectively over the same distance.

In breaking these records a single-seater body was used in both cases. In road racing trim the 3-litre car achieved a mean speed of 93.82 m.p.h. over two ways of a kilometre stretch and 95.07 m.p.h. in one direction.

The general construction of the engine is obviously similar to the 1912 type, particularly in respect of the stroke/bore ratio (which was actually increased to 2:l) and the *désaxe* position of the cylinders, the centre line of which was offset 20mm. in relation to the crank centre line. In detail, however, many changes were made. The angle of the four valves per cylinder was increased to 60 degrees and the tappet mechanism between cam and valve stem slightly modified. Additionally, the camshafts were driven by a train of spur wheels from the front of the crank, an extension of this driving a fore and aft shaft connecting to the magneto mounted on the crankcase and a centrifugal water pump mounted between the radiator and the-engine. A skew gear from this shaft drove a single oil pump which performed both scavenge and delivery functions, as will be later described.

The crankshaft showed marked novelty in design and construction. It was counterbalanced and made in two halves bolted at the centre, a construction dictated by the decision to carry the crankshaft in ballbearings. The crank itself was 50 mm. diameter on the journals and 40 mm. on the crankpin, and a double row ballbearing was employed for the centre main with a single row at each end of the crankcase. By this successful use of ballbearings and a high speed engine Henri initiated yet another change which was to have a permanent effect in racing-car design.

It is worth noting that the pinions in the camshaft drive were also mounted on ballbearings and that by removing eight nuts the entire camshaft drive could be removed. The use of exposed valve springs and valve guides was continued with a view to achieving maximum cooling and complete freedom from the passage of oil down the valve guides.

The inlet and exhaust valves were of equal diameter (40 mm. over the head) and it is worth noting that in accord with modern practice the main casting projected into the ports to give full protection for the valve guides, the ports themselves each being 35 mm. diameter. Both valves were returned by double coil springs, the outer having eight coils of 3 mm. wire and the inner eleven coils of 2 mm. wire. The valve lifts were identical in both cases at 9 mm., but the exhaust cam had a much more violent opening and longer dwell than the inlet. The inlet valve opened after the piston reached top-centre, but there was an overlap of some six degrees.

A fully open valve just cleared the slightly domed top of the piston head, the c.r. employed being 5.6:1.

As on the larger cars the pistons were machined out of solid steel billets with two plain 4 mm. piston rings, whilst the H section steel connecting rods carried plain white metal bearings.

The connecting rod measured 261 mm., i.e. stroke x 1.6, tapered slightly from 25 mm. to 16 mm. at the neck and the gudgeon pin was only 13 mm. diameter or less than 17 per cent of the bore. The top of the rod was split and compressed by a set pin to give positive locking for the gudgeon pin.

The lubrication system on the car was of particular interest. The earliest racing engines had been supplied with oil under gravity from a remote tank, but with increasing output and rotational velocities this scheme gave way to full pressure lubrication with the oil contained in the crankcase. The 1913 Peugeot scheme was one of the first to employ a dry sump system and is of particular. interest in that only one oil pump was used. This drew either oil or air from the base of the crankcase ; if the former it was delivered through to a large capacity tank mounted beneath the driver's seat, this tank being provided with an air-tight filler cap. If no oil was available from the sump the pump delivered air under pressure to the tank, which was thus held under a constant pressure from the pump. This drove the oil from the tank through a single pipe to six sight feeds mounted on the dashboard. Oil passed through these in a constant stream ; their purpose was to make clear to the driver and mechanic that oil was being despatched to the various lubrication points of the engine. The six offtake pipes led to the camshafts, the pump and magneto shaft, the main bearings and the camshaft drive, and each system could be pre-set so as to divide the flow in accordance with requirements. The oil delivered to the main ballbearings was collected in rings in the crankshaft and fed by centrifugal force into the big end bearing.

This system had the advantage of cool oil stored well away from the crank chamber, formed a visible assurance that the oil flow was correct and gave the opportunity of adjustment between one point and another. To prevent oil tank pressure flooding the sump when the engine was brought to rest there was an ingenious interconnection between the ignition switch and a cock on the main oil line to the sight feed. By this means the tank was isolated from the engine when the magneto was switched off.

The crankcase was of unusual design in that it was not split on a horizontal plane, but was a one-piece casting of barrel section. The two ends were enclosed by plates which supported the front and rear ball bearings, the centre main being fed into an accurately machined housing in a dividing wall between the front and rear halves of the crankcase. This design improved the stiffness of the bottom half of the engine very considerably, and was used on all subsequent Henri designs up to 1922, and on other racing cars until 1936.

Carburation was from a single vertical Claudel instrument feeding into a Y-shaped pipe, the exhaust manifold having individual take-offs for each pair of exhaust ports. All the cooling water was delivered to the exhaust side of the cylinder block and was then taken back to the radiator through two offtake pipes mounted in the centre part of the cylinder head but biased towards the exhaust side thereof. The system contained three gallons of water, 30 per cent of which was contained in the cylinder jackets and pipes.

Both engine and gearbox were mounted in a U section sub-frame which represented a refinement upon the scheme originally used on the 1912 cars. The engine and gearbox unit could, therefore, be aligned on this frame before it was installed in the chassis, the detail arrangements between the two being shown clearly in an illustration.

The 3-litre car was remarkable for the use of a cone clutch, and although the gearbox was of orthodox design it is worth noting that in an effort to save weight all the shafts were bored out. Similar pains in the saving of weight were taken in the construction of the rear axle in which the thickness of the steel outer members was brought down to a few millimetres, both being bolted to a differential housing formed in two light alloy casings.

The suspension was by semi-elliptic springs fore and aft. It is noteworthy that the rear shock absorbers were mounted directly on the rear axle, an arrangement which increased unsprung weight very slightly and offered substantial gains in mechanical simplicity. The front axle was chiefly notable for the use of positive trail to the king pins.

The braking system was entirely conventional, being formed with an internal expanding transmission brake placed just after the gearbox and a handbrake connecting to internal expanding shoes in the rear brake drums. A highly ingenious system of adjustment for the latter was embodied, it being actually possible for the mechanic to compensate for wear in the rear drums whilst the car was in motion. Two steel cables from the brake levers were brought through the frame and ran round two pulleys to end in a sleeve having free movement on a tubular cross-shaft. Each of the two sleeves had a short projecting boss threaded to a long spindle with a right- and left-hand thread. The centre of this spindle was enlarged to form a knurled nut and at one end there was a locking lever. By lifting a small cover in the floorboards the locking lever could be released and the spindle turned so as to bring the two sleeves together and to take up quite quickly the slack in the rear brake cables.

As on previous Peugeot racing cars no effort was made to streamline the bodywork, but due to the considerably smaller size of the car and engine the frontal area was reduced to 14½ sq. ft., so that in conjunction with the low weight of the car satisfactory figures for h.p. per sq. ft. frontal area and h.p. per ton were maintained.

In addition to their performance, these cars were astonishingly reliable and they set a trend in design which lasted for many years. In the R.A.C. T.T. races of 1914 both the Straker-Squire and Humber engines were obviously inspired by Henri's 1913 design, whilst the Sunbeam cars which won the race were an interchangeable replica thereof, as the Sunbeam designer, L. Coatalen, bought one of the Peugeot cars through an intermediary and imported it to England as a model. The 1914 Grand Prix Sunbean 4Q-litre cars were enlarged editions of the T.T. model, whilst the American Monroe design which won the Indianapolis race of 1920 obviously owed much to Peugeot influence.

DETAILS OF CAR

MAKE.-Peugeot
TYPE.-Coupe l'Auto
YEAR OF CONSTRUCTION.-1913
YEARS RACED.--1913-14
DESIGNER.-Henri
WHEELBASE.-9 ft. 4 in.
TRACK FRONT.-4 ft. 8½ in.
TRACK REAR.-4 ft. 8½ in.
HEIGHT TO SCUTTLE.-53 in.
HEIGHT TO DRIVER'S HEAD.-60 in.
FRONTAL AREA.-14.5 sq. ft.
UNLADEN WEIGHT.-16 cwt.
ALL-UP STARTING LINE WEIGHT.-21 cwt.
MAXIMUM SPEED.-95 m.p.h.
SPEED ON INDIRECT GEARS.-70 m.p.h. on Third
" " " " 45 m.p.h. on Second
30 m.p.h. on First
H.P. PER SQ. FT.-6.2
H.P. PER TON UNLADEN. 113
H.P. PER TON ALL-UP.-86
BORE.-78 mm.
STROKE.-156 mm.
STROKE/BORE RATIO.-2.2 : 1
CAPACITY.-2,980 c.c.
PISTON AREA.-29.4 sq. in.
B.H.P.-90 at 2,900 r.p.m.
H.P. PER SQ. IN.-3.06
B.M.E.P.-134 lb. sq. in.
PISTON SPEED FT./MIN.-3,000
CYLINDER HEAD.-Cast-iron integral with block
VALVES No.-Four
VALVES ANGLE.-60 degrees
VALVES AREA INLET.-15.6 sq. in.
VALVE AREA EXHAUST.-15.6 sq. in.
CYLINDERS.-Cast-iron in one block
FUEL.-Petrol
CARBURETTER.-Claudel
SUPERCHARGER.-Nil
MANIFOLD PRESSURE.-Atm.
IGNITION.-Mea high tension magneto
PLUGS No.-Four
PLUGS LOCATION.-Vertical in head
CRANKSHAFT.-Two-piece counterbalanced
MAIN BEARING No.-Three
MAIN BEARING TYPE.-Ball
BIG END TYPE.-White metal
LUBRICATION.-Dry sump
CAMSHAFTS No.-Two
CAMSHAFT LOCATION.-Overhead
CAMSHAFT DRIVE.-Train of spur gears
DRIVE LOCATION.-Front of crank
CLUTCH.-cone
GEARBOX LOCATION.-Separate from engine
GEAR RATIOS.-3.4, 4.8, 7.4 and 11:1
TRANSMISSION.-open propeller shaft, two universal joints, live axle with Hotchkiss drive
FRAME.-Channel
FRONT SUSPENSION.-Semi-elliptic
REAR SUSPENSION.-Semi-elliptic
SHOCK ABSORBERS.-Hartford friction
BRAKE SYSTEM.-Mechanical. Foot to internal expanding shoes on transmission. Hand, to internal expanding shoes on rear wheels
SQ. IN. PER TON LADEN.-380
WHEELS.-Rudge-Whitworth detachable
TYRES.-Pirelli, 895 x 135 Rear, 785 x 105 Front

RACING RECORD 1913 3-LITRE PEUGEOT

Date	*Event*	*Course*	*Speed*	*Lap Speed*
21/9/13	*Coupe* de SAuto	Boulogne	63.15 m.p.h.	65.6 m.p.h.
30/5/14	500 Mile Sweepstake	Indianapolis	SO.89 m.p.h. (2nd)	—

EXAMPLE No. FIVE

The 1914 Mercedes

THE Mercedes cars constructed by the Daimler Motoren Gesellschaft Unterturkheim, were amongst the most prominent competitors in the early history of motor racing.

The 60 h.p. type, driven by Camille Jenatzy, won the 1903 Gordon Bennett race and the 90 h.p. models were second, third, fifth and eleventh in the 1904 Gordon Bennet; event. In the first Grand Prix race of 1906 two cars finished tenth and eleventh ; in 1907 one finished tenth ; and in 1908 Salzer broke the lap record and Lautenschlager finished first and Poege fifth.

The Daimler Motoren-Gesellschaft directors then decided to withdraw support for racing and made no effort to reconsider their verdict until 1913. In this year they made an indirect approach by building some cars for their Belgian agent, Pillette, who entered them for the A.C.F. Grand Prix and the Grand Prix de France run by the Sarthe Club at Le Mans. Under the rules manufacturers alone were eligible for the A.C.F. race, in which entry was refused, but the cars ran in the Sarthe event from which much experience was gained. Although contemporary reports ascribed a mixture of chain and shaft drive to these entries none of the cars in fact used a live axle and they were therefore the last chain-drive models designed for Grand Prix racing. Some had four- and some six-cylinder power units and although one sleeve valve four-cylinder was run, the other three engines were largely based upon existing aircraft engines having a single overhead camshaft (driven by a vertical shaft in the rear) and inclined valves operated by exposed rockers. One of the engines used cylinders constructed from steel forgings with welded-up ports and sheet-steel water jackets.

There is no doubt that the data gained with these cars was of considerable value to constructors when they entered a team for the 1914 A.C.F. Grand Prix, the regulations of which stipulated a maximum engine capacity of 4½ litres unsupercharged and maximum weight of 21 cwt. bare.

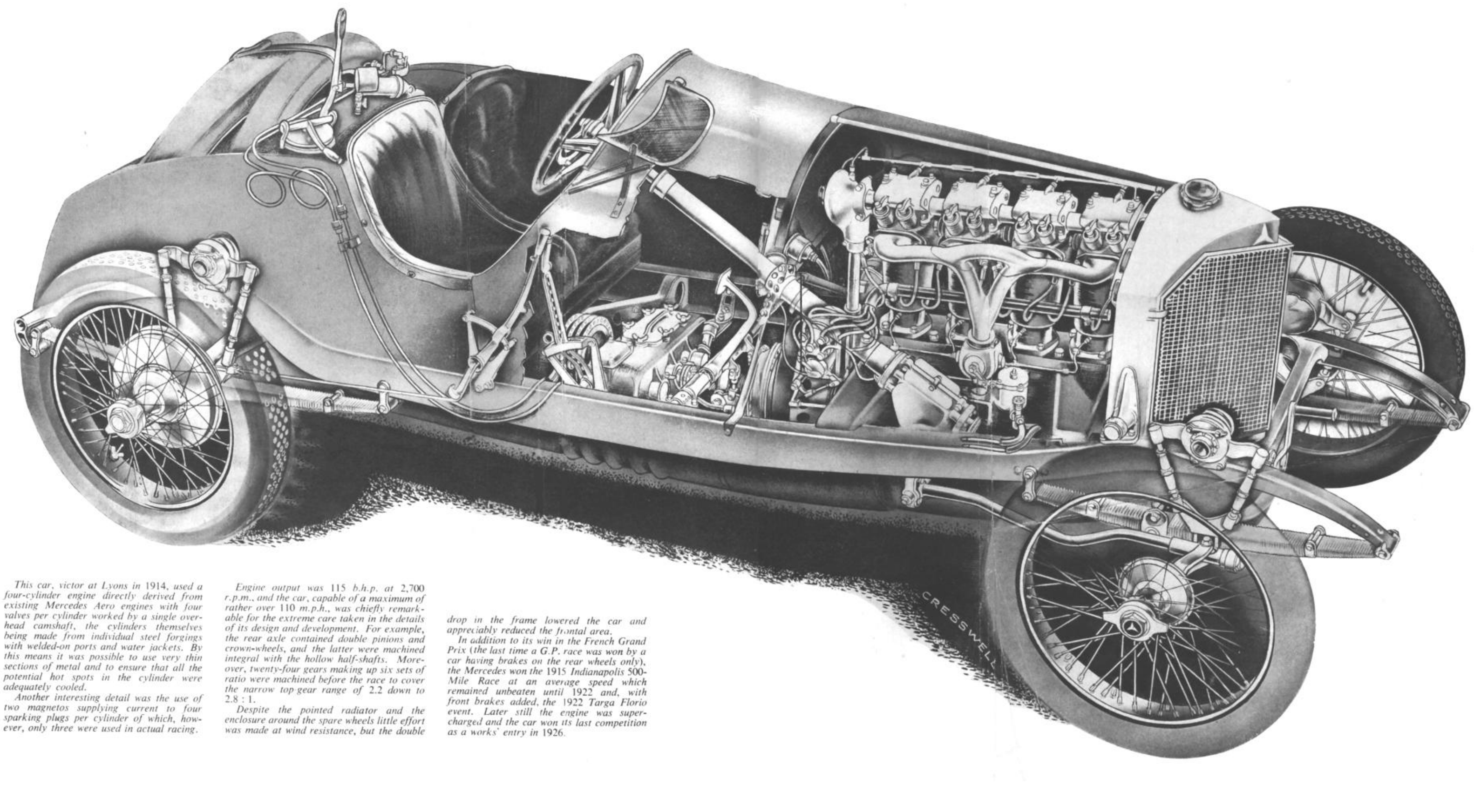
Mercedes decided to build cars with four-cylinder engines and live axles, and to enter the largest team permitted, viz., five cars. Despite the knowledge that other constructors would be incorporating such advanced features as double overhead camshafts and front-wheel brakes, the German models were conservatively engineered. The engineers made full use of the experience obtained by the aviation engine section of the business, but there were, of course, a number of deviations embodied with a view to increasing the r.p.m. and the power per litre. In particular the need for a large valve area led to the use of four valves per cylinder, together with two magnetos and a choice of three or four sparking plugs ; additionally, in order to avoid critical torsional oscillations the vertical drive to the camshaft and the cross drive to the magnetos was placed at the rear of the engine, adjacent to the flywheel.

In a works' publication, issued in 1938, the constructors estimated the speed of this car as 112 m.p.h., whilst in a prior publication of 1915 they recorded that the cars would do 103 m.p.h. when they left the works, which was improved to 120 m.p.h. at the time of the race. It is possible to check these figures against an average of 103.45 m.p.h. for fifty miles in the U.S.A. on a board track and 109 m.p.h. for a single lap.

PLATE XVIII

EXAMPLE No. FIVE

THE 1914 MERCEDES



This car, victor at Lyons in 1914, *used a four-cylinder engine directly derived from existing Mercedes Aero engines with four valves per cylinder worked by a single overhead camshaft, the cylinders themselves being made from individual steel forgings with welded-on ports and water jackets. By this means it was possible to use very thin sections of metal and to ensure that all the potential hot spots in the cylinder were adequately cooled.*

Another interesting detail was the use of two magnetos supplying current to four sparking plugs per cylinder of which, however, only three were used in actual racing.

Engine output was 115 *b.h.p. at* 2,700 *r.p.m., and the car, capable of a maximum of rather over* 110 *m.p.h., was chiefly remarkable for the extreme care taken in the details of its design and development. For example, the rear axle contained double pinions and crown-wheels, and the latter were machined integral with the hollow half-shafts. Moreover, twenty-four gears making up six sets of ratio were machined before the race to cover the narrow top gear range of* 2.2 *down to* 2.8 : 1.

Despite the pointed radiator and the enclosure around the spare wheels little effort was made at wind resistance, but the double drop in the frame lowered the car and appreciably reduced the frontal area.

In addition to its win in the French Grand Prix (the last time a G.P. race was won by a car having brakes on the rear wheels only), the Mercedes won the 1915 *Indianapolis* 500-*Mile Race at an average speed which remained unbeaten until* 1922 *and, with front brakes added, the* 1922 *Targa Florio event. Later still the engine was supercharged and the car won its last competition as a works' entry in* 1926.

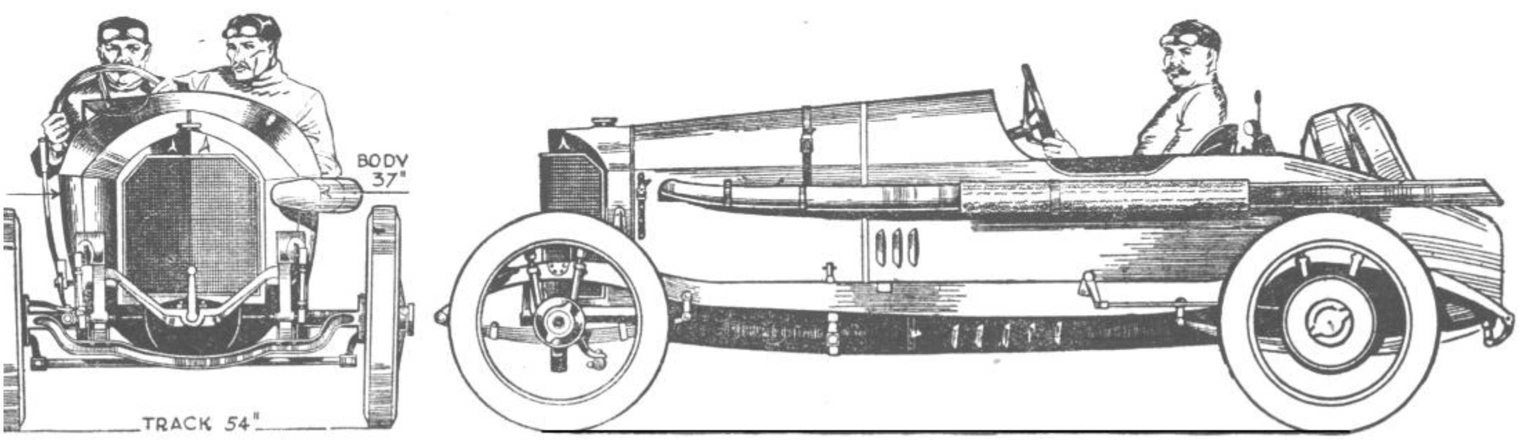
The Brooklands times achieved by one of these cars in 1921 give a flying lap at 104.19 and a standing lap at 84.46, and, on the balance of evidence, it is reasonable to place the top speed of this car at 112 m.p.h.

In using four valves per cylinder the designer followed the example set by Henri, of Peugeot, two years before, but by using a single camshaft with exposed rockers a certain degree of simplicity was obtained.

There was nothing in the general specification of the car to mark it out from many of the other forty entrants comprising the field, but the execution of the design was engineering of the first order and proof that the palm of victory goes more often to the designer who avoids foolishness than to the one who shows the greatest ingenuity.

Probably the most interesting feature of the engine, both in itself and in its influence upon subsequent designs, was to be found in the cylinder construction. Between 1900 and 1905 many cars had separately cast cylinders with, in some cases, electrically deposited sheet-copper water jackets. Subsequently it became more usual to have cylinders cast in pairs and, finally, in blocks of four, a system which undoubtedly added considerably to the stiffness of the engine as a whole. Mercedes, however, retained pairs of cylinders on their 1911 and '12 aero engines, and in the latter year developed a construction in which the cylinders were made from steel forgings, the ports and water jackets being subsequently welded into position.

The 1914 racing car engine followed this practice, but instead of mounting the cylinders on the crankcase in pairs welded together they were separately attached. Maintenance was probably improved by this scheme at the expense of rigidity, but there can be no question concerning the merits of the basic system of construction.



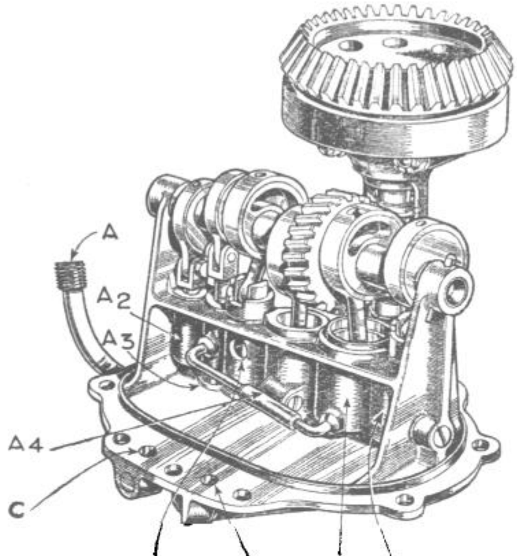
SCALE 1 : 30

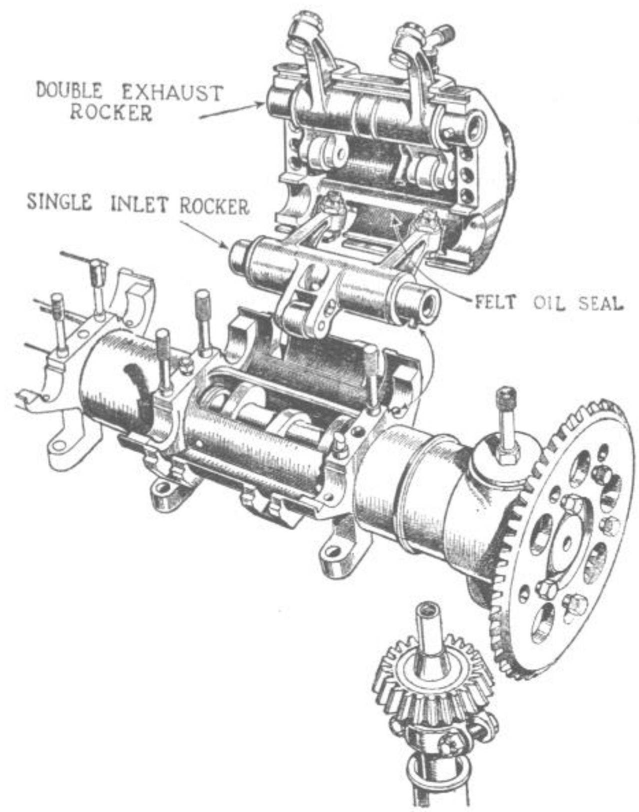
It is, of course, expensive in man-hours and requires highly expert welding, but it has the great technical merit of giving close control over the thickness of metal of every part and in particular makes it very easy to get water very close indeed to the valve seats. The valve gear on the racing car engine was also inherited directly from and was virtually a replica of that employed on previous aero engines, except that the number of valves per cylinder were increased to four, inclined at an included angle of about 60 degrees and with a timing as follows :

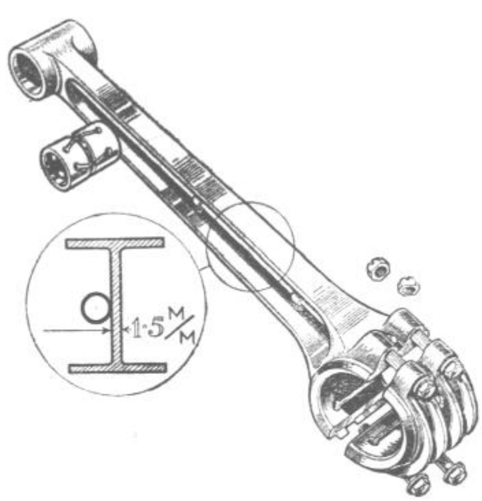
Inlet opens T.D.C.
Inlet closes 35 degrees after B.D.C.
Exhaust opens 50 degrees before B.D.C.
Exhaust closes 9 degrees after T.D.C.

All the valves are operated from a single overhead camshaft which runs in bronze bearings. Three cams per cylinder are provided, one operating the inlet valves through a forked rocker and the other two working on a rocker for each exhaust valve. The camshaft is mounted in a long tunnel running along the top of the engine with the rockers emerging through slots in the rocker box, the upper part of the valve stem and springs being entirely exposed with a view to giving maximum cooling and instant accessibility for checking valve clearances.

The camshaft drive consisted of a vertical shaft at the rear of the engine with bevel drive top and bottom, a cross-shaft providing drives for two Bosch magnetos one of which was a double magneto feeding eight sparking plugs on the carburetter side of the cylinders, the other feeding four plugs, i.e. one per cylinder on the exhaust side. Although provision was made for the use of sixteen sparking plugs, in all only twelve were actually used, all of them threaded horizontally into the combustion space. At the opposite end of the engine a vertical shaft, driven by bevel gears, connected to water pump, the offtake of which leads to a manifold delivering coolant to the base of







Above-Details of camshaft, rocker gear and camshaft drive

(Above Left)-The triple pump lubrication unit (vide text)

Left-Connecting rod showing big and little ends

each four water jackets, an interesting point being that these were carried almost the full length of the cylinder barrels. These were attached to the crankcase by four bolts which pass right through the main-bearing housings and serve at their opposite extremity as tie bolts for the main bearing caps. The crankshaft (48 mm. in diameter) was well counterbalanced, and ran in white metal bearings.

Two piston-type pumps with slide valves attended to the lubrication of the engine, but one of these (C) was a scavenger which sucked oil from the front end of the sump and delivered it into the rear half of the crankcase. The second piston (B) picked up oil from the rear of the sump and delivered it through a filter to the main bearing big ends and, by small pipes fitted on to the connecting rods, to the gudgeon pins. This, however, did not entirely complete the oil pump unit for a third piston (A) abstracted a small quantity of oil on each stroke from a reserve tank and delivered it into the suction side of the main oil pump. By this means the sump level was kept approximately constant and, perhaps more important, the oil stream going to the bearings was constantly refreshed by a supply of cool, clean oil. Supplementing this mechanical system was a pump operated by the mechanic's foot which could deliver oil either to the valve gear or to the crankcase at will. This delivered oil direct to the base of the cylinders, the camshaft bearings and the rockers.

The big ends were also white metal cast into detachable bronze shells, the rods themselves being particularly fine examples of the machinist's art with the web only 1.5 mm. thick. These components were nevertheless a source of weakness on the design, almost eliminating the 1915 Indianapolis winner, in which race de Palma had to finish on three cylinders. At the top end of the rod the gudgeon pin was locked in the boss with a floating bush interposed between pin and the little end.

The gudgeon pin ran in a cast-iron piston which had four very narrow rings, an interesting detail of the design being the oil return groove between Nos. 3 and 4 rings. This consisted of a shallow recess with knife edges and small holes drilled through for oil return purposes.

The crankcase was formed from two light alloy castings giving a four-point mounting in the frame, and it will be appreciated from the description of the main bearings that the bottom half was merely an oil container, all the stresses being taken through the upper half which also acted as a considerable stiffening element in the front end of the frame. The carburation on these engines was by a special Mercedes type instrument with a barrel type choke delivering to a Y branch manifold.

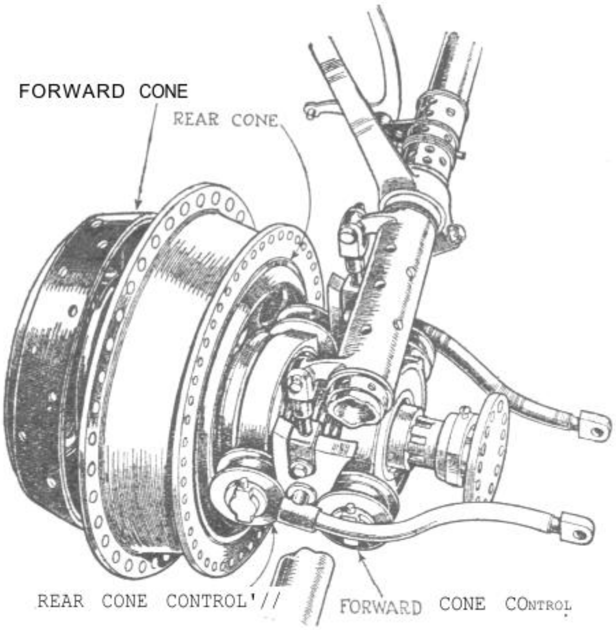
Power was transmitted through a highly ingenious double cone clutch, the purpose of which was to give the reliability and simplicity of the cone type coupled with moderate diameter and low spinning weight characteristic of the multi-disc form of transmission.

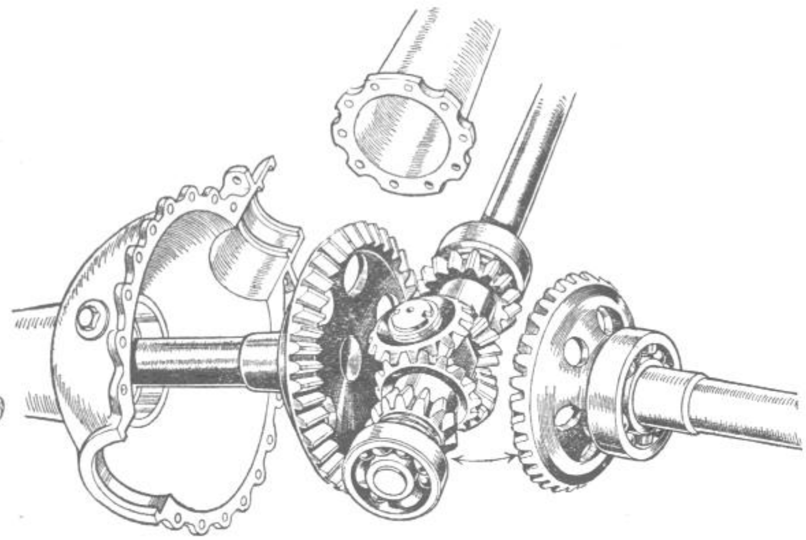
A short shaft was interposed between the clutch and the gearbox of orthodox four-speed type, behind which was a large spherical joint which takes the driving torque and propels the car. The propeller shaft was braced by a triangulated rod layout and the rear axle housing was light and stiff but of fairly orthodox design. Two halves were machined from the solid and held together by eighteen bolts.

The interior gearing was unusual with two crown-wheels and two pinions each driving one half-shaft. Between them lay the differential gear, and as a consequence the loading on the teeth was light, and, the pinion shaft being between two bearings, it did not deflect in the manner normal to the orthodox overhung design.

This form of construction is the subject of a Mercedes patent in 1899, the stated intention of which was to permit inclined countershafts so that the sprockets driven thereby should be in line with wheels inclined outwards and that the tyre tread would be more nearly parallel with the road surface when the car was running on the crown of the heavily-cambered roads of the time. Exactly the same principle was followed with the live axle on the 1914 racing car although the degree of inclination was very slight, only 1' 20" from the vertical.

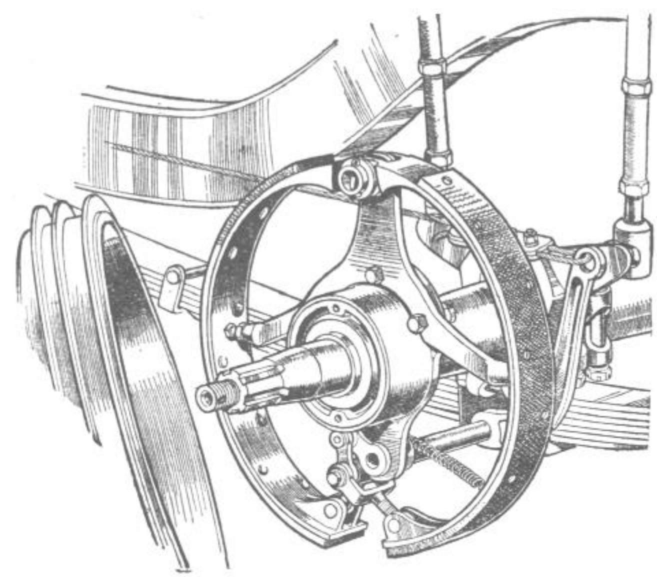
The detail of the rear axle design is yet a further example of the immense thoroughness with which these cars were prepared. The crown-wheel was in one with





Top, left-Clutch assembly

Top, right-Differential assembly



Right-Rear brake assembly

the half-shaft, the latter being hollowed to save weight. Sufficient half-shafts-cum-crown-wheels and pinions were constructed to give a choice of six alternative ratios between 2.2 and 2.7:1. The choice of gear ratios was indeed a severe headache for the designer. The 23.3-mile Lyons circuit was popularly supposed to have 100 corners : it certainly embraced a difference of 700 ft. between the highest and the lowest point, and one leg consisting of an eleven-mile switchback straight.

The external contracting brake on the propeller shaft was worked by the pedal and the hand lever expanded the internal shoes on the rear wheels, not, however through a cam, but by means of a toggle action. The shoes themselves were very thin and purposely made to distort so as to give a more equal pressure between brake linings and brake drums throughout the whole arc of the shoe.

Semi-elliptic springs were used with special Mercedes shock absorbers, which took the form of supplementary coil springs compressed by a face cam arrangement. The result was to give variable rate to the springing system, stiffening up, of course, as the axle departs from its normal position.

Steering was by means of a massive worm and nut box through a conventional linkage system in which both forked arms and spring-loaded ball joints were employed, whilst the chassis frame was normal steel channel section, but had a double drop so as to give a low centre of gravity.

Another feature of note was an embryo X-bracing member just aft the gearbox. Although the angle of the X was narrow it was of very stout construction and was employed not only to brace the frame, but also to locate the trunnion on the forward end of the torque tube. There was a double thickness of metal in the centre and great care was taken to see that the torque tube mounting was dead square. The frame was also braced by a cross-member under the radiator, by the engine, to some extent by the gearbox, by a light drilled channel section on the up-sweep over the rear spring and by a tubular member connecting the rear spring horns.

Acknowledgments.-Thanks are due to Daimler-Benz A.G., Stuttgart, for co-operation in providing data and drawings relating to the above car, and to Mrs. Ariel Clarke who gave full access to the car driven at Lyons by Pilette then in her possession and now owned by Mr. Briggs Cunningham.

DETAILS OF CAR

MAKE.-Mercedes
TYPE.- 4½ -litre G.P.
YEAR OF CONSTRUCTION.-1914
YEARS RACED.-1914-29
DESIGNER.-Paul Daimler, Nallinger
WHEELBASE.-9 ft. 4 in.
TRACK FRONT.-4 ft. 4½ in.
TRACK REAR.4 ft. 5 in.
HEIGHT TO SCUTTLE.-47 in .
HEIGHT TO DRIVER'S HEAD . – 60 in.
FRONTAL AREA.-13 sq.ft.
UNLADEN WEIGHT.-21.5 cwt.
ALL-UP STARTING LINE WEIGHT.-26½ cwt.
MAXIMUM SPEED.-112 m.p.h. at 2,900 r.p.m.
SPEED ON INDIRECT GEARS.-65 m.p.h. on Third
„ „ „ „ 42 m.p.h. on Second
„ „ „ „ 28 m.p.h. on First at 3,000 r.p.m.
H.P. PER SQ. FT.-8.9
H.P. PER TON UNLADEN.-107
H.P. PER TON ALL-UP.-87
BORE.-93 mm.
STROKE.-165 mm.
S./B. RATIO.-1.77:1
No. OF CYLINDERS.-Four
CAPACITY.-4,483 c.c.
PISTON AREA.-42 sq. in.
B.H.P.-115 at 2,800 r.p.m.
B.M.E.P.-120 lb.
H.P. PER SQ. IN.-2.73
PISTON SPEED FT./MIN.-3,050
CYLINDER HEAD.-Steel integral with barrel
VALVES No.-4
VALVES ANGLE.-60 degrees
VALVES AREA INLET.-22 sq. in.
VALVES AREA EXHAUST.-22 sq. in.
CYLINDERS.-Separate steel forgings with welded-up ports and water jackets
FUEL.-Petrol
CARBURETTER.-Mercedes
SUPERCHARGER.-Nil
MANIFOLD PRESSURE.-Atm.
IGNITION.-Two Bosch high tension magnetos
PLUGS No.-12
PLUGS LOCATION.-Horizontal, two on inlet, one on exhaust side each head
CRANKSHAFT.-One-piece counterbalanced.
MAIN BEARING No.-5
MAIN BEARING TYPE.-White metal
BIG END TYPE.-White metal
LUBRICATION.-Wet sump with automatic replacement of lost oil.
CAMSHAFTS No.-1
CAMSHAFT LOCATION.-Overhead
CAMSHAFT DRIVE.-Shaft and bevel gears
DRIVE LOCATION.-Rear of crank
CLUTCH.-Double cone
GEARBOX LOCATION.-Separate from engine
GEAR RATIOS.-2.7, 4.8, 7.4 and 11.1. (Variations of the top gear available from 2.2 to 2.7.)
TRANSMISSION.-Torque tube drive crown-wheel and pinion for each half-shaft with common differential,
FRAME.-Channel with centre X-brace.
FRONT SUSPENSION.-Semi-elliptic.
REAR SUSPENSION.-Semi-elliptic
SHOCK ABSORBERS.-Mercedes face cam adjustable.
BRAKE SYSTEM.-Foot ; external contracting on transmission with drum. Diameter 11½ in. x 2-7/8 in. wide. Hand : Rear internal expanding with flexible shoes in drum 13-3/8 in. diameter x 1½ in. wide.
SQ. IN. PER TON LADEN.-172.
STEERING.-Worm and nut. 14 turns lock to lock
WHEELS.-RudgeWhitworth detachable
TYRES.-Continental. Front 820 x 120
Rear 895 x 135

RACING RECORD 1914 G.P. MERCEDES

Date	*Event*	*Course*	*Speed*	*Lap Speed*
5/7/14	French G.P.	Lyons	65.5 m.p.h.	69.95 m.p.h.
30/5/15	500 Miles Sweepstake . .	Indianapolis	89.94 m.p.h.	98.6 m.p.h.
17/7/16	50 Miles Race . .	Omaha	103.45 m.p.h.	—
2/4/22	Targa Florio . . .	Madonie	39.2 m.p.h.	—

EXAMPLE No. SIX

The 1920 Ballot

THE genesis of the eight-cylinder in-line 5-litre racing cars, designed by Henri, for Ballot, in 1919, is described elsewhere, as is the performance of these cars at Indianapolis and in the Targa Florio of that year.

In 1920 the organisers of the 500 Miles Sweepstake at Indianapolis put a limit of 3 litres on engine capacity, and the Ballot brothers decided to compete with three cars which were virtually scaled-down versions of the 5-litre models from the hand of the same designer. All three cars finished (second, fifth and seventh), and R. de Palma was only deprived of victory by misfortune after having put up easily the fastest lap.

In 1921 a similar car was entered with front brakes added and led for the first three hours. In the French Grand Prix the design finished second.

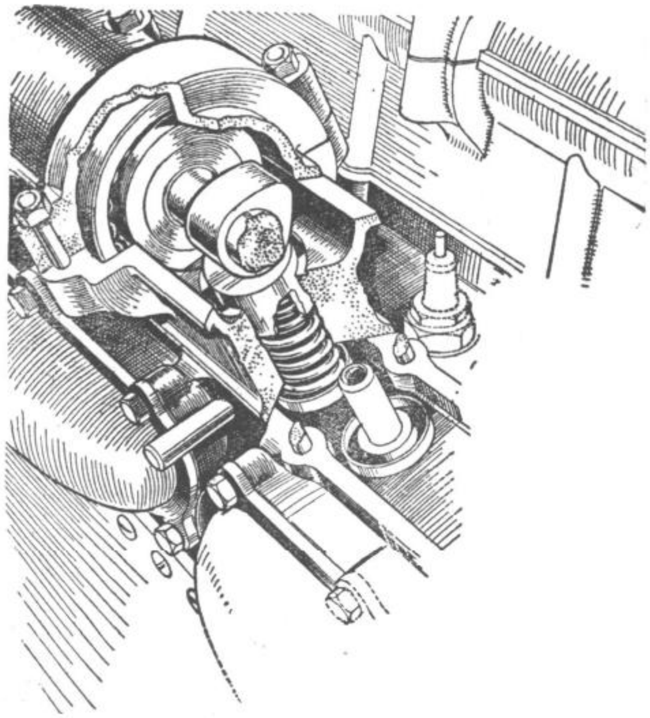
The best lap returned at Indianapolis was 100.75 m.p.h. in 1921, but in 1925 one of these cars put in a lap at Brooklands at 109.22 m.p.h. and a standing lap at 88.10 m.p.h. We may, therefore, have a little hesitation in putting the maximum speed of the car at 110-112 m.p.h.

As with the 5-litre model the Ballot showed many traces of Peugeot ancestry. Taking, firstly, chassis features, the drawing shows how Henri retained an engine and gearbox mounted in a sub-frame having a three-point mounting within the main side members, whilst the details of axles and brake, gear steering system are remarkably similar to those employed on the 1914 4½-litre Peugeots. In the brake mechanism, however, one major change was made in that the car was designed to employ a Birkigt type servo motor. This design was originally employed on the 1919 Hispana Suiza and was used by Henri under licence. It consisted of a disc-type brake, driven at slow speeds from a skew gear off the transmission ; the action of the pedal brought a stationary drum into contact with the rotating disc and the turning moment so generated was used to apply both front and rear brakes through a link motion. The result was a very much lighter pedal action than usual.

R. de Pahna, the first driver in the Ballot team, disliked this lightness and refused to have the servo, coupling the pedal to the rear drums and the hand lever to the front axle. It is this system which was present on the car inspected for this chapter, and hence disclosed in the drawings. The motion for the front wheels was carried through an ingenious rack-and-pinion device, and a pivoted cam was used to expand two shoes in the brake drum. The front drums were smaller than the rear, but, even so, the front axle and springs were severely stressed if the brakes were applied hard. In fact, in these circumstances, the king-pin visibly rotates axially and winds up the axle.

The transmission brake used on all racing cars up to this time disappeared, but the general design of transmission remained of conventional form-a Ferodo-lined cone clutch and a separate gearbox with exceedingly close ratios, as can be seen from the data chart. Hotchkiss drive was employed ; both front and rear springs being heavily damped with double Hartford shock absorbers.

The steering and control on this car were notably good, but that was due in part to the very rigid mounting of the steering box on a cross tube. On the other hand, as a consequence of using the sub-frame the engine contributed nothing towards frame stiffness, and with the extremely exiguous front cross members the fore part of the car was definitely " floppy." The engine was notable for the deliberate choice of a large stroke/bore ratio (1.73:1) in accordance with Henri's known theories on this subject,



The camshaft bears on a steel cylinder fitted over the valve springs

and despite the use of small cylinders both piston speed and maximum r.p.m. were held to very moderate figures. The limit on speed appears to be due to the rather poor design of the big end, which was, nevertheless, a beautiful piece of workmanship. Between the rod and the crankpin was a bronze bush made in two halves, dovetailed together and a close but running fit in the big end. This bush was white-metalled internally to face upon the crankpin, but the motion between its external face and the connecting rod was between the bronze and unhardened steel.

Light-alloy pistons were used. The crankshaft was built up in four sections, three of which were interchangeable. The parts were joined together by taper and key, and the scheme assisted the installation of the main bearings and made for easy replacements if needed.

Lubrication was by the normal Henri principle of a plunger pump scavenging oil from the crankcase, delivering it under pressure to a remote tank and then pumping it back to the main bearings.

The latter consisted of five Hoffman 90 x 123 mm. roller bearings fitted to the 42 mm. diameter crankpin journals. The main bearings were pressed into annular rings having an overall diameter slightly greater than the extreme radius of the crankshaft. The bearings were placed on to the pins in the crank assembly and then fed with bearings into the barrel type crankcase from the rear. Connecting rods were then fitted from above the big end, bolts being inverted so that the nuts could be tightened through inspection holes on the side of the crankcase. The main bearings were fed with oil by means of jets, catcher rings being placed on the webs so as to feed oil in the big ends.

The valve gear was evidently laid out with a view to high r.p.m. and has low inertia. An inverted steel piston fits over the valve springs and a cam bears on its upper

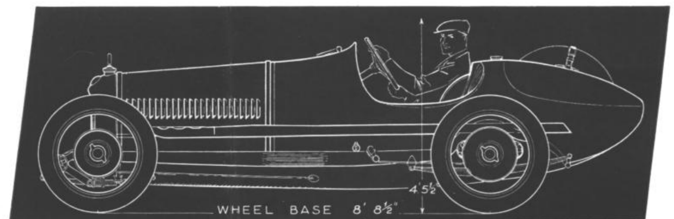
PLATE XIX

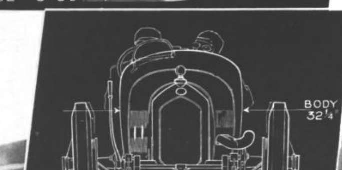
EXAMPLE No. SIX

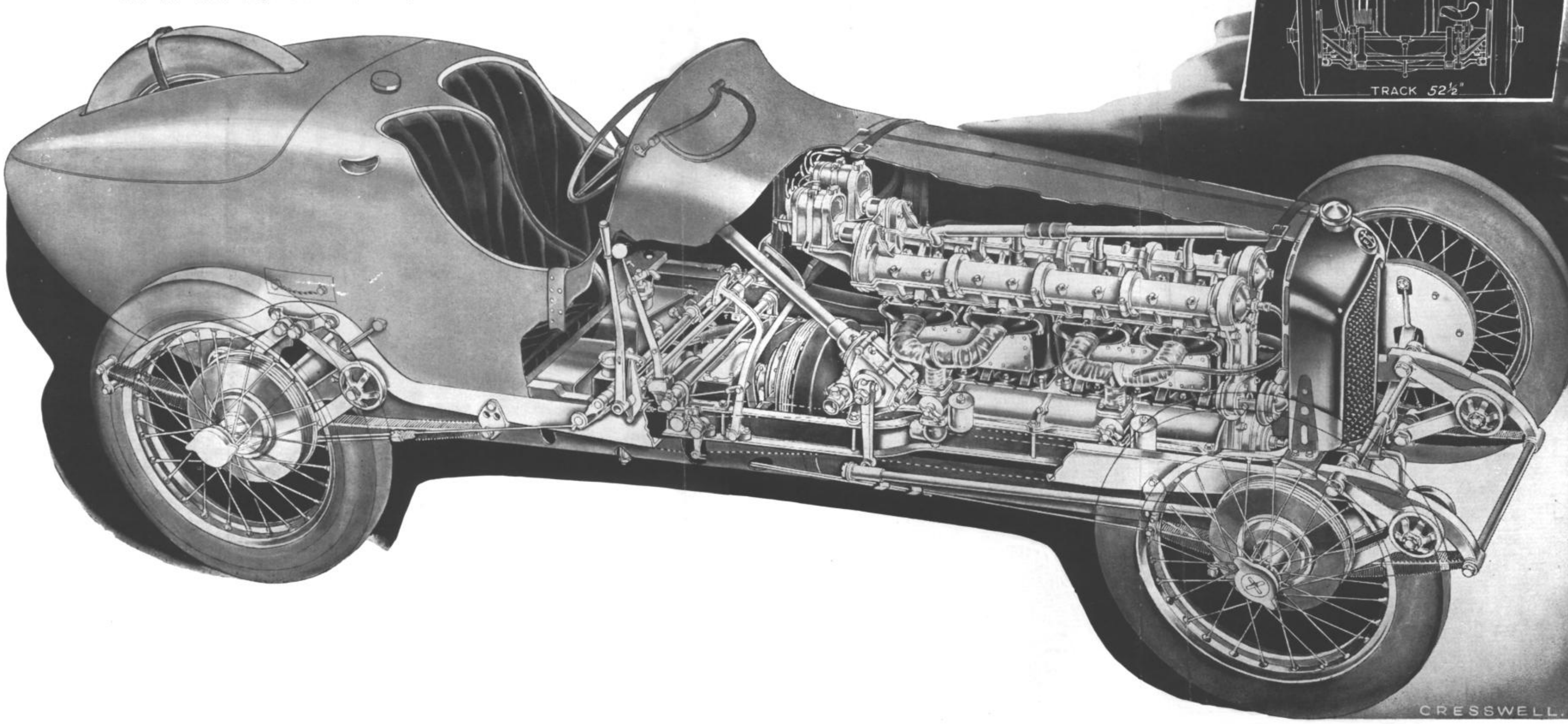
THE 1920 BALLOT

In 1919 the ex-Peugeot engineer, Henri, designed the 4.9-litre Ballot which was the first successful racing car with an eight-cylinder in-line engine. The following year he was responsible for this 3-litre straight-eight Ballot, which developed some 110 b.h.p. at 3,800 r.p.m. The whole design is obviously reminiscent of previous Peugeot practice, and although the crankshaft speed was considerably raised the piston speed was almost unchanged as a consequence of using eight small, in place of four large, cylinders. This car also was one of the first racing engines to use pistons cast in light alloy, and although four valves per cylinder inclined at 60 degrees were retained, the entire valve gear was now enclosed. The lubrication system, transmission and chassis design were directly inherited from 1913 Peugeot design and the front brake mechanism and body shape from the Peugeots built for the 1914 Grand Prix. The brakes were made under Isotta-Fraschini licence with floating front cams and fixed brake cross shafts. The long-tailed, barrel-shaped body contained one spare wheel mounted in the tail.

The improvement in performance compared with the 1913 four-cylinder car designed by the same man may be seen by comparing the speeds at Indianapolis where, for 200 miles in 1920, the eight-cylinder averaged 93.06 m.p.h. In 1921 the car averaged 93.66 m.p.h. for the first 200 miles at Indianapolis, was second in the French Grand Prix at Le Mans and first in the Italian Grand Prix at Brescia.







face. Two camshafts were used, each running in ballbearings, and driven from a train of gears at the front end of the crankcase. Four valves (inlet larger than exhaust) per cylinder inclined at 60 degrees were employed, and this angle was doubtless dictated by the fact that the cylinder head was non-detachable, the cylinders themselves being iron castings made in two blocks of four. Each block had a separate inlet manifold, with a Claude1 carburetter. On the left-hand side of the engine was a straightforward eight-branch outside exhaust.

K.L.G. plugs were used, these being in the centres of the cylinders and the firing order was 1-8-3-6-4-5-2-7.

The camshaft and auxiliary drives were almost replicas of those employed on the 3-litre Peugeot designed seven years previously, except that a short auxiliary shaft driven from the train of gears was used on the Ballot solely to drive a water pump having an out-flow to the exhaust side of the cylinder blocks. By reason of having eight cylinders the designer used two four-cylinder magnetos mounted on the platform attached to the valve housing and driven at engine speed from the rear of the camshafts.

The overall performance of the Ballot was much improved by the body design. This embraced a well-streamlined tail in which the spare wheel was longitudinally mounted and exceptionally low frontal area, the body being remarkably narrow for a two-seater. As shown in a drawing the seats were very much staggered in relation one to the other, the mechanic sitting sideways on and passing one arm behind the driver's seat. The underneath of the car was completely enclosed by an under tray, and although the axles were fully exposed there can be little doubt that the wind resistance of the car was considerably reduced compared to existing practice. Bearing in mind that it was originally designed in 1920, this car may indeed be considered a pioneer in many directions for it combined the multi-cylinder engine with limited engine capacity and a well-formed body. In the year of its original construction it was undoubtedly the fastest car of its type in the world.

Acknowledgments.-The car described and drawn in this chapter was put at the disposal of the artist and author by A. S. Heal, Esq. Further information has been received from M. C. Crowley Milling, Esq., who was the owner of the car in 1947.

DETAILS OF CAR

MAKE.-Ballot
TYPE.-3-litre G.P.
YEAR OF CONSTRUCTION.-1920
YEARS RACED.-1920-21
DESIGNER.-Henri
WHEELBASE.-8 ft. 8½ in.
TRACK FRONT.-4 ft. 4½ in.
TRACK REAR.-4 ft. 4½ in.
HEIGHT TO SCUTTLE.-49 in.
HEIGHT TO DRIVER'S HEAD.-53½ in.
FRONTAL AREA.-12 sq. ft.
UNLADEN WEIGHT.-18 cwt.
ALL-UP STARTING LINE WEIGHT.-23 cwt.
MAXIMUM SPEED.-112 m.p.h. at 3,550 r.p.m.
SPEED ON INDIRECT GEARS.-78 m.p.h. on Third
" " " " 60 m.p.h. on Second
" " " " 30 m.p.h. on First at 3,800 r.p.m.
H.P. PER SQ. FT.-9
H.P. PER TON UNLADEN.-119
H.P. PER TON ALL-UP.-93
BORE.-65 mm.
STROKE.-112 mm.
S./B. RATIO.-1.72:1
No. OF CYLINDERS.-Eight
CAPACITY.-2,960 c.c.
PISTON AREA.-41 sq. in.
H.P.-107 at 3,800 r.p.m.
B.M.E.P.-122 lb.
H.P. PER SQ. IN.-2.61
PISTON SPEED FT./MIN.-2,800
CYLINDER HEAD.-Cast-iron integral with block
VALVES No.-Four
VALVES ANGLE.-60 degrees
VALVE AREA INLET.-22.5 sq. in.
VALVE AREA EXHAUST.-18.6 sq. in.
CYLINDER BLOCK.-Iron castings in two blocks of four
FUEL.-Petrol
CARBURETTER.-Two Claudels
SUPERCHARGER.-Nil
MANIFOLD PRESSURE.-Atm.
IGNITION.-2 Marelli magnetos
PLUGS No.-Eight
PLUGS LOCATION.-Vertical in head
CRANKCASE.-Barrel type
CRANKSHAFT.-Five piece built up
MAIN BEARING No.-5
MAIN BEARING TYPE.-Roller
BIG END TYPE.-White metal on bronze floating bush
LUBRICATION.-Dry sump, centrifugal pressure to big ends
CAMSHAFTS No.-Two
CAMSHAFT LOCATION.-Overhead
CAMSHAFT DRIVE.-Train of gears
DRIVE LOCATION.-Front of crank
CLUTCH.-cone
GEARBOX LOCATION.-Separate from engine
GEAR RATIOS.-3.0, 4.2, 5.4, and 11.1
TRANSMISSION.-open propeller shaft to bevel drive rear axle
FRAME.-Channel with U section sub-frame for engine and gearbox mounting
FRONT SUSPENSION.-Semi-elliptic
REAR SUSPENSION.-Semi-elliptic
SHOCK ABSORBERS.-Hartford friction
BRAKE SYSTEM.-Foot : to all four drums through Birkigt type servo ; alternatively, pedal to rear, hand to front drums. Front drum diameter 14 in., rear 15 in.
SQ. IN. PER TON LADEN.-320
STEERING.-Worm and wheel. 1) turns lock to lock.
WHEELS.-Rudge-Whitworth detachable
TYRES.-Front 820 x 120
Rear 835 x 135

RACING RECORD 3-LITRE, EIGHT-CYLINDER BALLOT

Date	*Event*	*Course*	*Speed*	*Lap Speed*
30/5/20	500 Miles Sweepstake ..	Indianapolis	87.47 m.p.h. (second)	99.15 m.p.h.
30/5/21	500 Miles Sweepstake ..	Indianapolis	—	100.75 m.p.h.
26/7/21	French G.P.	Le Mans	73.6 m.p.h. (second)	—
4/9/21	Brescia G.P.	Brescia	90.4 m.p.h.	93 m.p.h.

EXAMPLE No. SEVEN

The 1922 Vauxhall

VAUXHALL Motors, Ltd. ran teams of cars in the 1912 and 1914 Grand Prix races, but following the resignation, in 1919, of Mr. L. H. Pomeroy, their technical director, they abstained from international racing in 1920 and 1921. The latter year, however, they decided to return to the field with an entry of three cars of 3-litre capacity for the 1922 Tourist Trophy races, organised by the Royal Automobile Club and run in June over the traditional Isle of Man circuit. Further entries in other events were planned in ignorance of the fact that the approved international formula for the years 1922-25 embodied a capacity limit of 2 litres. For this reason the cars were debarred from further international competition and restricted to appearances at Brooklands and various national races.

The cars were, moreover, unfortunate in the T.T. race, one being put out by a broken roller on a big-end bearing and another by a piece of metal breaking away from the light alloy piston skirt and jamming between the connecting rod and the crank cheek. Later in the year at Brooklands, the Vauxhall easily beat the Sunbeam car, which had won the T.T. and lapped at 108 m.p.h. (standing lap 93.69), whereas the best lap put up by a 3-litre Sunbeam was 102.9 m.p.h.

In 1925 this model broke the Class D standing kilometre record at 69.75 m.p.h. and the mile at 78.69 m.p.h., and covered the flying kilometre at an average of 111.85 m.p.h.

From these figures we can deduce that the speed between the end of the standing kilometre and the end of the standing mile was at an average of 99.8 m.p.h. and that the maximum speed was of the order of 112 m.p.h.

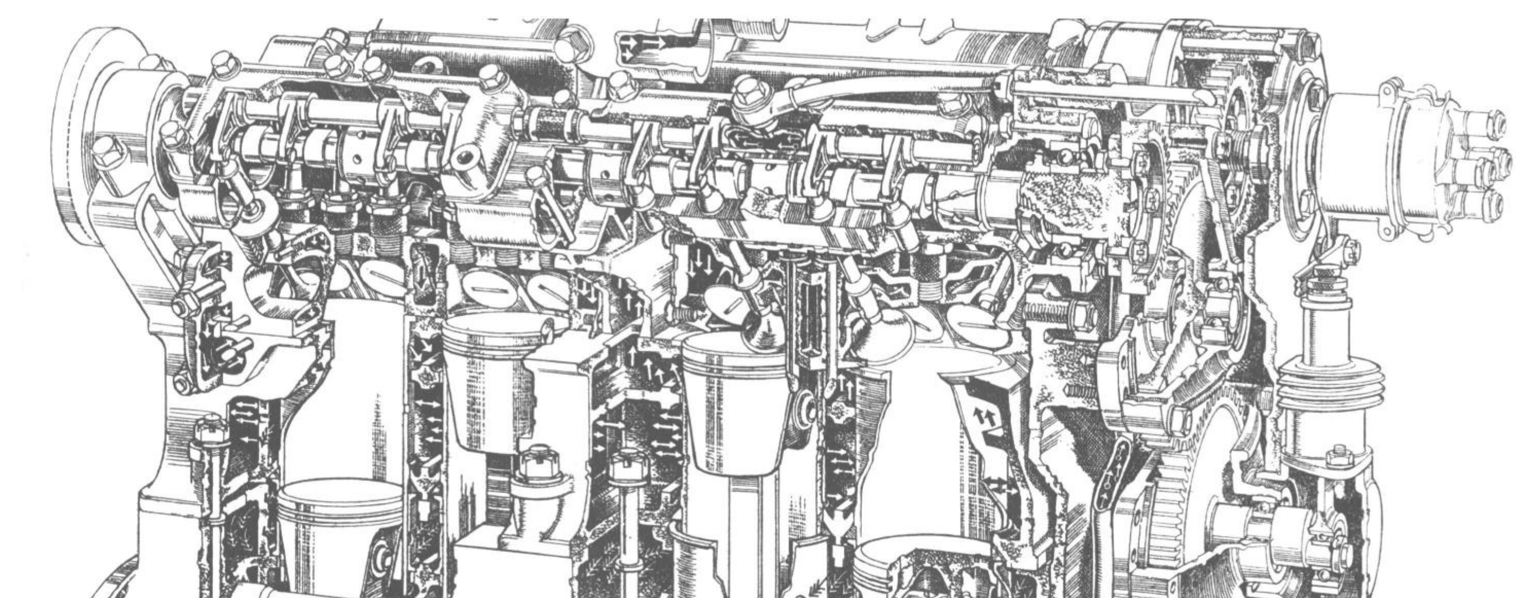
It will be seen that the performance of the cars was highly creditable, so much so that they might well have been serious contenders for Grand Prix honours if they had been constructed twelve months previously.

Two designers were employed, Dr. H. R. (now Sir Harry) Ricardo being responsible as a consultant for the engine design, and the chassis being the responsibility of Mr. C. E. King, who had succeeded to the position of chief engineer.

The chassis was in many ways typical of Vauxhall design of the time ; the rather narrow section frame, front axle beam, method of locking the springs, all bore the traditional hallmark. The use of a frame upswept at the front as well as the back was, however, distinctly novel, as was the unit construction of the clutch and gearbox. The multi-disc clutch and the internals of the gearbox were similar to the components used on the standard production cars, as were such minor items as the steering wheel, pedals and levers, all of which showed clearly their origin.

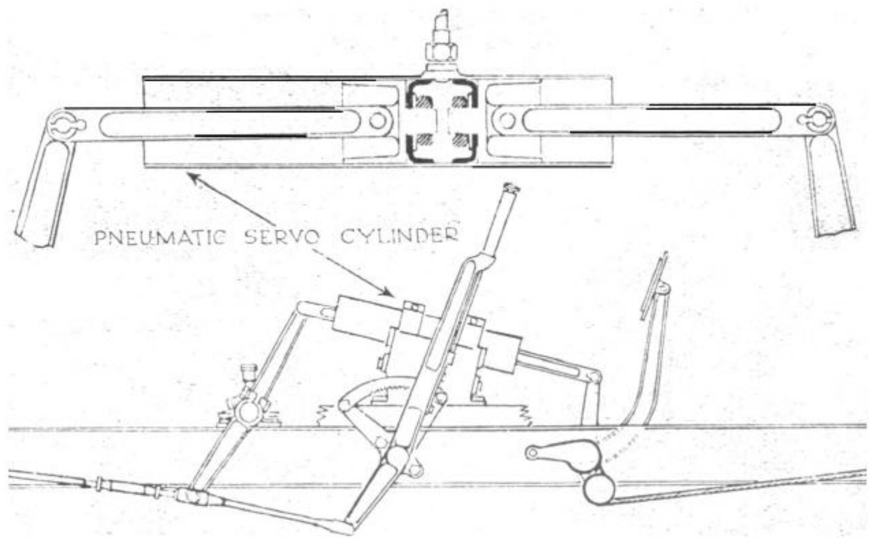
The ratios in the gearbox were, however, a good deal closer than those obtaining on the contemporary catalogue types, and the final drive was by straight-toothed bevels, giving a 3.75 to 1 ratio and a road speed of 25 m.p.h. per 1,000 r.p.m.

The transmission was unusual in that a disc-type universal was fitted behind the gearbox and a pot-type ahead of the rear axle. Hotchkiss drive was used and a novel feature of the rear axle was the elimination of the differential gear. This was done, in


CRESSWELL
INTAKE
OIL
STAGNANT WATER
CIRCULATING WATER

part, to reduce unsprung weight ; in part, because it was thought the drive to both wheels would improve adhesion and controllability.

A number of Vauxhall cars had been built in this fashion between 1914 and 1918 and used by various directors of the company, so the step was not made without a good deal of experience to back it up. In practice, it was found that the use of a differential-less axle on a car of this size and weight resulted in a markedly increased tendency to slide on corners, but also gave an excellent measure of control.



The T.T. Vauxhall employed compressed air to operate four-wheel brakes. The pedal and hand systems were independent as far as the driver was concerned, the former connecting to front,and the latter to rear wheel, or operating both simultaneously was a system of cylinders, pistons and rods put into motion by movement of a lever at the top of the steering column.

From the chassis viewpoint, the leading feature of the car was without doubt the fitting of an air-pressure servo device to operate the four-wheel brakes. As this arrangement has never been repeated, it is worth describing in detail. Braking on the 12 in. diameter front drums was by a conventional Perrot lever system; the brake arms being connected directly to the pedal by cables. As originally laid out, a system of rods was used to pull the brake levers backwards, thus giving a servo effect as the front axle rocked over on the springs under the influence of brake torque, but this evidently caused trouble, for when the cars appeared for the race the rods had been partly replaced by cables and the leverage inverted so that at the last stage the motion was reversed and an anti-servo action obtained. On the back wheels, considerably larger drums-16 in. internal diameter-were employed, and the shoes in these were expanded by the long hand brake.

In the centre of the steering column was a small lever which could control the entry of compressed air into a cylinder containing two pistons. One of these pistons, as shown in the drawing, was connected to the front brake system, the other to the rear. As they were of the same diameter, a perfectly even balance of force was applied to the brake rods. More important, very powerful braking could be obtained entirely without muscular effort on the part of the driver. This unique system also made it possible for the brakes to be left on whilst the driver was using his hands and feet to go through the motion of selecting a lower gear ratio as the car was coming down to a corner ; so although the use of the pneumatic servo involved good judgment, in certain circumstances it could prove of considerable value. Air pressure was provided by a small pump driven off the front timing case of the engine.

A distinctly daring step for a British racing car of 1922 design was the decision to use battery and coil ignition. Delco equipment was fitted, but unlike the contemporary Duesenberg, which is one of the few racing cars ever to use a dynamo, the Vauxhall relied solely on a 12-volt accumulator. This was mounted between the legs of the driver and mechanic, standing immediately on top of the clutch and gearbox housing. In order to obtain greater clarity this component has been eliminated from the cut-away drawing.

The stark but practical appearance of the car has always won the admiration of those who have seen it in pictures or in action. The radiator was set well back from the wheel centres, and the bonnet line was exceedingly low, only just clearing the top of the timing gears and valve covers. As can be seen from the drawing which accompanies this chapter, two large conical wind funnels gave protection to the driver and mechanic, and the former had, in addition, a small windscreen. As run in the T.T. race this screen was provided with a wiper operated manually by the mechanic, and some rudimentary front mudguards were also employed.

The body was of the utmost simplicity, formed, aft the scuttle, by two shallow side members and a large triangular fuel tank containing thirty gallons. On to the back of this were mounted two spare wheels. Air pressure from a hand-pump, worked by the mechanic, supplied fuel to the carburetter.

An interesting feature, originated on the 1914 models, and used on these cars, was the detachable scuttle. This was held down by clips and the regulation strap, as was the bonnet. The scuttle, however, was in one piece, and, by lifting it off, the whole of the centre section of the frame containing clutch, gearbox, instruments, and so on, was left free for inspection.

It will be observed that nothing in the way of streamlining was attempted. This may seem somewhat surprising in view of the fact that Vauxhalls were the first to use a really streamlined body at Brooklands, and owed much of their success on this track to this form.

The drag effect on the speed of the 3-litre car can be seen from the fact that after a long-tail body had been fitted in 1927, the lap speed rose to 116.09 m.p.h., over four miles an hour faster than the best recorded speed over the kilometre (achieved during 1925) with the two-seater body.

The 3-litre engine can fairly claim to be one of the most remarkable power units of all time. It was not, in the light of later development, outstanding on the basis of h.p. per litre, for there are many unsupercharged engines which have exceeded by 50 per cent or more the 43 b.h.p. per litre obtained in this design.

But power-per-litre is a poor basis of comparison and the output measured in relation to piston area is a far more solid ground of comparison. In this regard the Vauxhall engine developed 3.7 h.p. per sq. in. unsupercharged.

Another aspect of the same basic excellence is the 129 b.m.e.p. realised on the Vauxhall at 4,000 ft. per minute piston speed, whilst at the more normally accepted piston speed, of *circa* 3,500 ft. per minute, the b.m.e.p. was even higher, viz. 139 lb. per sq. in.

The facts regarding this engine are all the more remarkable when one investigates the details of its layout. It was the first multi-cylinder racing engine tackled by its now eminent designer ; the compression ratio and valve timing were moderate, and no tricks of " tuning " were employed.

In analysing the features contributing to the success of the engine, one immediately realises that it is based on unusually good values for volumetric and mechanical efficiency. The importance of the former is generally realised, and most racing car designers have spent a great deal of time securing the best possible filling of the cylinders. The Vauxhall volumetric efficiency exceeded 80 per cent in the speed range 2,700 and 3,800 r.p.m., and held up to 77 per cent at 4,500 r.p.m. The valve gear embodied two inlet and two exhaust valves per cylinder with an included angle of 90 degrees. The inlet ports were 1.34 in. diameter and the exhaust 1.3 in. diameter, and the lift of both was the same, viz., 9 mm. The inlet valves were masked for the first 0.05 in. of travel ; that is to say, the valve head was set back into the cylinder by this amount, and at the point of opening the cam has already given it considerable acceleration.

In order to make possible comparisons with other engines described in this book where the overall diameter of the valve head has been taken as a criterion, it should be put on record that the sizes are 1.45 and 1.38 respectively, and it is these figures which have been used in the table of statistics,

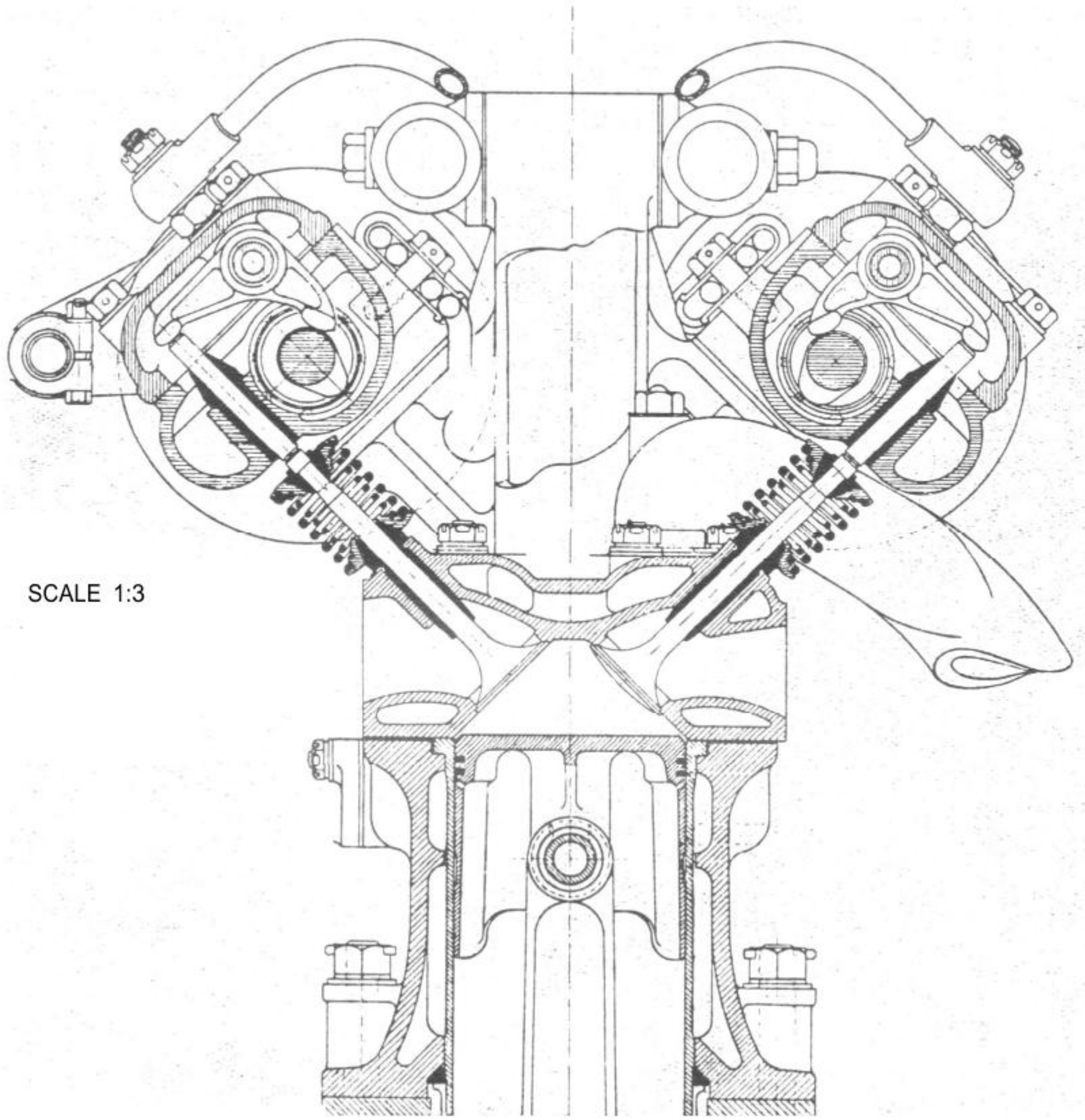
The use of rockers and short, non-adjustable tappets in the valve gear is clearly shown in the drawing, and needs no comment except that low-lift cams were used with moderate acceleration and very lightly stressed valve springs. The induction system was of distinct interest, as the twin-choke-type Zenith carburetter induced air across the crankcase, and the manifolding to cylinders Nos. 2 and 3, and 1 and 4 was entirely separate with no overlapping impulses to upset the distribution.

Ignition was by central sparking plug, there being, however, provision for an extra plug on each side. No advantage was derived from this arrangement, and consequently it was not used. Equal care, from a volumetric point of view, was given to the exhaust side of the engine, and Dr. Ricardo was one of the first to appreciate that each valve should have its own duct and pipe.

The cooling of the exhaust valves can be commended. Not only was there a reasonable amount of water around the entire circumference of the valve guide ; there was also a good water space around the base of the valve seat. The material used for the cylinder head was hard bronze, and no inserts for valve seats, either inlet or exhaust, were fitted or found subsequently to be necessary. There were actually two detachable heads, each containing two combustion spaces, and water was delivered direct to the exhaust side of each head from the pump through a " Y " branch manifold.

The circulation system was of distinct interest, for there was no direct connection between the head and the cylinder block. After the cold water had been delivered to the hottest part of the engine it was transferred through two external pipes to the top section only of the cylinder block. A long, vertical riser pipe was placed between the two cylinder heads, and water escaped from the top of the block up this pipe and thence back to the radiator. The lower part of the block was sealed off and contained stagnant water only.

When the engine was designed it was expected to obtain additional cooling from the use of alcohol fuel, and a very high compression ratio had been envisaged. This scheme was abandoned, as it was found difficult to provide an efficient form of combustion chamber whilst simultaneously avoiding the risk of the pistons being struck by the valves should they accidentally stick in full open position.



Details of the valve-gear and combustion chamber

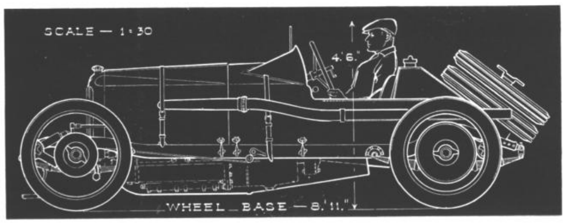
One might consider such thoughts unwarrantable pessimism on the part of a racing-engine designer, but, nevertheless, the compression ratio finally employed was the very moderate one of 5.8 to 1. This latter figure makes the power output of the engine all the more creditable, for a maximum indicated pressure of 162.5 lb. was realised at 3,500 r.p.m. (3,040 f.p.m.), and 159 i.m.e.p. at 4,500 r.p.m. (3,900 f.p.m.). The combustion efficiency at the highest speeds was 34.8 per cent, and at full load at 3,000 r.p.m. the consumption was only 0.45 pints per b.h.p. an hour.

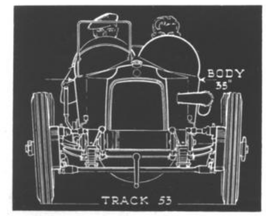
Possibly the most significant feature of this engine, was its phenomenally high mechanical efficiency. At 3,000 r.p.m. the figure is over 80 per cent and at 4,500 r.p.m.

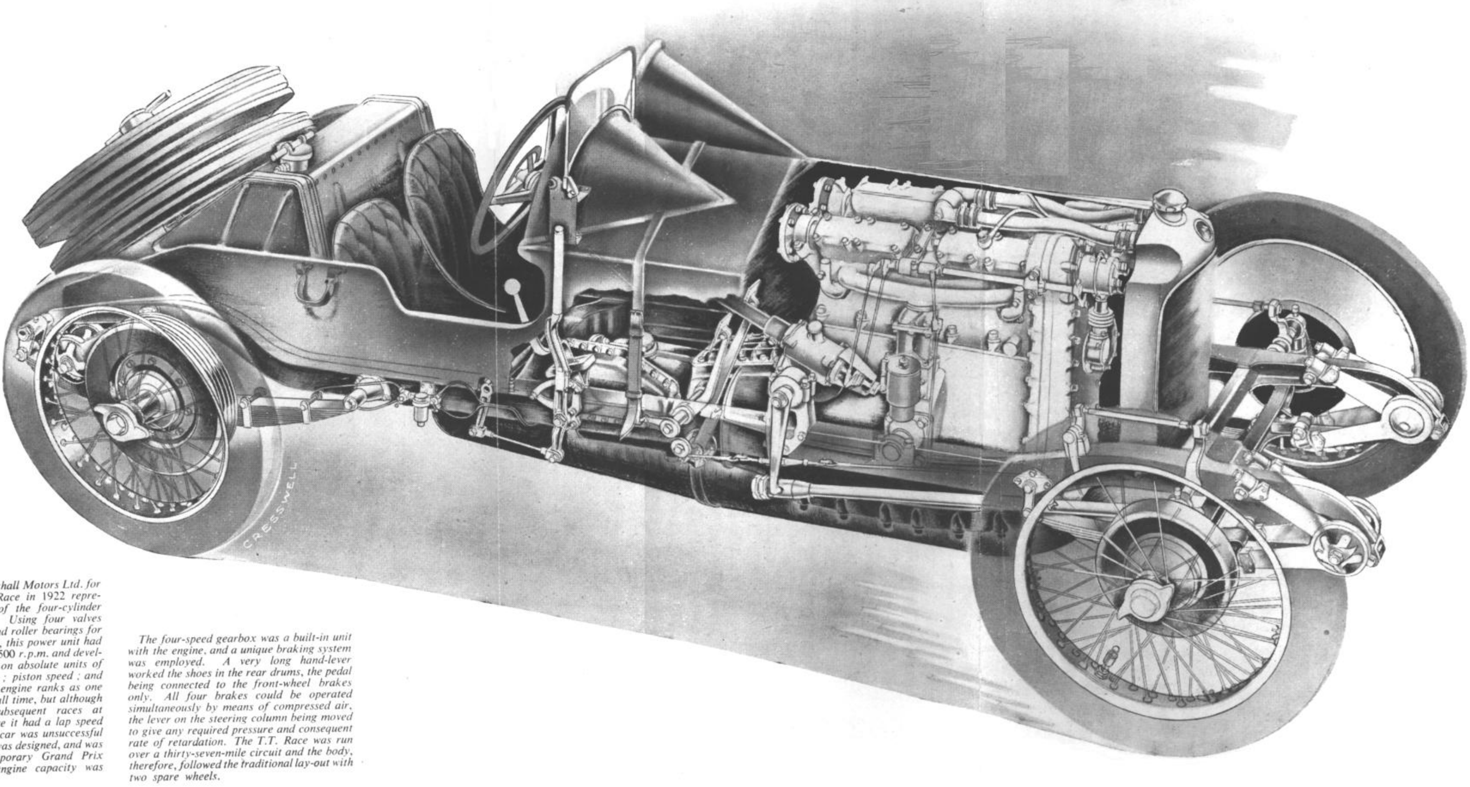
PLATE XX

EXAMPLE No. SEVEN

THE 1922 VAUXHALL







The cars built by Vauxhall Motors Ltd. for the Isle of Man T.T. Race in 1922 represented the apotheosis of the four-cylinder unsupercharged engine. Using four valves per cylinder, and ball and roller bearings for crankshaft and big-ends, this power unit had a crankshaft speed of 4,500 r.p.m. and developed 129 b.h.p. Based on absolute units of comparison (piston area ; piston speed ; and manifold pressure), the engine ranks as one of the most efficient of all time, but although performing well in subsequent races at Brooklands Track, where it had a lap speed of over 108 m.p.h., the car was unsuccessful in the race for which it was designed, and was excluded from contemporary Grand Prix events in which the engine capacity was limited to 2 litres.

The four-speed gearbox was a built-in unit with the engine, and a unique braking system was employed. A very long hand-lever worked the shoes in the rear drums, the pedal being connected to the front-wheel brakes only. All four brakes could be operated simultaneously by means of compressed air, the lever on the steering column being moved to give any required pressure and consequent rate of retardation. The T.T. Race was run over a thirty-seven-mile circuit and the body, therefore, followed the traditional lay-out with two spare wheels.

it is 78 per cent. Thus the Vauxhall engine may be considered to gain between 20 and 30 b.h.p. over normal designs solely by reason of abnormal mechanical efficiency.

This gain was earned by exceedingly careful design. In particular by ensuring that the whole engine was remarkably rigid. The crankcase, which was made in two halves, was exceptionally deep, and was joined together by a row of internal nuts along the side walls and also by long through bolts adjacent to the bearings. A shallow detachable sump was fitted at the base. The cylinder block was a light alloy casting of comparatively short length, and the cylinder proper formed from detachable wet liners, deeply spigoted into the crankcase. The top half of the latter was a double cell, which formed an air passage around the base of the cylinder liner. The carburetter drew air across the engine, and, therefore, received it slightly warmed, while the sealing-off of the water around the centre of the liner kept it at a high temperature. These features were deliberately included in order to reduce the viscosity of the oil on the cylinder bore and thereby lower piston friction losses.

The pistons themselves were of the Ricardo slipper type, the non-thrust surfaces being entirely " cut away." Only two piston rings were employed. Having thus done everything possible to reduce the losses in the top half of the engine, Ricardo decided to employ a complete ball and roller bearing layout for the crankshaft and big ends. Other factors influencing this decision were the desire to make the engine as short as possible in order to improve the overall stiffness and to reduce the possibilities of torsional vibration trouble. In order to eliminate the last named it was further decided to place the flywheel in the centre of the engine, and, after a good deal of consideration, a completely built-up crank, made from plain pins on to which the crank throws were shrunk as in gas-engine practice, was incorporated. A solid big end for the connecting rod could thus be provided, the bearing being a double row of short rollers located in a one-piece bronze cage, the outer race being made by hardening the eye of the connecting rod itself. Both crankshaft and connecting rod were made from low carbon case-hardened steel.

Lubrication was provided from two oscillating valveless plunger pumps, one supplying the oil to a gallery running the full length of the crankcase and provided with jets spraying lubricant to the crank throws, the other working at some 25 lb. per sq. in. and delivering oil to the valve rockers.

These pumps, together with a large-capacity air pump connected to the brake servo mechanism, and a smaller-capacity pump maintaining the pressure in the fuel tank, were driven from a train of spur gears fixed at the front end of the engine to drive the two camshafts. An elaborate system of spiders was employed in order to provide accurate meshing of the gears, there being no fewer than seven wheels in the complete train. This meshing had, of course, to be individually carried out, and the spiders were then fixed by a dowel pin in the correct position. A description of this item does, however, bring one to the point of criticism, which is this : although the scientific basis of the engine was of first-rate quality, the mechanical realisation of the principles involved resulted in an exceedingly complicated layout for a four-cylinder engine built in very small quantities.

The timing wheels are one case in point, others being the machining difficulties involved in aligning the holes for the long through bolts, whilst, as the cut-away drawing shows, there are a number of other points where the workshop has certainly been subordinate to the drawing office. Whether or not this caused such delays in construction as to reduce the time available for final tuning, and impaired the chances of the cars in the T.T. race, is a debatable point. Actually one engine was completed well ahead of time and ran on the bench the equivalent of over 4,000 miles on the road before the event. Nevertheless, a general lesson of racing-car design is that the layout must be appropriate to the resources and cash of the manufacturer, and it is by keeping this in mind that such constructors as Bugatti and Alfa Romeo scored their consistent victories over a long period of years.

Acknowledgments.-Thanks are due to Vauxhall Motors, Ltd., Anthony Brooke, Esq., and Messrs. Molyneux and West for assistance in obtaining data and drawings on this example.

DETAILS OF CAR

MAKE.-Vauxhall
TYPE.-T.T.
YEAR OF CONSTRUCTION.-1922
YEARS RACED.-1922-23 by Manufacturers
DESIGNERS.-King and Ricardo
WHEELBASE.-8 ft. 11 in.
TRACK FRONT.-4 ft. 5 in.
TRACK REAR.-4 ft. 5 in.
HEIGHT TO SCUTTLE.-47 in.
HEIGHT TO DRIVER'S HEAD.-54 in.
FRONTAL AREA.-14 sq. ft.
UNLADEN WEIGHT.-22.5 cwt.
ALL-UP STARTING LINE WEIGHT.-27 cwt.
MAXIMUM SPEED.-112 m.p.h. at 4,400 r.p.m.
SPEED ON INDIRECT GEARS.-98 m.p.h. on Third
,, ,, ,, ,, 70 m.p.h. on Second
,, ,, ,, ,, 48 m.p.h. on First at 4,800 r.p.m.
H.P. PER SQ. FT.-9.3
H.P. PER TON UNLADEN.-112
H.P. PER TON ALL-UP.-95.5
BORE.-85 mm.
STROKE.-132 mm.
S./B. RATIO.-1.55:l
No. OF CYLINDERS-Four
CAPACITY.-2,996 c.c.
PISTON AREA.-35.2 sq. in.
B.H.P.-129 at 4,500 r.p.m.
H.P. PER SQ. IN.-3.66
B.M.E.P.-125
PISTON SPEED FT./MIN.-3,900
CYLINDER HEAD.-Bronze, detachable in pairs
VALVES No.-Four per cylinder
VALVES ANGLE.-90 degrees
VALVE AREA.-Inlet 13.3 sq. in.
Exhaust 12 sq. in.
CYLINDER BLOCK.-Aluminium with wet cast-iron liners
FUEL.-Petrol
CARBURETTER.-Double choke Zenith
SUPERCHARGER.-Nil
MANIFOLD PRESSURE.-Atm.
IGNITION.-Delco coil with twin distributors
PLUGS No.-Twelve
PLUGS LOCATION.-In line in centre of head
CRANKCASE.-Light alloy Split on centre line of bearings. Separate sump added to base
CRANKSHAFT.-Built-up with central flywheel. Counterbalanced.
MAIN BEARING No.-Six
MAIN BEARING TYPE-Ball
BIG END TYPE.-Roller
LUBRICATION.-Wet Sump
CAMSHAFT No.-Two
CAMSHAFT LOCATION.-In head
CAMSHAFT DRIVE.-Train of gears
CAMSHAFT DRIVE LOCATION.-Front of engine
CLUTCH.-Multi-plate
GEARBOX LOCATION.-In unit with engine
GEAR RATIOS.-3.75
,, ,, 4.65
,, ,, 6.5
9.4
TRANSMISSION.-Open propeller shaft to bevel drive rear axle
FRAME.-Channel
FRONT SUSPENSION.-Semi-elliptic
REAR SUSPENSION.-Semi-elliptic
SHOCK ABSORBER TYPE.-Hartford friction
BRAKE SYSTEM.-Mechanical with compressed air servo
BRAKE DRUM DIAMETER.-Front 12 in.
Rear 16 in.
BRAKE DRUM WIDTH.-2½ in.
SQ. IN. PER TON LADEN.-320
STEERING.-Worm and wheel. 1½ turns lock to lock
TYRES.-Palmer 810 x 90 front
820 x 120 rear

RACING RECORD 1922 T.T. VAUXHALL

Date	*Event*	*Course*	*Speed*	*Lap Speed*
22/6/22	T.T.	Isle of Man	52.71 m.p.h. (third)	—
-/10/22	3-Litre Championship .	Brooklands	97.8 m.p.h.	108.27 m.p.h.

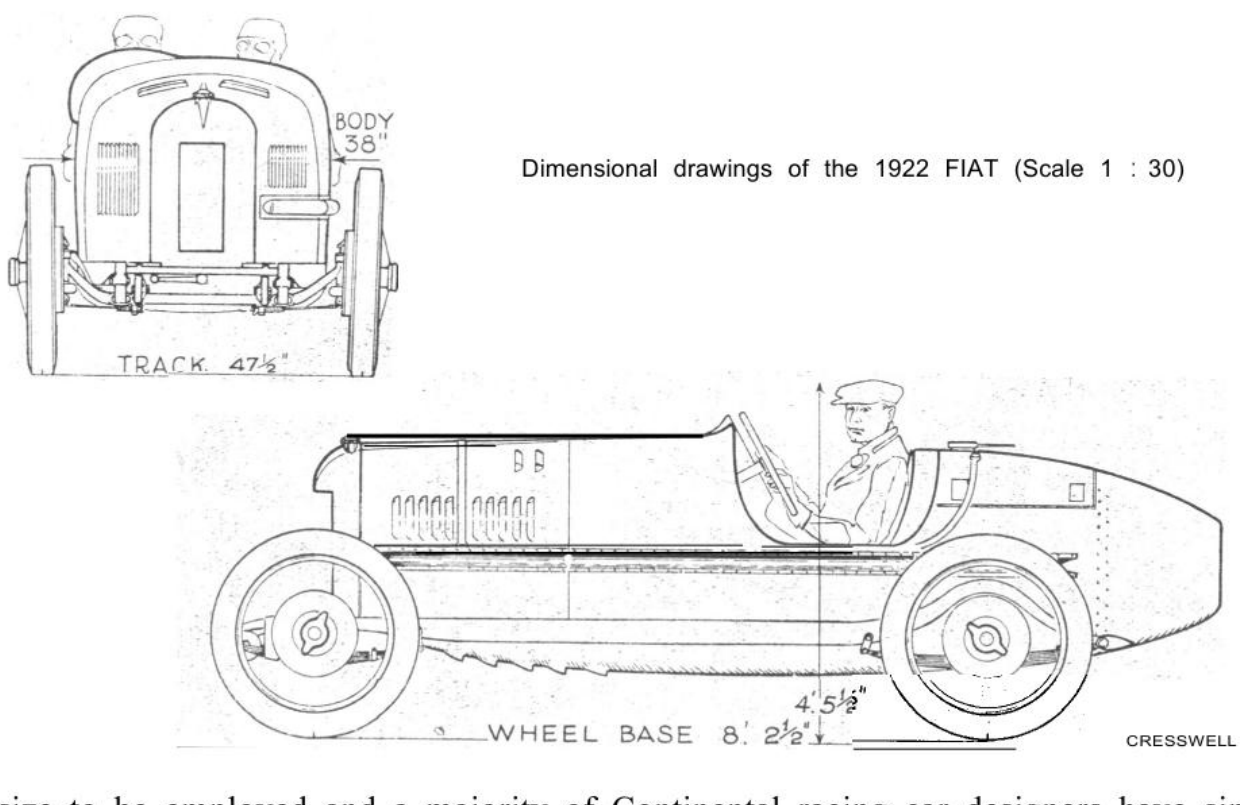
EXAMPLE No. EIGHT

The 1922 FIAT

FIAT cars were amongst the leaders in Grand Prix racing before the outbreak of the 1914 war. They were particularly successful between 1905-8 ; they consistently supported racing during the lean years of 1909, '10 and '11, and might well have won the 1912 Grand Prix, being only removed from the lead by the minor trouble of a broken fuel pipe. The Company abstained from racing in 1913, and although in 1914 the cars they ran at Lyons were of an advanced design, including an overhead cam-shaft and front wheel brakes, they were not successful, only one car finishing and that was last. Immediately after this race the engines were rebuilt with welded-up steel cylinders on the Mercedes model and a team was re-entered for the first post-war European event, the 1919 Targa Florio. Again they were unsuccessful and the type secured its only win when sold to an amateur (Count Masetti), who won the 1921 Targa Florio.

The technical merit of the design had, however, been established and the steel cylinder construction was utilised in the 1921 eight-cylinder Fiats built to the 3-litre formula.

These cars (which had cylinder dimensions 65 x 112 mm.) were notable for pioneering two other detail developments, viz. : the use of valves inclined at an included angle of " 100 " degrees in a fixed cylinder head and the conjunction of roller bearing big ends with a one-piece crankshaft. The former feature enabled valves of exceptional



Dimensional drawings of the 1922 FIAT (Scale 1 : 30)

size to be employed and a majority of Continental racing car designers have since chosen " 100 " degrees valve angle rather than 90 degrees. The use of roller bearings for the big ends was no novelty in itself, but the decision to have a one-piece crankshaft and to split the connecting rod big ends was a daring one which by its success has also led to wider acceptance.

The completion of the 3-litre cars was delayed by the labour troubles prominent in post-war Italy and they ran in only one race, the Italian Grand Prix, in which they proved themselves the fastest car of the year. They suffered from mechanical trouble, which prevented them from winning, but the lessons learnt in their construction were embodied in the design of the 2-litre cars constructed for the 1922 Grand Prix, in which they likewise proved themselves by far the fastest cars of their time.

In the French Grand Prix at Strasbourg the relative lap speeds of the three principal contenders were :

Fiat 87.75 m.p.h. (100)
Bugatti 80 m.p.h. (91.5)
Sunbeam 78 m.p.h. (89)

the percentage speeds being put in parentheses. Felice Nazzaro, who drove the winning car, averaged 79.2 m.p.h. for the whole distance of 498 miles, the relative speeds being :

Fiat 79.2 m.p.h. (100)
Bugatti 69.2 m.p.h. (87.5).

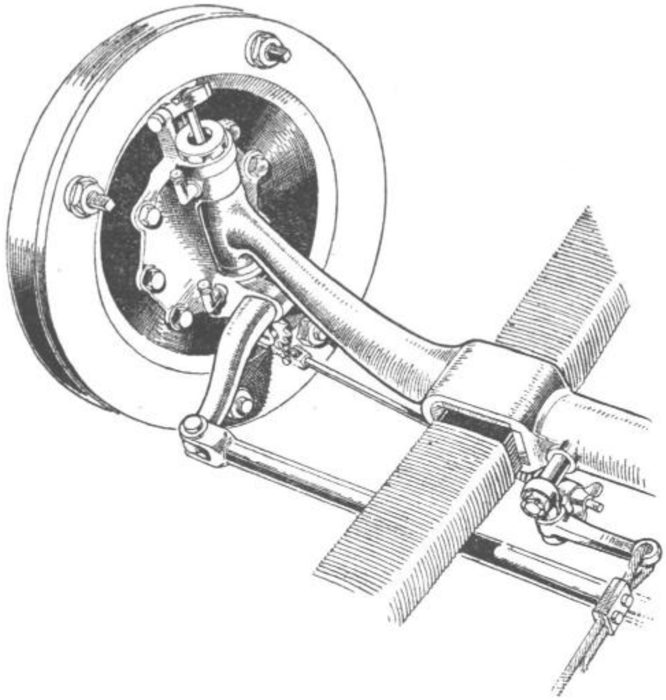
No Sunbeam finished.

This demonstration of superiority was such that in the Italian Grand Prix virtually no opposition was offered and the Fiats had a walk-over.

The disappointment which must have attended the construction of the 3-litre car was, therefore, more than atoned by the racing record of the 2-litre model.

The engineers responsible for this highly-original design (car Type 804 and engine Type 404) were Cavalli, Cappa, Bertarione and Bechia who were under the direction of Fornaca. The whole concept was very closely based on the preceding 3-litre car but the steel cylinder blocks were now welded up in pairs of three instead of pairs of four and the stroke reduced from 112 to 100 mm. As can be seen from the drawings, the crankshaft was heavily counter-weighted and ran in eight roller bearings, 10 mm. diameter and 18.5 mm. long, the diameter of the journals being 40 mm. Oil was fed into the main bearings and on escape was trapped in circular grooves machined in the face of the crank cheeks and was thence fed under centrifugal pressure to the big ends. These also had rollers of 8 mm. diameter and 18 mm. long with the crank pin 14 mm. diameter and, as before mentioned, the rollers ran in split cages which were, in the first instance, bronze and later changed to duralumin.

A feature of the connecting rods was their almost parallel section and great length, viz. stroke x 2.23. Light alloy pistons were employed and it is particularly interesting to know that they were held clear of the cylinder bores by piston rings which were an interference fit on the inside of the ring grooves. This gave a steel-to-steel bearing surface with a correspondingly short life but there was no objection to renewing the rings at the end of every race. It will be observed that two compression and one bottom ring were employed and that the pistons were liberally drilled around a deeply relieved waist.



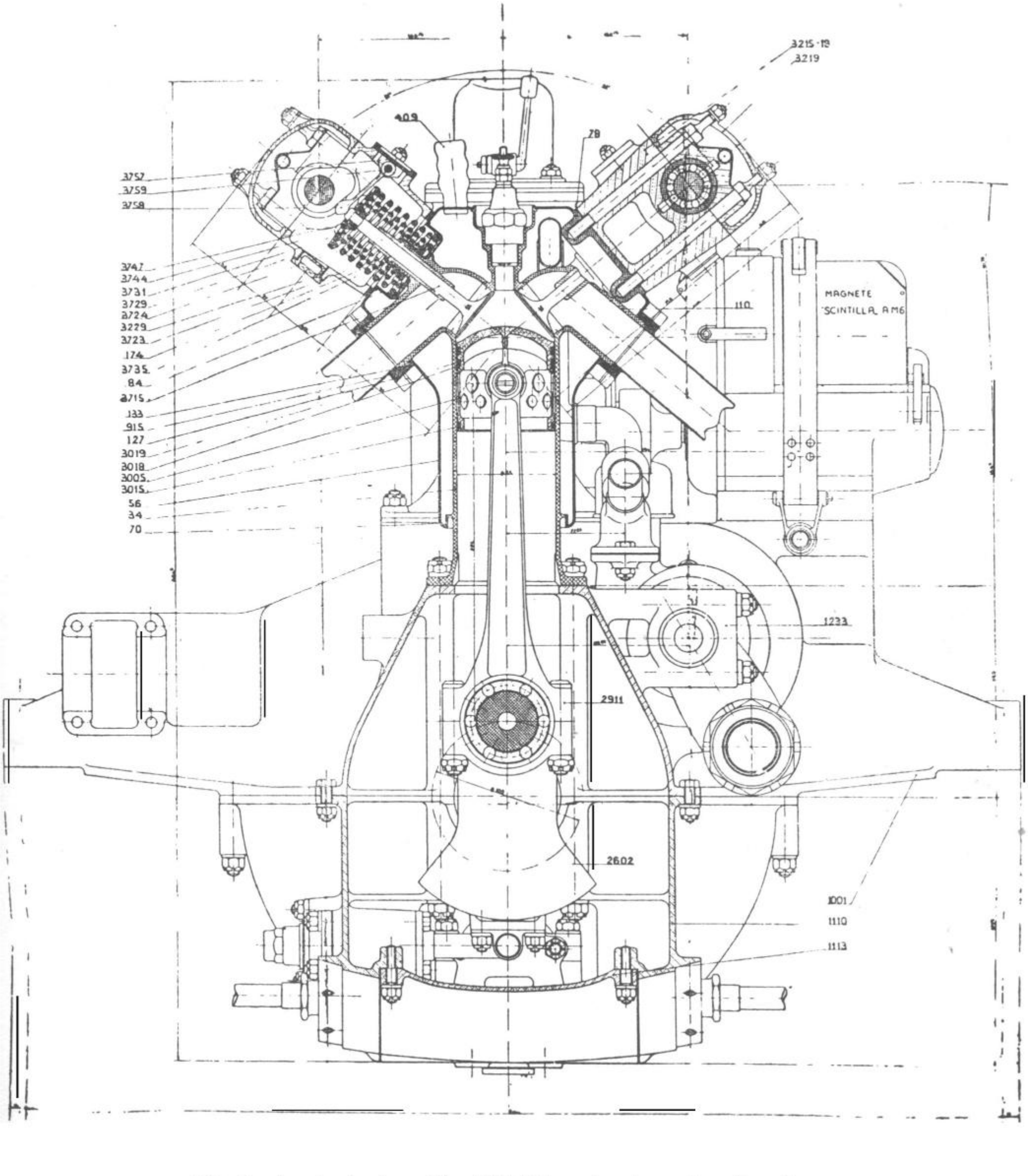
The front axle was tubular and the springs passed through the axle beam.

The full roller bearing crankshaft resulted in a notably short engine measuring only 27½ in. from the nose of the crank case to the face of the clutch housing, but the rather long connecting rods resulted in a great depth between the crank centre line and the valve ports. It will be observed that these made a somewhat sharp angle in relation to the valves and that the sparking plugs were positioned centrally in the head but masked with a hole about 12 mm. diameter. The good cooling of the threaded portion of the plug is a particularly commendable feature of this engine, which was also notable for the use of high velocity water on the exhaust side, a long conduit being placed within the head adjacent to the sparking plug bases and running immediately over the exhaust valve ports and guides.

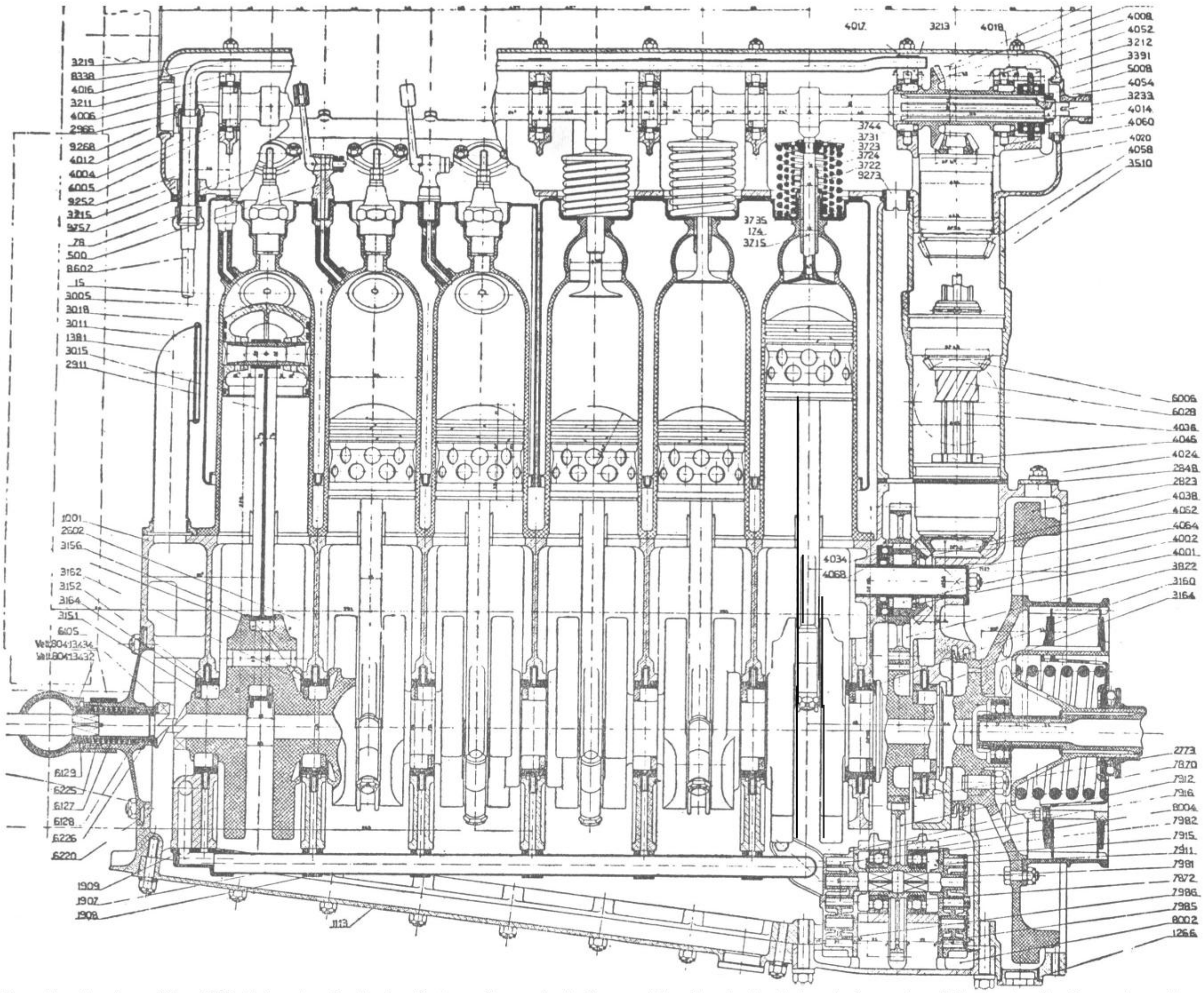
The valves themselves were closed by three large-diameter valve springs and opened by camshafts running in seven roller bearings through the medium of cam followers and owing to the large included angle between the valves the shafts were somewhat widely divided and presented some special problems in the layout of the driving mechanism. From external appearance it might be assumed that trains of gears were employed but in point of fact two spur gears only were used to drive a small sub-shaft at engine speed. This drove a short vertical shaft through the medium of bevel pinions and joined to these were two inclined shafts, each one of which drove a camshaft through the medium of bevel gears, the whole layout thus giving a Y formation.

A skew gear was mounted on the vertical shaft to drive a magneto which faced outwards to the exhaust side of the engine and there was an advance and retard mechanism which ensured maximum spark intensity at all positions exactly as on the 1910 model.

Dry sump lubrication was used, circulation being through an eight-gallon oil tank with a further reserve of eight gallons in a second tank, a pump being provided inside the scuttle so that the mechanic could avoid engine failure in the event of the oil consumption exceeding 50 m.p.g.



This 1 : 4 scale drawing of the 1922 Fiat engine shows the wide valve angle, masked sparking plugs and internal conduit feeding cold water direct on to the exhaust valve port. Other salient features are the use of roller bearings in conjunction with a split big end and the drilled light alloy piston separated from the steel cylinder by bottom seating piston rings.



The side elevation of the 1922 Fiat engine (scale 1 : 4) shows the method of assembling the steel cylinders in two pairs of three, also the three-piece drive to the two overhead camshafts and the skew gear which advanced or retarded the magneto which was driven to a cross shaft connected to the inverted bevel gear part number 6006. The continued use of compression taps is an interesting survival. contrasting strangely with the all roller bearing crankshaft.

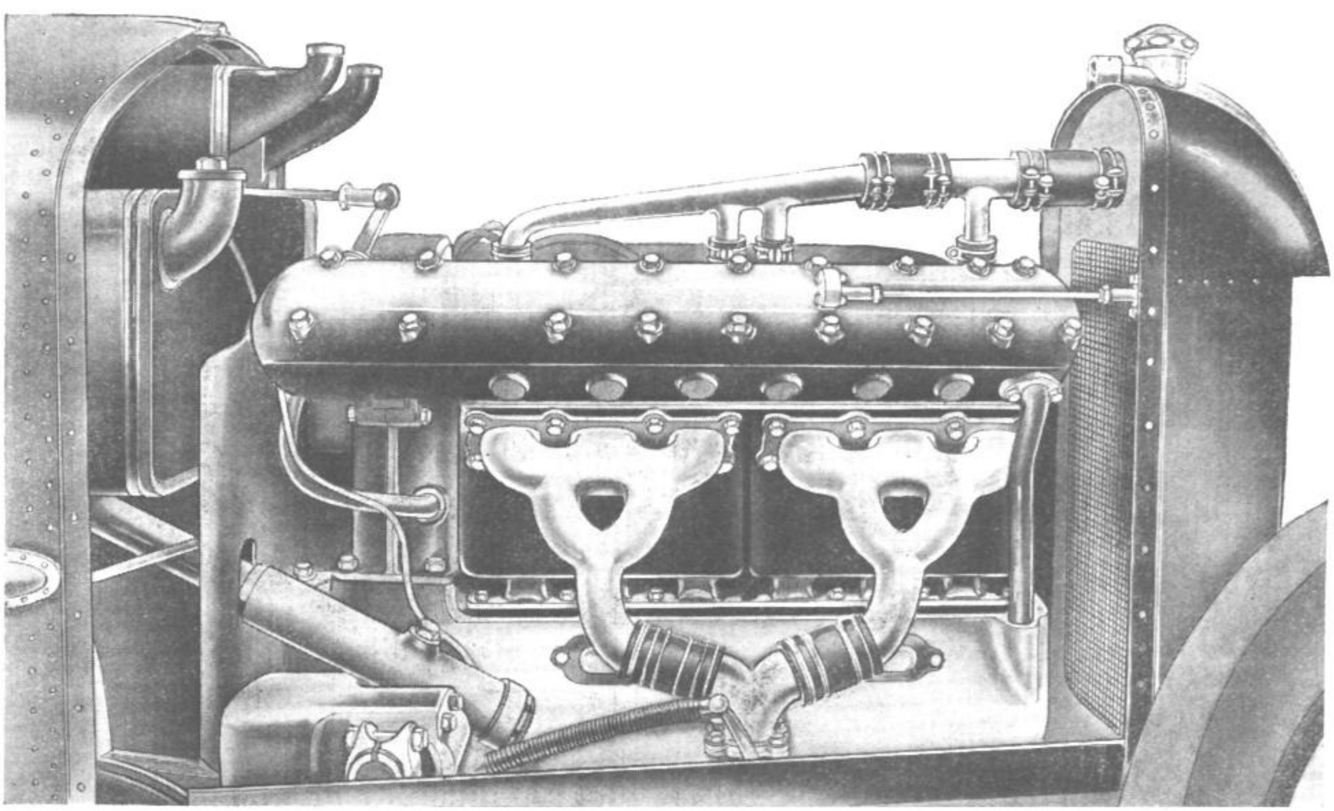
Although developing between 92 and 96 h.p. at 4,500 r.p.m. for the French Grand Prix, for the Italian Grand Prix the output was raised to 112 h.p. at 5,000 r.p.m. with a corresponding figure of 145.5 b.m.e.p.-an extremely creditable figure on a compression ratio of 7 : 1.

The drive was taken through a multi-plate clutch to a four-speed gearbox mounted in unit with the engine, this model and the T.T. Vauxhall being amongst the first to use this construction, which had been initiated, so far as racing was concerned, on the 4½-litre Fiats which ran in the 1914 French Grand Prix. At the back of the gearbox was a housing to receive a sphere which took the drive, the rear axle being of torque tube type suspended on semi-elliptic springs, the latter very short and stiff. The rear axle itself was notable in being made from thin gauge pressings welded together, and in the French Grand Prix it was found that one of the flanges at the wheel end was insufficiently strong and broke away, so that two out of the three cars lost a rear wheel.

The front axle had considerable technical interest. It was now realised that adequate front brakes imposed considerable stresses on the axle beam, and for this reason Fiat engineers fixed upon a tubular front axle, although one of small section. They decided to make it in two pieces joined together on the centre line, and by reason of this arrangement the centre, unstressed, part could be machined hollow. At the centre line it was serrated to prevent relative movement and pinned to avoid separation. The springs were taken through the front axle beam.

The front brakes themselves were operated by means of cables and bell cranks and thence, as is shown in a drawing, to a small chain and a vertical rod which went through the centre of a hollow king pin.

Brake drums were of aluminium with cast-iron liners.



Drawing of Engine, off side

The pedal effort of the driver was reinforced by a servo mechanism, of which no details are available. In principle a pump supplied oil to a piston and cylinder linked to the brake mechanism. It will be noted that the steering box was held on to the crank-case casting, which is a typical Fiat practice.

The dimensions of the car were kept as small as possible, the wheelbase being only 8 ft. 2 in. and the track 47 in. The frame and axles were of very slender proportions and the former was shaped to follow the contour of the two-seater body. Hence the frame members tapered not only towards the front, as was quite common, but were also cranked in at the back to follow the tail lines of the car. Nevertheless, the centre section of the body was comparatively wide and this, in conjunction with a marked stagger of the mechanic's seat in relation to the driver's, enabled the crew to be almost entirely enclosed within the main form of the car.

A large portion of the tail was taken up with a rectangular fuel tank and, as can be seen from a drawing, an under tray enclosed almost the entire bottom half of the vehicle. There can be no doubt that the drag losses on this car were considerably lower than normal. The exceptionally light weight of the complete vehicle was even more remarkable. The 1922 regulations stipulated a minimum weight of 12.7 cwt., and Fiats were weighed in at Strasbourg at approximately 13 cwt., and thus have the distinction of being the lightest cars to win a full Grand Prix race prior to 1939.

The complete superiority of these cars over contemporary 2-litre models, and the impression that they made on technical opinion, can be likened to the effect of the first Mercedes car in 1902 and the 1912-13 Peugeot models designed by Henri. No one was more aware of their significance than Mr. Louis Coatalen, who engaged one of the Fiat racing designers, Signor Bertarione, and charged him with responsibility for constructing the Sunbeam racing cars of 1923-4. The latter are described in Example No. 9 following this chapter, and the reader should appreciate that the cars have many similar features of design.

DETAILS OF CAR

MAKE.-Fiat
TYPE.-1922 G.P.
YEAR OF CONSTRUCTION.-1922
DESIGNERS.-Fornaca, Cappa and Bertarione
WHEELBASE.-8 ft. 2½ in.
TRACK.-Front 3 ft. 11½ in.
Rear 3 ft. 11½ in.
HEIGHT TO SCUTTLE.-50 in.
HEIGHT TO DRIVER'S HEAD.-53½ in.
FRONTAL AREA.-12.2 sq. ft.
UNLADEN WEIGHT.-13 cwt.
ALL-UP STARTING LINE WEIGHT.-18 cwt.
MAXIMUM SPEED.-105 m.p.h.
SPEED ON INDIRECT GEARS.-Unknown
H.P. PER SQ. FT.-7.6
H.P. PER TON UNLADEN.-142
H.P. PER TON ALL-UP.-102
BORE.-65 mm.
STROKE.-100 mm.
S./B. RATIO.-1.54:1
No. OF CYLINDERS.-Six
CAPACITY.- 1,991 c.c.
PISTON AREA.-30.8
B.H.P.-92 at 4,500 r.p.m.
B.M.E.P.-133
H.P. PER SQ. IN.-3.0
PISTON SPEED FT./MIN.-3,420
CYLINDER HEAD.-Steel integral with barrel
VALVES No.-Two per cylinder
VALVES ANGLE.-96 degrees
VALVES AREA INLET.-11.2 sq. in.
VALVES AREA EXHAUST.-11.2 sq. in.
CYLINDER BLOCK.-Steel barrels with welded-up ports and jackets in two blocks of three
FUEL.-Petrol
CARBURETTER.-Single Fiat
SUPERCHARGER.-Nil
MANIFOLD PRESSURE.-Atm.
IGNITION.-One magneto
PLUGS No.-Six
PLUGS LOCATION.-Vertical in head
CRANKCASE.-Light alloy split on centre line of bearings
CRANKSHAFT.-One-piece counterbalanced
MAIN BEARING No.-Eight
MAIN BEARING TYPE.-Roller
BIG END TYPE.-Roller
LUBRICATION.-Dry Sump
CAMSHAFT No.-Two
CAMSHAFT LOCATION.-In head
VALVES OPERATED.-Through fingers
CAMSHAFT DRIVE.-Gear-driven vertical shaft and bevels
CAMSHAFT DRIVE LOCATION.-Rear Of engine
CLUTCH.-Multi-plate
GEARBOX LOCATION.-In unit with engine
GEAR RATIOS.-Unknown, four speeds
TRANSMISSION.-Torque tube to bevel drive rear axle
FRAME.-Channel
FRONT SUSPENSION.-Semi-elliptic
REAR SUSPENSION.-Semi-elliptic
SHOCK ABSORBER TYPE.-Hartford friction
BRAKE SYSTEM.-Foot : mechanical with oil pressure servo to all four drums. Hand : rear drums only
BRAKE DRUM DIAMETER.-12.5 in.
BRAKE DRUM WIDTH.-1½ in.
SQ. IN. PER TON LADEN.-250
STEERING.-Worm and nut
TYRES.-Pirelli. Front 31 X 3½
Rear 32 x 4
WHEELS.-Rudge-Whitworth

RACING RECORD, 1922 GRAND PRIX FIAT

Date	*Event*	*Course*	*Speed*	*Lap Speed*
16/7/22	French G.P.	Strasbourg	79.2 m.p.h.	87.75 m.p.h.
3/9/22	Italian G.P.	Monza	86.89 m.p.h.	91.3 m.p.h.

EXAMPLE No. NINE

The 1924 Sunbeam

WHEN the 2-litre formula was opened in 1922 Mr. Louis Coatalen, of the Sunbeam Company, engaged Henri as his chief designer. Discounting the hazards and misfortunes of racing, this engineer could fairly claim that he had produced the fastest formula cars for 1912, '13, '14, '19 and '20. No new design came from his board in 1921, but his 1920 Ballots were third in the French G.P. and won the Italian G.P. This was an impressive record and one may presume that he set to work on the Sunbeam project with abundant confidence. For various reasons, however, he abandoned the multi-cylinder principle which he had done so much to popularise with his Ballot-produced cars and chose a four-cylinder engine with characteristic large stroke/bore ratio, cast-iron cylinders, and unmistakable Henri valve gear. In the transmission he decided to use three speeds but retained the characteristic Hotchkiss drive. The front axle was notable for being constructed in three sections.

When put to the test these cars proved quite incapable of meeting the challenge of the six-cylinder Fiats with their greater piston area, two valves per cylinder and full roller bearing engines. Henri's engagement at Sunbeam was subsequently terminated. He was replaced by an ex-Fiat engineer, Bertarione, who copied the bulk of the 1922 chassis, into which he fitted an entirely new engine. The design of this, naturally enough, bore a very strong resemblance to the 1922 Fiats, the principal change being in a slight increase in bore and reduction in stroke.

These cars were victorious in the French Grand Prix at Tours in 1923 and in this way became the first British car to win a major international event. At the end of the year they were dismantled and completely rebuilt under Bertarione's supervision for 1924. They emerged as almost entirely new cars in which radical changes had been incorporated, particularly in the use of a supercharger for the power unit. Moreover, the supercharging in itself was on a then novel system in that the blower aspirated from the carburetter and delivered mixture under pressure to the manifold.

In 1924 this team of cars were undoubtedly the fastest 2-litres in Europe. As recounted elsewhere, only misfortune prevented them from winning the French Grand Prix two years in succession, and they secured the lap record. They won the Spanish Grand Prix of 1924, but by 1925, in which year the same cars were run, they had fallen behind in the matter of power per litre and were consistently outpaced.

In 1924 the car was hand-timed on the Lyons circuit at 130.5 m.p.h. for a flying kilometre, but there is reason to believe that this exaggerated the true speed. In September, 1924, this type averaged 114.23 m.p.h. over five miles, and, five years afterwards, when the engine was developing an additional 30 h.p., 126.08 m.p.h. for five kilometres. The lower of these speeds almost certainly does the car an injustice, but it is improbable that the true speed under neutral conditions would be more than an additional 10 m.p.h. A maximum of 125 m.p.h. is certainly not far from the truth.

Supercharging was by a Roots type blower mounted horizontally at the front of the crankcase and driven directly from the crankshaft, and the increased length of the engine with the blower on its nose meant that the 1923 frame had to be scrapped.

When rebuilt the car was 4 in. longer, 2½ in. lower and 275 lb. heavier than the previous year, the weight increase being due, not only to the greater overall dimensions, but also to the considerable revisions in the transmission. The previous car had an inverted cone clutch, three-speed gearbox and Hotchkiss drive. As can be seen from the cut-away drawing, the 1924 model was changed to torque tube drive ; it had a four-speed gearbox taking power from the Hele Shaw multi-disc clutch and in place of the right-hand gear change, a central lever was employed.

Taking 5,500 r.p.m. as maximum revs., the speeds on the various gears would be 100, 72 and 47 m.p.h. on the indirect ratios, whilst it is reasonable to assume that all these speeds could be raised by 5 per cent for brief periods.

The frame itself was comparatively small in section and well cranked in at the back in order to follow the line of the tapering tail, so that although the rear spring shackles came under the frame at the front end they were mounted on outriggers at the back end.

To allow for the angular displacement characteristic of torque tube drive, the axle beam was held on to the rear spring by split, white-metalled trunnion bearings. The springs were thereby totally relieved from either power or brake torque.

The brakes themselves are of interest because of the elaborate system of compensation and the use of a friction-servo motor. This design was actually a legacy from the 1922 Henri-designed four-cylinder models and on two of the team identical parts were used in the 1924 season. A cross-shaft mounted behind the gearbox drove (at reduced speed) a friction disc connected to the pedal. Movement of the pedal engaged the friction faces and these in turn applied front and rear brakes through the mass of cables and pulleys which constituted the compensating gear. The hand-brake worked on the rear drums only and a " racing ratchet " (as on the 1914 cars) was used. In this design the ratchet did not come into play unless a knob on the top of the handle was intentionally depressed by the driver.

The front axle followed the tradition of Henri design, being built in three sections, but was actually a new construction for the 1924 cars, which had a 4 in. greater track than the 1923 models. The rear axle dimensions were, however, left unchanged, this giving the car its noticeable crab-track appearance. The centre section of the front axle beam was tubular, the outer ends solid, each being bolted to the centre piece by a flange inside the spring pads.

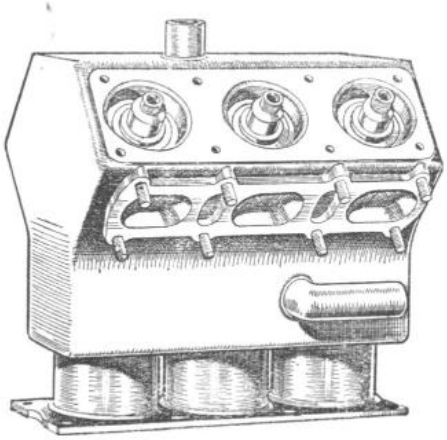
A novelty in racing car design was the use of an oil cooler fitted beneath the radiator, but in 1925 the former component was deleted and heat dissipation was left to the very large oil tanks in the dry sump system. These can be seen placed on each side of the torque tube and together they hold more than 15 gallons of oil.

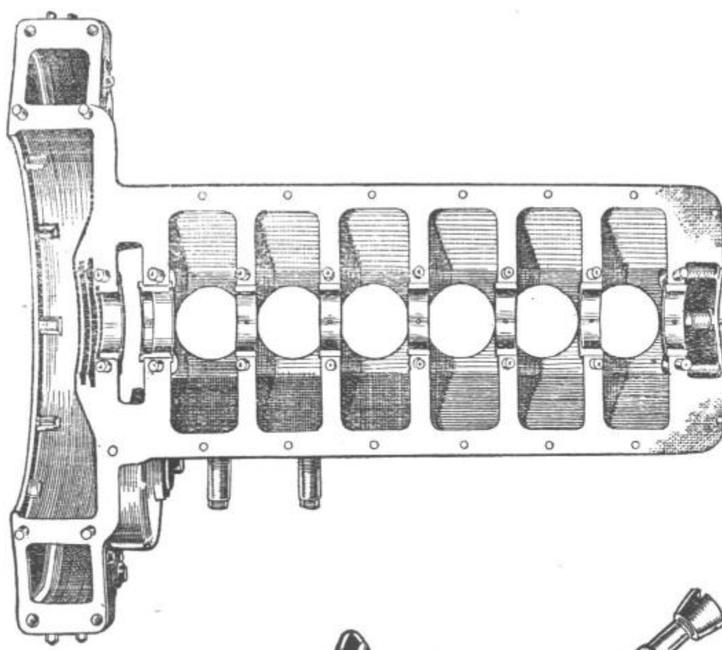
The undershield was cut-away beneath them and wire mesh panels inserted so as to provide air flow around the tanks.

Another feature, rare at the time, was the spring-loaded escape valve for the radiator. An internal projection from the filter cap fitted fairly closely over the over-flow pipe, leaving only a small annular space between them. This made an effective baffle against water loss by surging when applying brakes hard and as a further safeguard a spring-loaded valve was placed at the farther end of the pipe and would only " blow off" if steam pressure became considerable. In this event the steam was blown on to the driver's right elbow so that he was aware that the radiator needed replenishment.

The drawings show the 1924 appearance of the car, but notes about two points are needed.

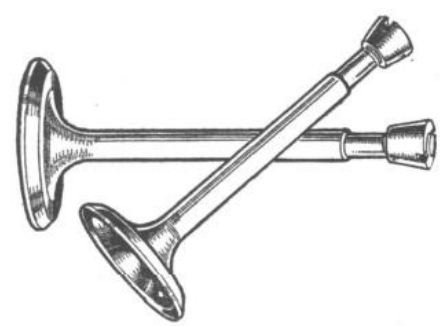
First, in both drawings the car is shown fitted with a V-shaped wire stone-guard. For some reason these do not seem to have been employed by the cars in the 1924 Grand Prix event, although they generally ran with them in position. Secondly, double Hartford shock absorbers are shown on the front axle, but it is likely that in the first race the cars had a single unit only.

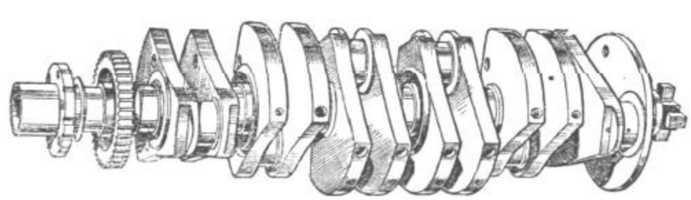




Top, left-A drawing of one block of the steel cylinder

Top, right-An inverted view of the top half of the crankcase





Lower, right-The inlet and exhaust valves, the latter of tulip form having 20 per cent less area than the former.

Left-The roller bearing crankshaft had eight bearings in all, two on each side of the rear timing gear wheel. The crank was counterbalanced and the big ends were of the roller-bearing type.

In 1924 engine design was at the turning point between the universal reliance upon induction at atmospheric pressure and the equally widespread employment of forced induction by a supercharger which has since followed. The details of these developments are recorded in another chapter.

The Sunbeam design has historic significance, not only in the fact that it was one of the first Grand Prix types to be supercharged, but that it was actually the first in Europe to compress mixture instead of pure air.

The illustrations of the Sunbeam engine show that the blower received mixture from the Solex carburetter through a rather long, curved pipe, the main object of this scheme being, apparently, to have the carburetter adjacent to the pits for adjustment if needed.

There are two principal advantages derived from sucking mixture from the carburetter through the blower, instead of blowing pure air to the carburetter. These are of such magnitude that all subsequent designers of blown engines have come to recognise them, the last to do so being Mercedes-Benz, who finally dropped their traditional blowing into the carburetter in the middle of 1937.

By pumping mixture full use can be made of latent heat given by the evaporation of fuel to reduce manifold temperature and much better mixing and distribution results from imparting mechanical carburation to the charge. Manifolds on racing engines should run at the lowest possible temperature and blowing air alone, a boost of 10 lb. per sq. in. results in a rise in temperature of approximately 80 degrees C. This, in turn, lowers the air density by 25 per cent, which reduces power to approximately the same degree.

High temperatures are also undesirable from a detonation point of view, so that there is a double reason for keeping the charge temperature down. By passing mixture through the blower the charge temperature can be kept at any desired figure simply by using enough alcohol in the fuel, the liquid having a high latent heat and also the valuable property that one can use exceedingly rich mixtures without losing power thereby.

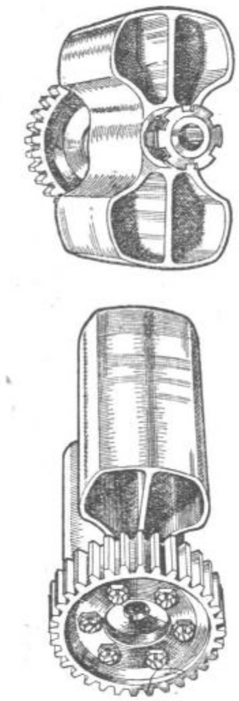
In view of the importance of this development, no little credit is due to Captain J. S. Irving, for his pioneer work in 1923-4, when chief engineer to the racing department at Sunbeams.

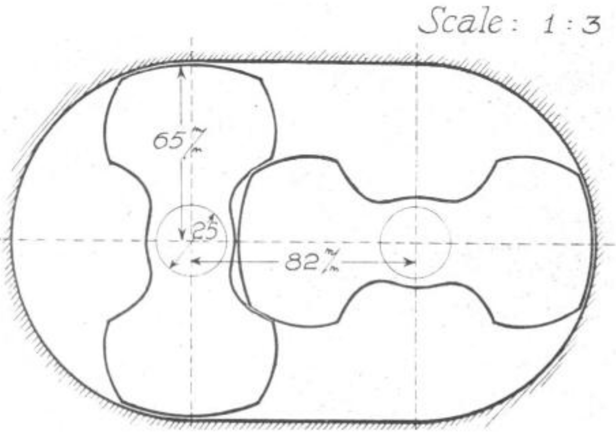
The blower was a normal Roots type, with, however, the interesting characteristic that the blower gears were mounted remote from the driving end so that all the drive torque of the blower had to be taken through one rotor shaft. This is an undesirable arrangement and has been abandoned on later designs of superchargers, but it must be confessed that no trouble seems to have arisen on this score on the engine in question.

The capacity of the blower was approximately 1.85 litres per r.p.m., so that the supercharge pressure of 6-7 lb. per sq. in. implies a volumetric efficiency of between 75 and 82 per cent. As will be seen, the mixture is supplied to dual three-branch manifolds, whilst on the bottom side of the supply pipe there is a large explosion valve with an off-take pipe projecting through the bottom cowling of the car.

The scale drawing of the rotor paddles shows that they were somewhat unorthodox in shape and gave a very wide seal between the case and the periphery of the rotor. Captain Irving observes that when the engines were being tested, violent knocking in the blower was experienced under certain conditions. This he eventually traced to a trapping of air in the recesses on each side of the shaft. The trouble was removed by milling a small flat along the small diameter. This allowed the air to pass from one side to the other as the rotors turned.

When originally assembled, the blower gave over 10 lb. per sq. in. boost, which was more than was needed, and is equivalent to a volumetric efficiency of approximately





The Roots blower rotors (left) were made from steel forgings and had connecting gears remote from the driving end. The scale drawing shows dimensions and the wide surface seal between the periphery of the rotors and the casing.

90 per cent. At the same time it was found that as the mixture temperatures rose there was certain distortion in the outer case and this necessitated increasing the clearances between the rotor and the casing, a very common modification in the development of all forms of blowers. The pressure dropped as a result to approximately 7 lb. per sq. in.

It will be seen that the crankcase was made from light alloy castings in two parts, with eight main bearings of roller type. The crankshaft is shown in a separate drawing which discloses the first of a train of timing gears at the back-end with a supporting bearing on each side. At the nose a four-star laminated spring drive was provided for the blower. The crankshaft was heavily counterweighted. The big ends were also of the roller type and the use of split cages and big ends in conjunction with roller bearings was a direct legacy from Fiat design. The construction has proved highly satisfactory and was used subsequently by Delage and Mercedes-Benz, but the highest standards of workmanship and fitting are required.

The connecting rod was a finely machined piece of work, and a point of particular interest was the deep ribbing of the lower cap.

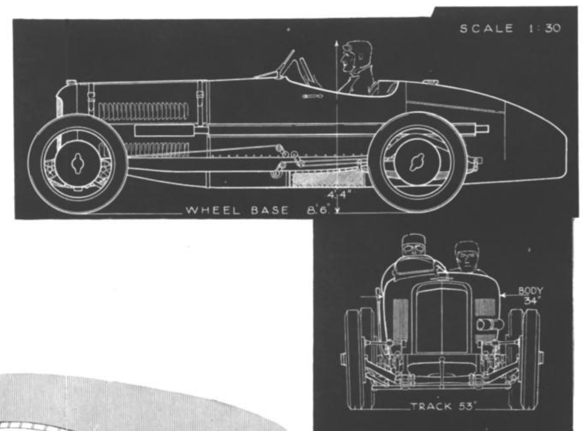
The cylinders were attached to the crankcase in two blocks of three, each cylinder being a separate forging welded to the bottom plate. These forgings constituted the cylinder barrels, with fixed heads, and a good deal of difficulty was experienced in welding them on to the bottom plate so that they were exactly in line. Once this had been done, the ports were welded up on to the head, and subsequently thin steel water jackets were welded around the entire assembly.

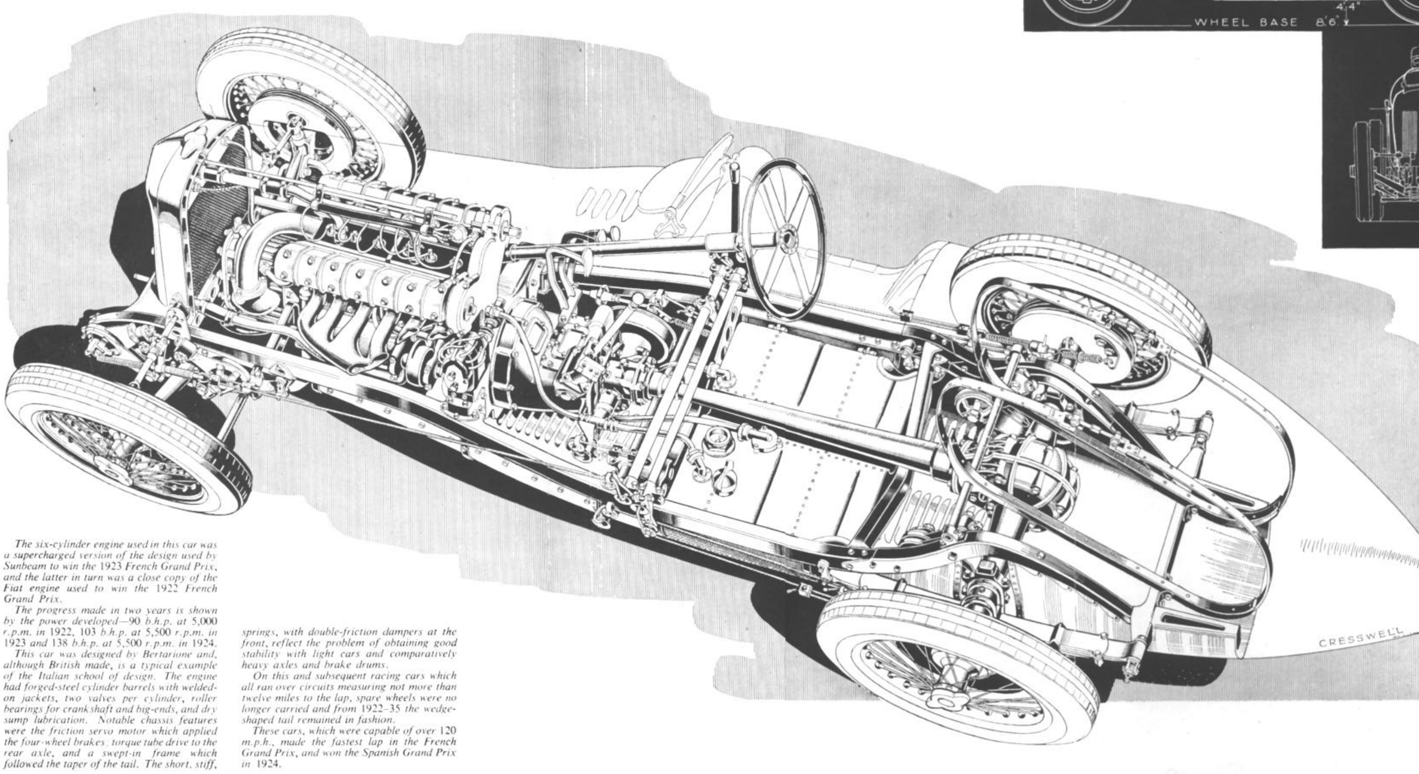
The result was two blocks of three cylinders, each having their own common water jacket, porting, etc., and bolted separately to the crankcase. The aluminium

PLATE XXI

EXAMPLE No. NINE

THE 1924 SUNBEAM





The six-cylinder engine used in this car was a supercharged version of the design used by Sunbeam to win the 1923 French Grand Prix, and the latter in turn was a close copy of the Fiat engine used to win the 1922 French Grand Prix.

The progress made in two years is shown by the power developed—90 b.h.p. at 5,000 r.p.m. in 1922, 103 b.h.p. at 5,500 r.p.m. in 1923 and 138 b.h.p. at 5,500 r.p.m. in 1924.

This car was designed by Bertarione and, although British made, is a typical example of the Italian school of design. The engine had forged-steel cylinder barrels with welded-on jackets, two valves per cylinder, roller bearings for crankshaft and big-ends, and dry sump lubrication. Notable chassis features were the friction servo motor which applied the four-wheel brakes, torque tube drive to the rear axle, and a swept-in frame which followed the taper of the tail. The short, stiff, springs, with double-friction dampers at the front, reflect the problem of obtaining good stability with light cars and comparatively heavy axles and brake drums.

On this and subsequent racing cars which all ran over circuits measuring not more than twelve miles to the lap, spare wheels were no longer carried and from 1922–35 the wedge-shaped tail remained in fashion.

These cars, which were capable of over 120 m.p.h., made the fastest lap in the French Grand Prix, and won the Spanish Grand Prix in 1924.

camshaft housings were, however, continuous castings, extending the whole length of the shaft and thus tied the unit together at the top end.

The valves, as have been previously stated, were inclined at 96 degrees, and operated through short steel pistons by two camshafts, these also running in ball bearings. Both cams gave a lift of 0.4 in., but the inlet valve had a 30 per cent greater area than the exhaust, the respective diameters being 1.625 in. and 1.437 in. at the throat. Quite a normal valve timing was used, viz. : inlet opens, 10 before T.D.C. ; inlet closes, 62 after B.D.C. ; exhaust opens, 50 before B.D.C. ; exhaust closes, 15 after T.D.C. A feature of the engine was high torque at low r.p.m.

The pistons were domed and slightly recessed at the sides to give clearance to the valves, and the compression ratio quite moderate, viz. : only 6 to 1. Two compression rings 2 mm. wide were employed with an oil scraper ring : there was also a bottom ring.

It is interesting to note that the diameter of the gudgeon pin was 18 mm., viz. : 27 per cent of the bore, a large figure for racing engines of those days.

Ignition was by Bosch magneto, driven by a skew gear at the rear of the engine, and incorporating a quick thread arrangement so that at all ignition timings maximum spark intensity was available. Sparking plugs were 18 mm. K.L.G. type 180. Incidentally, it is worth while mentioning that this type of K.L.G. plug had quite remarkable heat-resisting properties and was very much in advance of its time in this respect.

The plugs were masked as they were also in the Fiat design, the masking hole being approximately 4 in. deep and 10 mm. diameter, i.e. half the diameter of the plug.

During the 1924 Grand Prix Sunbeam cars were held back by misfiring, but this was later traced to defective magnetos, which had been installed the night before the race to replace instruments which had been carried over from the previous year. As run in this race, the engine developed 138 b.h.p., at 5,500 r.p.m., and the maximum speed of the car was approximately 125 m.p.h. Subsequently, certain developments were made which increased the power to 170 b.h.p. at 5,500 r.p.m. The position of the carburetter was changed and the blower casing heavily ribbed, the engine so modified being shown in a drawing in Part III.

Originally, the fuel was a mixture of approximately equal quantities of petrol, benzole and methyl alcohol petrol, made up by the Shell Co. Later the proportion of alcohol was increased.

The enhanced power naturally led to a corresponding gain in speed, and it is interesting to note that, whereas, in 1924, the five-mile record was taken at 114.23 m.p.h. by D. Resta, in 1929 it was raised to 126 m.p.h. by Jack Dunfee, who, in 1930, broke the 2-litre one-hour record at 117.49 m.p.h.

In the course of a long career in road racing, hill-climbing and track events engine failure was almost unknown and as a combination of reliability with performance the engines certainly have an outstanding record.

Acknowledgments.- A. S. Heal, Esq., has kindly placed one of the Sunbeam team cars at the disposal of author and artist, and J. L. Wyer, some-time member of the Sunbeam Experimental Department, has assisted with horse-power curves and data regarding the supercharging of these engines. Captain J. S. Irving, M.I.Mech.E., some-time chief engineer of the Sunbeam Company, has also given valuable assistance in the preparation of this chapter.

DETAILS OF CAR

MAKE.-Sunbeam
TYPE.-2-litre G.P.
YEAR OF CONSTRUCTION.- 1924
YEARS RACED.-1924 and 1925 in international racing ; up to 1930 by constructors in other competitions.
DESIGNERS.- Coatalen, Henri, Bertarione.
WHEELBASE.-8 ft. 6 in.
TRACK FRONT.-4 ft. 5 in.
TRACK REAR.-4 ft. 1 in.
HEIGHT TO SCUTTLE.-45 in.
HEIGHT TO DRIVER'S HEAD.-52 in.
FRONTAL AREA.-10.8 sq. ft.
UNLADEN WEIGHT.-15.7 cwt.
ALL-UP STARTING LINE WEIGHT.-20.7 cwt.
MAXIMUM SPEED.-125 m.p.h.
SPEED ON INDIRECT GEARS.-100 m.p.h. on Third
,, ,, ,, ,, 72 m.p.h. on Second
,, ,, ,, 47 m.p.h. on First at 5,500 r.p.m.
H.P. PER SQ. FT.-12.7
H.P. PER TON UNLADEN.-176
H.P. PER TON ALL-UP.-133
BORE.-67 mm.
STROKE.-94 mm.
S./B. RATIO.-1.4: 1
NO. OF CYLINDERS.-Six
CAPACITY.-1,988 c.c.
PISTON AREA.-32.9 sq. in.
B.H.P.-138 at 5,500 r.p.m.
H.P. PER SQ. IN.-4.2
B.M.E.P.-170lb. sq. in.
PISTON SPEED FT./MIN.-3,400
CYLINDER HEAD.-Integral with steel barrel.
VALVES No.-Two per cylinder
VALVES ANGLE.-96 degrees
VALVE AREA-Inlet 12.5 sq. in.
VALVE AREA.-Exhaust 9.7 sq. in.
CYLINDER BLOCK-Steel barrels with welded ports and jackets in blocks of three
FUEL.-Petrol, Benzole, Alcohol
CARBURETTER.-Solex horizontal.
SUPERCHARGER.-Roots at engine speed.
MANIFOLD PRESSURE.-7 lb. boost (1.47 atm)
IGNITION.-one Bosch magneto
PLUGS No.-Six.
PLUGS LOCATION.-In centre of head
CRANKCASE.-Two-piece light alloy
CRANKSHAFT.-One-piece counterbalanced
MAIN BEARING No.-Eight
MAIN BEARING TYPE.-Roller
BIG END TYPE.-Roller with split big ends
LUBRICATION.--Dry Sump
CAMSHAFT No.-Two
CAMSHAFT LOCATION.-In head
CAMSHAFT DRIVE.-Train of gears
CAMSHAFT DRIVE LOCATION.-Bear of crank
CLUTCH.-Multi-plate
GEARBOX LOCATION.-In unit with engine
GEAR RATIOS.-3.75, 4.92, 6.96, 10.3
TRANSMISSION.-Torque tube location of bevel drive
FRAME.-Channel
FRONT SUSPENSION.-Semi-elliptic
REAR SUSPENSION-Semi-elliptic
SHOCK ABSORBER TYPE.-Hartford Friction
BRAKE SYSTEM-MECHANICAL.-Foot : through propeller shaft driven servo to all four wheels ; Hand : direct to rear wheels
BRAKE DRUM DIAMETER.-Front 14 in.
Rear 14 in.
BRAKE DRUM WIDTH.-Front 2 in.
Rear 2 in.
SQ. IN. PER TON LADEN.-330
STEERING.-Worm and wheel, 1-1/8 turns lock to lock
TYRES.-RAPSON.-Front and Rear 765 x 105
WHEELS.-Rudge-Whitworth knock-on

RACING RECORD

Date	*Event*	*Course*	*Average Speed*	*Lap Speed*
3/8/24	French G.P.	Lyons	69.6 m.p.h. (Fifth)	76.7 m.p.h.
25/9/24	Spanish G.P.	San Sebastian	62.54 m.p.h. (First)	67.42 m.p.h.
26/7/25	French G.P.	Montlhéry	68.2 m.p.h. (Third)	—

EXAMPLE No. TEN

The 1927 1½-Litre Delage

BEFORE the 1914-18 war Delage cars had a long string of competition successes, particularly in voiturette races. They built Grand Prix racing cars for the first time in 1913 and one of them was victorious in the 1914 Indianapolis event. In the 1914 French Grand Prix they entered a team of highly original cars with front brakes, five-speed gearboxes and positively closed valves. Although they made fast practice times they were disappointing, both in this event and in subsequent races in which they ran in the U.S.A.

Louis Delage took no part in 3-litre formula races, but in 1922 authorised the construction of a four-cylinder 2-litre engine with dimensions 70 x 130 mm. The engine showed up well on m.e.p., giving a figure of 125 lb. per sq. in. between 2,000 and 3,500 ft./min., but was deficient in piston area and only 80 b.h.p. was realised. It was, therefore, scratched from racing and replaced the following year by a twelve-cylinder 2-litre (51.3 x 80 mm.), designed by M. Plancton, having the remarkable piston area of 38.7 sq. in. This developed 120 b.h.p. at 6,000 r.p.m. in 1924 and 195 b.h.p. at 7,000 r.p.m. in supercharged form in 1925. In this latter year the car was highly successful; it won both the French and Spanish Grand Prix, made record laps in both events, and was acclaimed Champion of Europe.

M. Lory was largely responsible for the development of the car and he, aided by M. Gauthier, was entrusted with the design of a 1½-litre model to run under the formula recognised for 1926-7. This stipulated maximum cylinder capacity of 1½ litres, one occupant and a minimum width for the body of 80 cm. The minimum weight was 600 kilos for 1926 and was raised to 700 kilos in 1927 or, approximately, 11.8 and 13.8 cwt. respectively.

The car shown in the drawing and made the subject of this description is the 1927 model. Although based on the design of the earlier year it incorporated many changes; indeed, the difference between the two models is considerably greater than is generally realised.

On the 1926 models the exhaust pipes were placed on the right-hand side of the car, and throughout the year much trouble was caused by, and races lost, on account of the driver's feet becoming burnt. In 1927 the exhaust pipe was changed to the left-hand side and this involved removing the twin blowers, previously mounted centrally, and substituting a single blower on the nose of the timing cover. Other changes were a different design of radiator, thicker camshafts and considerably stiffer steering arms. There was an increase in weight from 14.76 cwt. to 15.8 cwt., both of these figures, it will be noted, being well above the minimum demanded.

These alterations had a considerable effect upon the fortunes of the design. Whereas the 1926 edition had only one win to its credit (the British Grand Prix), in 1927 the cars carried all before them, winning the French, the British, the Italian, and the Spanish Grands Prix.

The Brooklands speeds for this car are 117.19 m.p.h. for the flying lap and 95.78 m.p.h. for the standing lap, and one may reasonably deduce a maximum speed of a little over 125 m.p.h. This figure fits well with the speed of 129.75 m.p.h. realised by the eight-cylinder Talbot, of contemporary construction and identical cylinder capacity, over a F. S. Kilometre in 1926, for on lap speeds the Talbot showed itself slightly the faster car of the two.

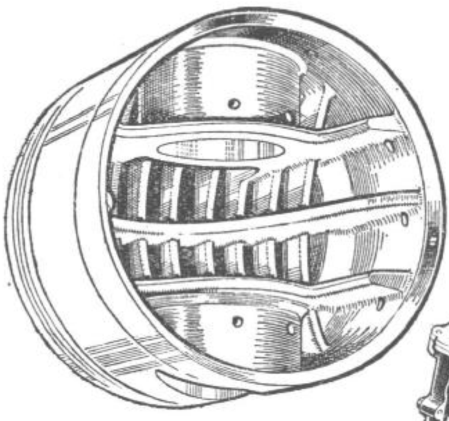
In 1925 the riding mechanic disappeared, and as only the driver was, by the regulations, permitted in the car, the way was paved to a marked change in external appearance. It became possible, for the first time, to offset the whole transmission towards the mechanic's side of the car and to place the driver's seat very low down with the propeller shaft running past him at about thigh level.

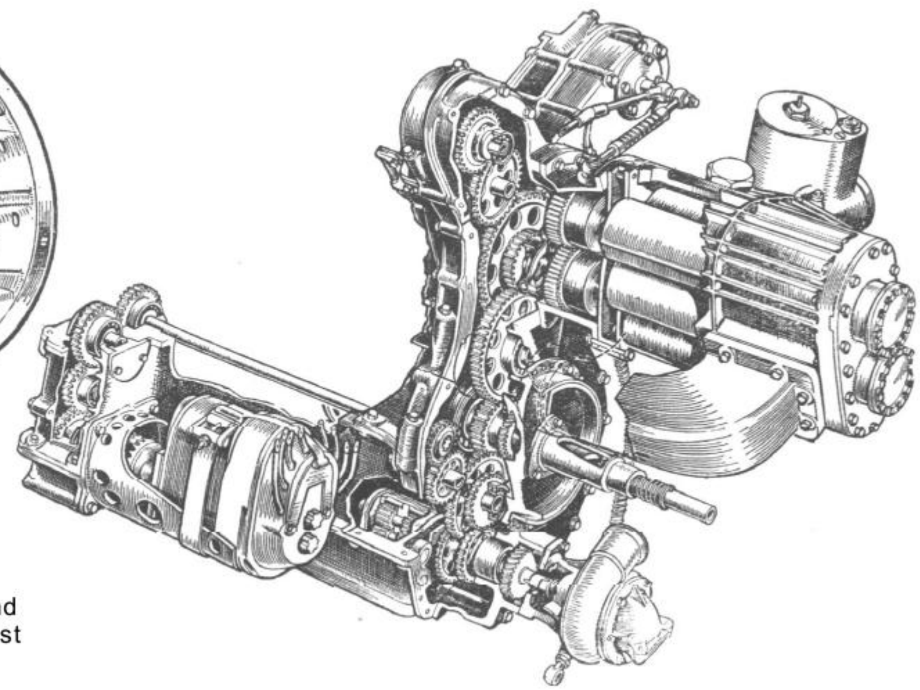
The Delage was the first design in which this principle was embodied, the bevel pinions being offset four inches to the left side of the car, making the proportions from the centre of the bevel box to the track 42.5 : 57 : 5 ; and by this means the height of the scuttle was reduced to 35 in. In consequence, although the body width could not be reduced to less than 31.5 in. the frontal area of the car came to the remarkably low figure of 9½ sq. ft.

Thus, supposing that the engine power was in proportion to the capacity, one would have expected this 1½-litre model to have compared quite favourably with the 2-litre which had preceded it. In fact, however, the power-per-litre was increased to a remarkable extent, and although the sustained maximum r.p.m. cited were 6,500, the engine could be run at 8,000 r.p.m., at which speed it gave 170 b.h.p. in its original form. This is within 20 h.p. of the 1925 twelve-cylinder Delage and is equivalent to an m.e.p. of 177 lb. per sq. in., a particularly fine figure in view of the low boost pressure and moderate compression ratio. Whether the engine could be run continuously at 8,000 r.p.m. is somewhat doubtful, and it is significant that the transmission included a five-speed gearbox with a fifth speed which reduced engine r.p.m. by 19 per cent. On this gear 8,000 r.p.m. would correspond with 162 m.p.h., which would have demanded far more horsepower than was available, and it is likely that 132 m.p.h. at 6,500 r.p.m. was the maximum ever attained on this gear in exceptionally favourable circumstances. It will, however, be seen that the driver had the option of running at, say, 128 m.p.h. at either 6,300 in overdrive or 7,500 r.p.m. in direct. A multi-plate clutch lay between the engine and the gearbox and the latter was of extreme length which, taken in conjunction with the engine mounting, resulted in there being virtually no cross bracing between the radiator and the driver's seat. This gave the car a characteristic weaving motion that affected the steadiness on the straight and impaired handling qualities on corners.

As a further result of the unusual length of the engine gearbox unit the open propeller shaft was particularly short. The rear axle assembly had a centre section built up from two steel forgings bolted together on the centre line, the outer halves being made from ball-mouthed steel tubing less than 5 mm. wall thickness. No light alloy entered into the construction, but this notwithstanding, the entire assembly was very much lighter than many more modern designs which make the extensive use of non-ferrous materials. Alternative crown-wheels and pinions were available, giving final axle ratios as low as 6.1: 1 and as high as 4.7: 1, but it may be taken that 5.2: 1 was a normal ratio on which the figures in the data panel have been based. The considerable lateral offset of the bevel box to the near side has already been mentioned, and, in consequence, the steering column came into the position normal to a two-seater car.

On the 1927 model great attention was given to rigidity of the steering connections and these were all made of very deep section so as to resist the stresses imposed upon them with the minimum of deflection. The steering mechanism was of the worm and wheel type with a ratio giving 1½ turns of the hand wheel from lock to lock. The wheel itself was of the René Thomas flexible type. A sketch shows the massive proportions of the off-side stub axle and these were duplicated in the drop arm and the corresponding near-side wheel linkage.





Above-Details of the pistons

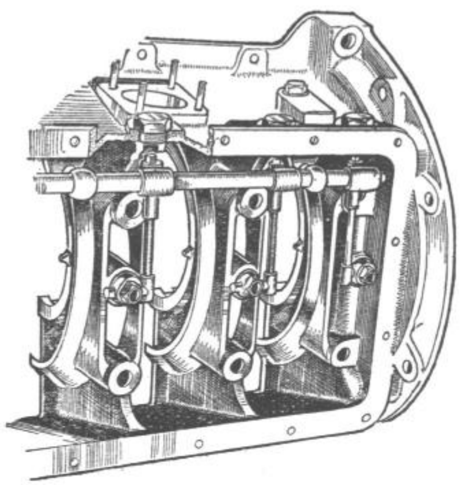
Right-The mass of auxiliary and camshaft drive gears of almost legendary fame

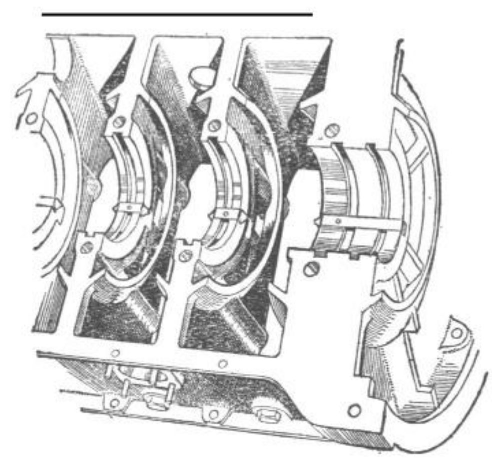
The brakes were of moderate diameter-approximately 14 in. internal, light alloy, non-servo shoes in all four wheels being applied by an internal expanding friction servo driven off the back of the gearbox. In this, movement of the pedal expands small brake shoes which grip a freely mounted drum and the tendency of this to turn is transmitted to the brake linkage to front and back wheels. Such a device enables high unit pressures to be used without excessive pedal effort, but has the disadvantage of being unsympathetic in action and liable unexpectedly to lock the wheels. In order to avoid this, the front brake arms were arranged to give a negative servo effect. It will be seen that pendant levers were pulled forward by a chain run over a sprocket. Hence, as the front brakes come on and the axle tends to twist forward on the springs, there is a " letting go " action, whereas if the levers had been pulled straight backwards the axle twist would have caused the brakes to go on harder and harder.

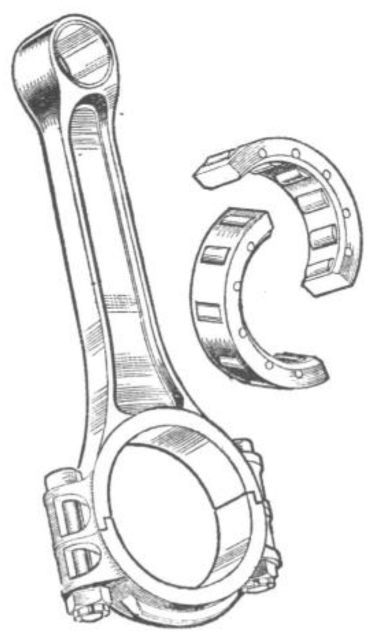
Semi-elliptic springs were used fore and aft, being short and stiff, as can be gauged from the fact that the minimum ground clearance between the central oil tank and the road is about 3 in. Friction-type shock absorbers were fitted to both front and rear axles and placed inside the bodywork.

In order to find adequate area for the radiator with its low height, the bottom tank had to come very low to the ground-in fact, well below the front axle beam. For this reason it was placed ahead of the front axle and a long pipe carried the water back to the exhaust side of the cylinder block. The water pump was driven by the front timing wheels and the radiator core was of the tubular type-possibly one of the earliest departures from the honeycomb form on a modern racing car.

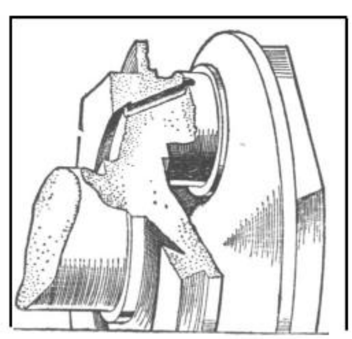
In addition to low frontal area the car was well streamlined without going to the more complete aerodynamic form. The shock absorbers were mounted out of the slipstream, and the bottom of the car fitted with a full-length light alloy under-tray. The tail was entirely filled by the petrol tank and the filler caps covered by a flap.

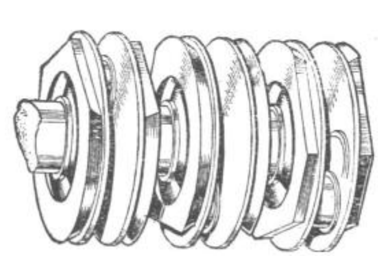






These detail views of the crankcase, crankshaft and a connecting rod demonstrate the emphasis on rigidity planned by the designer. In particular the heavy section connecting rod which weighed 14½ ozs. is noteworthy





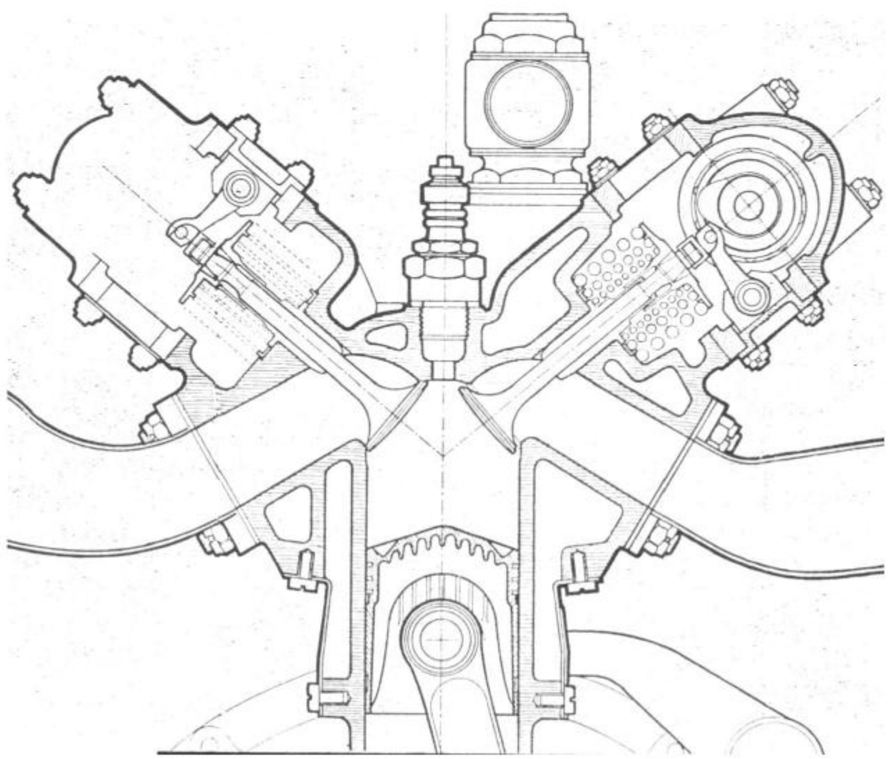
In addition to the sound general design seen in the drawing there are almost innumerable detail items of value, only a few of which can be mentioned. One of these is a lock which prohibits the use of either third, fourth and fifth ratios, or first and second. By moving one of these small catches the driver can be quite sure of not getting into the wrong ratio when once he knows the type of course on which he will be running. The gear positions were first, right-hand forwards, and top, left-hand backwards, with overdrive extreme left-hand forwards. It may be presumed that the real object of the catch was to make sure that the driver brought the lever back, slightly right and back again to engage direct drive and not too far across to the right, which would engage second gear, with disastrous results to the transmission and engine.

Another point is the fixing of the steering column on to the dashboard by means of a miniature rack and pinion. This makes a very solid fixing, but at the same time, by slackening off one face and loosening the mounting bolts on the steering box, the column can be raised or lowered and then fixed in the new position with the greatest of ease.

A touchstone by which we may fix the success or otherwise of a racing car is the advance it represents in power output, subject to its achieving reasonable standards of reliability. By this test, the l½-litre Delage engine was truly a milestone in design, for whereas in 1925 the 2-litre twelve-cylinder Delage developed 190 b.h.p.-viz., 95 b.h.p. per litre-in 1926 the l½-litre model developed 170 b.h.p., equal to 113.5 b.h.p. per litre, or a gain of nearly 20 per cent.

The gain in terms of h.p. per sq. in. of piston area was much less and from this absolute viewpoint there is, indeed, very little difference in merit between these two engines.

Reliability was first class. The Delage Company ran twenty cars in seven races during the period 1926-27, out of which they won five, finished first, second and third in two, and had three retirements due to engine trouble. Ten years afterwards, Richard Seaman ran for a complete season without engine trouble and, in fact, won three races in succession without any adjustment being carried out, probably a record in the history of the racing automobile.



This cross-section of the Delage shows the large angle of inclination of the valves, the concentration of water round the exhaust valves and the large diameter gudgeon pin. (Scale I : 3)

When examining the engine in detail, one sees that designer Lory was imbued by the maxim " Nothing too much trouble : no expense spared."

The bottom half of the engine, truly the fount of reliability, was made from three light-alloy castings divided horizontally. The bottom one was merely a shallow tray, which acted as an oil collector for the dry-sump lubrication. The other two halves carried the nine roller bearings for the crankshaft, which were 10 mm. wide by 49 mm. in diameter, and the crank itself had circular webs, the big ends being 32 mm. diameter. The crank was in one piece, hardened and ground all over, and each big end lubricated by an ingenious arrangement of jets. As can be seen from a detailed drawing, oil was fed through a gallery pipe to each bearing, eventually meeting a three-piece unit. The centre jet sprayed oil on to the main roller bearing, and the two jets at right angles thereto sprayed oil sideways on to the crank web. This had an annular recess to collect the oil and pass it under centrifugal pressure to the big end.

Although the oil pressure was only between l-2 lb. per sq. in. a large volume was provided and, with good fitting bearings, troubles on these engines were almost unknown. Such a scheme is, of course, only suitable for roller bearing big ends, and in this case each connecting rod ran on twelve rollers, each 6½ mm. diameter and 11 mm. long. These were located in a split light-alloy cage, each half looking after six rollers and the complete assembly weighing 2¼ oz. No particular trouble was taken to ensure that the two halves of the cage exactly matched but accuracy on the internal track of the split big end is vital to success.

The lower half of the rod was deeply ribbed for rigidity, and a feature was the easy radius between the shoulder of the big end and the H-section part of the rod. The complete rod with the big end assembly weighed 14½ oz., and its stiffness had obviously been very much in the eye of the designer.

This stiffness was obtained not only by the section of the rod, but also by its shortness, for it was only twice the length of the stroke-a low figure-whilst the gudgeon pins, 22 mm. in diameter, were only 31 per cent smaller than the big ends and measured nearly 40 per cent of the cylinder diameter.

To conclude this review of the reciprocating parts, the original pistons gave a compression ratio of approximately 6.5 to 1, and were exceedingly light die-castings, weighing only 5¾ ozs., complete with rings. The gudgeon pins weighed a further 2 oz., hence the total reciprocating weight of this engine amounted to 22 oz.

The layout of the crankshaft was distinctly unusual. The angles relative to No. 1 crankpin were : No. 2, 90 degrees ; No. 3, 180 degrees ; No. 4, 270 degrees ; No. 5, 270 degrees ; No. 6, 180 degrees ; No. 7, 90 degrees ; and No. 8, 360 degrees, reading the degree scale clockwise.

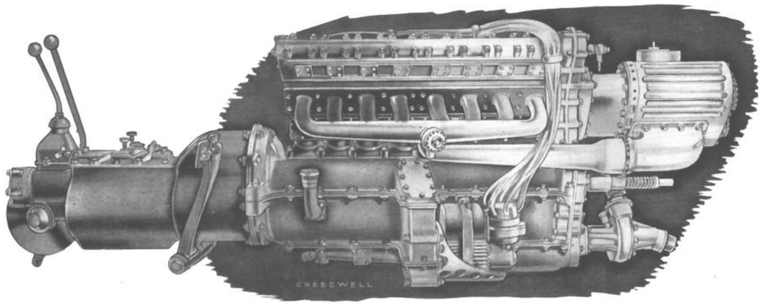
This scheme would involve difficulties on a production crankshaft, although these disappear if the crank, as in this case, was machined from the solid. There appear to be no particular virtues in the arrangement from the view-point of balance, but the firing order given (viz. : l-8-3-5-7-2-6-l) may give better balance of flow than the more orthodox l-3-2-5-8-6-7-4 which has been used on the Alfa Romeo and other more recent cars.

Just as rigidity had been uppermost in the designer's mind when tackling the bottom half of the engine, so it is plain that problems of volumetric efficiency were most carefully considered when dealing with the upper part of the engine. Each

PLATE XXII

EXAMPLE No. TEN

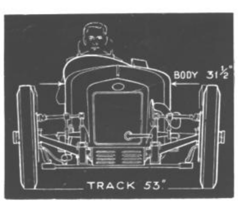
THE 1927 DELAGE

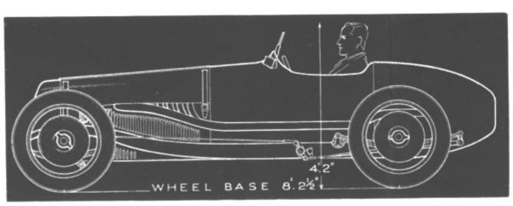


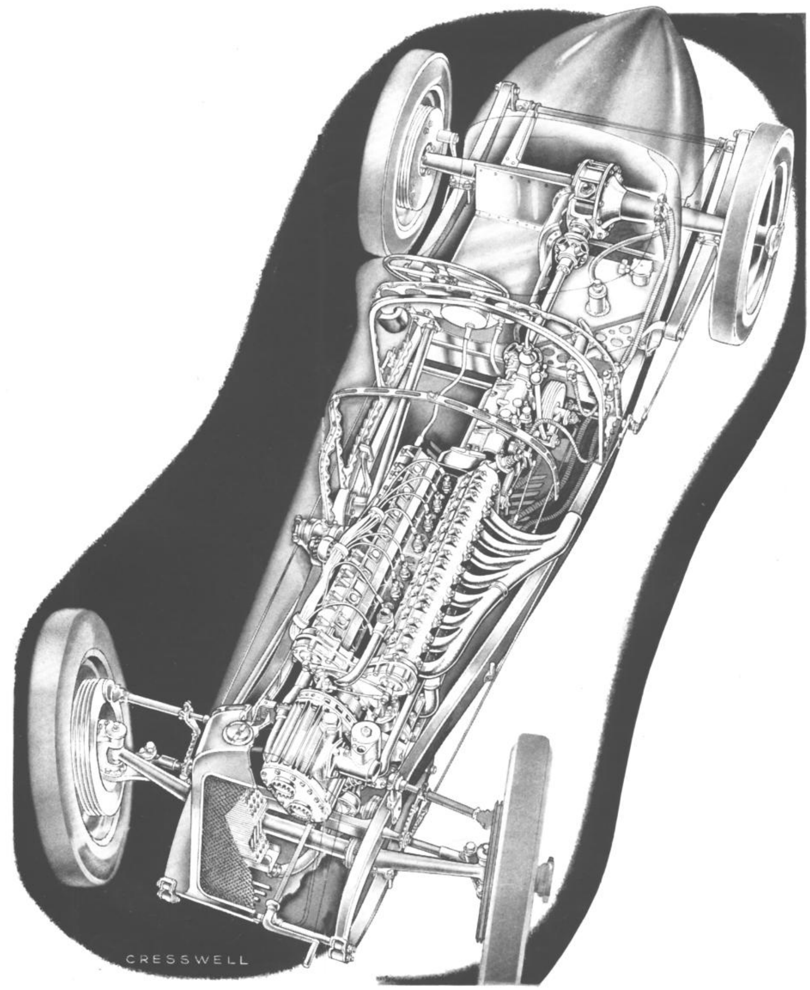
This car was designed by Lory to a formula limiting capacity to 1½ litres and requiring the driver only as crew. Despite the engine size, 177 b.h.p. was obtained by combining supercharging, eight small cylinders, and an engine speed of 8,000 r.p.m., although to ensure reliability a five-speed gearbox with an overdrive permitted the maximum speed of 127 m.p.h. to be reached at 6,500 r.p.m. Owing to the very small stroke of 76 mm. the piston speed at this r.p.m. was within normal limits. The two valves per cylinder were placed at an included angle of 100 degrees, and the ports were so carefully designed that the volumetric efficiency considered in relation to the boost pressure has rarely been exceeded. The engine also had a remarkably high mechanical efficiency, roller bearings being used throughout the whole of the crankshaft assembly and for almost all of the auxiliary drives, the total number of bearings of this kind being no less than 48. The cylinder block was in one iron casting.

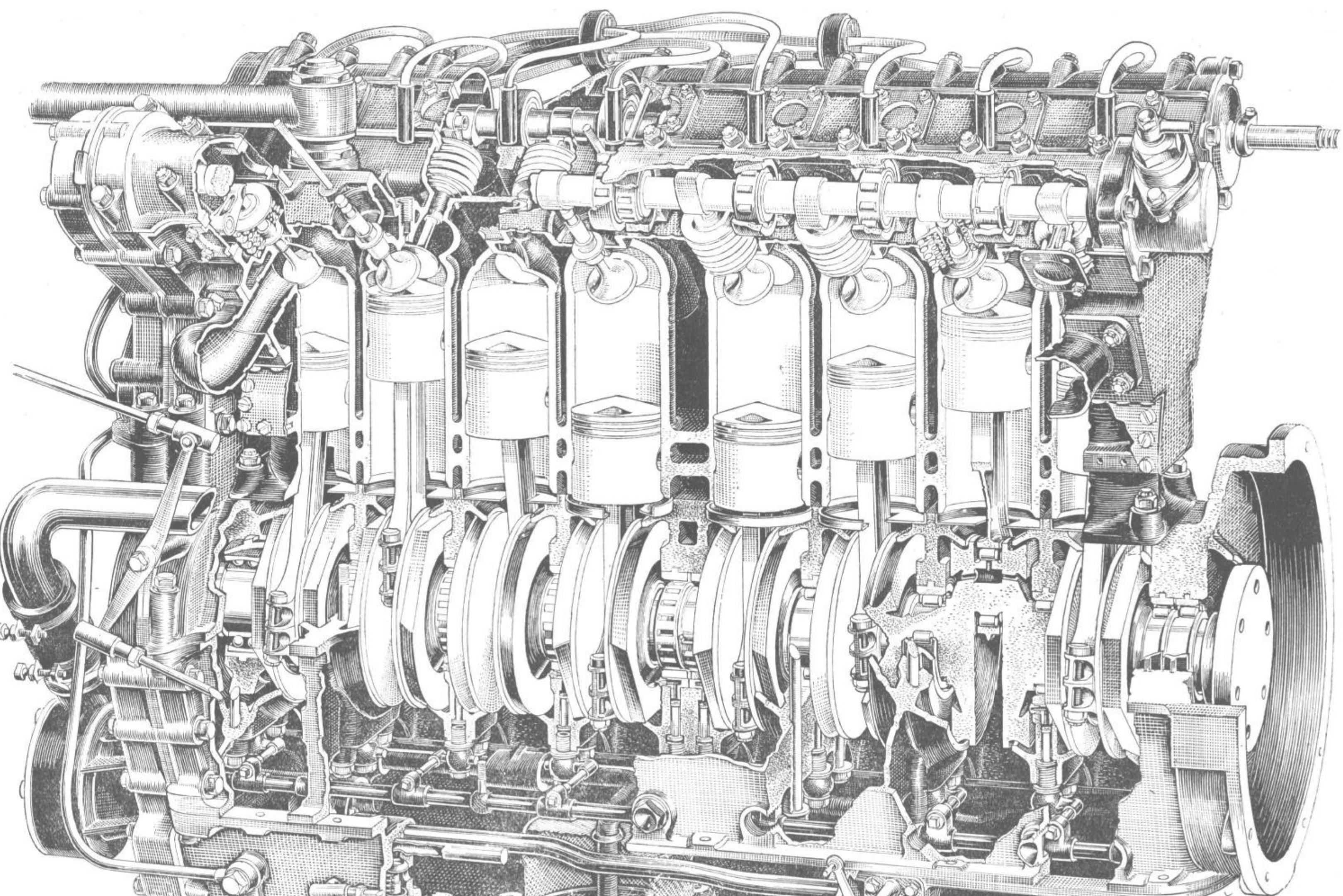
Engine and transmission were offset, thereby lowering the driver and reducing frontal area.

The extreme length of the engine and gearbox unit and the corresponding lack of bracing from the front hub centres to the scuttle is particularly well shown in this drawing. A further point of interest is the friction-type servo motor which, driven off the back of the gearbox, augmented the brake pedal pressure. The arms on the brake cross shafts are pulled forward so that movement of the axle on the springs does not itself set up a self-locking action. This car proved itself to be faster than the preceding 2-litre models, was unbeaten in 1927, and was winning races in the 1½-litre category ten years after its date of construction.








CRESSWELL

cylinder had one inlet and one exhaust valve inclined at 50 degrees. This angle permitted the inlet valve to be a good deal more than half the diameter of the bore, the exact size being 3 1 mm. as against an exhaust valve of 29 mm. The 7 mm. lift of the valves was moderate. The inlet valve opened 18 degrees B.T.C. and closed 50 degrees A.B.C. ; the exhaust opened 58 degrees early and shut 25 degrees late, the overlap, therefore, being 43 degrees. Triple valve springs were used and rather small followers were interposed between the cam and the valve stem, these being one of the least satisfactory parts of the engine and liable to rapid wear.

The design of the inlet manifold is interesting ; nowhere is a constant diameter followed, but, on the other hand, the cross-sectional areas seem carefully planned to meet the gas flow requirements at each individual point.

The m.e.p. and r.p.m. figures are certainly matters on which the designers deserve congratulation, particularly bearing in mind the comparatively low boost pressures employed. A b.m.e.p., of 177 lb. per sq. in. at 8,000 r;p.m., with only 7.5 lb. boost, is very creditable and certainly implies a high mechanical efficiency despite a stroke/bore ratio of 1.36:1, which gives a maximum piston speed of no less than 4,000 f.p.m.

The Roots blower had a theoretical capacity of 1.4 litres and ran at engine speed, being driven off the train of gears which connects the crankshaft to the two camshafts. There seems little doubt that it was a direct legacy from the twin blowers which were fitted to the twelve-cylinder 1925 cars, one on each side of the crankcase. The 1926 edition of the Delage engine followed the practice of two blowers, these presumably having the same rotor form and being made slightly shorter than the old 2-litre models. They were driven from a gear placed roughly in the middle of the nearside of the crankcase and driven by a lay-shaft from the front timing. Each blower had its own carburetter and fed to manifolds bolted direct on to the near side of the cylinder block.

In 1927 the cylinder block was re-designed so that the exhaust could be transferred to the near side and, as the magneto already occupied the middle of the off side of the crankcase, the blower was put on the nose of the timing case.

A single unit now replaced the previous twin blowers, so the length of the rotors had to be doubled from 110 mm.-a convenient figure giving good stiffness-to 220 mm., which was really too long. However, at the comparatively low pressures used, the blower does not appear to have given any trouble.

At the front of the engine lay the mass of the timing and auxiliary drive gears which have secured an almost legendary fame. The camshafts were not symmetrically mounted on the cylinder head and the gearing to the inlet and exhaust shafts was not, therefore, interchangeable. The camshaft drive involved no less than eight gears, to which should be added seven to the magneto, two to the oil pump, and two to the water pump, whilst originally there were a further four for the supercharger installation, all of these running on roller bearings.

The pumps for the dry-sump lubrication system were housed in the bottom section of the crankcase, and a by-pass valve from the pressure side inter-connected with the accelerator pedal so that on full throttle there was a substantially higher oil pressure and greater circulation than on part throttle. This scheme is open to the objection that the highest loading in the engine (due to inertia) will occur with the throttle shut and virtually no oil circulation, but presumably the drivers were forewarned to avoid this condition as much as possible.

The cylinder block was a single iron casting with open sides covered by steel sheets. A centrifugal pump mounted on the front of the crankcase supplied water to the near side of the block from whence it circulated up through the head which was so designed that a large mass of water surrounds the exhaust valves and ports. Much of the success of the engine must be attributed to the good water flow. A cross-section brings this point out very clearly.

The 18 mm. sparking plugs were masked, the diameter of the inter-connecting passage being 8 mm., whilst the camshafts ran in a split light housing with a ball bearing placed on each side of each cam. Lubrication was through the centre of the camshafts, the diameter of which was increased considerably as between 1926 and 1927.

The Delage engine literally represents a technical *tour de force* both in design and construction, the casting of the eight-cylinder block in itself being an achievement of no mean order.

On the other hand, the engine was heavy and measured 55 in. from the timing case to the rear universal joint. This in conjunction with the method of engine mounting led to a frame which was very weak in torsion and it can be argued that excellent engine design was offset to a material extent by deficiencies in chassis layout.

Acknowledgments.-R. Parnell, Esq., has been of the greatest assistance in providing a complete car with components and drawings upon which this chapter has been based.

RACING RECORD

Date	*Event*	*Course*	*Average Speed*	*Lap Speed*
18/7/26	European G.P. . .	San Sebastian	— (Third)	81.5 m.p.h.
7/8/26	English G.P. . . .	Brooklands with Chicanes	71.61 m.p.h.	—
3/7/27	French G.P. . .	Montlhéry	77.24 m.p.h.	81.43 m.p.h.
3 1/7/27	Spanish G.P.	San Sebastian	80.52 m.p.h.	85.41 m.p.h.
4/9/27	European G.P. . . .	Monza	90.04 m.p.h.	94.31 m.p.h.
1/10/27	English G.P.	Brooklands with Chicanes	85.59 m.p.h.	—

DETAILS OF CAR

MAKE.-Delage
TYPE.- 1½-litre G.P.
YEAR OF CONSTRUCTION.-1926-27
YEAR RACED.-1927, by manufacturers
DESIGNER.-Lory
WHEELBASE.-8 ft. 2½ in,
TRACK FRONT.-4 ft. 5 in.
TRACK REAR.-4 ft. 5 in.
HEIGHT TO SCUTTLE.-35 in.
HEIGHT TO DRIVER'S HEAD.-50 in.
FRONTAL AREA.-9½ sq. ft.
UNLADEN WEIGHT.-15.8 cwt.
ALL~UP STARTING LINE WEIGHT.-19.3 cwt.
MAXIMUM SPEED.-128 m.p.h. on 5.2:1 direct 4th at 7,500 r.p.m.
THEORETICAL MAXIMUM AT 8,000 R.P.M. on 5TH OVERDRIVE.-162 m.p.h.
SPEED ON INDIRECT GEARS.-108 on Third
" " " " 82 on Second
" " " " 61 on First at 8,000 r.p.m.
H.P. PER SQ. FT.-18 on direct top
H.P. PER SQ. FT.-145 at 130 m.p.h. on overdrive 5th.
H.P. PER TON UNLADEN.-215
H.P. PER TON ALL-UP.-177
BORE.-55.8 mm.
STROKE.-76 mm.
S./B. RATIO.--1.36:1
No. OF CYLINDERS.-Fight
CAPACITY.-1,488 cc.
PISTON AREA.-31 sq. in.
B.H.P.-170 at 8,000 r.p.m.
H.P. PER SQ. IN.-5.8
B.M.E.P.-177 lb. sq. in.
PISTON SPEED FT./MIN.-4,000
CYLINDER HEAD.-Cast-iron integral with block
VALVES No.-Two per cylinder
VALVES ANGLE.-1 00 degrees
VALVE AREA-INLET.-9.30 sq. in.
VALVE AREA EXHAUST.-8.16
CYLINDER BLOCK.-Cast-iron in one block with detachable plate on water jackets
FUEL.-Petrol, Benzole, Alcohol
CARBURETTER.-Cozette horizontal
SUPERCHARGER.-Roots at engine speed
MANIFOLD PRESSURE.-7 lb. boost (1.47 atm)
IGNITION.-one Bosch magneto
PLUGS No.-Eight
PLUGS LOCATION.-In centre of head
CRANKCASE.-Two-piece light ahoy split on bearing centre line with detachable sump bolted on.
CRANKSHAFT.-One-piece counterbalanced
MAIN BEARING No.-Nine
MAIN BEARING TYPE-Roller
BIG END TYPE.-Roller with split big ends
LUBRICATION.-Dry Sump
CAMSHAFT No.-Two
CAMSHAFT LOCATION.-In head
CAMSHAFT DRIVE.-Train of gears
CAMSHAFT DRIVE LOCATION.-Front of crank
CLUTCH.-Multi-plate
GEARBOX LOCATION.-In unit with engine
GEAR RATIOS.-4.4 (overdrive), 5.2 (direct), (alternatives 4.7 highest, 6.1 lowest), 6.6, 8.75, 11.7
TRANSMISSION.-Open propeller shaft to bevel drive rear axle
FRAME.-Channel
FRONT SUSPENSION.-Semi-elliptic
REAR SUSPENSION.-Semi-elliptic
SHOCK ABSORBER TYPE.-Hartford Friction
BRAKE SYSTEM.-Mechanical, foot through propeller shaft driven servo to all four wheels ; hand, to rear wheels.
BRAKE DRUM DIAMETER.-Front 14 in.
Rear 14 in.
BRAKE DRUM WIDTH.-Front 1½ in.
Rear 1½ in.
SQ. IN. PER TON LADEN.-270
STEERING.-Worm and Wheel 1½ turns lock to lock
TYRES.-Michelin 765 x 120 Front and Rear
WHEELS.-Rudge-Whitworth knock-on

EXAMPLE No. ELEVEN

The Type 35 Bugatti

BUGATTI cars have won more road races than any other make, quite possibly more than all other makes added together. This is all the more remarkable in that when Ettore Bugatti had his works situated in German-administered Alsace he took but little part in racing. His post-1919 Grand Prix types were not immediately successful, although one of the 1922 straight-eight 60 x 88 mm. 2-litre cars ran second in the French Grand Prix at Strasbourg, and his remarkable tank-type streamlined car, using the same engine, was placed third in the 1923 French Grand Prix at Tours. In 1924, however, a basically unchanged engine was installed in an entirely new chassis which, given the type number 35, commenced the remarkable run of successes associated with this marque. This model broke the lap record in the 1924 Spanish Grand Prix and, in the following two years, Bugatti cars achieved a total of 1,045 victories, including, in 1926, the French, European and Italian Grands Prix, using a modified power unit of 1½ litres capacity. This 1½-litre, the Type 39, was less successful in the 1927 formula races, but in other events 806 wins were realised in this year. So many successes were based on the fact that the Type 35 Bugatti was at once a racing car and a catalogue model which was used very largely by amateur drivers. In 1928, '29 and '30, in the period of *formule libre,* Bugatti fortunes were at their zenith and fourteen victories of the first order were secured in these three seasons.

During these years, the chassis design, which was conceived for the French Grand Prix at Lyons in 1924, was untouched, apart from minor changes to wheels, brakes and the radiator. The 1922 engine was substantially modified in 1925 by the use of a built-up crankshaft with five main bearings and roller-bearing connecting rods with one-piece big ends. This arrangement took the place of a shaft running on three roller bearings but carrying white metal big ends. The cylinder dimensions remained unaltered at 60 x 88 mm., and for the duration of the 2-litre formula Bugatti remained faithful to atmospheric induction, endeavouring, not unsuccessfully, to offset deficiencies in power with superior road holding and chassis design.

The change to a 1½-litre formula in 1926 made forced induction essential and led to the introduction of the Type 39. This was the successor of a 1½-litre eight-cylinder built for the French Touring Car Grand Prix run at Montlhéry in 1925 under a limit of 12.8 m.p.g. and the engine was really identical to the Type 35 except that capacity was reduced by changing the cylinder dimensions to 52 x 88 mm., and a Roots type supercharger was mounted on the offside of the crankcase and driven from the front end of the crankshaft by a train of gears. Bugatti showed his essential versatility by simultaneously developing an alternative model with 2.3 litres capacity, having dimensions 60 x 100 mm., termed the Type 35B. This, supercharged in the same way as the Type 39 but with a correspondingly larger capacity blower, ran in and won the 1926 Targa Florio which was a *formule libre* event. This car was followed in 1927 by the Type 35C, which had the original bore and stroke of 60 x 88 mm., but supercharged .and with larger radiator, more forwardly mounted, and bigger brake drums than the 1924 cars.

In maximum speed there was practically nothing to choose between these models ;

in fact, the evidence of the record book seems to indicate that the 1½-litre variation may have been the fastest of them all.

In 1928 the Type 35B model secured a standing kilometre record at 76.27 m.p.h. and the standing mile at 85.14 m.p.h. The same car averaged 122.5 m.p.h. over a flying kilometre, and although these speeds were subsequently slightly exceeded they may be taken as representative of the performance of this model.

In 1930 the Type 35C averaged 83.44 m.p.h. for the standing kilometre and 94.01 m.p.h. for the standing mile, giving an intervening speed of 119 m.p.h., but it was incapable of breaking flying records in the face of the superior top speed of such cars as the P.2 Alfa Romeo and twelve-cylinder Delage, which would exceed 130 m.p.h.

One would expect from engineering statistics that the Type 35 Bugatti, even in supercharged form, would be a somewhat slow car, and this expectation, borne out by measured performance, makes it all the more remarkable that the average circuit speeds of the Bugatti should be so high.

It is thus apparent that there was something about the Bugatti design enabling each horse-power to be utilized to far better advantage than on other racing cars of its period. The secret of this maximum realisation of power is to be found in the extraordinary controllability, road holding, and general stability of the Bugatti cars, qualities which the Types 35 B and C share with practically every other product from Bugatti's drawing-board and which derive from the excellent chassis design..

A unique feature of this, and all other Bugatti cars, is the reversed quarter-elliptic springs connected to the rear axle by shackle bolts. In consequence a radius arm is necessary to deal with the driving torque for which purpose (on this particular model) two external arms, with ball joints, are attached to the frame. The latter makes an interesting study in itself, and shows the familiarity of the designer with the fundamentals of design. The depth of the frame varies continuously throughout its length in accordance with the loads imposed upon it so that although inspection of the dumb-irons, which are only three-quarters of an inch deep, gives an impression of the utmost frailty, the depth of the frame members at the mid-point is 6¾ in.

Torsional strength is even more important in frame design than beam strength. The Bugatti frame in itself is not very good in this respect, but the car as a whole is exceedingly rigid. The two dumb-irons are tied together by a tube, whilst the straight-eight engine, being rigidly anchored at four points, ties up the entire front part of the frame in an admirable fashion. The back part of the frame is stiffened by transverse tubular members, as shown in the cut-away drawing.

Insistence on stiffness is the theme, not only of the frame, but also of the steering connections and spring mountings. The rear springs are wide and as there is only one oscillating joint the transverse rigidity is excellent. Similarly, at the front end of the car the orthodox shackle is replaced by a trunnion through which the rear end of the spring leaf passes, the centre of the spring passing through the centre of the front axle.

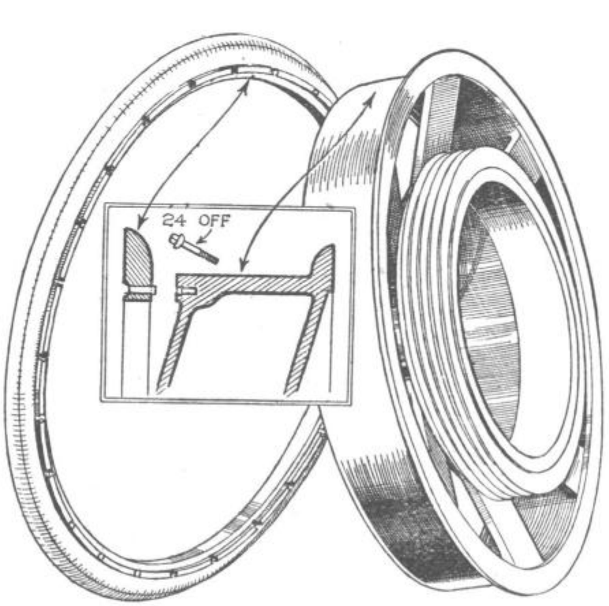
The latter is a unique design, being hollow, of double diameter and yet of single-piece construction. There is a large-section hole between the front springs and one of very much smaller diameter between the springs and the stub-axle bearing. This apparent miracle of machining was accomplished by boring the axle right through with a large-diameter drill as an initial operation, shaping it, closing up the outer portions, and then finally redrilling with a smaller diameter cutter.

Readiness to accept difficult problems of this nature has always been a particular quality of Bugatti, as can be seen from the fact that the steering arms are tapered rectangles pulled up into corresponding holes and all of them carefully shaped to a varying section, offering a resistance to deformation that accords with the load imposed.

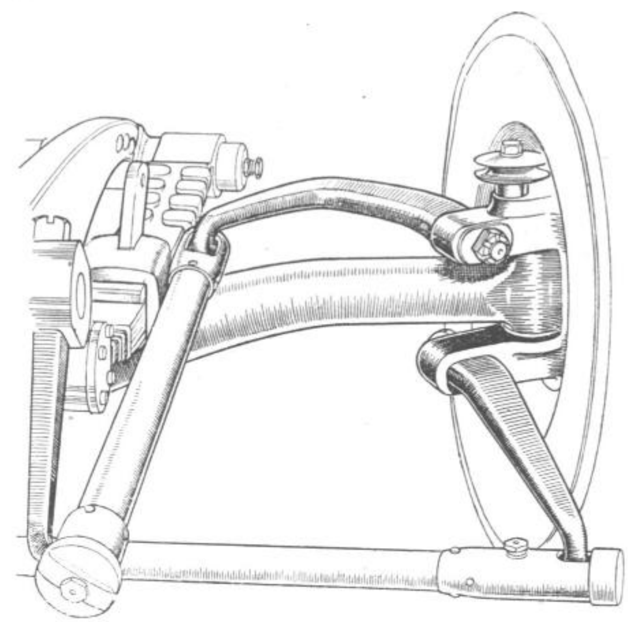
The steering box in itself contained a worm and wheel, all the moving parts running on ball bearings, and in order to prevent external loads being imposed by chance misalignment of the steering column, or following flexing of the box, a leather universal joint was incorporated in the open steering column.

The braking system was notable for direct action without servo mechanism, although a slight degree of servo action was acquired by placing the brake camshafts ahead of the centre line of the front axle together with the nearly vertical mounting of the front brake levers.

Entirely unconventional brake drums, cast integral with light alloy wheels, were introduced in 1924 and were at first a failure, as serious tyre trouble was experienced. This was due to incorrect design of the rim, and when modified no further trouble



The cast alloy wheel and brake drum in its original form with detachable rim.



The steering connections were of exceptional stiffness.

was experienced. On the later type of cars the wheels were made in one piece, but the earlier models had a detachable rim held on by twenty-four small set screws. The scheme had the merit of preventing the tyre detaching itself from the wheel whilst combining wheel and drum conferred a considerable reduction in unsprung weight. It also permitted a change of brake shoes during a race at the same time as wheels and tyres were changed.

The rear axle was an exceedingly light construction, having a two-piece aluminium alloy casting for the bevel-box, with straight-cut teeth and semi-floating half shafts running in steel tubes flanged up and bolted to the centre section. On these cars there was a choice of five final ratios giving by stages from 4.5:1 up to 3.7:1.

The gearbox in itself was remarkable for having the lay-shaft side by side with the main shaft, the depth of the box thereby being appreciably reduced.

The rear petrol tank held twenty gallons, and although the bodywork was reasonably well streamlined the driver was mounted high so as to be given maximum control and visibility, the latter being enhanced by the narrow radiator and bonnet.

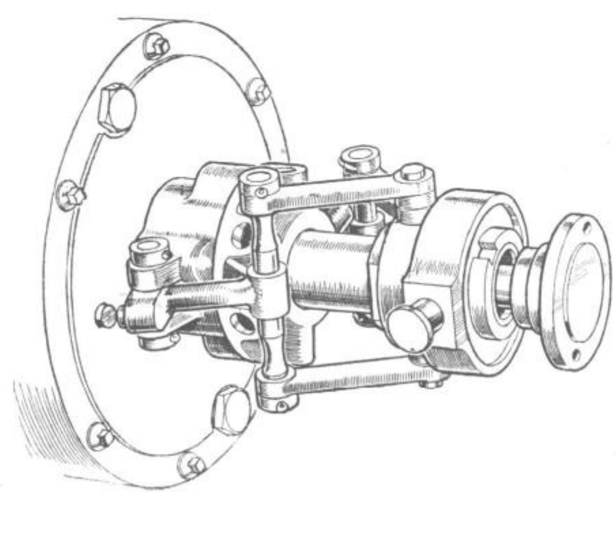
As befitted the son of an eminent artist, Ettore Bugatti always achieved good lines both in his cars as a whole and in each individual part of them. He insisted that his draughtsmen should be able to conceive three-dimensionally and draw in perspective as a prelude to laying out a part on strictly engineering lines. Many hold the view that the Type 35 Bugatti is the most characteristic representation of the normal racing car.

Supercharged to about 10 lb. per sq. in. the Type 35 engines gave about 120 horse-power in 2-litre form and between 130 and 140 horse-power in 2.3-litre guise, peak revs. being between 5,000 and 5,500 r.p.m. Sixty b.h.p. per litre is no outstanding feat for a supercharged power unit and certainly cannot be held to justify the complicated construction of the engine.

There are, however, some points to be put forward in extenuation. The design was the last but one of a series of adaptations from a prototype introduced very shortly after the 1914-18 war, and this prototype itself showed obvious signs of derivation from engines put on to the drawing board by the same hand in the 1913-14 period. Another point is that Bugatti, in this engine, clearly expressed his choice of simple machining operations backed up by highly skilled handwork in fitting and assembly, as against a type that requires a great deal of expensive tooling and jigging, but can be easily put together by ordinary labour. Finally, although the engine was of moderate output it was, when driven within the limits for which it was designed, exceedingly reliable.

The drawings show that the valves were placed vertically in the head and opened by a single camshaft operating through rocking fingers. Three valves per cylinder were used, two inlets of 0.9 in. diameter and one exhaust of 1.4 in. diameter. The lift was 7 mm., and the valves sizes, when converted into area, show clearly Bugatti's typical interest in exhaust scavenging. Whereas most racing engines have larger inlet than exhaust areas, Bugatti reversed this, the figures being 1.27 and 1.54 sq. in. per cylinder respectively. Hence, although the proportion of inlet-valve area to piston area was reasonably high (0.26), the exhaust-valve area was exceptionally large, so much so that it was necessary to open out the combustion space to allow for the valve.

Partly as a consequence of the vertical valve stems, partly because of the valve area, the cooling of the head was, to say the least, indifferent. In point of fact, there can be few successful racing engines which have run with so little water in contact with so many hot spots. The cross-section drawing shows how thin are the water spaces around



The operating mechanism of the multi-plate clutch at which the levers exert centrifugal effect that considerably augments the spring pressure.

PLATE XXIII

EXAMPLE No. ELEVEN

THE Type 35 BUGATTI

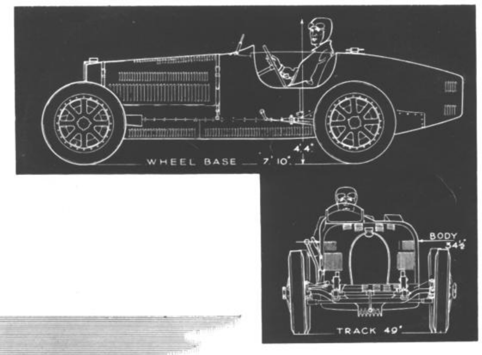
The chassis and general arrangement of this type of car were conceived and built by Ettore Bugatti for the 1924 French Grand Prix. In the following year the 2-litre eight-cylinder engine, with three vertical valves per cylinder, was improved by introducing a five-bearing crankshaft with roller bearings for main and big-ends in place of the three bearing crankshaft with white metal big-ends used previously.

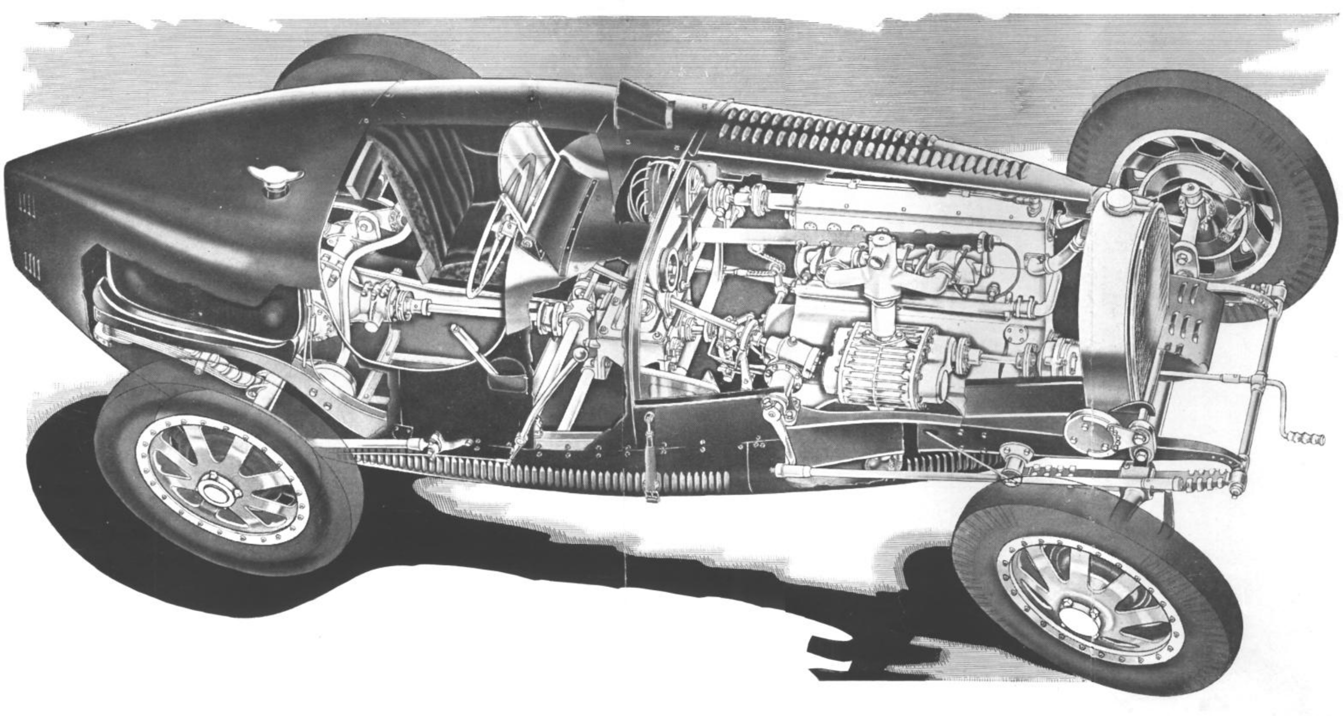
In 1926 a supercharged version was built, Type 35B, with a 2.3-litre engine and 35C with a 2-litre engine; also a variant (Type 39) with a 1½-litre engine for competition under the Grand Prix formula of 1927.

All these cars were identical with the exception of bore and stroke and supercharger size, and there was little difference in the output developed which was about 130 b.h.p.

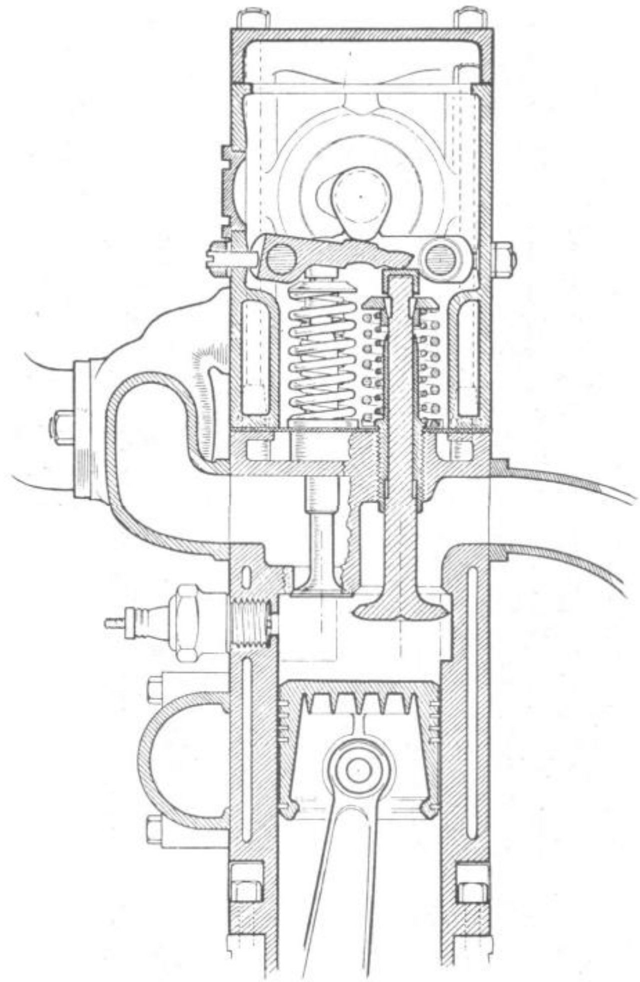
Remarkably high average speeds were secured in relation to the h.p. developed, the cars having stability and road holding far in advance of their time, which enabled them to win twenty-three races in five racing seasons. The frame side-members are developed to a depth of 7 in. in the centre part of the car, and the front part of the chassis is stiffened by bolting the sump thereto at four points. The springs were short and stiff and reverse quarter elliptics at the rear were used in conjunction with a stroke arm and outside radius arms for the rear axle.

A highly characteristic feature of this car was the aluminium wheels, which were cast in unit with the brake drums. These made it possible to change the brake shoes when changing the wheel, the brakes themselves being fully compensated but worked direct from the pedal without servo motor assistance.





the bore, and although matters are improved around the sides of the cylinder head, there is only cast-iron cooling for the important bridge which forms the adjoining sides of the inlet and of the exhaust valve seats.

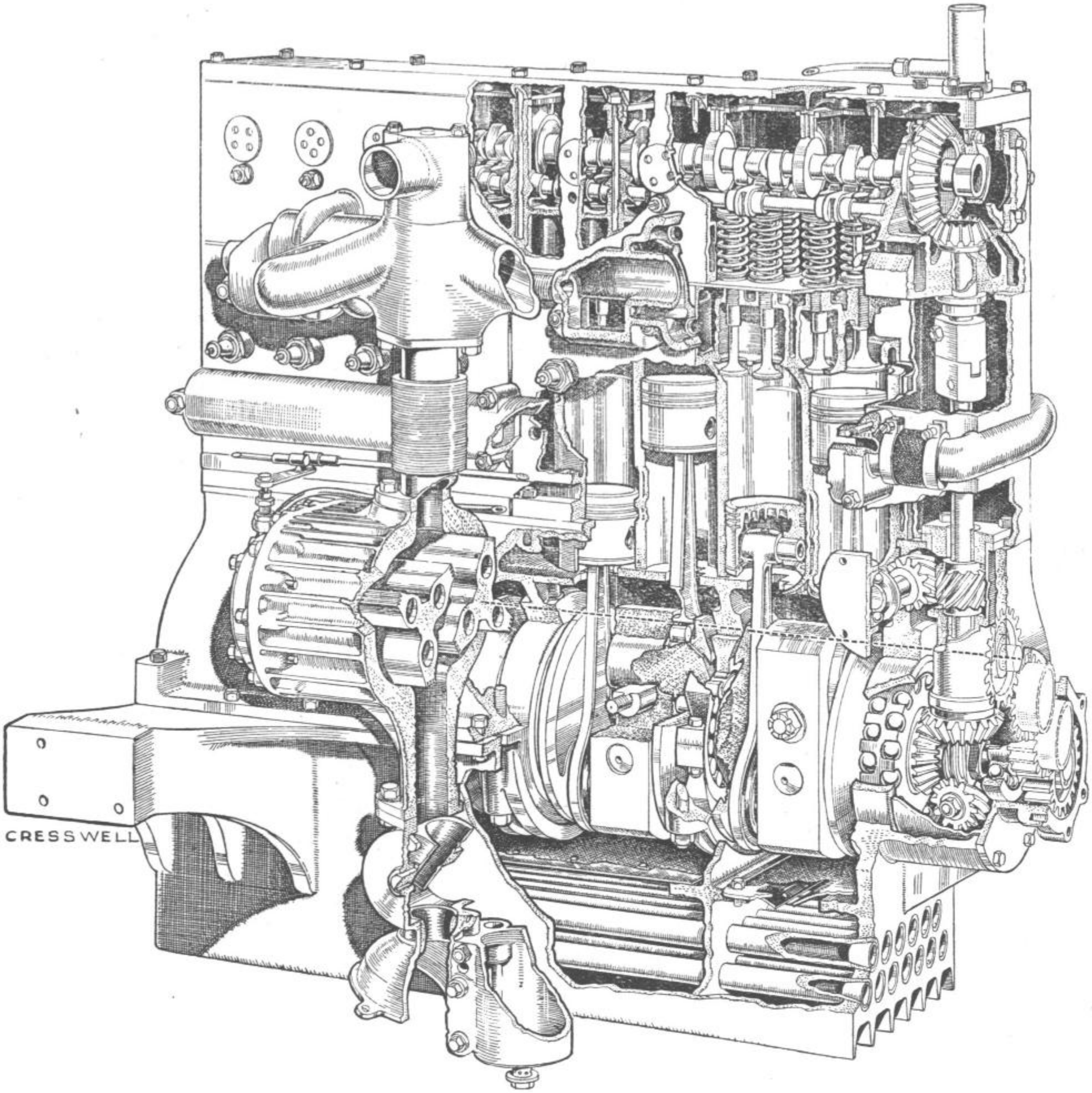


Details of valve gear and combustion chamber. (Scale 1 : 3)

Further, although the valve stems themselves were long, the valve guides were short, and the proportion of their length in contact with the water shorter still. Even the sparking plug screwed into a nearly solid mass of metal with only small water passages near to it. One interesting point should, however, be observed, which is that the top of the cylinder block was cast with an open face subsequently covered over by a thin aluminium plate which lies between the block and the camshaft housing, and forms a water seal. By this means the casting could be definitely cleaned from foundry sand and any misplaced coring would be evident.

The cylinders were cast in two blocks of four, the camshaft housing being common to all eight bores and made of light alloy with the cam running in pressure-lubricated plain bearings. Three cams per cylinder were used, clearance being adjusted by hard steel shims placed on top of the valve stems.

The bottom half of the engine had a conventional light-alloy crankcase split horizontally, but the three inner, roller, bearings were supported solely from the top half. The main journals were no less than 2½ in. diameter, and the roller bearings in which they run locked in split steel races 5½ in. diameter, these, in turn, being held to the top half of the crank by three steel straps. The outer bearings were ball type



located by both halves of the crankcase. The big ends had roller bearings, each connecting rod having seventeen rollers 7/16 in. by 7/16 in. running on a crankpin approximately 1¾ in. diameter.

The rods themselves, being made in one piece, had to be fitted on a built-up crankshaft. The centre part of this was made with two webs coupled together with taper and key. The remainder of the shaft was made by using split main bearing housings as before mentioned, and locking adjacent sections of the shaft together by pins with taper flats on them, as shown in the drawing. Obviously, the alignment of the shaft depended to a formidable degree on the skill of the workmen concerned, but, equally, the machining operations were all very straightforward.

Lubrication was not through the shaft, but by means of jets which received the oil at about 15 lb. pressure from a conventional gear-type pump and squirted it into annular grooves around the periphery of the webs, from there to the big ends under centrifugal force.

The pistons were short and characterised by rather small gudgeon pins only 13 mm. diameter placed low down in the skirt. This permitted a wide top land and three compression rings per piston. Some engines also had an oil control ring at the base of the piston skirt.

As dry-sump lubrication was not employed, only one pump was fitted, but an attempt at oil cooling was made by using a very deep sump which not only had radiating fins on the base, but also thirteen copper tubes running fore and aft to carry cooling air right through the oil. In point of fact, this arrangement (in conjunction with the naturally high ratio of surface area of crankcase to cylinder volume on a straight-eight engine) was highly successful, and these engines would run on the track and road with moderate oil temperatures.

A train of gears at the front of the engine ran for the supercharger and a vertical drive shaft for the valve gear. The shaft turned at engine speed and a simple dog coupling allowed for engine dismantling and variations for expansion. There were two transverse drives, one for the water pump. Although the latter was mounted on the exhaust sides, for some reason the off-take from it was carried round to the inlet side of the engine where a long cast gallery supplied water to drilled holes into the cylinder block.

Typical of the designer's habit of compressing everything into the smallest space is the way in which the bottom bevel for the camshaft drive was recessed to receive the worm of the skew gear which drives the oil pump, and it will also be noted that whereas the whole of the crank assembly runs in anti-friction bearings, the camshaft mechanism utilises plain bearings.

The Roots supercharger was mounted centrally, driven at engine speed and had a three-lobed rotor. It drew mixture from a vertical carburetter and delivered through a riser pipe with T branch to two separate water-heated manifolds, one for each cylinder block. There were four inlet ports, each 1 in. by 2 in. and, of course, feeding two cylinders apiece. This layout, which involves the gas being turned through six right angles during the course of its passage from the blower to the valve head, is scarcely conducive to the utmost efficiency, but on the other hand, the scheme had a neat appearance and gave reasonably good distribution as between one cylinder and another.

The valve overlap was approximately 30 degrees, the inlet opening approximately 10 degrees before top dead centre.

By contrast with the somewhat tortuous inlet arrangements, the exhaust pipes evidence meticulous attention to gas flow. Each set of cylinders had a four-branch Y-type manifold with very easy curves bringing the gas down into a central member made of welded-up steel, which joined into a common tail pipe. This exhaust system was employed on all Bugatti cars from the earliest models up to the 3.3-litre types and was both useful and good-looking.

Both the firing order and the layout of the crankshaft were unique amongst straight-eight engines. The latter goes 1, 5, 2, 6, 3, 7, 4, 8, i.e. taking each block of cylinders separately the firing sequence is 1, 2, 3, 4 on the front four bank, and 5, 6, 7, 8 on the back four. This was coupled with a singular crank arrangement, the front half of which is shown in the cut-away drawing, the back being identical but moved through

90 degrees. In this layout the engine is well balanced except for a couple between the front and back halves of the shaft, which imposes severe loads on the centre bearing.

Ignition was by a single magneto driven from the back end of the camshaft, and although in this position the timing is affected by clearances in the gears the mechanical and electrical inertia effects in the magneto acted as a damper on torsional resilience in the camshaft itself.

As can be seen from the drawing, the sparking plugs were heavily masked, the slot being rectangular. The location of the plugs on the inlet side is one more evidence of Bugatti's talent for setting theory at naught, as the latter has always dictated a policy of firing the charge from the hot side of the head to a cool area and not, as on this engine, vice versa.

Equally unconventional was the Bugatti clutch, which was a small diameter, multi-plate type with practically no flywheel effect. The latter was not really needed on a straight-eight, high-speed engine and, in this design, the crankshaft had a considerable mass of its own. The distinctive feature of the clutch was in the operating gear. There was no means of positively disengaging the clutch plates, but movement of the pedal pushed back a swinging yoke which ran over a grooved collar. This imparted movement to a set of levers which, in turn, released pressure from two push buttons, which normally held the plates against each other.

When the clutch was engaged the pressure required to transmit the drive was provided in two ways. There was a light external spring to provide initial grip, but the main source was the centrifugal effect of the levers, which, in accordance with mathematical laws, increased the pressure applied as the square of the engine speed.

A drawing shows the mechanism partially dismantled and with the levers in an exaggeratedly elongated position.

The design of these engines was entirely characteristic of Ettore Bugatti, being unconventional in nearly every aspect, demanding the utmost in skilled workmanship and fitting, and yet, at the same time, reflecting a severe, almost brutally practical outlook, as exemplified in the locking arrangements for the crankshaft.

The Type 35 Bugatti may certainly claim to be the world's most successful racing car and as such can justifiably be taken as a norm against which prior and subsequent designs may well be compared. Certainly no other model has been capable of such wide use, that is to say for sprints, hill climbs, track racing, and road racing, and in the hands of both professional and amateur drivers, expert and not so expert.

DETAILS OF CAR

MAKE.-Bugatti
TYPE.-35B and C
YEAR OF CONSTRUCTION.-1926-30
YEARS RACED.-1926-30, by manufacturers
DESIGNER.-E. Bugatti
WHEELBASE.-7 ft. 10 in.
TRACK FRONT.-4 ft. 1 in.
TRACK REAR.-3 ft. 11 in.
HEIGHT TO SCUTTLE.-42 in.
HEIGHT TO DRIVER'S HEAD.-52 in.
FRONTAL AREA.-10.8 sq ft..
UNLADEN WEIGHT.-15.1 cwt.
ALL-UP STARTING LINE WEIGHT.-185 cwt.
MAXIMUM SPEED.-120 m.p.h.
SPEED ON INDIRECT GEARS.-100 m.p.h. on Third
" " " " 72 m.p.h. on Second
52 m.p.h. on First
H.P. PER SQ. FT.-12.2
H.P. PER TON UNLADEN.-173
H.P. PER TON ALL-up.-145
BORE.-60 mm.
STROKE.-TYPE B-100 mm.
TYPE C-88 mm.
S./B. RATIO.-B 1.67: 1
C 1.47:1
CAPACITY.-TYPE B-2,261 c.c.
TYPE C-1,955 c.c.
No. OF CYLINDERS.-Eight
PISTON AREA.-35 sq. in.
H.P.-135 at 5,300 r.p.m.
H.P. PER SQ. IN. OF PISTON AREA.-3.85
B.M.E.P.-134 lb. sq. in.
PISTON SPEED FT./MIN.-TYPE B-3,500
TYPE C-3,060
CYLINDER HEAD.-Cast-iron integral with block
VALVES No.-Two inlet, one exhaust per cylinder
VALVES ANGLE.-Vertical
VALVES AREA INLET.- 10.02 sq. in.
VALVES AREA EXHAUST.-12.3 sq. in.
CYLINDER BLOCK-Cast-iron in two blocks of four
FUEL.-Petrol, Benzole, Alcohol

CARBURETTER.-vertical Solex
SUPERCHARGER.-Three-lobed Roots with optional gear ratios
MANIFOLD PRESSURE.-10 lb. boost (1.66 atm)
IGNITION.-One magneto
PLUGS No.-Eight
PLUGS LOCATION.-Inlet side of head
CRANKCASE.-Two-piece light alloy split on centre line with bottom half carrying engine bearers
CRANKSHAFT.-Built-Up counterbalanced
MAIN BEARING No.-Five
MAIN BEARING TYPE.-Ball and roller
BIG END TYPE-Roller with one-piece big ends
LUBRICATION.-wet Sump
CAMSHAFT No.-One
CAMSHAFT LOCATION.-In head
CAMSHAFT DRIVE.-Vertical shaft and bevel gears
CAMSHAFT DRIVE LOCATION.-Front of crank
CLUTCH.-Multi-plate with centrifugal servo assistance
GEARBOX LOCATION.-Separate from engine
GEAR RATIOS.-3.6 (optional ratios 3.37 highest, 4.5 lowest), 4.7, 6.65, 8.72
TRANSMISSION.-open propeller shaft to bevel drive rear axle
FRAME.-Channel
FRONT SUSPENSION.-Semi-elliptic
REAR SUSPENSION.-Splayed reverse quarter-elliptic
SHOCK ABSORBER TYPE.-Bugatti friction
BRAKE SYSTEM.-Mechanical ; foot, through differential compensator to all four wheels ; hand, to rear wheels
BRAKE DRUM DIAMETER.-Drums integral with wheels 11 in. internal diameter
BRAKE DRUM WIDTH.-2 in.
SQ. IN. PER TON LADEN.-294 sq. in.
STEERING.-Worm and wheel, 1 turn lock to lock
WHEELS.-Bugatti patent, light alloy castings
TYRES.-Dunlop, 29 x 5.00 for special rim, front and rear

RACING RECORD-TYPE 35B-2.3-LITRE

Date	*Event*	*Course*	*Average Speed*	*Lap Speed*
25/4/26	Targa Florio . . .	Short Madonie	45.68 m.p.h.	46.8 m.p.h.
12/6/27	Rome G.P.	Trefontana	68.88 m.p.h.	—
14/8/27	Coppa Ciano..	Montenero	50.14 m.p.h.	
6/5/28	Targa Florio	Short Madonie	45.65 m.p.h.	46.2 m.p.h.
22/4/28	Alessandria G.P. .. .	Alessandria	63.45 m.p.h.	66.5 m.p.h.
5/7/28	Marne G.P.	Rheims	82.49 m.p.h.	91.4 m.p.h.
15/9/29	Monaco	Monaco	49.83 m.p.h.	—

TYPE 35C-2-LITRE

Date	*Event*	*Course*	*Average Speed*	*Lap Speed*
24/4127	Targa Florio . . :.	Short Madonie	44.61 m.p.h.	46.6 m.p.h.
9/9/28	Italian G.P. ..	Monza	99.14 m.p.h.	102.8 m.p.h.
3/6/28	Tunis G.P.	Bardo	*75.6* m.p.h.	77.85 m.p.h.
10/6/28	Rome G.P.	Trefontana	78.55 m.p.h.	80.4 m.p.h.
28/7/28	San Sebastian . ..	San Sebastian	80.58 m.p.h.	88.25 m.p.h.
5/5/29	Targa Florio .	Short Madonie	46.21 m.p.h.	47.3 m.p.h.
30/6/29	French G.P. . .	Le Mans	82.66 m.p.h.	—
14/7/29	German G.P. .	Nürburg	66.79 m.p.h.	69.97 m.p.h.
20/7/30	Eifel Races .	Nürburg	68.04 m.p.h.	—
21/9/30	French G.P.	Pau	90.4 m.p.h.	—
6/4/30	Monaco . .	Monaco	54.63 m.p.h.	56.01 m.p.h.
20/7/30	European G.P.	Spa	72.1 m.p.h.	—

Also many other wins with works-entered cars (and by private owners) in races of less than Grand Prix status or on circuits not used subsequently.

EXAMPLE No. TWELVE

The 4.5-Litre Bentley

IN periods of technical weakness it becomes possible for the series type high-performance car to compete with, and on occasions beat, the pure racing design.

It has been recorded elsewhere that the years 1928-31 constituted such a period, and it is, therefore, not inappropriate to include amongst the examples of Grand Prix cars a catalogue model which was originally designed for sports car racing and only found itself in a Grand Prix event by the accident of fate.

Such a one was the 4½-litre supercharged Bentley, which achieved second place in the French Grand Prix of 1930 when driven by Sir Henry Birkin, Bart. In this event he was beaten by a Type 35C Bugatti, but in turn was faster than a large number of these and other racing cars.

The 4½-litre Bentley was a direct development and enlargement of a 3-litre model produced in 1920 which was in turn largely inspired by the 1914 Grand Prix racing cars.

The original design had cylinders measuring 80 mm. x 149 mm., and the larger type was a scaled-up version with dimensions 100 x 140 mm. The 4½-litre was produced largely with an eye to the Le Mans twenty-four-hour race and was entered for this event in 1927. The following year the type won the event, and in 1929 it obtained second, third and fourth places behind a 6½-litre six-cylinder Bentley, which came home first by a margin of seventy-two miles.

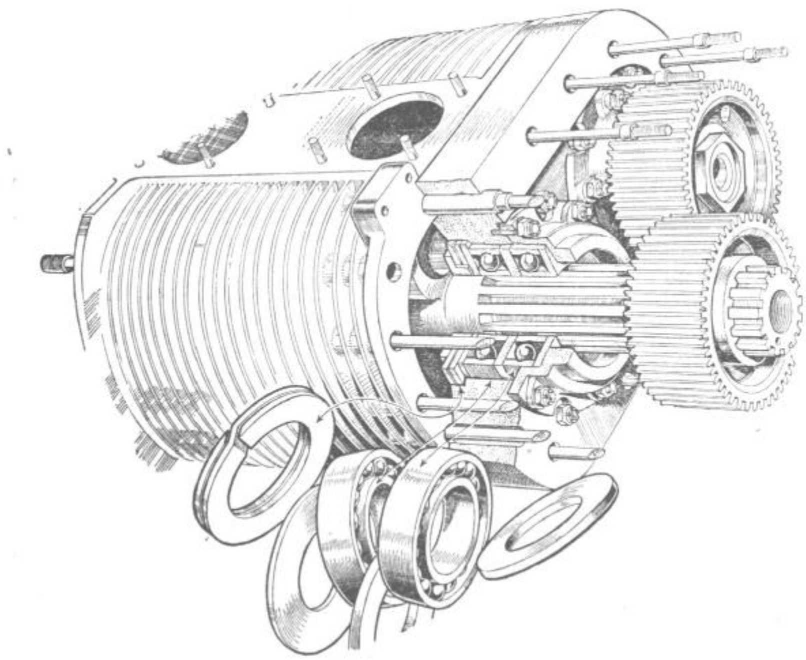
The reliability of the larger car made it the choice of Mr. W. O. Bentley and his technical associates for the subsequent events in which his company was interested, but Sir H. R. S. Birkin, advised by Mr. Amherst Villiers, was of the opinion that even better results could be obtained by supercharging the 4½-litre. It was realised that considerable modifications would have to be made to the engine if reliability were to be obtained, but finance being forthcoming, the necessary work was started privately by Birkin to Villiers' designs in the winter of 1928-9, and the car made its debut in the Irish Grand Prix of the latter year.

A Roots-type blower, having a capacity of 5.6 litres, was driven from the front end of the crankshaft and mounted between the front dumb-irons. Three cars were prepared for racing, two with a wheelbase of 10 ft. 10 in., and one with a wheelbase of 9 ft. 10 in. The bodies had, of course, to comply with the Le Mans and other regulations of the time governing sports car races, and this, in conjunction with the long stroke of the engine and the high side-members of the frame, of necessity resulted in a large frontal area. Running stripped as in the French Grand Prix, the frontal area amounted to approximately 17 sq. ft., whilst with head lamps, mudguards added, this figure would increase to approximately 19 sq. ft.

The standard engine in unblown form developed 125 h.p. at 3,500 r.p.m., and supercharging increased this by 80 per cent, so that approximately 240 h.p. was realised at 4,200 r.p.m. By calculation this power is sufficient to drive the car at 125 m.p.h., and on the top gear used (3.0 to 1) this speed would be equivalent, neglecting wheel spin, to 3,900 r.p.m.

No positively accurate information is available concerning the maximum speed of this car on the road, but Sir Henry Birkin claims to have reached 135 m.p.h. at Pau. This would imply over 4,000 r.p.m. on the engine and, on theoretical grounds, a higher h.p. than it is known to have developed. A similar car has, however, lapped Brooklands at 127 m.p.h. and on balance of evidence therefore a maximum road speed of 130 m.p.h. is acceptable.

It will be seen on a maximum speed basis the Bentley was the equal of the racing Type 35 B and C Bugattis, but it was handicapped by great weight, the figure for



The Roots type blower, giving a boost of circa 12 lb., employed exceptionally wide gears and an ingenious method of scaling the rotor shafts.

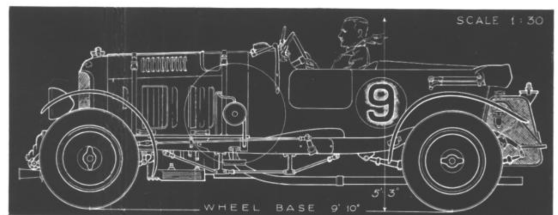
the short-chassis car in racing trim being about 38 cwt. bare, and 41.5 cwt. one up plus fuel, etc. Thus the b.h.p. per ton is figured distinctly unfavourable as compared with cars designed and built specifically for Grand Prix racing.

This handicap also extends to the braking system, despite the use of drums nearly 16 in. in diameter.

The general features of the design are vividly portrayed in the sectionalised drawing and one should note that engine construction largely determined the aspect of the whole car. The comparatively long stroke and the employment of a single overhead camshaft inevitably gave a considerable height from the top face of the crankcase to the camshaft cover, and thus imposed a comparatively high radiator and dashboard assembly. The choice by the designer of wet-sump lubrication employing large oil capacity, and, therefore, a deep base to the crankcase, brought the centre line of the crank high from the ground and necessitated a wheel of 16 in. radius. Thus the engine design is primarily responsible for the frame being 2 ft. off the ground, and for the driver's head being 63 in. above the ground.

The high centre of gravity of the Bentley forced the use of stiff and heavily damped springs in order to prevent excessive roll on corners. The drawings show that double Hartford shock absorbers were used at the back, and that all four semi-elliptic springs were closely bound, in addition to being fitted with U-section clamps.

Stiffness of springing was also imposed by the considerable unsprung masses, the rear axle in particular being abnormally large and heavy, whilst the use of large-diameter



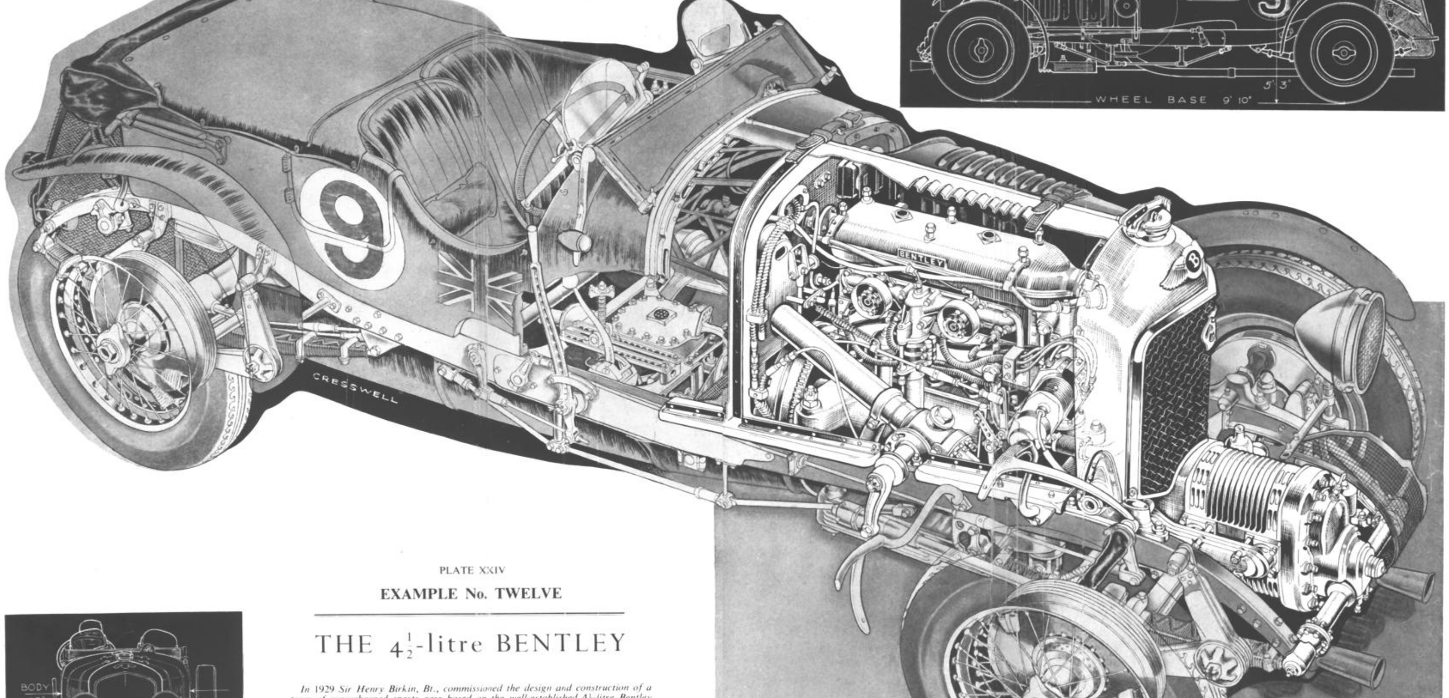
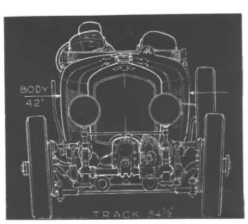


PLATE XXIV

EXAMPLE No. TWELVE

THE $4\frac{1}{2}$-litre BENTLEY



In 1929 Sir Henry Birkin, Bt., commissioned the design and construction of a team of supercharged sports cars based on the well-established 4½-litre Bentley chassis. Under the direction of Amherst Villiers, the rotating parts of the engine were substantially stiffened and power increased from 130 to 240 b.h.p. by the addition of a large capacity Roots-type blower driven direct from the crankshaft, and mounted between the front dumb irons.

The regulations governing this class of racing limited the changes that could be made to the chassis layout and specifically required a four-seater body. Notwithstanding the size of the car and an all-up weight of some two tons, Sir Henry entered for the 1930 French Grand Prix, and after a non-stop run at an average of 88.8 m.p.h., he finished second behind a Type 35 Bugatti. A drawing shows the exceptionally massive nature of the Bentley; detail features of interest being the bracing of the frame and the large explosion valves on the inlet manifold.

cast-iron brake drums added to the problem, which, however, was mitigated by the considerable sprung mass of the car, for it must be remembered that the criterion is not the unsprung weight, but the ratio of sprung to unsprung masses.

The gross weight, well over 2 tons with driver and fuel aboard, must make the Bentley the heaviest car ever to compete in a Grand Prix race. Much attention was given to reducing the weight of detail parts by drilling, but there was a large amount of heavy equipment, the large filler caps and outsize fuel tank, for instance. Inspection of the car shows that many components are unnecessarily, even absurdly, heavy.

The frame was of conventional design, of U-section with tubular bracing at the front of the dumb-irons, and just under the driver's seat. Being only 4 in. deep, it was not surprising that it was found to have inadequate beam stiffness, and to overcome this a cantilever arrangement of bars was bolted to the under section, a feature which effected improvement, although, of course, it left the torsional stiffness virtually unchanged. All connections in the frame were by high-tensile bolts exactly fitted into hand-reamered holes.

The engine was bolted direct to the side-members, the gearbox being separately locked on a small sub-frame assembly. The standard D-type Bentley gear ratios were employed, but the gear pinions were cut with especially coarse teeth. There can be no doubt that the closeness of the indirect ratios, and the high speeds obtainable on all of them, were a considerable help in maintaining performance on road circuits.

The clutch was an orthodox single-plate type, and power transmitted from the gearbox by a Hotchkiss drive system employing pot-type universal joints, an interesting legacy from the 1914 T.T. Humber designed by Mr. Burgess, who assisted W. O. Bentley in the layout of these cars.

The steering mechanism calls for little notice, being worm and wheel, with 1-7/8 turns from lock to lock.

The complete absence of streamlining, or any attempt towards it, is largely explained by the necessity of building the car according to regulations, which prescribed a four-seater body having minimum dimensions, and also carrying lamps and mudguards. A hood was also required by the Le Mans authorities, and hence the designer could exercise little initiative in these directions. It is worth remembering that the regulations regarding passenger accommodation at Le Mans have in more recent years been considerably relaxed and the aerodynamic opportunities now available were not present when this car was designed.

At the back of the body a large fuel tank with a capacity of approximately forty-five gallons gave a range at, say, 8 m.p.g., of 360 miles without refuelling. Various fuels were tried on these engines, ranging from pure benzole to approximately 30/70 petrol:benzole mixture.

It will be seen that both the fuel tank and the radiator have cam-type, quick-opening fillers, and it is worth putting on record that the Bentley Company were amongst the pioneers of these fittings, which have obvious advantages over the screw-type filler caps which had been previously employed on all racing cars. Both the radiator and the rear tank were fully protected from flying stones, a necessary feature at a time when road surfaces were liable to break up during the course of a twenty-four-hour event.

By modern standards the fuel lines from tank to carburetter seem unduly small but the flow was, of course, calculated for petrol/benzole mixture and not for alcohol blends, which make far greater demands on the system. Air pressure was employed to force fuel from the tank to the supercharger.

The last-named component was of Roots form, but as designed by Amherst Villiers, embodying many detail refinements.

As shown in a drawing the gears connecting the rotor were of exceptional width and had special means to ensure accurate meshing of the teeth in relation to the relative position of the rotors. The latter were in one with the steel shafts which ran on two ballbearings at each end with an ingenious metal seal which, again, is the subject of a detail sketch. The blower had two induction ports in an exceptionally deeply ribbed case. The prototype blower case had, in fact, been water cooled, but difficulties were experienced with keeping the water connections tight and in avoiding porosity in the casing, and this particular project was therefore abandoned. The blower was mounted ahead of the radiator and driven directly from the nose of the crankshaft and aspired mixture from two S.U. carburetters of the constant vacuum type.

On the pressure side of the system particular care was given to the design of the two explosion valves. Due to the length of the inlet pipe a considerable volume of gas was present and in the early development work it was found that if the release valve spring was too heavy the pipe connections failed to withstand the explosion loads ; if too light the valve might stick open and a stream of constantly burning gas would emerge.

The attention given to the induction system was scarcely matched by the exhaust arrangements which included a number of abrupt bends very close to the valve ports.

Two inlet and two exhaust valves per cylinder were used, being inclined in the fixed cylinder head at approximately 60 degrees. The valve gear betrays obvious signs of derivation from 1914 racing car practice, being virtually an enclosed version of the scheme used on the winning Mercedes car, that is to say a single camshaft driven by bevels and vertical shaft which works the valves through rockers, there being one inlet cam connecting to a forked rocker and two exhaust cams. The camshaft ran in a tunnel through which the rockers emerged, but whereas on the Mercedes the outer end of the latter, and the valve springs, were exposed, on the Bentley the whole mechanism was enclosed in an aluminium cover.

Additionally, on the Bentley the vertical shaft was at the front end of the engine together with a right-angle drive connecting the two magnetos.

Two sparking plugs per cylinder were fitted horizontally on opposite sides of the head. In the Bentley the cylinder block is a single iron casting, open at the sides, where it was closed by a sheet of light alloy. Water circulation was by means of a large centrifugal pump driven from the nose of the timing mechanism, the water being led somewhat surprisingly to the base of the inlet side of the block and emerging through five separate branch pipes immediately above the exhaust manifold.

The crankcase was formed from two exceptionally deep light-alloy castings which are split on the centre line of the five main bearings. On the blower car both crankshaft and bearings were specially designed by Amherst Villiers. The former was particularly massive, the main bearings being of 80 mm. diameter and the big ends 55 mm. diameter, whilst exceptionally deep and stiff bearing caps were used.

The connecting rods, also, were of special design joined to concave light-alloy pistons with deep concave heads giving a low nominal compression ratio of 5:l.

The piston design was, of course, determined by the sports car regulations for which the car was primarily designed. These forbade the use of alcohol fuel, and as with 12 lb. boost a 5:1 compression ratio is the equivalent of 6.5:1, from a detonation viewpoint the figure was reasonable when running on petrol/benzole mixture.

It is worth noting that the m.e.p. and h.p. per sq. in. developed by this engine were equal to any full racing car built between 1927 and 1932.

From a power per litre standpoint the engine was, of course, completely compromised by inadequate piston area and it also suffered from certain detail defects, notably a tendency to crack the cylinder head on the exhaust side if run for prolonged periods on full throttle.

The comparative success of the Bentley in competition with the purely racing types of its own era, the spectacular feats of driving by Birkin, and the magnificent and imposing appearance of these cars, have all contributed to give them a heroic and legendary fame in England. This is by no means undeserved, but from the viewpoint of sober technical narrative, one must not forget that their successes at the time were partially due to the comparatively inferior performance of the contemporary racing cars.

DETAILS OF CAR

MAKE.-Bentley
TYPE.-Supercharged 4½ litre
YEAR OF CONSTRUCTION.-1929
YEARS RACED.-1929, 1930
DESIGNERS.-W . O. Bentley, Amherst Villiers
WHEELBASE.-9 ft. 10 in.
TRACK FRONT.-4 ft. 6½ in.
TRACK REAR.-4 ft. 6½ in.
HEIGHT TO SCUTTLE.-55 in.
HEIGHT TO DRIVER'S HEAD.-63 in.
FRONTAL AREA.-17 sq. ft.
UNLADEN WEIGHT.-38 cwt.
ALL-UP STARTING LINE WEIGHT.-41.5 cwt.
MAXIMUM SPEED.-130 m.p.h.
SPEED ON INDIRECT GEARS.-100 m.p.h. on Third
" " " " 80 m.p.h. on Second
50 m.p.h. on First
H.P. PER SQ.FT.-14.2
H.P. PER TON UNLADEN.-126
H.P. PER TON ALL-UP.-116
BORE.-100 mm.
STROKE.-140 mm.
S./B. RATIO.-1.4:1
No. OF CYLINDERS.-Four
CAPACITY.-4,486 c.c.
PISTON AREA.-48.5 sq. in.
B.H.P.-240 at 4,200 r.p.m.
H.P. PER SQ. IN.-4.95
B.M.E.P.-165 lb. sq. in.
PISTON SPEED FT./MIN.-3,860
CYLINDER HEAD.-Cast-iron integral with block
VALVES No.-Four per cylinder
VALVES ANGLE.-60 degrees
VALVE AREA INLET.-13.6 sq. in.
VALVE AREA EXHAUST.-13.6 sq. in.
CYLINDER BLOCK.-Cast-iron in one block

FUEL.-Petrol, Benzole
CARBURETTER.-Two S.U. horizontal
SUPERCHARGER.-Roots at engine speed
MANIFOLD PRESSURE.-12 lb. boost (1.82 ata)
IGNITION.-Two Bosch Magnetos
PLUGS No.-Eight
PLUGS LOCATION.-Horizontally opposed sides of the head
CRANKCASE.-Two-piece light alloy split on bearing centre line
CRANKSHAFT.-One-piece counterbalanced
MAIN BEARING No.-Five
MAIN BEARING TYPE.-White metal
BIG END TYPE.-White metal
LUBRICATION.-Wet Sump ; l
CAMSHAFT No.-One
CAMSHAFT LOCATION.-In head
CAMSHAFT DRIVE.-Vertical shaft with bevel gears
CAMSHAFT DRIVE LOCATION.-Front of crank
CLUTCH.-Single plate
GEARBOX LOCATION.-Separate from engine
GEAR RATIOS.- 3, 4.05, 4.95, 8:1
TRANSMISSION.-Open propeller shaft to bevel drive rear axle
FRAME.-Channel
FRONT SUSPENSION.-Semi-elliptic
REAR SUSPENSION.-Semi-elliptic
SHOCK ABSORBER.-Hartford friction
BRAKE SYSTEM.-Mechanical ; foot, to all four drums, hand to rear wheels
BRAKE DRUM DIAMETER. 15.75 in. front and rear
BRAKE DRUM WIDTH.-2 in. front and rear
SQ. INS. PER TON LADEN.-193
STEERING.-Worm and wheel 1-7/8 turns lock to lock
WHEELS.-Rudge-Whitworth detachable
TYRES.-Dunlop 6.00 x 21, front and rear

EXAMPLE No. THIRTEEN

The P3 Alfa-Romeo

IN the five years 1924-29 the celebrated 2-litre straight-eight Alfa Romeo Type P2 had had the engine output raised from about 130 b.h.p. to nearly 170 b.h.p. with an associate step up in maximum speed from circa 125 m.p.h. to 140 m.p.h. At these higher rates of speed the chassis was found to be seriously defective and in 1930 it was being beaten by cars of lesser power output but with better road holding.

In 1931, after seven years of racing life, it was therefore retired and its place taken by two cars, both developed from the 1,750 c.c. six-cylinder supercharged sports cars which the Company was then making as a catalogue model and running with great success in sports car races. One of the new cars was fitted with an engine having the same bore and stroke as the sports model (65 x 88 mm.) but with eight cylinders in line in place of six giving a capacity of 2.3 litres and an output of some 160 b.h.p. This car was called the " Monza " and the most notable feature of the engine was the use of two blocks, each with four cylinders, and a two-piece crankshaft with a train of gears placed in the centre of the engine and driving two overhead camshafts and a single blower on the right-hand side of the car.

An alternative model embodied the bold concept of fitting two six-cylinder 1,750 c.c. engines and gearboxes in one chassis. There had in the past been instances of engines with double crankshafts which were normally geared together, but in the Alfa Romeo the units were quite separate, both as to crankcase and gearbox, and also in respect of the propeller shaft, crown-wheel and pinion. There were also two gear levers connected together and these gave the driver the option of left- or right-hand changing for he sat centrally in the car.

This literal twin-six car was, in fact, the first Monoposto to run in European G.P. racing, although Bugatti built a team of such cars for 1,100 c.c. racing in 1926, and there were also the modified American track racing cars which ran at Monza in 1927. Despite being handled by well-known drivers such as Nuvolari, this car was not a successful type, one of its defects being a high unladen weight amounting to 23 cwt. On the other hand, the Monza type was reasonably successful, but with about the same output as obtained on the P2 it was never able decisively to compete with the Type 51 Bugattis and the corresponding Maserati cars. Alfa Romeo, therefore, decided to introduce another car, the P3, in which the best points of both the 1931 models would be reproduced. The engine was an enlarged edition of the immediately preceding eight-cylinder, bore being increased to 65 mm. and stroke to 100 mm., giving an engine capacity of 2.65 litres. The same general layout was employed but with inlet and exhaust systems reversed and two blowers placed on the near or left-hand side of the car. The driver was mounted centrally behind the engine and it was the P3 which became known to the world as the Monoposto and achieved world-wide fame by an almost absolute mastery of road-racing circuits in events for which it was entered.

In detail, the cars were run in six events in 1932, of which they won four, were beaten by an accident of lap counting in one and by reason of mechanical defects in the other. In 1933 they ran in two races and won both.

This finished the life of the P3 as originally designed. In 1934 it became the P3 Type B, with the chassis enlarged by adding to both wheelbase and track, and with the engine capacity increased to 2.9 litres by boring out the cylinders to 69 mm. In this form it won the Monaco and French Grands Prix 1934, and a large number of minor races in this and subsequent years. This description is restricted to the car in its original form.

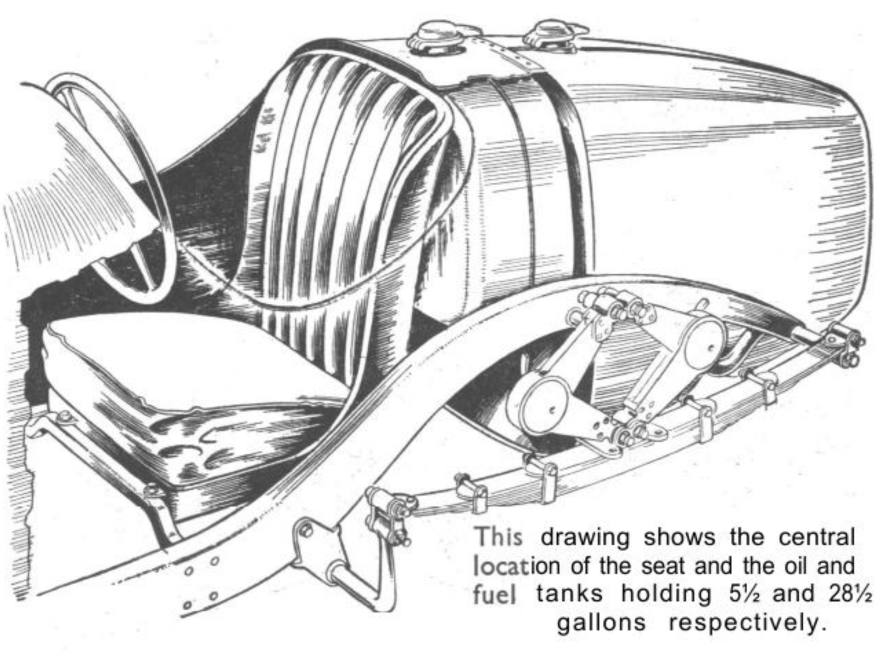
Probably the most striking feature is the exceptionally low weight. The car was officially weighed-in to race at 15.2 cwt., and as low as 14 cwt. was claimed for it in completely stripped condition. This is an altogether exceptionally low figure, both in relation to the wheelbase and the engine size, and everywhere one studies the design, it is evident that power to weight ratio and the acceleration were uppermost in the designer's mind, with maximum power and top speed a secondary consideration. The unique transmission system undoubtedly contributed materially towards weight reduction, as well as having certain other advantages.

Reference to drawings shows that two propeller shafts were used, the torque being divided immediately behind the gearbox and power transmitted to two bevel boxes, one at each end of the axle beam.

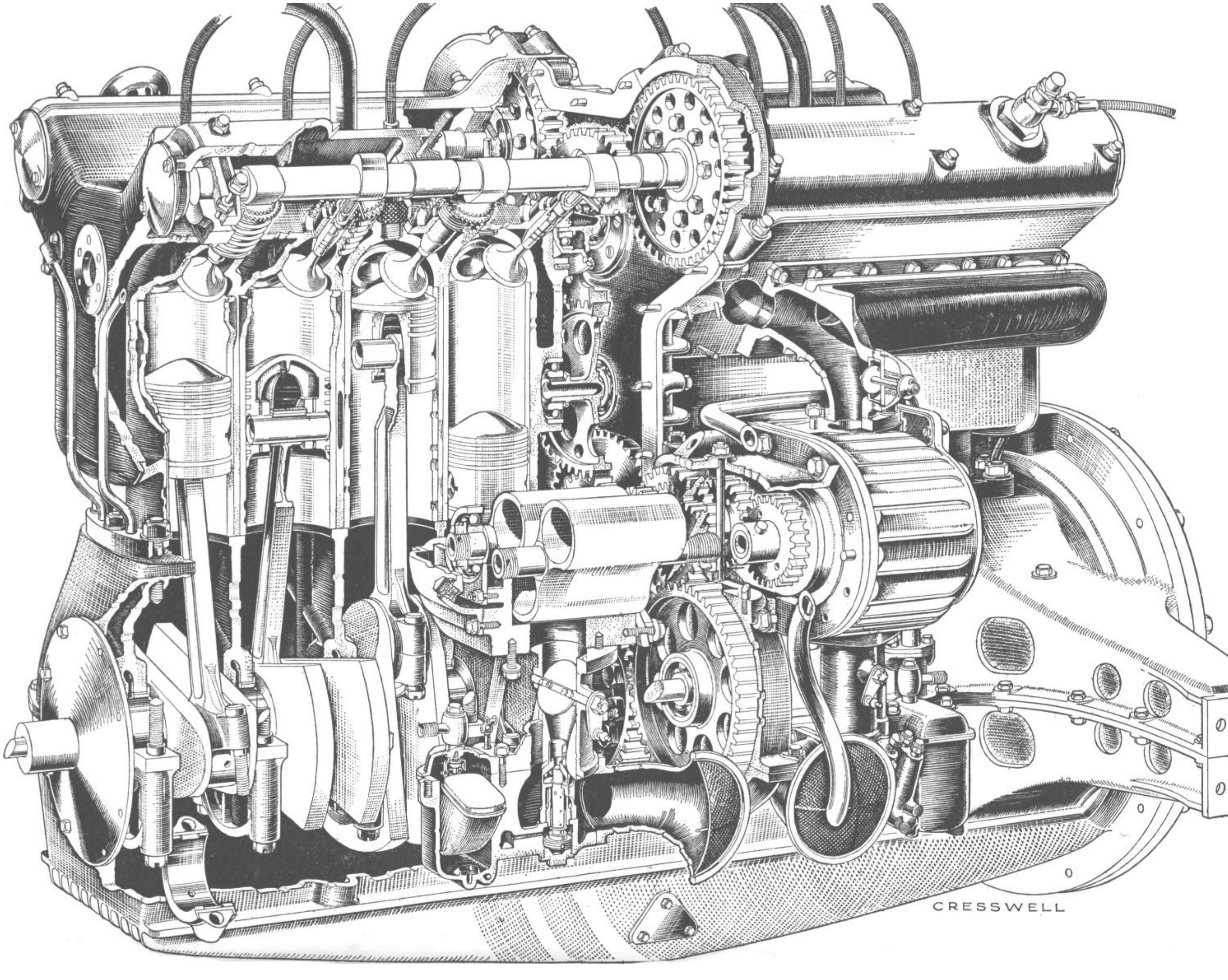
A normal live rear axle has a considerable weight and it is also weak as a beam if it is used to transmit the tractive effort of the road wheels to a central torque tube. With the triangulated design used on the P3 the heavy centre of the normal axle has been replaced by a light-steel tube and the two light-alloy bevel housings do not have to embrace a differential gear ; each pair of bevels has to transmit only half the total torque.

The " half" shafts were, in fact, no more than stubs and this again showed a useful reduction in weight. Moreover, as the differential unit was placed before the final gear reduction, this in turn can be much lighter than normal and, in addition, can be reasonably regarded as sprung weight.

A drawing shows the schematic layout and it should be noted that the first stage gears could be changed and the overall ratios from engine to rear wheels correspondingly varied without dismantling the rear axle. The latter contained two alternative crown-



This drawing shows the central location of the seat and the oil and fuel tanks holding 5½ and 28½ gallons respectively.

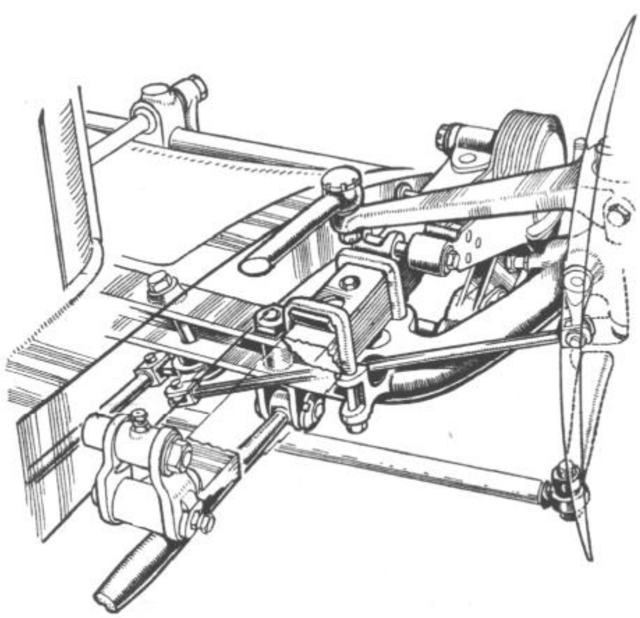

CRESSWELL

wheels and pinions offering either 10.33 or 11.36, and there were a number of possible choices, first stage gears varying between 23.31 and 27.27. On the lowest ratio 5,400 r.p.m. equalled 104 m.p.h. with the smallest size of tyre. On the highest gear with the largest possible tyre 150 m.p.h. is theoretically available at the same engine speed.

The whole of this rear axle and torque tube assembly was mounted on semi-elliptic springs, shackled at both ends. These were mounted on outriggers as the frame had the same width as the body, that is, only 26 in. to the outside of the channel. The rear of the back springs was mounted directly on an extension of a cross-tube, which braced the chassis transversely ; at the front, a separate bar cranked through a right angle was led through the shackle.

The side rails of the frame were 5 in. deep and were somewhat meagrely cross-braced, but at the front of the car torsional stiffness was improved by the rigid four-point mounting of the engine. There was also a small diameter tube between the extreme front of the dumb-irons. Behind the engine, however, the frame had only three small diameter cross-tubes, the effectiveness of two of which was lessened by their being cranked.

The semi-elliptic front springs also were shackled at both ends, the axle being located by two radius arms attached below the H-section axle beam and set inside the springs. The axle was, therefore, prevented from turning when the front brakes were applied. The worm and wheel steering box was mounted centrally behind the cylinder block, a short extension leading to the long drop of the arm mounted on the right-hand side of the car, which connected to the steering arms through an unusually long push-pull rod. The result, of course, was a considerable discrepancy between the arc struck by this steering rod and that imposed upon the axle by the much shorter radius rods, the effects, however, being mitigated by the limited vertical motion permitted on the front wheels.



The arrangement of the front axle radius arm which is in compression during braking can be seen in this detail drawing.

The front axle was conventional and pierced on each side between the spring pads to permit the passage of brake rods. By a system of bell cranks, this moved another rod (threaded to provide adjustment) through the hollow king pin, and the layout, therefore, was unaffected by angular motions of the road wheels. A conventional arm worked an ordinary cam to expand the shoes both front and back. The linings were Ferodo M.R.

The Alfa has a perfectly straightforward mechanical linkage, employing rods throughout, and, in view of the inherently low mechanical efficiency, the ratio between pedal travel and shoe travel had to be such that comparatively slight wear in the brakes brought the pedal to the limit of its travel. The adjustment was accessible so that the brakes could be taken up during a pit stop but the cars were normally driven by Continental drivers of great experience, whose cornering technique was such that comparatively little braking was needed.

The springs themselves were provided with a number of clips and had a considerable number of leaves, the shock absorbers being applied direct to the locating plates embraced by the U-bolts attaching them to the axles. The shackles were short and stiff and gave good sideways location.

Rapid adjustment was also provided for the friction shock absorbers, a single pair being used at the front and a double set at the rear.

As shown in a separate drawing, the fuel tank constituted the rear half of the body and held approximately twenty-eight gallons, being preceded by an oil tank holding rather over five gallons. No really serious effort was made in streamlining, although the body (on the 1932-3 models) was kept down to frame width and a reasonable profile was, all things considered, maintained.

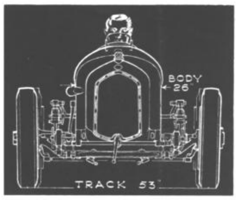
The gear gate and lever came up between the driver's legs, the clutch pedal being mounted on the left of the gearbox and the brake pedal on the right thereof, with the accelerator pedal on the extreme right. The driving position was high relative, not only to the road, but also to the pedals, which gave a comfortable position, and there was ample elbow room for the driver even with the narrow body first fitted. The height of the seat was, of course, a consequence of the central position, for the use of two propeller shafts does not lessen the need for clearance above the torque tube in the full bump position. It will be appreciated that the seat lay across the apex of the V and that any practical advantage on the score of height could only be obtained if the rear axle had cleared the squab, with the two other sides of sufficient width to embrace the side of the seat.

The instrument panel was very simple. It was notable for having two tachometers driven separately from the back end of each camshaft. This seems to argue at once a degree of pessimism as regards the reliability of the instrument, and of alarm lest the prescribed revolution limit should be exceeded. Under the scuttle was a reserve tank and the scuttle itself was quickly detachable, thereby facilitating removal of the gearbox.

The engine of the P3 was, as has been previously mentioned, a direct development of the Monza type. The train of gears placed between the two cylinders to drive the camshafts and blowers was the same, the valve gear, crankcase, crankshaft, were similar. The basic difference was a change of cylinder dimensions which brought the stroke/bore ratio from 1.29: 1 up to 1.54: 1. Constructionally a major change consisted in the transfer of the inlet system from the right to the left hand of the engine (exhaust vice versa), and the use of two small capacity blowers each feeding one cylinder block, whereas

PLATE XXV

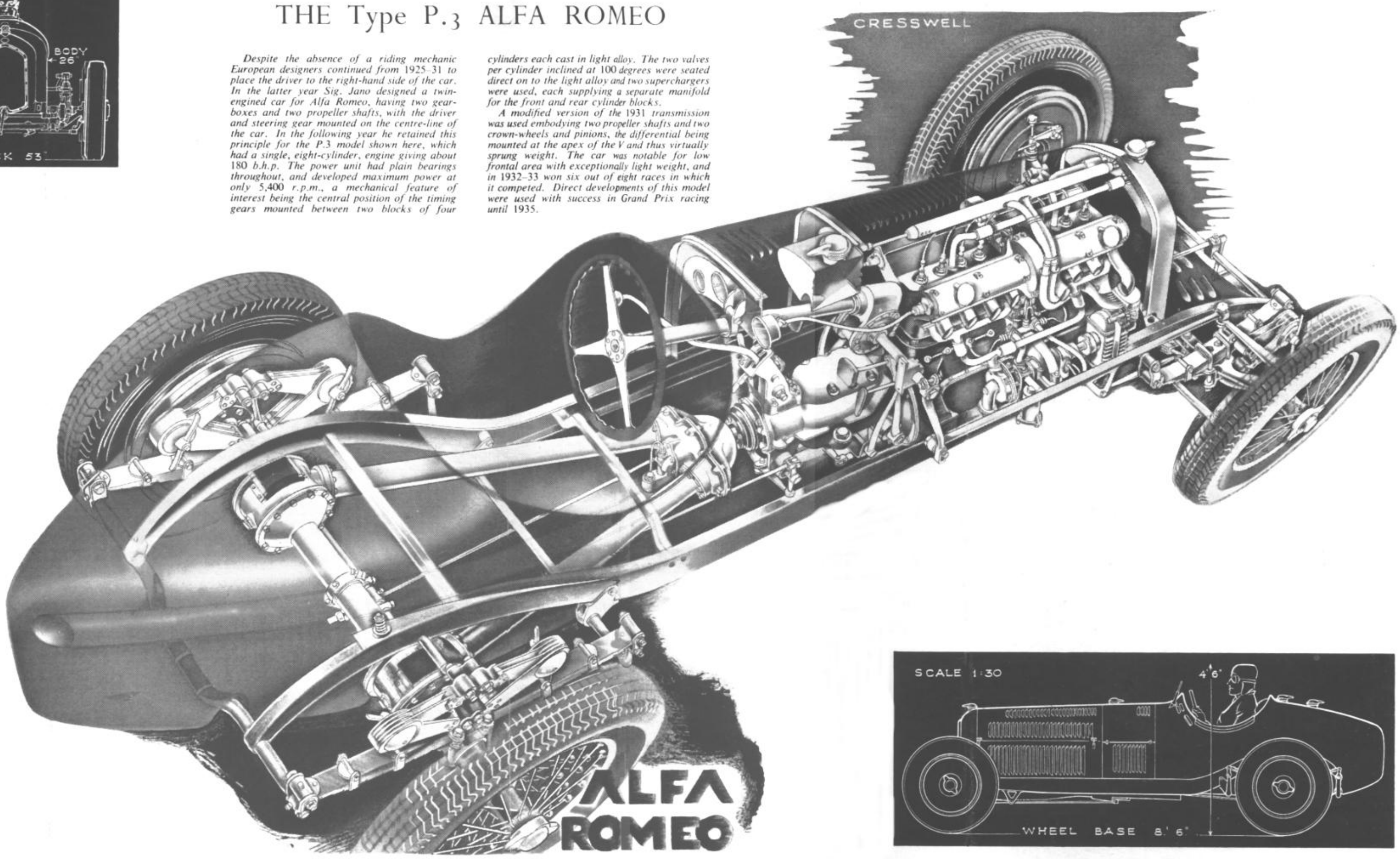
EXAMPLE No. THIRTEEN



THE Type P.3 ALFA ROMEO

Despite the absence of a riding mechanic European designers continued from 1925–31 to place the driver to the right-hand side of the car. In the latter year Sig. Jano designed a twin-engined car for Alfa Romeo, having two gear-boxes and two propeller shafts, with the driver and steering gear mounted on the centre-line of the car. In the following year he retained this principle for the P.3 model shown here, which had a single, eight-cylinder, engine giving about 180 b.h.p. The power unit had plain bearings throughout, and developed maximum power at only 5,400 r.p.m., a mechanical feature of interest being the central position of the timing gears mounted between two blocks of four cylinders each cast in light alloy. The two valves per cylinder inclined at 100 degrees were seated direct on to the light alloy and two superchargers were used, each supplying a separate manifold for the front and rear cylinder blocks.

A modified version of the 1931 transmission was used embodying two propeller shafts and two crown-wheels and pinions, the differential being mounted at the apex of the V and thus virtually sprung weight. The car was notable for low frontal area with exceptionally light weight, and in 1932–33 won six out of eight races in which it competed. Direct developments of this model were used with success in Grand Prix racing until 1935.



the Monza type had one blower feeding all eight cylinders. It may be estimated that the P3 engine developed approximately 190 b.h.p. at 5,400 r.p.m., this being the equivalent of 173 lb. per sq. in. at 3,550 f.p.m. piston speed, a useful but by no means outstanding figure.

The general construction of the engine is so clearly shown in the accompanying drawing that few words are needed to outline the main constructional details. The top and bottom halves of the crankcase and the cylinder block and the valve covers were all made in light alloy, steel liners being fitted into the bores. The valves (as shown) seat directly in the integral light-alloy head. The connecting rods were steel and the pistons, of conventional racing design with dome crown, gave a compression ratio of *circa* 6.0 : 1.

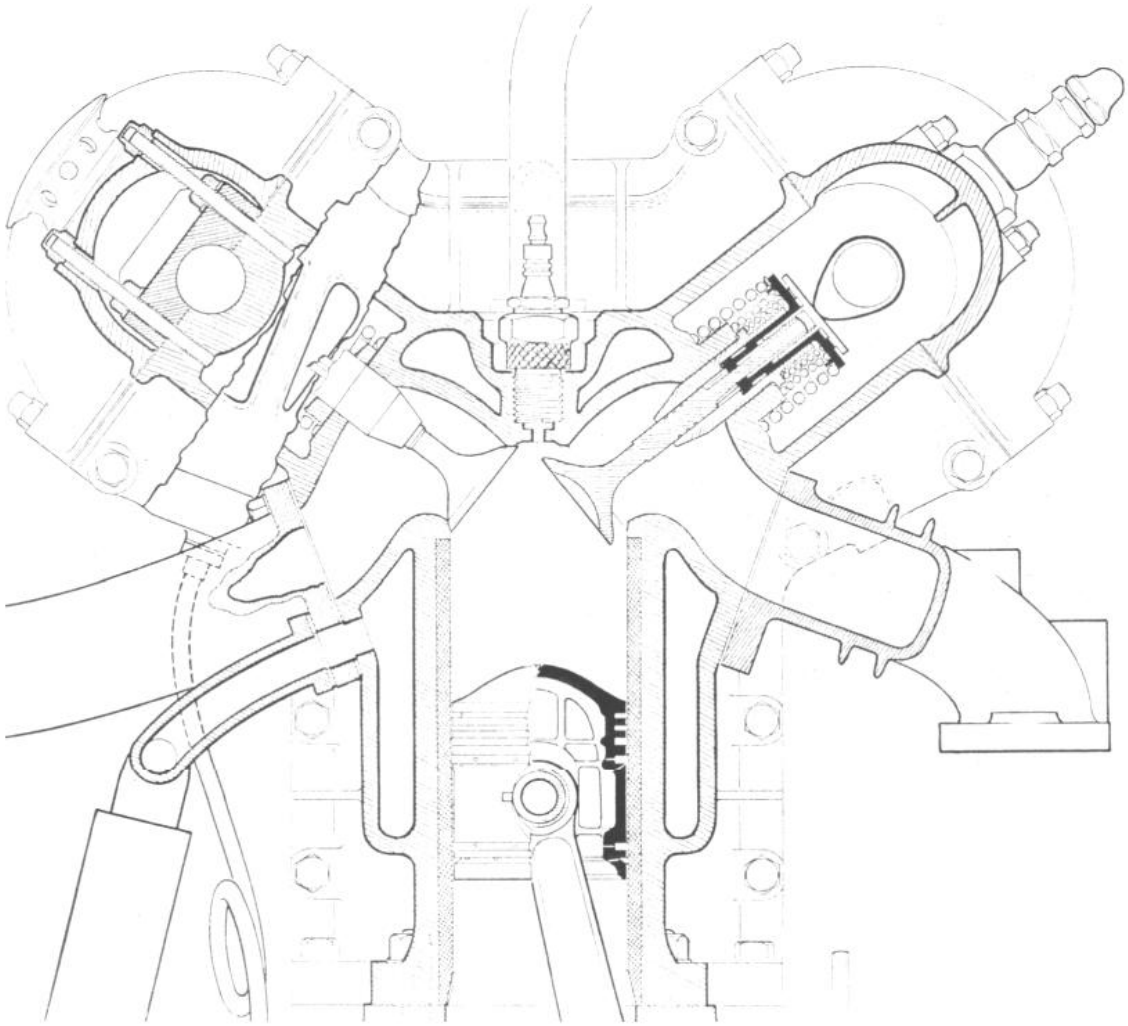
The valves followed the common European practice of 100 degrees included angle, and the cams operated direct on to the valve stems. The side thrust from the cam was taken first on to a steel mushroom which was screwed on to the end of the valve, and this transferred the load to another mushroom which was pushed over the valve and prevented from rotating by an engagement with two slots. The faces between the two mushrooms were serrated, and clearance can be obtained by screwing down the top member. Normally the two were held locked together by the pressure of the triple valve springs. The lower mushroom slides in an enlarged portion of the valve guide.

The head and valves were symmetrical, so that either port could be used for inlet or exhaust, according to the mounting of the block on the crankcase. There was good water flow around the valve seats and partly owing to the absence of any insert large diameter valves (39 mm.) were fitted. Heat transfer from the exhaust valve through the guide was, however, limited by the comparatively small area of steam in contact with the guide, and the equally limited cooling of the guide itself.

The valve opening was identical for both the inlet and exhaust sides of the engine, the inlet opening 20º before top centre and the exhaust closing 20º after top centre ; the exhaust opening 50º before bottom centre and the inlet closing 50º after bottom centre. Both valves had the same lift of 9 mm.

As will be seen in the accompanying drawing, the central gear on the crank engaged with an intermediary, which in turn coupled with a gear (having internal.and external teeth) which took the drive direct to the rotors of the two blowers. The number of external teeth on this gear could be changed and provision made for correspondingly changing centres of the driving and driven wheels. Having rotors 90 mm. long, each blower had a theoretical swept volume of 1,350 c.c., and, assuming 80 per cent volumetric efficiency, they were jointly capable of providing a 72 per cent boost running at 1.1 times engine speed, which is equivalent to just under 11 lb. gauge pressure.

Each blower delivered to one block of four cylinders, despite the fact that the crankshaft is the conventional straight-eight arrangement with the equivalent of one four-cylinder engine in the middle with the front and back half of a four on each side of it. The ideal porting of such an engine would be, therefore, one inlet tract to the centre pair of cylinders, Nos. 4 and 5, one to Nos. 3 and 6, one to Nos. 2 and 7, and yet another to Nos. 1 and 8. That is to say, the cylinders would be so paired that



Cross section of the P3 engine. Scale 1 : 3

one would be in the front block of four, another in the back block. Such an arrangement would be complicated, but the chosen layout, although it satisfied the Latin passion for superficial logic and neatness of form, carried these qualities to a point where they became a perversion, for it satisfied the demands neither of distribution nor even feeding impulses.

The crankshaft was made in two pieces bolted together in the centre through the main timing wheel and running in ten plain bearings. It was fully counter-weighted, lubrication being by pressure from a gear-type oil pump mounted on the offside of the engine. The rods were machined all over and, although somewhat primitive in section, had stiffening ribs. The length of the rod was 2.15 times the stroke ; the gudgeon-pin diameter was 18 mm.

Each camshaft ran in three long, plain bearings, and the near-side shaft drove a small air pump to provide fuel pressure. Large-size breathers were provided on the camshaft cover, the crankcase breathing through large-bore copper pipes, bent round to finish close to the gauze over the intake for the Weber carburetters. The single magneto, disposed on the right-hand side of the engine, gave current for the 18 mm. Champion plugs (Type R. 11), and the latter were well cooled but heavily masked. For these reasons plug bother, either burning or oil, was absent from these engines, which, apart from cracked valve seats, were thoroughly reliable.

This is to be expected in view of the comparatively low specific output, and one cannot help feeling that no really serious effort was made to increase the power per litre. The maximum speed was probably as great as was desirable on a car of such low weight with fixed axles, and the low-speed torque was, in any case, more than the gearbox could reliably absorb. As is well known, stripped gear teeth was a serious trouble on the P3, particularly as the swept volume, and thus the low-end torque, was steadily increased from the original 2.65 litres by successive enlargements of the cylinder bore. In its later forms the designer endeavoured to overcome this trouble by taking out the first speed and widening the gear teeth, but this modification does not, strictly speaking, come within the framework of this chapter as it was not undertaken until 1935.

Acknowledgments.-Thanks are due to Messrs. A. F. Ashby, R. Arbuthnot, T. D. Crook, Kenneth Evans and Thomson and Taylor, Ltd., in obtaining the foregoing data upon this car.

ALFA ROMEO P3-RACING RECORD

Date	*Evenr*	*Course*	*Average Speed*	*Lap Speed*
5/6/32	Italian G.P. . . .	Monza	104.13 m.p.h.	112.7 m.p.h.
3/7/32	French G.P.	Rheims	92.26 m.p.h.	99.5 m.p.h.
17/7/32	German G.P. . . .	Niirburg	74.13 m.p.h.	77.55 m.p.h.
11/9/32	Monza G.P. . .	Monza	110.8 m.p.h.	113.7 m.p.h.
13/8/33	Coppa Acerb0 . . .	Pescara	88.03 m.p.h.	—
10/9/33	Italian G.P. . .	Monza	108.58 m.p.h.	115.8 m.p.h.
24/9/33	Spanish G.P.	San Sebastian	83.32 m.p.h.	—

DETAILS OF CAR

MAKE.-Alfa Romeo
TYPE.-P3
YEAR OF CONSTRUCTION.-1932
YEARS RACED.-1932-33 and (Type B) 1934
DESIGNER.-Jano
WHEELBASE.--8ft. 6in.
TRACK FRONT.-4ft. 5in.
TRACK REAR.-4ft. 5in.
HEIGHT TO SCUTTLE.-42½ in.
HEIGHT TO DRIVER'S HEAD.-54in.
MAXIMUM WIDTH.-26in.
FRONTAL AREA.-10.25 sq. ft.
UNLADEN WEIGHT.-15.2 Cwt.
ALL-UP STARTING LINE WEIGHT.- 18.2cwt.
MAXIMUM SPEED.-140 m.p.h.
SPEED ON INDIRECT GEARS.-102 m.p.h. on 3rd
" " " 70 m.p.h. on 2nd
" " " 40 m.p.h. on 1st
H.P./SQ. FT.- 18.6
H.P./TON UNLADEN.-260
H.P./TON ALL-UP.-210
BORE.-65
STROKE.-100
S./B. RATIO.-1.54:1
NUMBER OF CYLINDERS.-8
CAPACITY.-2,650 c.c.
PISTON AREA.-41 sq. in.
B.H.P.-190
R.P.M.-5,400
B.M.E.P.-173 lb. sq. in.
PISTON SPEED FT./MIN.-3,550
CYLINDER HEAD.-Integral, Al
VALVES NO.-2
VALVES ANGLE.-100 degrees
VALVES AREA INLET.-14.8
VALVES AREA EXHAUST.-14.8
CYLINDER BLOCK.-Al with dry steel liners

FUEL.-Petrol, Benzole or Alcohol
CARBURETTER.-2 Weber
SUPERCHARGER(S).-2 Roots
SUPERCHARGE PRESSURE.-1.6 ata. (10lb. boost)
IGNITION.-1 Marelli Magneto
PLUGS NO.-8
PLUGS LOCATION.-Central in head
CRANKCASE.-Two piece, light-alloy split on c/line of bearings
CRANKSHAFT.-Two-piece counterbalanced, 2, 4, 2 layout
MAIN BEARING NO.-10
MAIN BEARING TYPE.-White metal
BIG END TYPE.-White metal
LUBRICATION.-Dry sump
CAMSHAFT NO.-2
CAMSHAFT LOCATION.-In head
CAMSHAFT DRIVE.-Train of gears
CAMSHAFT DRIVE LOCATION.-Centre of crank
CLUTCH.-Twin Plate
GEARBOX LOCATION.-Unit with engine
GEAR RATIOS.- 3.52 (3.3 optional)
" " 4.56
" " 6.54
11.8
TRANSMISSION.-Torque tube drive, divided propeller shafts to double bevels
FRAME.-Channel
FRONT SUSPENSION.-Semi-Elliptic
REAR SUSPENSION.-Semi-Elliptic
SHOCK ABSORBER TYPE.-Friction
BRAKE SYSTEM.-Mechanical
BRAKE DRUM DIAMETER.-15¾ in.
BRAKE DRUM WIDTH.- 1¾ in.
SQ. IN. PER TON LADEN.-380
WHEELS TYPE.-Rudge
TYRES.-28 x 5.50, front and rear

EXAMPLE No. FOURTEEN

Mercedes-Benz, Type W.25B

IN October 1932, that is to say after the first season of the P3 Monoposto Alfa Romeo, the A.I.A.C.R. introduced a new formula to cover Grand Prix motor racing for the three years 1934-36. The intention, which was to be dramatically falsified, was to lower what was then considered to be the dangerously high level of speed reached on the contemporary Maserati and Alfa Romeo cars which, with approximately 3-litre engines, could reach nearly 140 m.p.h. The means to this end were a weight limit, excluding driver, fuel, oil and tyres, of 750 Kg. (14.75 cwt.) and a minimum frontal area governed by a body width of at least 33½ in.

This ruling coincided with the rise to power of the Nazi Party. Already in Italy the Fascists had consciously used motor racing as an instrument of national prestige and international propaganda, and Hitler, who had a life-long passion for motor racing, and knew the winners of all the important racing events for many years, decided to encourage German constructors to follow this example.

A subsidy of £20,000 per annum was offered to both Mercedes-Benz and Auto-Union in 1934, but it may be doubted if this in itself counted for much when the subject of designing a pure racing car came up for discussion by the board of the Daimler-Benz Co., in 1932. Eight years had elapsed since either component of this amalgamation had embarked on a similar project, but a decision to compete under the 750 Kg. international formula was taken in March, 1933, and by May a team was got together under the leadership of Dr. Hans Nibel, who had originally been with the Benz Co. Assisting him was another member of the Benz Co., Wagner, who had been responsible for the rear-engined Benz racing cars of 1924. The question of making the new cars with rear engines was very carefully considered, but was rejected in the belief that :

(1) Rear engine mounting does not result in any weight reduction.

(2) As shown in wind-tunnel tests, the drag factor is about the same on both types.

(3) If the engine position and transmission are well arranged, the propeller shaft, running between engine and rear axle, presents no design problems.

(4) The smaller moment of inertia which is obtained with rear-engined cars has a beneficial effect in relation to the vertical axis, but is inconvenient in relation to the longitudinal axis and the suspension of the car, and adhesion to the road is impaired.

(5) It is particularly important on fast cars to have first-class adhesion for the front wheels, and on rear-engined cars the weight distribution is unfavourable in this respect.

Having decided upon the normal engine position on the foregoing grounds, work proceeded rapidly, and a complete car was sufficiently far advanced to be shown to Hitler in January, 1934, and was ready for road tests at Monza in March, 1934, ten months having elapsed for the whole of the design and construction period.

As a racing car, it was an interesting blend of the orthodox and the heterodox. The use of a straight-eight engine with a twin overhead camshaft and supercharging was in line with normal practice. Independent front springing, independent rear springing with combined gearbox and bevel box, a supercharging system feeding air under pressure to the carburetter, and hydraulic brakes were all distinctive breakaways from convention. Nevertheless, the whole car was obviously impregnated with traditional Unterturkheim thinking, despite the inclusion of two Benz men amongst the designers. This was most strongly shown in the design of the power unit and before analysing the details of the construction one must refer to the fundamental (and then somewhat surprising) decision of the responsible engineers that it would be possible to use four litres of swept volume without over-stepping the weight limit of 750 Kg., and that 400 b.h.p. on the flywheel could be usefully employed by the road wheels.

The last racing car built at Stuttgart was the eight-cylinder, 2-litre, model designed by Dr. Porsche and run by the works between 1924 and 1926. 160 b.h.p. was claimed for this model and road racing experience in the subsequent six years all went to show that this was about the maximum power which could be profitably utilised on ordinary road circuits. Alfa Romeo, Bugatti and Maserati had all it is true built larger and more powerful cars in the period 1929-33, but the successes of these models had been limited to exceptional circuits such as Monza and A.V.U.S. The decision to override the example of experience was undoubtedly based on the belief that the problem of transmitting vastly more power into the rear wheels could be solved by using independent suspension for each wheel and by thus eliminating the torque reaction effect which lifts the entire axle around the bevel pinions on the car with orthodox axles and thus provokes wheel spin.

The use of independent suspension for the front wheels would, it was thought also permit the use of increased maximum power by enabling the driver to control the car at far higher speeds than had hitherto been reached on the road.

Experimental work on independently sprung cars had been going on at Stuttgart for two or three years and some of the smaller models of the range had used independent suspension on all four wheels since 1932. On these cars a transverse leaf spring and wishbones was used at the front end, and a swing axle with coil springs at the back of the car. The choice of independent suspension all round for racing cars was thus not an adventure into the unknown, but from a technical viewpoint it is interesting to note that the type of spring was reversed as compared with the touring cars ; that is to say, leaf springs were used for the swing axle at the rear, coil springs for the front wheels.

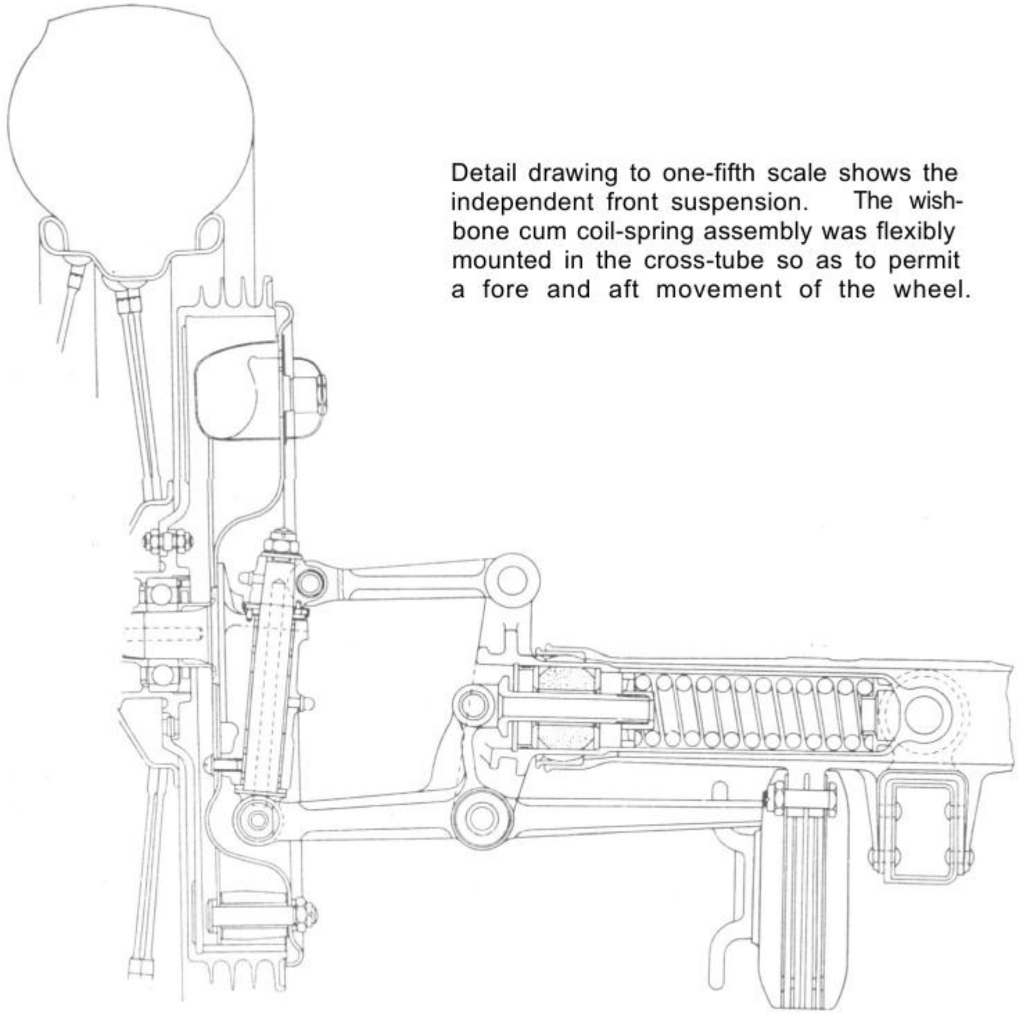
At the front end of the W.25 a cross-tube with an o.d. of 2¾ in. was superimposed upon the box section frame member, which was also 2¾ in. deep at this point, increasing to 6.4 in. by the scuttle. The suspension wishbones were pivoted on to this tube and were of equal length (5 in.), with their pivot points spaced 5½ in. apart.

From the time when they commenced development work on i.f.s. systems Mercedes-Benz engineers have sought to provide wheel movement in a horizontal as well as in a vertical plane. They took out a number of patents on methods to secure this end in conjunction with transverse leaf and other types of spring. On the W.25 racing car the entire wishbone assembly could pivot around a bearing mounted at the outer end of the frame cross-member, the movement being restrained by stops placed on each side of the coil spring housing, this being clearly shown in the assembly photograph on a Plate.

The king pin was recessed deeply into the brake drum so that the bearings were widely spaced and gave first-class support to the wheel under severe lateral loads caused by high-speed cornering. This arrangement, of course, gave vertical motion for the front wheels and put the front roll centre at ground level.

Coil-type springs were employed having a length, under normal load, of 5½ in., and o.d. of 1¾ in. These springs were placed inside the cross-tube and connected to the bottom wishbones through a bell crank ; the lever relationship between this and the wheel arm being 0.45 to 1.

This suspension system was coupled to a friction damper moved by a long extension of the bottom wishbone.



Detail drawing to one-fifth scale shows the independent front suspension. The wishbone cum coil-spring assembly was flexibly mounted in the cross-tube so as to permit a fore and aft movement of the wheel.

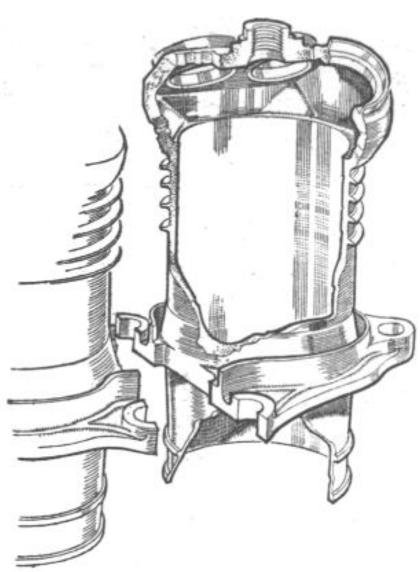
The vertical travel from normal to full bump with this arrangement was limited to 1.8 in., and obviously, although these cars were provided with independent springing, they were far from offering the soft low-rate suspension which later proved highly beneficial. As a consequence, the slight error in geometry arising from the fact that the short swinging track rods differed in length from the suspension wishbones did not give rise to any serious consequences in the shape of severe reactions passed through to the steering wheel.

With the exception of Maserati all Grand Prix racing cars from 1923 to 1934 employed mechanical braking systems, but with the advent of independent suspension it became obvious that it would be difficult to arrange the required linkage. For this reason, and for the added attraction of weight saving, the Mercedes-Benz used Lockheed on both front and rear wheels. The aluminium drums were notable for their unusual width of 2¾ in. and for the use of very stiff light alloy brake shoes expanded in the normal way by Lockheed assembly connected to a pair of master cylinders both joined to the pedal. By using a floating balance member it was possible to change the proportion of braking between front and rear by modifying the pivot point whilst damage to one of the pipe lines could not result in more than a pair of brakes being put out of operation. Additionally, on the W.25B a handbrake was mechanically connected to the rear shoes.

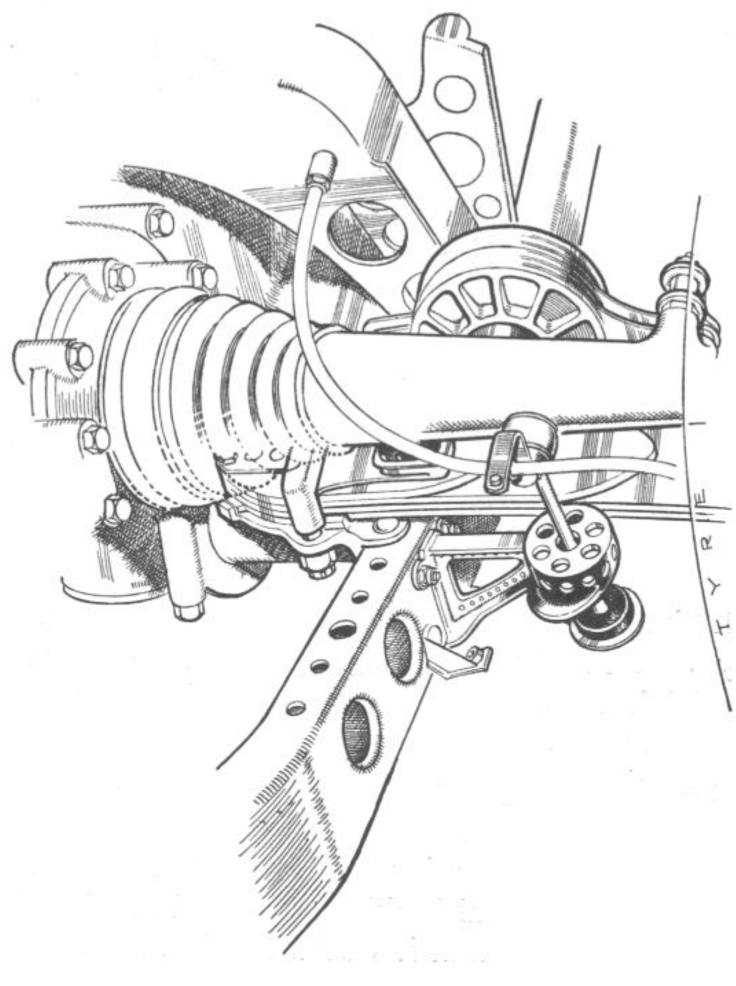
Steering was by the traditional Mercedes worm and nut, this arrangement giving 2¼ turns from lock to lock on a 41 ft. turning circle.

The box-section frame was liberally pierced at the front end to reduce weight and reinforced by two cross-tubes of 2 in. diameter riveted to brackets, and at the rear end the combined bevel box and gearbox casting was mounted on a 3 in. diameter cross-tube.

The four-speed gearbox was of normal design, except that all ratios were indirect, the propeller shaft thereby being lowered by 3½ in. with the crankshaft on the same line. Trunnion bearings on each side of the bevel box located tubes connecting to the rear hubs and enclosing the driving half-shafts. In this design a single universal was placed each side of the bevel box and the term " swing axle " used to denote the fact that each wheel swings around an arc struck from the axis of the trunnion.



Above-Details of cylinder construction.

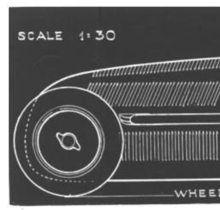


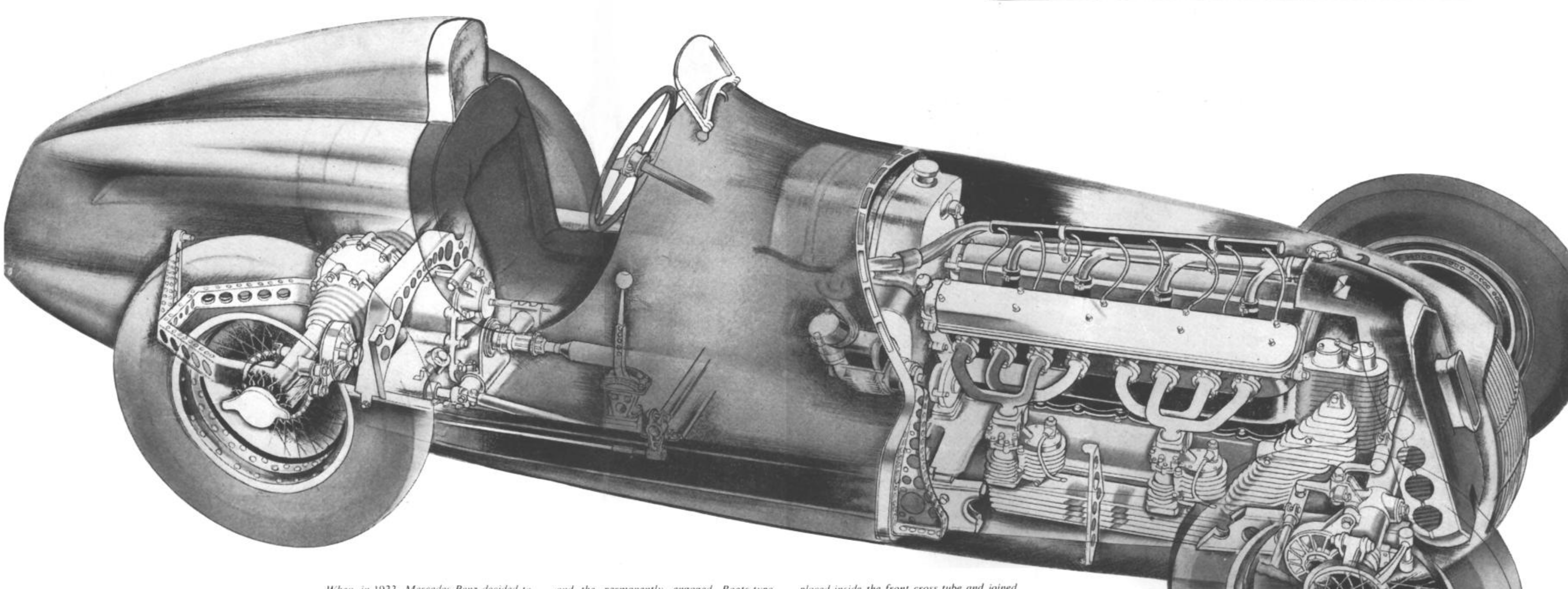
Right- The independent rear suspension utilised quarter-elliptic springs only 14½ inches long.

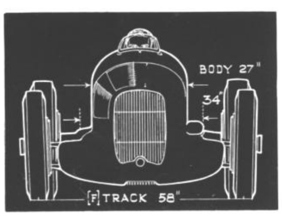
PLATE XXVI

EXAMPLE No. FOURTEEN

THE 1935 MERCEDES-BENZ Type W.25B







When, in 1933, Mercedes-Benz decided to return to Grand Prix racing after an absence of nine years they built a highly original design under the direction of Dr. Ing. e. h. Hans Nibel. Despite the drastic weight limit of 750 Kg. maximum for the years 1934–37 they used an eight-cylinder 3.36-litre engine giving 300 b.h.p. on Benzol mixture. The capacity and output were quickly raised to 3.99 litres and 430 b.h.p. on alcohol mixture.

Designed by a Benz-trained man the car was nevertheless redolent of Mercedes practice. The forged-steel cylinders were assembled in blocks of four with welded-on jackets, and the permanently engaged Roots-type blower, running at 2.78 times engine speed, delivered pressure air to the two double-choke carburetters. Also in the line of tradition was the use of four valves per cylinder, inclined at 60 degrees and roller bearings for both main and big-ends, the latter being split to permit the use of a one-piece crankshaft which ran in five bearings in the barrel-type crankcase. The gearbox was built in one unit with the bevel box and both were fixed to the frame, the drive being taken through swinging half-axles with a short transverse leaf spring beneath them. The front wheels were also independently sprung, coil springs being placed inside the front cross tube and joined to the suspension links by bell cranks.

The frame was made from pierced box section. The driver was centrally mounted, the seat height being reduced by the use of indirect gears which lowered the propeller shaft in relation to the rear axle centre line. The radiator was enclosed by a curved cowl, but the traditional wedge-shaped tail was continued.

This car, capable of some 175 m.p.h., won two out of the five major races for which it was entered in 1934 and five out of seven in 1935.

Suspension was by a quarter-elliptic spring on each side of the car, each one of which had four leaves 3-1/8 in. wide with only 14½ in. in length between the clamp point and the outer shackle.

The total deflection permitted by rubber stops was 2.4 in., the movement from the normal position to full bump being only 1.2 in.

It is apparent that at the rear, also, the suspension was of the solid type compared to later developments, although probably more flexible than that provided on contemporary cars. It must, however, be emphasized that the benefits of independent springing on these early cars were not derived from very large vertical motion on the wheels.

Looking at the overall design one finds that the swing axle system gave a roll centre 2-3/8 in. above the universals at the back, and that the rear springs were much stiffer than the front. In consequence one would expect these cars to have a marked oversteering tendency and there is, in fact, good ground for believing that they were markedly slower on corners than the more conventionally sprung vehicles. On the other hand, the absence of transverse torque effect on the rear wheels gave them a big advantage when accelerating away from corners, and also promoted steadiness on the straight at high speeds. The former aspect was particularly noticed by the drivers of competing cars, who found that when they were struggling with wheel spin the German cars were using their immensely superior h.p. per ton to full advantage.

The engine originally installed for the 1934 season was an eight-cylinder 78 x 88 mm. giving a swept volume of 3.36 litres. This gave 354 b.h.p. on alcohol fuel, but before the end of the year it had been replaced by the M.25AB power unit in which the bore had been enlarged to give dimensions 82 x 88 mm. (swept volume 3.71 litres), and the M.25B 82 x 94.5 mm. with a swept volume of 3.99 litres. The last named gave 430 b.h.p. and weighed 468 lb. compared with 453 lb. for the original engine.

Apart from the small changes in bore and crank throw these engines were identical.

In accordance with Mercedes practice dating back to the 1914 G.P. winner, the cylinder blocks were fabricated from separate Krupp steel forgings. These were welded in sets of four to a base plate and had built-up and welded-in valve ports. Each block of four cylinders was surrounded by a water jacket 1.0 mm. thick, a construction that is exceedingly light and gives very close control over water spacing and passages. The cylinder head was asymmetrical and again, in accordance with Mercedes tradition, four valves per cylinder, each of 34 mm. diameter, were used. These valves were inclined in the cylinder head at an included angle of 60 degrees, the cylinder head being slightly thicker than the walls, the latter being 2½ mm. and the former 6½ mm. Supports for the valve guides were welded in situ and the camshaft boxes were separate castings in one piece bolted on to the top of the block and running the whole length of the engine. On the M.25 series the cylinder blocks were bolted to a light alloy barrel-type crankcase casting which was extended at the front end to include the mounting for the Roots type blower and the bevel drive thereto. This casting was 1,044 mm. long, 217 mm. deep, and 275 mm. wide (say 40 in., 8½ in., and 10¾ in.).

A ribbed, light-alloy sump was bolted on to the bottom of the case and the crankshaft complete with main bearings inserted into the crankcase proper from the rear end.

The crank was unusual in having five main bearings, the intermediates being placed between two and three, four and five, and six and seven. The crankshaft was one piece and counterbalanced ran on roller main bearings with split races, the front bearing being 52 mm. diameter and the other four bearings 63 mm. diameter. The centre bearing had hardened tracks 25 mm. wide, the others running on tracks only 80 mm. wide. The centre of each track was relieved by an oil groove 3 mm. wide which connected with the pressure side of the lubrication system. There were no internal oil ways in the crank, oil from the main bearings being thrown off into recessed collector rings machined in the cheeks of the crankshaft and thence through the hollow crankpins through a 3 mm. hole into the big ends. The fillets between the cheeks for both main and crankpins were notable for exceptionally deep radii.

The crankpins were 53 mm. diameter, the tracks being 19.5 mm. wide, minus the area of an oil delivery recess. The crankshaft being in one piece, the big ends and the connecting rods were split, the caged rollers running directly in a hardened track formed inside the rod and cap. Serrations were provided at the joint between the two and on these rods four big-end bolts were used.

Conventional H-section rods with very carefully designed blending into the big end were employed, the gudgeon pins being splash-lubricated.

The pistons were of completely conventional design having a pronounced crown and made by Mahle in Y alloy.

Valve gear comprised two overhead camshafts lifting the 34 mm. diameter valves 8.5 mm. through the intermediary of fingers. Each camshaft was 32½ in. long, supported in five plain bearings and driven by a train of gears from the rear end of the engine. These gears were also extended below the crankshaft centre line to provide a drive for the gear type oil pumps, the scavenge pump delivering to a tank on the scuttle containing eleven gallons of pure castor oil. The fuel and water pumps were driven from a right angle drive at the opposite (forward) end of the engine. Fuel was supplied to the pressure type carburetters by an aircraft type pump with a spring loaded by-pass valve, the suction side being connected to the tank which was formed in one piece as the tail of the body.

The fuel pump was placed on the offside of the engine, the water pump on the nearside, the latter delivering water to the exhaust side of the cylinders with four 1.2 in. diameter offtake pipes mounted above the cylinder heads.

Ignition was by 18 mm. Bosch sparking plugs threaded directly into the cylinder head and only slightly masked. The Bosch magneto was driven from the back of the timing gears and projected into the driving compartment.

The supercharger was placed at the extreme nose of the engine and the rotors mounted vertically and driven continuously by bevel gears at twice engine speed.

In accordance with Mercedes tradition dating back to 1922 pure air was fed to pressurised carburetters mounted in the orthodox position in relation to the inlet manifold. Whereas, however, the volume of air delivered had on the earlier cars been controlled by a friction clutch which engaged the blower only on full throttle, on the 1934 design the same effect was contrived more simply and with lower weight by a relief valve inter-connected with the carburetter throttles.

The need for such a device will become apparent if it is appreciated that a blower running at a fixed speed in relation to the engine, and with no throttle on the intake side builds up an excessive pressure in the pipe leading to the carburetters when the throttles in the latter are partly or wholly closed. To avoid the very high temperatures which would result from this phenomenon a butterfly throttle was mounted on the delivery side through which excess air could be vented into the atmosphere. As the carburetter throttles reached a position in which the engine required pressure air the spill valve was shut off being until, of course, it was closed with the throttle fully opened. This device led to the extremely high pitched supercharger scream which was characteristic of the early Mercedes-Benz engines.

All the M.25 series engines had supercharger rotors measuring 106 mm. from tip to tip, the length varying with the particular mark and capacity of the engine. On the B type the length was 240 mm. and theoretical delivery 1.72 litres per revolution so that, taking the blower gear ratio of 2: 1 into account, there was a total theoretical delivery of 3.44 litres per revolution of the crankshaft. This gave a boost of 1.66 ata, or say 10 lb. gauge pressure, a figure somewhat magnified by the high output air temperature.

The pressure air was delivered from the blower through a deeply ribbed light alloy manifold to a pair of twin choke carburetters, each feeding one set of cylinders so that each jet and choke assembly fed only two cylinders, the grouping being one and three, two and four, five and seven, six and eight. These groupings correspond with the firing order and result in two consecutive deliveries followed by a long interval. On the other hand, the pipe lengths are nearly the same. It will be recognised that the float chamber as well as the choke tube was subject to boost pressure and the fuel pump had to deliver into the sealed float chamber against this contra pressure.

With this system the latent heat of the fuel played little part in lowering the manifold temperature, and the resultant high supercharge temperatures led in turn to wide clearances so as to avoid seizure. These resulted in a marked drop in the m.e.p. curve below 3,000 r.p.m., the peak of the torque curve being reached at 4,000 r.p.m. Power was delivered by a plate clutch to the fixed gear-cum-bevel box aggregate at the rear of the car through a propeller shaft 2¼ in. diameter, the engine being mounted squarely in the frame on both axes.

During the three years 1934-36 five marks of this five-bearing type of engine were produced. In detail they were :

Mark	*Dimensions*	*Capacity Litres*	*Weight*	*B.H.P.*
M.25A	78 x 88	3.36	449 lb.	302 (354)
M.25AB . .	82 x 88	3.71	449 lb.	348 (398)
M.25B .	82 x 94.5	3.99	456 lb.	430
M.25C . .	82 x 102	4.3	473 lb.	415 (462)
ME.25 . .	86 x 102	4.74	465 lb.	456 (494)

Two sets of power figures are given in the above table, the first being for the engines as tested in the early stages of development over the full range from 1,500 r.p.m. up to a maximum of 5,800 r.p.m. (in some cases running on petrol : benzole) and italicised figures in parenthesis which give the highest power recorded at maximum r.p.m. at any stage during the life history of a particular unit. In every case the higher figures were achieved using W.W. fuel (*vide* example No. 16).

These figures and the curves reproduced in Chapter 30 show that although there was a steady gain in power output there was a regression of m.e.p. at a given piston speed. This was only to be expected as the engines became progressively short of valve area in relation to swept volume. The Mercedes-Benz W.25 series were exceedingly successful in their racing programme, particularly during the first two years. In 1934 results measured either by race wins or average speeds were not decisive and the cars won only four out of ten major races held. Dr. Nibel died in November, 1934, and thus did not live to see the major successes achieved in 1935 in which his designs won eight out of ten major races.

Acknowledgments.-Full assistance was given by the constructors and in particular Directors Wagner and Hoppe, and racing mechanic Müller.

DETAILS OF CAR

MAKE.-Mercedes-Benz
TYPE.-W.25B
YEAR OF CONSTRUCTION.-1935
YEARS RACED.-1934 Engines M.25A
1935 Engines M.25B and M.25C
DESIGNERS.-Nibel and Wagner
WHEELBASE.-8 ft. 11 in.
TRACK FRONT.-4 ft. 10 in.
TRACK REAR.-4 ft. 7 in.
HEIGHT TO SCUTTLE.42 in.
HEIGHT TO DRIVER'S HEAD.-48 in.
FRONTAL AREA.-11.8 sq. ft.
UNLADEN WEIGHT.-16.8 cwt.
ALL-UP STARTING LINE WEIGHT.-20 Cwt.
MAXIMUM SPEED.-175 m.p.h.
SPEED ON INDIRECT GEARS.-According to circuit
H.P. PER SQ. FT.-36.5
H.P. PER TON UNLADEN.-510
H.P. PER TON ALL-UP.-430
BORE.-82 mm.
STROKE.-94.5 mm.
S./B. RATIO.-1.15:1
No. OF CYLINDERS.-Eight
CAPACITY.-3,990 c.c.
PISTON AREA.-65 sq. in.
B.H.P.-430 at 5,800 r.p.m.
H.P. SQ. IN.-6.62
B.M.E.P.-242 lb. per sq. in.
PISTON SPEED FT./MIN.-3,600
CYLINDER HEAD.-Integral with steel cylinders
VALVES No.-Four per cylinder
VALVES ANGLE.-60 degrees
VALVES AREA INLET.-22½ sq. in.
VALVE AREA EXHAUST.-22½ sq. in.
CYLINDER BLOCK.-Forged-steel barrels welded together in sets of four with sheet water-jackets
FUEL.-Petrol-Benzole or alcohol mixture
CARBURETTERS.-Two double choke Mercedes-Benz
SUPERCHARGER.--One Roots at 2.0 engine speed
SUPERCHARGE PRESSURE.-10 lb. boost (1.66 ata.)
IGNITION.-one Bosch magneto
PLUGS No.-Eight
PLUGS LOCATION.-Centre in head
CRANKCASE.-Barrel type with crank inserted from end
CRANKSHAFT.-One-piece counterbalanced
MAIN BEARING No.-Five
MAIN BEARING TYPE.-Roller
BIG END TYPE.-Roller in split housing
LUBRICATION.-Dry Sump
CAMSHAFT No.-Two
CAMSHAFT LOCATION.-In head
CAMSHAFT DRIVE.-Train of gears
CAMSHAFT DRIVE LOCATION.-Rear of crank
CLUTCH.-Single plate
GEARBOX LOCATION.-In unit with bevel box
GEAR RATIOS.--According to the circuit
TRANSMISSION.-Open propeller shaft 3½ in. below centre line of hubs. To step up gears on combined gearbox and bevel drive. Swing axle with enclosed half-shafts to rear wheels
FRAME.-Pierced box section
FRONT SUSPENSION.-Independent to each wheel with bell crank connecting to horizontal coils placed within front cross-member
REAR SUSPENSION.-Independent to each wheel with swing axle. Transverse mounted quarter-elliptic leaf springs
SHOCK ABSORBER TYPE.-Friction
BRAKE SYSTEM.-Lockheed hydraulic
BRAKE DRUM DIAMETER.-15¾ in. internal
BRAKE DRUM WIDTH.-2 in. front, 2¾ in. rear
SQ. IN. PER TON LADEN.-272
STEERING.-Worm and nut 2¼ turns lock to lock
WHEELS TYPE.-Rudge
TYRES.-Front 525 by 17
Rear 525 by 19

RACING RECORD MERCEDES-BENZ, TYPE W.25

Date	*Event*	*Course*	*Average Speed*	*Lap Speed*
3/6/34	Eifel Races	Nürburg Ring	76.12 m.p.h.	79.00 m.p.h.
1/7/34	French G.P . . .	Montlhery	N.F.	89.5 m.p.h.
15/8/34	Coppa Acerbo . .	Pescara	80.26 m.p.h.	—
9/9/34	Italian G.P . . .	2.68 Miles at Monza	65.37 m.p.h	—
23/9/34	Spanish G.P ...	San Sebastian	97.13 m.p.h.	100.8 m.p.h.
30/9/34	Czechoslovak G.P	Brno	—	82.29 m.p.h.
22/4/35	Monaco Grand Prix	Monaco	59.43 m.p.h.	60.08 m.p.h.
16/6/35	Eifel Races	Nürburg	72.98 m.p.h	—
23/6/35	French Grand Prix	Montlhery with Chicanes	77.14 m.p.h	—
30/6/35	Penya Rhin Grand Prix	Mountjuich	66.99 m.p.h.	68.94 m.p.h.
14/7/35	Belgian Grand Prix	Spa	97.87 m.p.h.	103.7 m.p.h.
28/7/35	German Grand Prix	Nürburg	74.5 m.p.h. (3rd)	80.73 m.p.h.
25/8/35	Swiss Grand Prix . .	Berne	89.95 m.p.h.	99.5 m.p.h.
22/9/35	Spanish Grand Prix	San Sebastian	101.92 m.p.h.	—

EXAMPLE No. FIFTEEN

The 6-litre Auto-Union Type C

WHEN, in 1933, the recently formed combine of four Saxon automobile companies, Horch, Audi, Wanderer, and D.K.W., called Auto-Union, decided to enter Grand Prix racing under the 750 Kg. formula, they were wise enough to take over a project which was already begun as a private venture by Dr. Ing. h. c. Ferdinand Porsche and his partner Adolf Rosenberger.

As is well-known, Dr. Porsche was in charge of design at Austro-Daimler from 1906-23, and in 1924 he had been responsible for the supercharged four-cylinder 2-litre Mercedes, and the extremely fast, if somewhat unstable, 2-litre eight-cylinder supercharged model. Herr Rosenberger was a wealthy amateur racing driver whom, it is not irrelevant to note, had many successes in 1925 with the 2-litre Benz rear-engined " tear-drop " cars. These ran in the Italian Grand Prix of 1923, and in the following year Rosenberger put up a record time for the Hercules hill climb, near Kassel, and was first, and made best lap, in the Solitude races. His Benz experience showed him that there were many virtues in a rear-engined racing car and, Porsche agreeing on technical grounds, the design for a 1934 G.P. model was based on a V. 16 cylinder engine placed behind the driver and ahead of the rear axle. The gearbox was driven by a sub-shaft and mounted behind the rear axle, and the fuel tank mounted between the back of the driving seat and the front of the cylinder block. A tubular frame was used to carry water from the engine to the front-mounted radiator, and all four wheels were independently sprung, using Porsche-type trailing links and torsion bars on the front and a swing axle with transverse leaf spring at the rear. As originally designed the A type P. Wagen had a bore and stroke of 68 x 75 mm. and the 4.36-litre engine developed 295 b.h.p. at 4,500 r.p.m. with a boost pressure of approximately 9 lb.

The car made its first public appearance on March 6, 1934 (when Hans Stuck broke three world records on the A.V.U.S. Track), and in the ensuing season of Grand Prix racing was successful in the German, Swiss and Czechoslovak Grands Prix, and took second place in the Italian Grand Prix. In 1935 the design was slightly modified (B type), torsion bars were used at the back and the bore was increased to 72.5 mm. Some 375 b.h.p. was now obtained at 4,700 r.p.m. from 4.95-litre capacity with a boost of 11 lb. per sq. in. The top speed of the car was, thereby, increased from approximately 170 to approximately 180 m.p.h., and running a prototype model at the end of 1934 Hans Stuck broke the standing kilometre record at 101.56 m.p.h. and the standing mile record at 116.75 m.p.h. (20/10/34, A.I., No. 254). These figures show that the car averaged 159.5 m.p.h. between the end of the kilometre and the mile post, but despite this excellent performance, Auto-Union won only one major race in 1935, the Italian Grand Prix, and three minor events, the Tunis and Czechoslovak Grands Prix and the Coppa Acerbo. In 1936, therefore, the car was subject to such a further and more substantial re-design and called the C type.

The main engine casting was unchanged but the swept volume was raised to over six litres, whilst a variety of modifications were made to the chassis. This model was used throughout 1936 and 1937, and in the former year was definitely the most successful car of the year in which it won three out of five major Grands Prix, and three out of six of the lesser events. The lap record was broken on six circuits during the year.

The improved performance of the C over the B type can be directly assessed by a study of the record book. The standing kilometre speed was raised to 117.3 m.p.h. and the standing mile to 134.5 m.p.h. (26/10/37, AI., No. 304), and the inferred average between two timing strips was 180 m.p.h.

With 520 b.h.p. available 205 m.p.h. was claimed as possible at 5,000 r.p.m., but there is no direct evidence that so high a speed was ever reached during road racing. A more accurate valuation can be based on a timed speed over five kilometres, which was 195.13 m.p.h. (23/3/36, A.I., No. 284), but even this was achieved with a combination of final gear ratio and tyre size used only for virtually track races, such as Tripoli and A.V.U.S. For the ordinary run of road racing ultimate speed was sacrificed for acceleration and the car was geared to 175 m.p.h. at 5,000 r.p.m. on top gear.

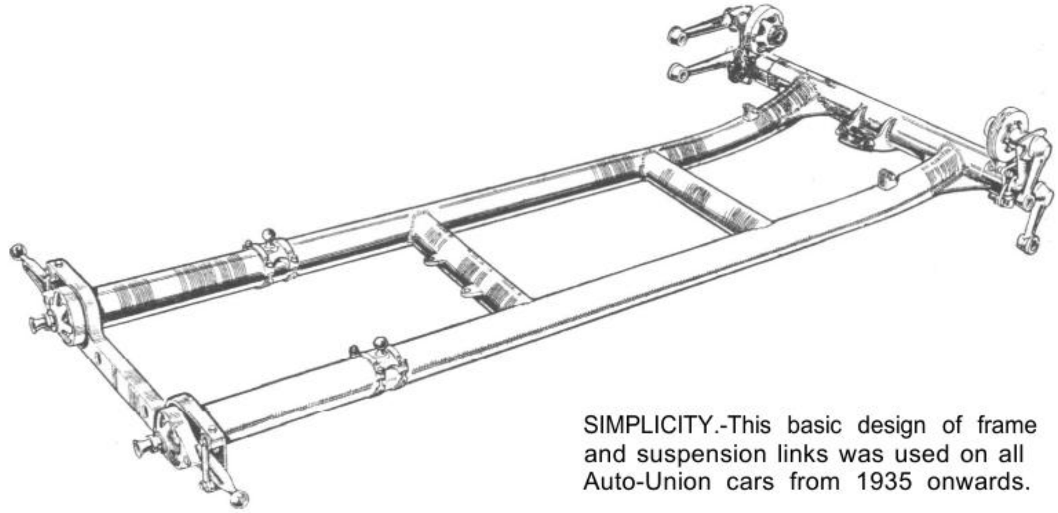
Although unorthodox in conception and execution the design of the Auto-Union was notable for simplicity and straightforward engineering with no effort to solve problems by resort to complicated expedients. The position of the fuel tank is a good illustration of the manner in which first principles were regarded. During the 750 Kg. formula, events were run over a fixed distance of 310 miles and as it was normally unnecessary to change a complete set of tyres at shorter intervals than 150 miles, it was clearly desirable for the car to run at least this distance without a fuel stop. Allowing, therefore, for a consumption at the rate of 3½ m.p.g., plus a reasonable margin, the tank had to hold a minimum of fifty gallons, amounting to 400 lb. in weight. On these figures there would be a difference of some 15 per cent between the weight of the car leaving the starting line and on its last lap before refuelling, and Dr. Porsche thought it highly important that this comparatively large variation should not result in any change in fore and aft weight distribution.

With a normal rear-mounted tank the proportion of weight carried on the rear wheels would fall from 58 per cent to 51 per cent, and the absolute loading from 12.2 cwt. to 9.2 cwt. Placing the tank on the mid-point of the chassis ensured that there was no change in the proportion, etc., weight distribution, the total variation in axle load being from 12.2 cwt. to 10.4 cwt.

As a direct consequence, however, of placing both fuel tank and engine behind the driver the latter was brought very far forward in relation to the wheelbase, the lower rim of the steering wheel being only 38 in. from the centre of the front hubs. On the other hand, it was possible to mount the driver very low on the car with no complication arising in respect of propeller shafts and clutch housings, etc. The top of the driving seat, therefore, was only 11 in. and the scuttle barely 35 in. from the ground. The general construction of the car also permitted an exceptionally low frame height.

The frame members themselves were round chrome molybdenum tubes 4.1 in. in diameter with a wall thickness of 0.10 in. (approximately 13 gauge), and as shown in a drawing the side tubes were parallel and slightly upswept at the front to join a tubular cross member, reinforcements being provided by wide radial fillets. This cross member was out-rigged to provide a mounting for the suspension units, two other tubular cross members being supplemented by a box section which tied together the extreme rear-end of the frame. Separate water pipes were used in 1936 as experience had quickly shown that the welds in the 1934 design were not 100 per cent watertight. This very simple structure weighed approximately 130 lb.

The front suspension units consisted of two trailing arms 3.75 in. long connected to the king-pin by ball and socket joints. Each bottom arm was joined to a 36 in. long torsion bar placed within the front cross member and extending the full width thereof, that is the anchor point for the bar at the offside wheel was on the nearside of the car and vice versa. The torsion bars were 16 mm. diameter and gave an overall deflection of 350 lb. per in., with a normal wheel movement above and below the neutral plane of 2.35 in.



SIMPLICITY.-This basic design of frame and suspension links was used on all Auto-Union cars from 1935 onwards.

The upper trailing link was mounted on a tubular stub welded to the main cross member and was connected to the rotating discs of an adjustable friction type damper.

This type of suspension resulted in the wheelbase shortening slightly on full bump, but in the straight ahead position gave immunity from gyroscopic reactions as the wheels had a complete vertical motion.

The worm and rocker shaft steering box was mounted on the centre line of the car, and the drop-arm was linked to individual track rods running to each wheel, but although this gave geometrically correct motion in the straight ahead position, errors in geometry arose when the wheels were turned on to the lock. The steering column was offset to the right at an angle of 2½ degrees and was surmounted by a 16½ in. diameter wheel which was quickly detachable so as to make it possible for the driver to enter and leave the car.

Suspension at the rear was also by torsion bars, a transverse link leading from the wheel and the bars being mounted inside the frame. At the back the torsion bars were 24 mm. diameter, but the suspension was considerably softer than at the front, being 233 lb. per in. It was easy to pre-load the bars through the medium of fine splines where they engaged the operating links. The latter were free from side loading or torque effects, as the rear axle assembly consisted of a swing axle with radius arms.

The driving shafts were contained in short axle tubes which ended in an hemi-sphere engaging with a similarly shaped bearing which took all side thrust and a single Porsche homokinetic joint lay upon the axis of this bearing on each side of the bevel box. Braking and drive torque were taken through short arms running at an angle of 57 degrees from the hubs to spherical joints on the frame, so that as the rear wheels rose and fell they were subject to changes in track and to variations of toe-in. Both

PLATE XXVII

EXAMPLE No. FIFTEEN

THE 1936 6-litre AUTO-UNION

The rear-engined cars, designed by Dr. Ing. h. c. Ferdinand Porsche for Auto-Union, competed in the 750 kg. formula of 1934–37 with great success.

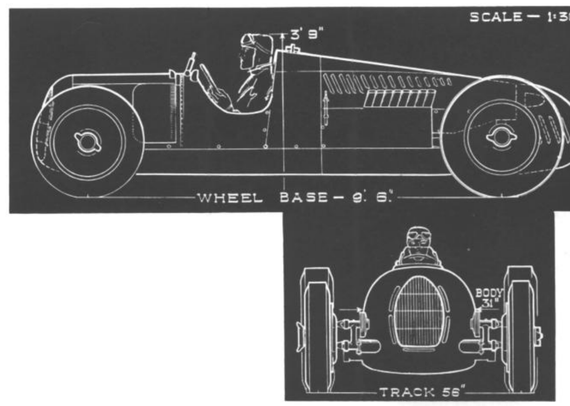
Although basically unchanged during the four years the engine capacity was raised in two stages from 4.36 litres to 6 litres, and engine output from 295 b.h.p. at 4,500 r.p.m. to 520 b.h.p. at 5,000 r.p.m.

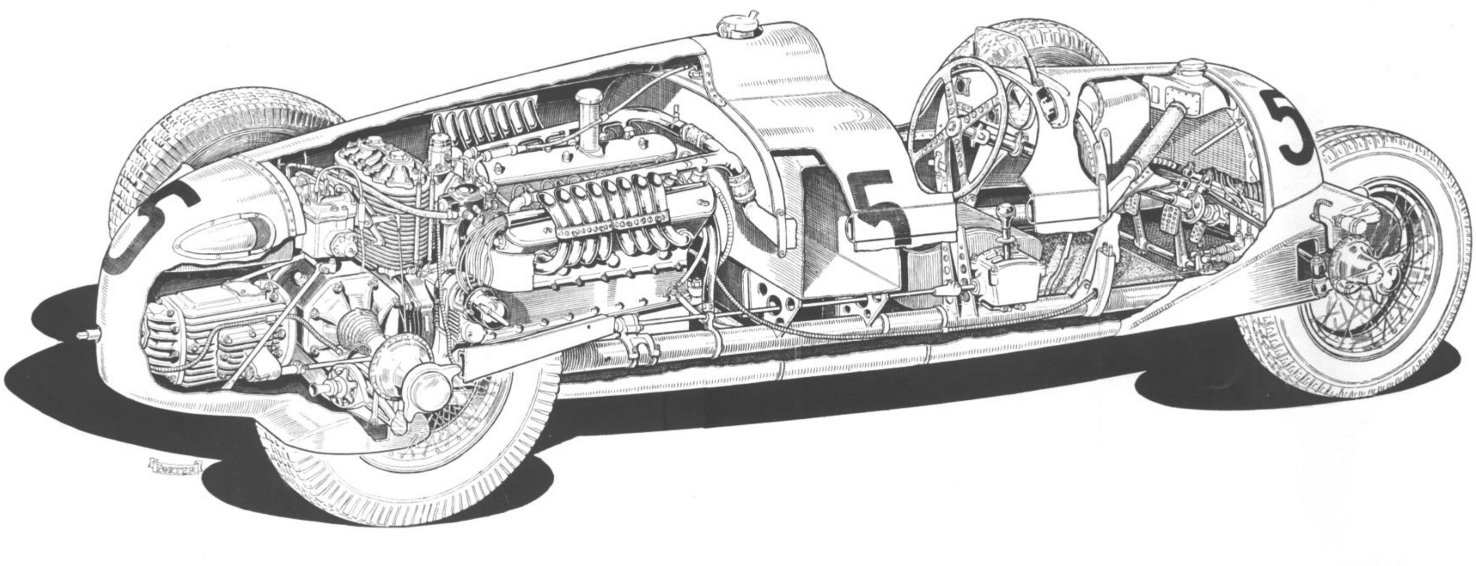
The sixteen-cylinder power unit was of basically simple construction, a light alloy casting forming both crankcase and water jackets with double cylinder liners. Two light alloy detachable cylinder heads with eight combustion chambers in each were extended to the centre line of the engine to form the inlet manifold and to provide a support for the single overhead camshaft which operated all thirty-two valves. The supercharger was driven by spur wheels from the vertical camshaft drive and the five-speed gearbox was mounted behind the rear-axle centre.

Drive to the rear wheels was through a Z.F. limited slip differential to swinging half shafts with torsion bar springs enclosed within the tubular frame. The front suspension was by trailing links with transverse torsion bars enclosed within the front cross member.

The forty-six-gallon fuel tank was placed between the engine and the driver and the latter, therefore, sat very far forward on the car. Weight distribution was, however, unaffected by changes in fuel level. These cars, with the highest possible gearing, would considerably exceed 200 m.p.h., and with the lower gearing used for road races would reach over 180 m.p.h. They were capable of averaging 117.245 m.p.h. over a kilometre from a standing start.

They won three out of five major races in 1936 and in the two seasons in which they were run by the manufacturers scored twelve victories in all.





front and rear suspensions were, however, of the utmost mechanical simplicity and the ratio of sprung : unsprung weight was 3.85 : 1.

The bevel housing was made from a steel casting and the gears which had a Klingelnberg-Palloid tooth-form offered alternative ratios of 3.0 or 3.3:1. A Z.F. limited slip differential was used, power being received from a five-speed gearbox. The ratios in this box were, of course, varied according to the circuit, further changes in the relation of engine to rear wheel speed being effected by changes of tyre size. Typical overall ratios in this box were 2.00 on first, 1.292 on second, 1.078 on third, 0.965 on fourth, and 0.863:1 on fifth. Thus, as between the highest and the lowest gear engine speed was increased by 2.32 times, but the high torque developed by the engine on the C Type made it possible for many races to be run using the two upper ratios only.

The gears were contained in a heavily ribbed casting of silicon light alloy, and the two shafts were arranged one above the other, the lower being connected to the clutch, the upper to the bevel pinion so that one pair of wheels was always engaged with no direct drive in the ordinary sense.

One selector fork moved a pair of ratios, i.e. second and third, and the fourth and fifth, these gears being coupled by dog clutches. The first and reverse gears, which were rarely used, were separately actuated. The gear-shaft bearings were positively lubricated by pressure oil supplied through a hollow clutch shaft and in addition the wheels themselves were sprayed by an oil stream when they were transmitting power. This was arranged by making the selector block open or mask the jet used for the appropriate gears.

As can be seen from the general arrangement drawing the box was placed behind the axle centre and a short shaft ran beneath the differential to connect with the twin plate clutch mounted at the back of the engine. The whole of the transmission unit was, of course, assembled as one piece with the power unit and lay at the slight angle of two degrees from the horizontal.

Reference has already been made to successive increases in engine size between 1934 and 1936, but although the cylinder diameter was increased in two stages from 68 mm. to 75 mm., and the stroke rose from 75 mm. to 85 mm., the cylinder centres remained unchanged. On the C Type engine, however, the crankshaft diameter was increased from 62 mm. to 70 mm. on the main bearings and from 58 mm. to 68 mm. on the big ends. As on the chassis, so on the engine, the general design, despite the use of sixteen cylinders, had a fundamental simplicity which compels admiration.

A single light-alloy casting of silicon alloy was extended below the centre line of the main bearings and upwards to embrace the water jackets of all sixteen cylinders. The bottom half of the engine was, in fact, simply an oil trap and contributed little to the stiffness, which was taken care of by webs which supported the main bearings which lay on each side of every crank throw.

The cylinder bores themselves were formed from wet steel liners, sealing at a face joint at the bottom and being located by the detachable cylinder-heads at the top. The latter were made in light alloy and contained two valves placed at 90 degrees, the inlet valve having a diameter of 35 mm. Both valves were seated on bronze inserts, the exhaust being on the outer side of the block and the inlet ports passing into the centre of the vee. A cross-section shows how the two heads were extended to form a conduit running down the centre of the block, which received mixture from the rear-mounted Roots supercharger. One 18 mm. sparking plug was used per cylinder, offset slightly to provide for easy changing.

The narrow angle of the vee made it possible to work all thirty-two valves from one camshaft. This was driven by bevel gears from the back of the engine and ran along the centre line of the block. The cams worked the inlet valves directly through short followers, and the exhaust valves by push-rods running to the outside of the block and engaging with rockers. The inertia of the valve gear on the exhaust side was, therefore, fairly considerable, but this engine was never intended to run at high r.p.m., as Dr. Porsche thought the use of 4.36 litres, as compared with the 2.9 litres and 3.3 litres of Alfa Romeo and Bugatti, was in itself an adequate guarantee of sufficient power in 1934, and not until 1937 did any other constructor build an engine of comparable capacity to the succeeding Auto-Union models. A limit of 5,000 r.p.m. was envisaged and the early engines peaked at only 4,500 r.p.m.

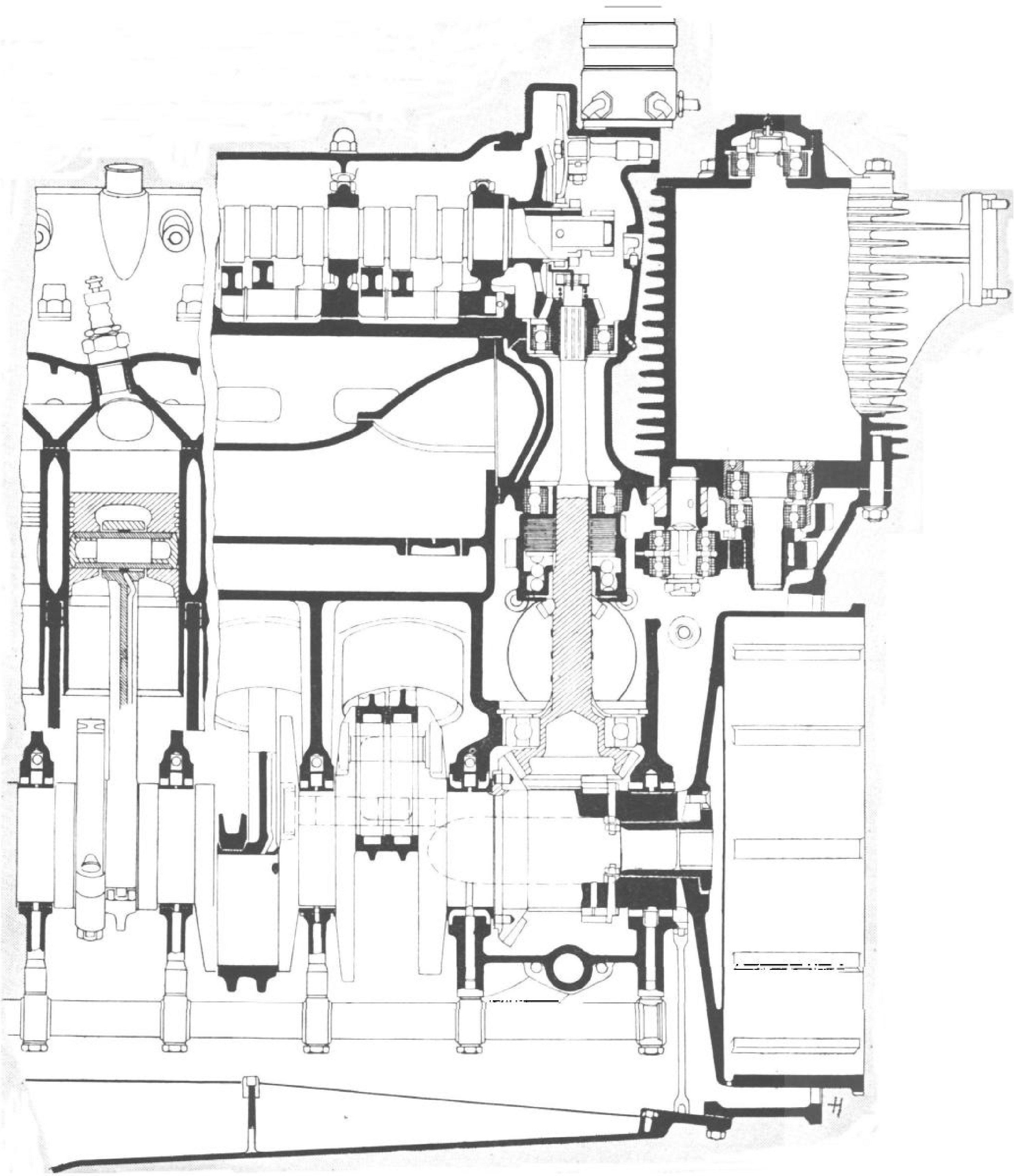
The cylinder heads were in one casting for each block and the cylinder centres staggered by the width of one big end, which amounted to 19 mm. The Roots-type blower was mounted vertically at the rear of the engine, being driven by a train of spur wheels from the camshaft drive. A torque limiting clutch was placed between the driving shaft and the first gear wheel.

The crankshaft for the first engine was a one-piece forging of hardened nickel chrome steel and lead-bronze bearings were used for both the mains and big ends. When the engine was enlarged and the power increased to meet the higher speed of the 1934 Mercedes-Benz cars, these bearings proved inadequate, and in order to use roller bearings for the big ends, the Hirth crankshaft design was adopted. In this, multiple pieces are joined by serrations on the crank pins, the shaft being held together by bolts passing through the eye of the pin, which had a diameter of 68 mm. This permitted the use of one-piece connecting rods running on twenty-eight rollers (5.5 by 5.5 mm.) located in a light alloy cage. The 22 mm. gudgeon pin ran on needle bearings. Lead-bronze was continued for the main bearings, which were 70 mm. diameter, and although the first crankshaft had no counter-balancing, on later designs a degree of counter-weighting was employed.

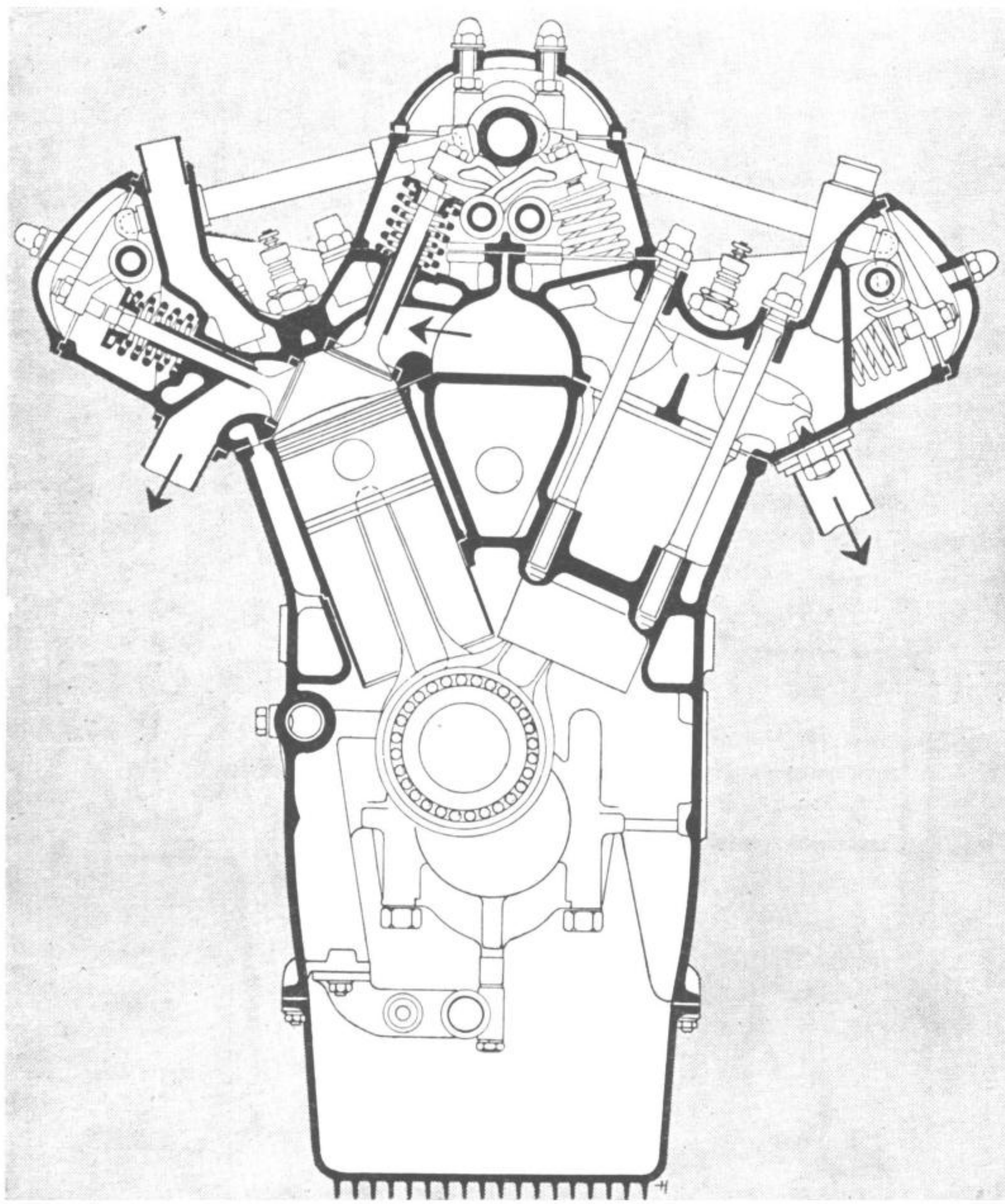
The light-alloy pistons were of conventional design, and it should be noted that the section drawings show the 1934 type, with a flat crown and no internal ribbing. In 1935, when the compression was raised from 7.1 to 9.1, a dome-shaped crown was used and the head heavily ribbed, although the weight was actually decreased.

Despite the depth of the crankcase, lubrication was with a dry sump, the scavenged oil being fed to an oil cooler placed below the radiator at the front of the car and then led into an oil tank immediately ahead of the driver. From there a gravity head was available to the pressure pump which ran at five times engine speed and had an output of 6½ gallons per minute.

As already mentioned, Dr. Porsche's original concept centred around the use of the largest engine possible within the very rigorous weight limit of 750 Kg., and on the first design a boost of only 10 lb. per sq. in. (1.66 ata) was used. Despite successive increases in engine size it was also necessary to raise the b.m.e.p. and boost pressures, and in 1937 the limit of a single-type Roots-type was reached. This type has the advantage of mechanical reliability, absence of wear and can be run without oil, but it is



General arrangement of Auto-Union engines, types A, B and C. Scale 1 : 4.



Cross section of Auto-Union 16-cylinder engine. Scale 1 : 4.

merely a displacer with no internal compression, and the overall efficiency rapidly falls as the boost pressure is raised. The accompanying increase in charge temperature can be offset by the use of fuels with high alcohol content, but these do not seriously reduce the amount of power required to drive the blower, and even with the most careful machining of the rotors and the utmost attention to clearances, the overall engine power may deteriorate if the boost be raised above 13 lb. per sq. in. (1.85 ata); 18 lb. boost (2.2 ata) is the absolute limit for reasonable efficiency.

Alternative superchargers with considerably different proportions of length to diameter of rotor were tried on the C type cars, but there was a negligible difference in their overall performance. Particulars were :

	C. Blower	S. Blower
Rotor length	190 mm.	230 mm.
Rotor diameter	128 mm.	116 mm.
Delivery per blower revolution	2.275 litres	2.860 litres
Blower to engine ratio	2.11:1	2.05: 1
Blower boost	12 to 13.51b. sq. in.	12 to 13.51b. sq. in

In every case the supercharger casing was made in silicon alloy and heavily ribbed to assist cooling and prevent distortion. The end covers were made from the same material and the rotors machined from high tensile steel.

On all Auto-Union engines the superchargers drew mixture from the carburetters and delivered it to the engine. By this means the latent heat of vaporisation of the alcohol-rich fuel lowered the temperature rise in the blower and assisted in keeping small clearances without mechanical seizure. On the 1936 C type engine a mechanical diaphragm pump delivered fuel at 4.3 lb. per sq. in. to a dual choke horizontal Solex carburetter.

The data table and curves in Chapters 28 and 30 indicate that the peak m.e.p. figures for all the Auto-Union engines were obtained at fairly low r.p.m. Subject to adequate maximum power, there are considerable advantages in developing an engine with high torque at low speeds, for acceleration is then considerably improved without excessive gear changing. In this matter, Auto-Union practice diverged markedly from that of Mercedes-Benz. Whereas, however, the 6-litre Auto-Union engine cannot claim to be remarkable for specific output, its power-to-weight ratio gives a very favourable figure indeed. The total weight with clutch came to only 540 lb., and equivalent of 1.08 lb. per b.h.p.

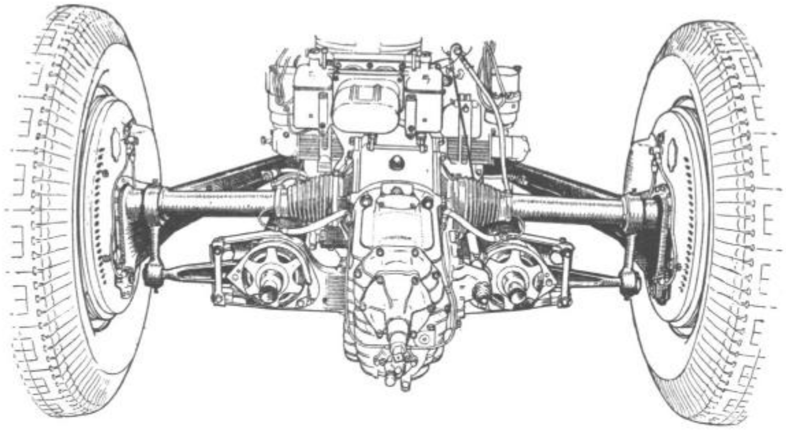
This extremely low figure was the engineer's answer to the endeavour of the A.I.A.C.R. to lower road speed by imposing a weight limit of under 15 cwt., but this figure admittedly excluded some of the heaviest parts of the car. It was only a popular fallacy that the 750 kg. formula resulted in 500 h.p. cars weighing less than 15 cwt. for the dry weight of the Auto-Union complete was 16.2 cwt., and the starting-line weight 6.2 cwt. more, the individual weights being :

Engine 540 lb.	*Fuel 410 lb.	Rear Axle 258 lb.
Accessories 258 lb.	*Driver 175 lb.	*Tyres 158 lb.
Frame 135 lb.	Gearbox 82 lb.	Body 76 lb.
*Wheels 70 lb.	*Oil 70 lb.	*Water 65 lb.
Steering 35 lb.	Springs 23½ lb.	

Total 2,508 lb. (22.4 cwt.).

The items marked with an asterisk, amounting in all to 948 lb., were exempt from the scales, and when deducted left the bare weight for weighing-in purposes at 710 kg.-a margin of nearly 6 per cent within the prescribed limit.

The general arrangement of the Porsche design contributed to this satisfactory state of affairs, but on the other hand the cars were undoubtedly difficult to handle even apart from the special problems raised by their exceedingly high power/weight



Perspective layout of the rear suspension

ratio. With nearly 60 per cent of the weight carried on the rear wheels, and the exceptionally high roll centre at the rear brought about by the use of the swing-axle system, the cars were fundamentally inclined to over-steer, and owing to the extremely forward mounting of the driver the tail could move through a considerable angle before the pilot realised the breakaway point had been reached. He would then find it hard to counteract this lag in his reaction and in addition it was by no means easy to gauge the precise position of the rear end of the car. Cornering, therefore, presented very special difficulties, and although both Varzi and Stuck performed creditably with these cars, only Bernd Rosemeyer really mastered them and was able to use their potential performance to the full.

Acknowledgements.-The author is deeply indebted to Prof. Dr. Ing. Eberan van Eberhorst for supplying facts and drawings of this car and to Robert Braunschweig for the part he played in obtaining them.

RACING RECORD OF C TYPE AUTO-UNION

Date	*Event*	*Course*	*Average Speed*	*Lap Speed*
13/4/36	Monaco G.P.	Monte Carlo	—	56.01 m.p.h.
14/6/36	Eifel Races	Nürburg	72.71 m.p.h.	74.46 m.p.h.
26/7/36	German G.P. . ..	Nürburg	81.8 m.p.h.	85.52 m.p.h.
15/8/36	Coppa Acerbo .	Pescara	86.48 m.p.h.	89.04 m.p.h.
23/8/36	Swiss G.P. ..	Berne	100.45 m.p.h.	105.42 m.p.h.
13/9/36	Italian G.P. .	Monza with chicanes	84.59 m.p.h.	87.18 m.p.h.
5/7/37	Vanderbilt Cup ..	Roosevelt Field	82.56 m.p.h.	—
11/7/37	Belgian G.P.	Spa	104.87 m.p.h.	107.7 m.p.h.
15/8/37	Coppa Acerbo . ..	Pescara with chicanes	87.61 m.p.h.	92.00 m.p.h.
22/8/37	Swiss G.P. ...	Berne	97.8 (4th)	106.8 (P)
26/9/37	Czechoslovak G.P. ..	Brno	(3rd)	92.8 m.p.h.
21/10/37	Donington G.P. ..	Donington	82.86 m.p.h.	85.62 m.p.h.

DETAILS OF CAR

MAKE.-Auto-Union
TYPE.-C
YEAR OF CONSTRUCTION.-1936
YEARS RACED.-1936-7
DESIGNER.-Dr. F. Porsche
WHEELBASE.-9 ft. 6½ in.
TRACK, FRONT.-4 ft. 8 in.
TRACK, REAR.-4 ft. 8 in.
HEIGHT TO SCUTTLE.-35 in.
HEIGHT TO DRIVER'S HEAD.-42 in.
MAXIMUM WIDTH.-38 in.
FRONTAL AREA.-10.8 sq. ft.
UNLADEN WEIGHT.-16.2 cwt.
ALL-UP STARTING LINE WEIGHT.-22.4 cwt.
MAXIMUM SPEED.-175 m.p.h. at 5,000 r.p.m. on fifth speed with 10:33 bevels and 7.00 x 19 in. tyres
SPEED ON INDIRECT GEARS.-157 m.p.h. on fourth; 137 m.p.h. on third; 113 m.p.h. on second; 75 m.p.h. on first
H.P. PER SQ. FT.-48
H.P. PER TON UNLADEN.-585
H.P. PER TON LADEN.-430
BORE.-75 mm.
STROKE.-85 mm.
S./B. RATIO.-1.13:1
No. OF CYLINDERS.-16
CAPACITY.-6,006 c.c.
PISTON AREA.-109.5 sq. in.
B.H.P.-520 at 5,000 r.p.m.
H.P. PER SQ. IN.-4.75
B.M.E.P.-230 lb. sq. in.
PISTON SPEED FT./MIN.-2,900
CYLINDER HEAD.-Light alloy detachable for each bank of cylinders
VALVES No.-Two per cylinder
VALVES ANGLE.-90 degrees
VALVE AREA.-Inlet 23.7 sq. in.
Exhaust 20 sq. in.
CYLINDER BLOCK.-Aluminium casting in unit with crankcase. Wet steel liners
FUEL.-Petrol-Alcohol mixture
CARBURETTER.-2 Solex
SUPERCHARGER.-Roots driven at engine speed x 2.11
MANIFOLD PRESSURE.-13 lb. sq. in. (1.85 ata)
IGNITION.-Two magnetos
PLUGS No.- 16
PLUGS LOCATION.-offset on centre line of head
CRANKCASE.-Light alloy casting embracing water jackets, split below centre line of bearings. Light alloy sump added to base.
CRANKSHAFT.-Built-up Hirth, counterbalanced
MAIN BEARING No.-10
MAIN BEARING TYPE.-Lead-bronze
BIG-END TYPE.-Roller
LUBRICATION.-Dry sump
CAMSHAFT LOCATION.-Between cylinder heads on centre line of engine
VALVES OPERATED.-Inlet valves direct with followers; exhaust valves by transverse push rods and rockers
CAMSHAFT DRIVE.-Vertical shaft and bevel gears
CAMSHAFT DRIVE LOCATION.-Rear of engine
CLUTCH.-Multi-plate
GEARBOX LOCATION.-In unit with engine behind rear axle centre
GEAR RATIOS.-2.84, 3.19, 3.22, 4.25, 6.6 using 10 : 33 bevels; 10 : 30 optional
TRANSMISSION.-By shaft running beneath bevel gears to all indirect five-speed box; final crown-wheel and pinion with optional ratios 3.0 or 3.3 : 1. Swinging half-shafts (with Porsche joints and torque arms) take drive to rear wheels
FRAME.-Tubular
FRONT SUSPENSION.-Porsche type trailing links with torsion bars
REAR SUSPENSION.-Swing axle with torsion bars
SHOCK ABSORBER TYPE.-Friction
BRAKE SYSTEM.-Lockheed two leading shoe with double master cylinders
BRAKE DRUM DIAMETER.-16.4 in.
BRAKE DRUM WIDTH.-1.97 in.
SQ. IN. PER TON LADEN.-362 sq. in.
WHEELS.-Rudge detachable
TYRES.-Continental, 5.25 x 17 front; 7 x 19 rear or 7 x 22 optional

EXAMPLE -No. SIXTEEN

The 1937 Mercedes-Benz, Type W.125

TO put the W.125 Mercedes-Benz into proper perspective it is essential to have an understanding of the affect on design of changes in formula, and also the time lag between commencement of a design and its appearance in racing.

The formula limiting maximum weight to 750 Kg. (agreed in October, 1932) had validity in the years 1934, ‘35 and ‘36, but by the end of 1935 it was recognised that it had completely failed to check the power and speed of racing cars. The problem of a revised ruling for the years 1937, ‘38 and ‘39 then came under review, and on February 13th, 1936, the A.I.A.C.R. accepted, as a basis for these years, a proposal by the Bureau Permanent International des Constructeur d’Automobiles an organisation which represented all the constructors, including, of course, those engaged in active racing. They suggested that weight should be fixed at a minimum in place of a maximum figure, and be simultaneously related to cylinder volume The maximum engine size was to be 3,460 c.c. with supercharger or 4,500 c.c. unsupercharged, and using either of these sizes of engine the minimum weight was 850 Kg. or 16.7 cwt. However, insofar that the 850 Kg. minimum included wheels and tyres, whereas the 750 Kg. maximum excluded these components, this aspect was of no great technical significance. Novelty lay in assessing a supercharger as worth an extra 30 per cent in engine capacity.

This proposal was never effective, because in September, 1936, the A.I.A.C.R. decided to raise the unblown capacity ratio from 1.3 to 1.5 to 1, to retain the minimum weight limit of 850 Kg. for the largest size of engine, to accept 4,500 c.c. as the maximum capacity unblown, and thus to limit supercharged engines to 3,000 c.c. Seven months had passed between the date of the original proposals and their adoption in modified form, and to spare constructors the almost impossible task of producing new designs within six months, it was agreed to extend the 1934-6 regulations for a further year and to embrace the new rules for the seasons 1938, ‘39 and ‘40.

The abortive February formula is not, however, of mere academic interest for it led to the Mercedes-Benz W.125 being originally planned for an engine capacity of under 3½ litres, a figure corresponding with the original straight-eight M.25 series engine produced in 1934. This makes it the more interesting that the car was designed to have a wheelbase 3 in. longer than the 1935 W.25B type and 1 ft. longer than the 1936 W.25E type, a change dictated by reasons of stability and road holding, but highly convenient when it was decided to fit an enlarged engine for the " extended " year of the old formula. It is nevertheless remarkable that it was possible to install a 5.66-litre engine with nine bearings, which was 5½ in. longer and 45 lb. heavier than the original 1934 type, and still keep within the original 750 Kg. weight limit.

The new engine developed over 600 b.h.p. and these cars represent an all-time high from the viewpoint of h.p. per ton and per sq. ft. of frontal area.

The new car was based upon a very stiff frame made from nickel-chrome molybdenum tube, a material chosen for its remarkable resistance to fatigue and ease of manipulation. The side members consisted of a sheet only 1.5 mm. thick formed into oval section tubes 5½ in. deep and 3½ in. wide, the details of which are disclosed in a

PLATE XXVIII

EXAMPLE No. SIXTEEN

The 1937 Mercedes-Benz, Type W125

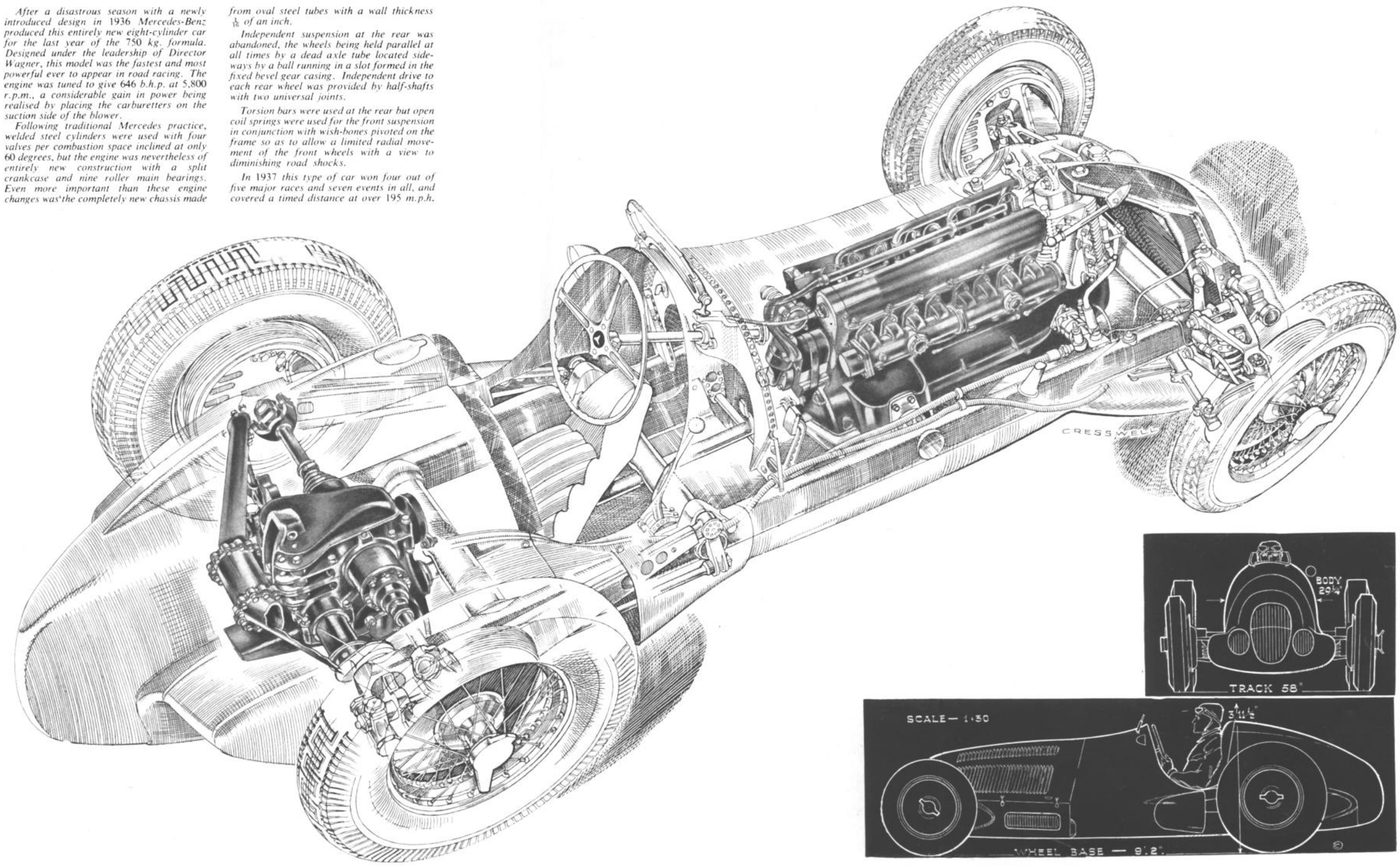
After a disastrous season with a newly introduced design in 1936 Mercedes-Benz produced this entirely new eight-cylinder car for the last year of the 750 kg. formula. Designed under the leadership of Director Wagner, this model was the fastest and most powerful ever to appear in road racing. The engine was tuned to give 646 b.h.p. at 5,800 r.p.m., a considerable gain in power being realised by placing the carburetters on the suction side of the blower.

Following traditional Mercedes practice, welded steel cylinders were used with four valves per combustion space inclined at only 60 degrees, but the engine was nevertheless of entirely new construction with a split crankcase and nine roller main bearings. Even more important than these engine changes was the completely new chassis made from oval steel tubes with a wall thickness $\frac{1}{16}$ of an inch.

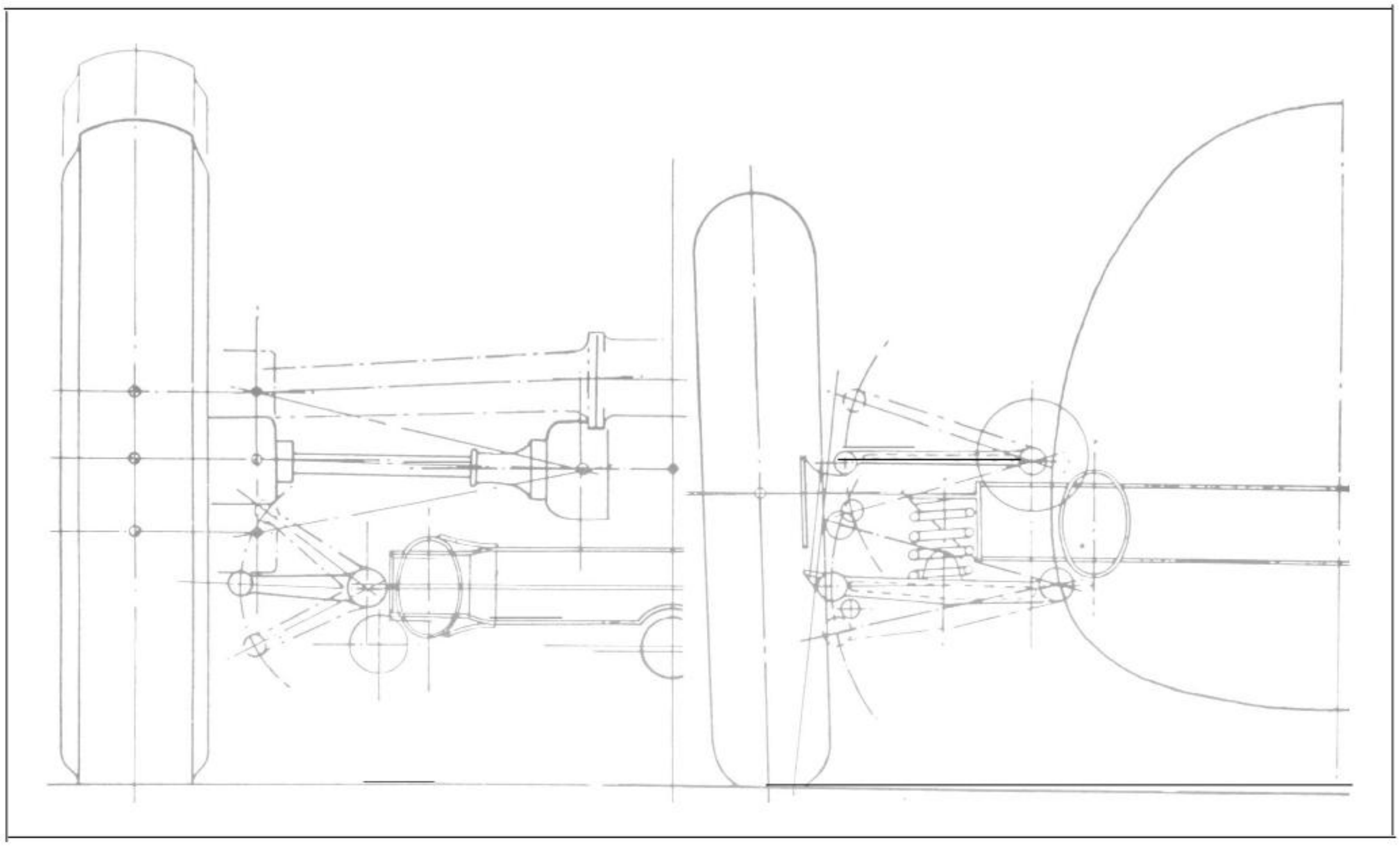
Independent suspension at the rear was abandoned, the wheels being held parallel at all times by a dead axle tube located sideways by a ball running in a slot formed in the fixed bevel gear casing. Independent drive to each rear wheel was provided by half-shafts with two universal joints.

Torsion bars were used at the rear but open coil springs were used for the front suspension in conjunction with wish-bones pivoted on the frame so as to allow a limited radial movement of the front wheels with a view to diminishing road shocks.

In 1937 this type of car won four out of five major races and seven events in all, and covered a timed distance at over 195 m.p.h.



drawing. These side members were braced laterally by four round tubes, all approximately 4 in. in diameter, but actually varying slightly according to their position in the frame. At the rear two closely spaced cross tubes provided a three point mounting



These factory drawings show the front and rear wheel motions and schematic suspension layout, adopted on the 1937 Mercedes-Benz Type W. 125. Scale 1 : 10

for the complete transmission aggregate, at the front the cross tube was extended through the side members to provide the mounting for the independent front suspension system.

On the new car the short wishbones and horizontally enclosed coil springs of the previous models were abandoned in favour of long wishbones with an open coil spring, the design being almost identical with the arrangement employed on the type 500K and 540K production cars since 1934. The wishbones were of unequal length, the top measuring 10 in. between the two pivot points and the bottom 11.8 in., and provided a total movement of 5¾ in. of which 3 in. was from normal to full bump position. This was an increase of some 50 per cent upon the travel permitted on the previous design of the cars and the W.125 can justly claim to have pioneered the modern movement toward truly soft independent suspension for racing motor cars.

An interesting refinement is to be found in the immensely long king-pin employed, this extending practically the whole length between the outer ends of the wishbone arms and providing exceptional support against cornering and braking loads. The projection of the king-pin to the ground gives an offset to the tyre centre of 1.25 in.

Great care was taken to ensure accurate steering geometry. A primary track rod swung on arms mounted on the frame, there being short rods extending on each side, swinging approximately (but not exactly) around the arc struck by the wishbones.

Steering was through a worm and nut box mounted immediately behind the engine with a long push-pull rod running down the exhaust side of the engine.

It has been seen that the front suspension involved the application of known schemes; the 1937 design for the rear suspension was, however, a complete breakaway from convention, so far as racing cars were concerned. As power and speed rose the simple swing axle employed on the 1934 cars was found to be inadequate mechanically and undesirable geometrically. In particular, the high roll centre provided by a swing axle resulted in too great a proportion of the roll couple of the car being taken on the rear wheels. The type W.25 was, in consequence, an inherent over-steerer, a particularly undesirable feature on a car with over 400 b.h.p. per ton in which the rear wheels would spin between 50 and 150 m.p.h. on top unless care was exercised by the driver,

Director Wagner, who was responsible for much of the work on these cars, enunciated the doctrine that a rear suspension must fulfil two primary duties, viz : maintain wheels parallel at all times and provide complete freedom from side float. These are characteristics of a well-mounted live axle, but the unsprung weight of such a component was thought to be intolerable on a racing car. There remained a form of construction, designed by either Trepardoux or Bouton for the Count De Dion before the turn of the twentieth century, which consisted of open shafts driving the wheels through two universal joints from a bevel box mounted on the frame, the wheels being located by a dead tube attached to the hubs.

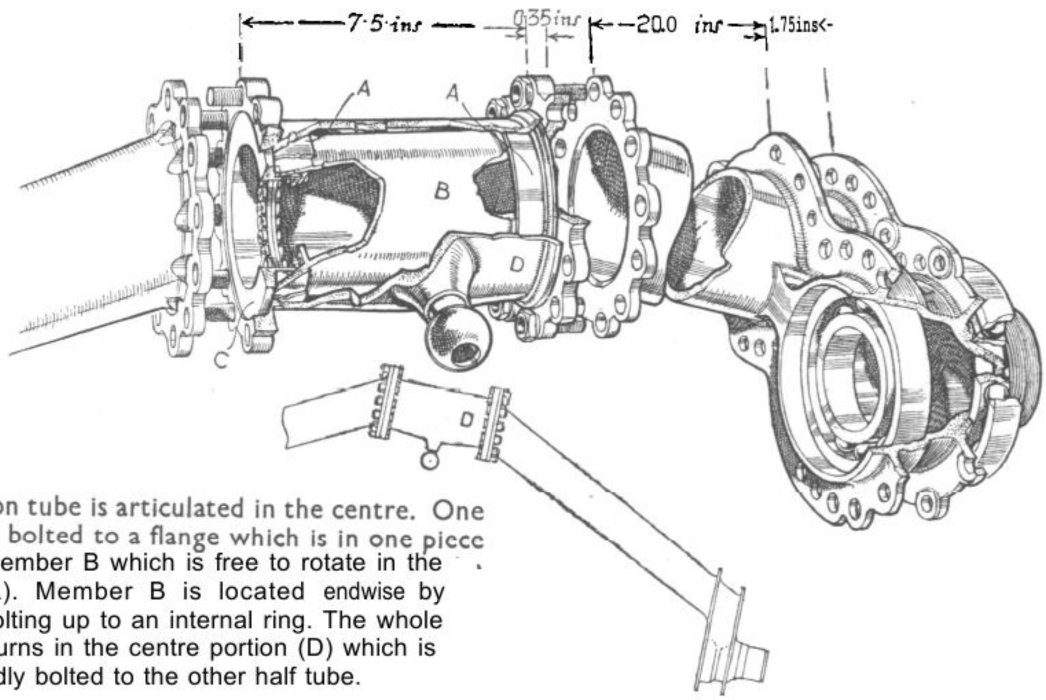
The first Mercedes-Benz experiments with such a layout were carried out during 1936, but trouble was experiencedwith the splines in the driving shafts, and with the sideways location of the De Dion tube, which was by a projection running between two large rubber rollers.

For 1937 an entirely new scheme was devised. The inner universal joints were of true De Dion type, consisting of hardened pins engaging with bronze blocks which in turn fit into hardened steel slots attached to the differential gear. With this arrangement the blocks can have an angular relation to the slots and can also move in and out thereof and splines are thereby avoided. The De Dion tube was located sideways by a hardened steel ball formed in one with the centre portion and running in a long slot formed at the back of the bevel box. This gave the required sideways rigidity. Torque arms were connected to ball joints on the side of the frame, the distance from the hub centre to the ball joints being 36 in.

From this arrangement it follows that as the rear wheels rise and fall they swing about a 36 in. radius imposed by the arms and also that if only one wheel rises this wheel traverses an arc and has an angular relationship to the other rear wheel. This would only be possible by twisting the De Dion cross tube which would then act as an excessively strong torsion anti-roll bar whereby (apart altogether from the severe stresses which would thus be set up) the handling qualities of the car would be impaired.

To relieve the De Dion tube from torsion it was necessary to divide it so that one half could turn in relation to the other, although externally the W.125 De Dion tube appears to be in only three pieces with the centre part having the two long arms bolted directly to it. This is not so, for the centre part includes a highly ingenious oscillating joint, the details of which are clearly disclosed in a drawing. This also shows the remarkable construction used for the outer "halves" each one of which consists of a side tube and hub machined from a single forging and including varying wall sections and a slight taper from the inner to the outer end.

Each wheel was connected through a 6½ in. lever to a torsion bar 18 mm. diameter and 22½ in. long. These torsion bars were splined at each end, copper plated, and mounted outside the frame, and the arrangement permitted a maximum traverse on the rear wheels of 7 in.with 3½ in. from normal to full bump position. Thus the softness of the front suspension was matched by a corresponding increase in wheel movement on the rear springing as compared with the previous design. The actual rate of the suspension at the back varied with wheel motion as the motion of the link connecting the torsion bar to the wheel offers a decreasing mechanical advantage and raises the rate by some 30 per cent at the full bump position.



The De Dion tube is articulated in the centre. One half tube is bolted to a flange which is in one piece with the member B which is free to rotate in the bushes (A). Member B is located endwise by flange C bolting up to an internal ring. The whole assembly turns in the centre portion (D) which is rigidly bolted to the other half tube.

The use of the De Dion tube at the rear and of nearly parallel movement for the front wheels produced a car with general under-steer characteristics. This gave the driver a much higher degree of control over the car as any required degree of over-steer could always artificially be engendered by spinning the back wheels, there being some 600 h.p. per ton nominally available for this purpose.

The power unit was three point mounted in the frame and, although square to it, the crankshaft was inclined from the horizontal with the propeller shaft continuing this angle so that the centre line of the bevel pinion was much below the centre line of the crankshaft.

The gearbox and bevel drive were developed from the 1936 car (with the requisite modifications for the De Dion drive) and in place of the spur type step-down gears used on the 1934 model the bevel gears were mounted on the central axis of the car 8.8 in. below the wheel centres. Four indirect gears were used, two on each side of the bevels, their shafts lying one above the other and the upper shaft engaging with a pair of spur wheels driving the half shafts through the medium of a Z.F. differential.

This component consists essentially of a cage bolted to the final spur wheel which carries oval shaped " fingers " engaging with a ring of inner recesses connected to one half shaft, and a ring of outer recesses connecting to the other half shaft. The number of recesses carried is slightly different for each shaft and to obtain differential movement between the wheelsthe " fingers " have to pass from one recess into another. Two things follow. Firstly, on a corner the drive is transmitted irregularly to the inner and outer wheels ; second as the difference in speed between the wheels increases, so does the power loss in the differential until, on sharp corners, the efficiency figure may fall to as low as 50 per cent By this means drivers were relieved from the embarrassment of having grossly excessive power at the rear wheels when actually cornering, and from the obligation to use the throttle with the utmost care and delicacy.

Changes in gear ratio could be effected by altering the bevel wheels, the final spur wheels or by changing the gears themselves The lowest final ratio was 4.70:1 overall, a normal ratio was 3.52: 1, and there was a highest possible gear of 3.28: 1. Normal tyre size at the back was 7.00 by 22 with an effective diameter of 36 in., but both 7 by 19 and 7 by 24, with effective diameters of 33.4 in. and 38 in. respectively, were possibilities giving 200 m.p.h. at 5,800 r.p.m., using the highest gear and biggest tyre and 188 m.p.h. and 178 m.p.h. on the two smaller wheels.

The way in which these variations were employed in racing can be realised by comparing the ratios used for the 1937 Monza test runs with the gears used at Berne and Monaco. In the latter race the first and second gear ratios were left unchanged in the box, but the third and top were altered and the lowest gearing employed for the final drive. Resultant ratios were overall: 4.7, 5.95, 6.1 and 9.55: 1. The relation of these gear ratios to road speeds is of some interest and can be set out in a table as follow :

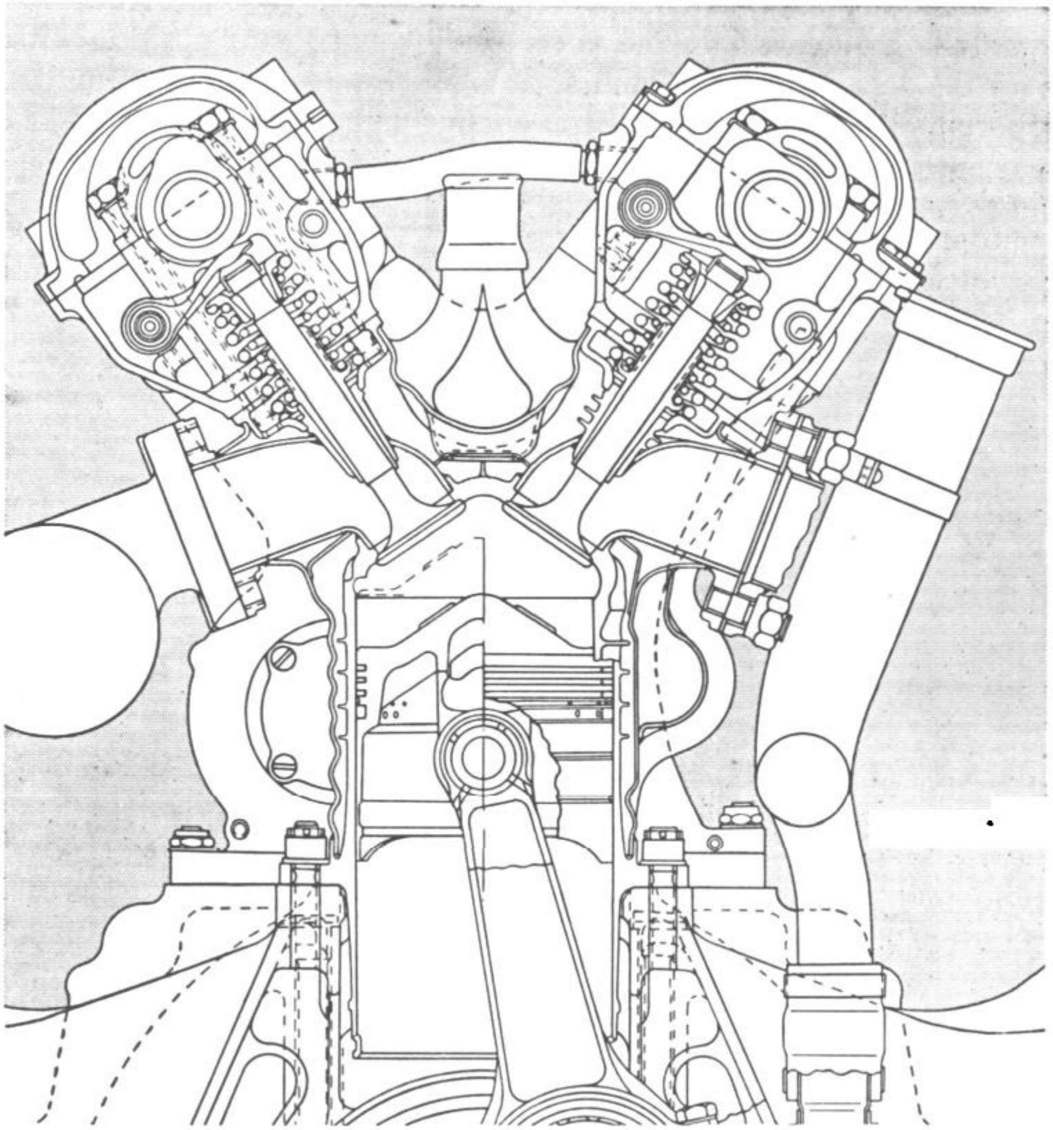
W.125 ROAD SPEEDS AT 5,800 R.P.M.

Course	I	II	III	IV
Monza	m.p.h. 73 (8.0)	m.p.h. 114 (5.15)	m.p.h. 132 (4.45)	m.p.h. 166 (3.52)
Berne	Ditto minus 5	cent by use of	smaller wheels	
Monaco	60 (9.55)	93.5 (6.15)	96 (5.95)	122 (4.70)

The right-hand gear lever was provided with a conventional gate, means however being provided to ensure the lever would not jump out of any given position. No handbrake was fitted, reliance being placed solely upon the Lockheed hydraulic brakes with double master cylinders as developed for the prior design. Considerable developments had, however, taken place in the brake shoes, the two leading shoe system being adopted and the brake drum diameter increased with light-alloy drums having inserted liners.

Weight distribution was another factor greatly aiding the stability of the cars. On the type W.125, Director Wagner made great efforts to put the polar moment as high as possible by massing the weight of the engine and the gear-cum-bevel box aggregate at opposite ends of the frame, as is particularly well shown in the perspective drawing of the car.

The 5.66-litre engine, designated the M.125, followed the main principles previously established, but had entirely new detail design. Cylinders made from steel forgings with welded-up ports and welded water jackets in blocks of four were retained and there were no substantial changes in the valve gear layout, angle of valves, camshaft drive, piston and connecting rod design. Split roller bearings were continued for big-end and main bearings, together with a one-piece crankshaft, but the latter was designed to

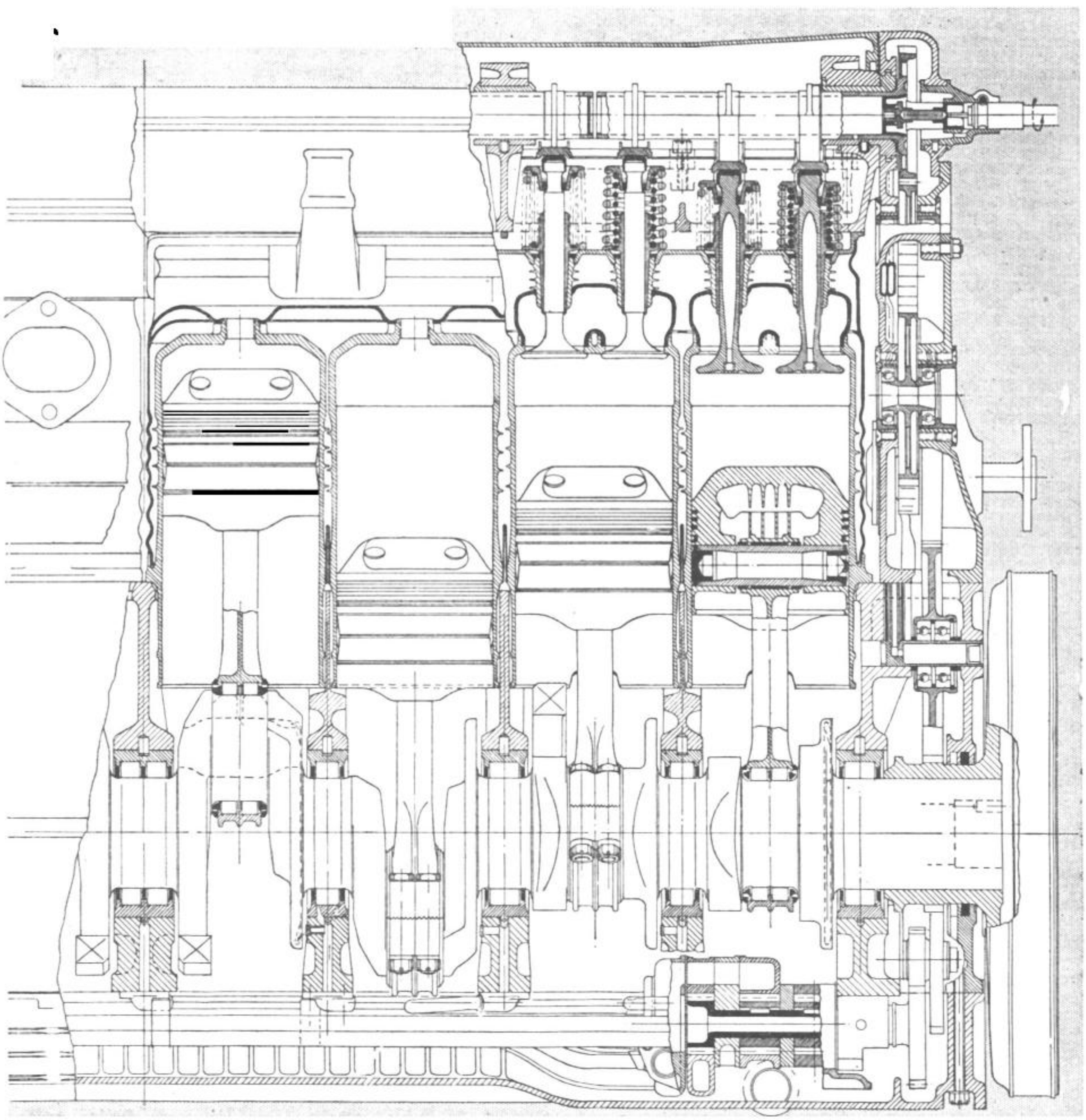


The I937 Type W.125 racing engine bears an almost startling resemblance to World War I Mercedes aviation engines, the most notable change being the use of two overhead camshafts. This drawing shows clearly the welded-up constructlon of the cylinder block which is connected to the exceedingly deep crankcase by through-bolts, which also retain the bottom halves of the nine main bearing caps. Scale I :3.

have nine main bearings inserted into an open bottomed crankcase, the bearing caps being retained by through bolts which also held the cylinder block on to the crankcase. Any loss in lateral stiffness was made good by set screws with heads external to the crankcase and threads engaging with the side of the main bearing cap.

Engine dimensions were increased to 94 x 102 mm., and all the internals of the engine stiffened substantially. The diameter of the big ends was raised from 53 mm. to 63 mm., and that of the main bearings from 63 mm. to 66 mm The width of the big ends was increased from 30.5 mm. to 33 mm., and in place of the main bearings having a uniform width of 29 mm., the centre bearing was made 35 mm. wide, and the other bearings 25 mm. wide . The main bearings employed 10 by 18 mm. rollers and the big ends double rollers 8 by 10 mm This resulted in a substantially bigger engine, the length of the crankshaft, for instance, being increased by some 5½ in. By very careful attention to detail, however, the weight increase amounted to less than 45 lb. compared with original 3.36-litre layout.

Inspection of the lateral and cross-section drawings of the engine reveals the notable continuation of Mercedes tradition in the detail layout. Points of particular interest are the way in which the cylinders were deeply spigoted into the crankcase and provided with stiffening ribs around their circumference The water jackets were corrugated to allow for differential expansion, the ports being welded into position with welded-in supports for the detachable valve guides. It is interesting to note that on the exhaust side the supports were finned to supply extra cooling and that the exhaust valves



This longitudinal section of the W.125 engine (scale 1 : 4) gives additional details of the cylinder construction and shows the split housings for the rollers used for both main and big-end bearings.

were hollow so as to permit sodium cooling. The inlet and exhaust valves had a common diameter of 39 mm. with a total valve area of 29.6 sq. in., the output per square inch of valve area thus being 21.8 b.h.p. The relation of valve area to piston area was 0.30 : 1, the lift on the valves being held at 8.5 mm. The cross-sectional drawing also indicates the very steeply domed pistons which gave a compression pressure (without boost) of 165 lb., equivalent to a nominal compression ratio of approximatel 6:l.

It will be seen that the piston crown was exceptionally thick (approximately 8 mm.) and that four projections were machined on the head, these registering with the centre of the valve ; hence, should the valves stick for any reason there was some chance of their being returned to their seat without being bent by impact with the piston.

The gudgeon pin ran on a plain bronze bush let into the steel connecting rod. The diameter of the pin was only 24 mm., that is to say less than 25 per cent of the piston diameter, which is a remarkably low proportion.

The connecting rod itself was a nearly parallel H-section with ribs running from the eye of the big end up into the rod itself. The faces of the two halves of the big end were serrated and held in place by four bolts.

Lubrication was on the dry-sump system, a large oil tank being placed between the frame and the crankcase on the left-hand (i.e. on the exhaust) side of the engine. The sump consisted of a shallow light-alloy casting bolted on to the bottom of the unusually deep crankcase. Gear-type oil pumps were driven by a long shaft projecting forward from the rear-end camshaft drive.

A right-angle drive was provided at the front end of the engine with the water pump mounted on the left-hand exhaust side and a fuel pump on the opposite side. The latter drew fuel from the rear tank through a flexible pipe 7/8 in. o.d. and had a return pipe of equal size, a spill valve despatching surplus fuel back into the tank. In conformity with the usual practice on this series of engines the Roots blower was mounted vertically in front of the engine and driven by bevel gears.

Changes, however, were made from the M.25 series, in which rotor diameters of 106 mm. had been used with successive enlargements of up to 255 mm. in length. On the M.125 the rotors were also 255 mm. long, but increased in diameter to 185 mm., giving a theoretical delivery of 2 litres per revolution. At the same time, however, the blower speed was raised to engine speed by 2.78:1, giving a boost pressure from 10 to 12 lb. per sq. in.

For the Eifel Races of 1937 the cars were run with the long-established Mercedes arrangement of the supercharger supplying pressure air to two twin choke carburetters mounted close to the cylinder block. Although such a scheme offers complete freedom from liquid deposition of fuel even when using extremely rich alcohol mixtures and may possibly give better inter-cylinder distribution it presents other serious problems, particularly air delivery temperatures which lead to distortion of the rotors and casing, which lead in turn to excessive clearances with impaired volumetric efficiency at low engine speeds. As far back as 1924 the Sunbeam Co. had realised the merits of passing fuel/air mixture through the blower and within two years all constructors, other than Mercedes-Benz, had followed this practice. Thirteen years elapsed before this company decided to fall into line but the cars running in the Vanderbilt Trophy on July 5th, 1937; had suction carburetters and these were retained for subsequent events..

The marked effect of this change in the carburation system can be seen by comparing the curves relating b.m.e.p . to piston speed on the M.125 engine and M.25B engines (*vide* Chapter 27). In particular it will be seen that at 2,000 f.p.m. there is an increase of over 18 per cent. in b.m.e.p., a gain following directly on the lowered overall temperature of the ingoing charge, derived from the latent heat of vaporization of the fuel. This was Standard Oil Co.'s W.W.

1937 FUEL FORMULA

Methyl alcohol 86.0 ; Acetone 8.8 ; Nitrobenzene 4.4 ; Sulphuric ether 0.8.

It is not uninteresting to make comparison between the power obtained on this fuel and with 50-50 petrol/benzole mixture. Using two normal fixed choke D-B type carburetter son the suction side of the blower the figures are as follows :

GAIN IN B.H.P. WITH ALCOHOL FUEL

R.P.M.	*B.H.P. 50/50*	*B. H.P. W. W.*	*Gain %*
1,500	147	163.5	11.3
2,000	224	238	11.7
3,000	360	390	8.5
4,000	452	492	9.0
5,000	515	555	8.0
5,500	534	572	7.0
5,800	545	568	4.2

These outputs, for 3 minutes duration, were eclipsed by the use of the " Schiebervergaser. " The " Schiebervergaser " (developed by Herr Scheerer) consisted of a double choke, double jet assembly to which was added a barrel-type throttle which disclosed a very large jet. This third portion of the assembly was used only on wide-open throttle, in which condition the consumption is increased to approximately 2 lb/b.h.p . hour, but with very large gains in power. Thus :

GAIN IN POWER WITH " SCHIEBERVERGASER "

R.P.M.	*B.H.P.*	*B.H.P. Gained*	*B.H.P. Gained %.*
1,500 - - - - - - -	170.5	7	5
2,000 - - - - - - -	248	10	4
3,000 - - - - - - -	406	16	4
4,000 - - - - - - -	525	33	7
5,000 - - - - - - -	610	55	9
5,500 - - - - - - -	625	53	9
5,800 - - - - - - -	646	78	14

The progressive advantage with increasing speed is particularly notable and it is safe to say that no road racing car has ever developed more power than the Mercedes type W.125. One car was timed at 193 m.p.h. on the Spa Circuit, but given a sufficiently high back axle ratio there is no reason to doubt that they could exceed 200 m.p.h. by a useful margin.

Acknowledgements.-Every assistance has been given to the author and artist by the constructors and, in particular, Directors Wagner and Hoppe, Herr Scheerer, and racing mechanic Müller.

DETAILS OF CAR

MAKE.-Mercedes-Benz
TYPE.-W.125
YEAR OF CONSTRUCTION.-1937
YEAR RACED.-1937
DESIGNERS.-Dirs Max Sailer and Wagner, Ob. Ing., Hess and others
WHEELBASE.-9 ft. 2 in.
TRACK FRONT.-4 ft. 10 in.
TRACK REAR.-4 ft. 7 in.
HEIGHT TO SCUTTLE.-41 in. (unladen)
HEIGHT TO DRIVER'S HEAD.-47½ in. (unladen)
FRONTAL AREA.-12½ sq. ft.
UNLADEN WEIGHT.-16.4 Cwt.
ALL-UP STARTING LINE WEIGHT.-21.8 cwt.
MAXIMUM SPEED.-200 m.p.h. with highest gear and largest tyre
SPEED ON GEARS.-According to circuit.
Normal.-166 m.p.h. on Fourth ; 132 m.p.h. on Third ; 114 m.p.h. on Second ; 73 m.p.h. on First at 5,800 r.p.m.
H.P. PER SQ. FT.-51.5
H.P. PER TON UNLADEN.-787
H.P. PER TON ALL-up.-595
BORE.-94 mm.
STROKE.-102 mm.
S./B. RATIO.-1.085:1
No. OF CYLINDERS.-Eight
CAPACITY.-5,660 cc.
PISTON AREA.-86 sq. in.
B.H.P.-646 at 5,800 r.p.m.
H.P. PER SQ. IN.-7.52
B.M.E.P.-252 lb. sq. in.
PISTON SPEED FT./MIN.-3,900
CYLINDER HEAD.-Integral steel
VALVES No.-Four per cylinder
VALVES ANGLE.-60 degrees
VALVE AREA.-Inlet 29.6 sq. in.
VALVE AREA.-Exhaust 29.6 sq. in.
CYLINDER BLOCK.-Forged steel barrels welded together in sets of four with sheet water jackets.
FUEL.-86 per cent Methyl/Alcohol mixture
CARBURETTERS.-One Mercedes-Benz with triple choke tube, and twin-float chamber
SUPERCHARGER.-One Roots at 2.78 engine speed
SUPERCHARGE PRESSURE.-12 lb. boost (1.8 ata.)
IGNITION.-One Bosch magneto
PLUGS No.-Eight
PLUGS LOCATION.-Centre of head
CRANKCASE.-Two-piece light alloy split below centre of main bearings.
CRANKSHAFT.-One-piece counterbalanced
MAIN BEARING No.-Nine
MAIN BEARING TYPE.-Roller
BIG END TYPE-Roller in split housing
LUBRICATION.-Dry sump
CAMSHAFT No.-Two
CAMSHAFT LOCATION.-In head
CAMSHAFT DRIVE.-Train of gears
CAMSHAFT DRIVE LOCATION.-Rear of crank
CLUTCH.-Single plate
GEARBOX LOCATION.-In unit with bevel box
GEAR RATIOS.-3.52, 4.45, 5.15, 8.0
All the above ratios could be varied with circuit.
TRANSMISSION.-Open propeller-shaft inclined to bring bevels 8.8 in. below centre line of hubs. All indirect gearbox with shafts mounted transversely driving exposed half-shafts with double universal joints through spur wheels and Z.F. differential
FRAME.-Oval tube
FRONT SUSPENSION.-Independent to each wheel with wishbones and open coil springs
REAR SUSPENSION.-De Dion type with torsion bar springs
SHOCK ABSORBER TYPE.-Hydraulic
BRAKE SYSTEM.-Lockheed hydraulic
BRAKE DRUM DIAMETER.-15¾ in. internal
BRAKE DRUM WIDTH.-2-3/16 in. front, 3 in. rear
SQ. IN. PER TON LADEN.-290 sq. in.
STEERING.-Worm and nut, 2¼ turns lock to lock
WHEELS TYPE.-Rudge
TYRES FRONT.-5.25 by 17 Continental
TYRES REAR.-7 by 19 Continental ; 7 x 22 or 7 x 24 optional

RACING RECORD OF TYPE W.125

Date	*Event*	*Course*	*Average Speed*	*Lap Speed*
13/6/37	Eifel Races	Nürburg Ring	82.2 m.p.h. (2nd)	84.8 m.p.h.
11/7/37	Belgian G.P.	Spa	102.2 m.p.h. (3rd)	108.8 m.p.h.
2/10/37	Donington G.P. . .	Donington	82.57 m.p.h. (2nd)	85.62 m.p.h.
25/7/37	German G.P.	Nürburg Ring	82.77 m.p.h.	85.56 m.p.h.
8/8/37	Monaco G.P.	Monte Carlo	63.27 m.p.h.	66.8 m.p.h.
22/8/37	Swiss G.P. . . .	Berne	98.55 m.p.h.	107.14 m.p.h.
12/9/37	Italian G.P.	Leghorn	81.5 m.p.h.	84.5 m.p.h.
26/9/27	Czechoslovak G.P. . .	Brno	85.97 m.p.h.	94.89 m.p.h.

EXAMPLE No. SEVENTEEN

Mercedes-Benz Type W.163

IN September, 1936, the A.I.A.C.R. agreed that racing for the years 1938, '39 and '40 should be governed by a sliding scale relationship between a minimum weight and a maximum engine capacity. The upper limit of cylinder volume was set at 3-litre supercharged and 4½-litre unsupercharged, and cars with either of these size of engines had to weigh not less than 850 Kg. or 16.7 cwt. with wheels and tyres.

The new formula was designed to limit racing car performance. In this it was admittedly successful, but the art of the designer was so exercised that the reduction in sheer speed was less than might have been anticipated, and in 1939 the smaller cars were as fast on a circuit as the 650 b.h.p. models built two years previously.

Performance was sustained in the face of reduced engine capacity by increasing piston area, r.p.m. and supercharge pressure (that is to say by maintaining as far as possible the weight of air handled per minute), by reducing the various resistances and finally by improving braking and road holding.

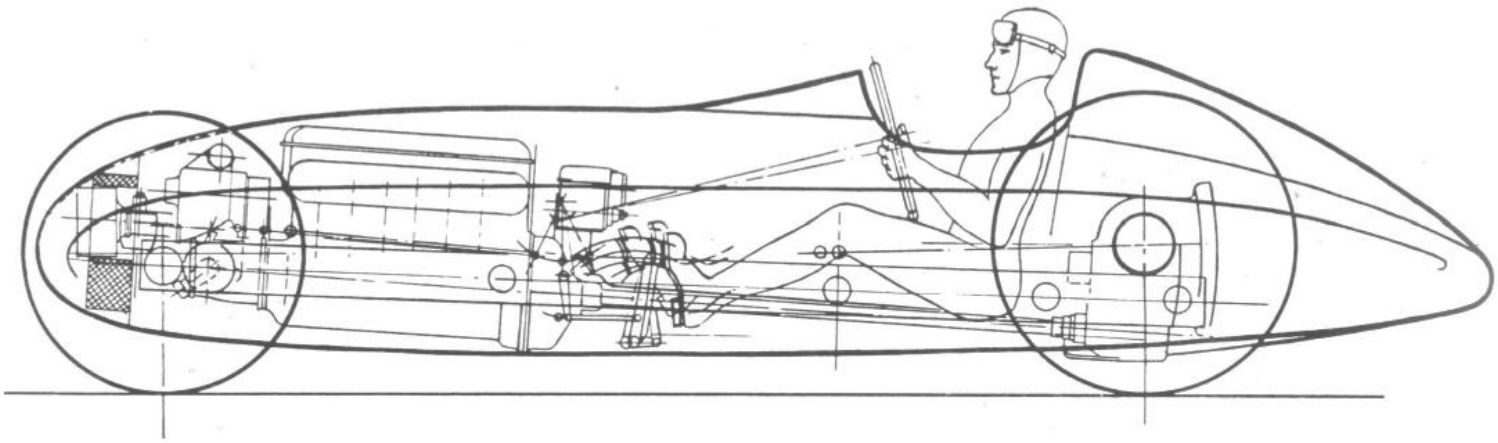
By using twelve cylinders in V formation in place of eight cylinders in line piston area fell by only 26 per cent, although cylinder volume was reduced by 47 per cent as between 1937 and 1938. Engine r.p.m. were raised from 5,800 to 7,800, i.e. by 35 per cent, and the absolute manifold pressure from 27 lb. per sq. in. to 34 lb. per sq. in., i.e. by 26 per cent. The net effect of all these changes was a drop in power of some 30 per cent.

The formula limited the extent to which this reduction in power could be offset by changes in chassis design or body form, for the minimum weight limit prevented the h.p. per ton factor being adjusted to meet the lower gross output and a minimum body width of 85 cm. (339 in.) prevented any substantial reduction in frontal area.

The form of the body was refined with a view to reducing drag, but as the total wind resistance (wind and tractive losses) of the tyres accounts for at least half the power required to drive the car at high speeds it is obvious that no practical changes in body form could produce any large change in overall drag. Experience with the short chassis 1936 car had already indicated paramount need for softer springing and the highest possible polar moment of inertia, and on fundamental grounds it was obviously desirable that soft springing should be coupled with the lowest possible centre of gravity.

Keeping all these factors in mind the Mercedes-Benz design department had a general scheme for the 1938 3-litre type 154 on the drawing board by March, 1937. A completed car was ready for test at Monza twelve months afterwards in March 1938 The type W.163 was a slightly modified type 154 used for the 1939 season and a broad description covers both models.

The 5.6-litre type W.125 had proved a highly successful design, particularly from the viewpoint of road holding and general control, but in order to meet the particular requirements which have been specified above the height of the 3-litre car was very much reduced by decreasing the stroke from 102 mm. to 70 mm. and placing the cylinders in V formation. The top of the engine was brought within 29 in. from the ground at its highest point at the front of the car. In the mid part of the car the seat was dropped so that the top of it came only 9¼ in. from the ground (an arrangement made possible only by a substantial change in the transmission arrangements). As a consequence of these two modifications it became possible to lower the height of the scuttle from 41 in. to 34½ in. These changes did not substantially affect the frontal area as the new design was much wider than its predecessor, but they did enhance the



The low overall height of the V.12 engine can be seen in this drawing which was produced in 1937 during the project stage of the 3-litre design.

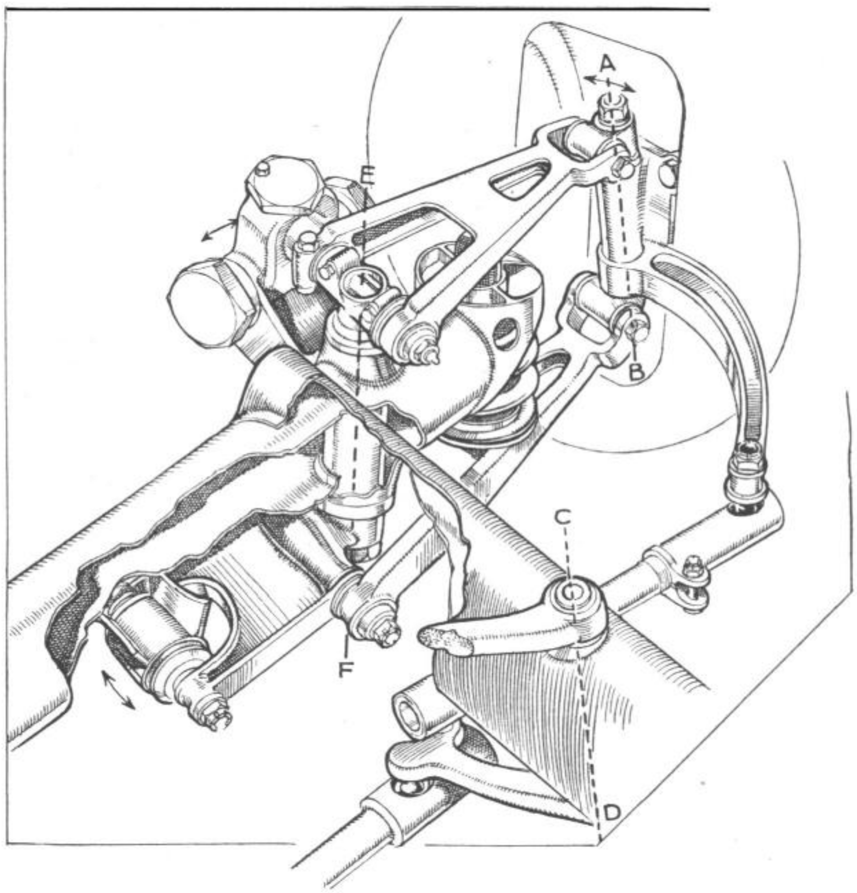
general stability. The frame and suspension of the 3-litre cars were almost identical with the 1937 units. The wheelbase was reduced by approximately 2½ in., the track remained unaltered and the frame was an identical conception comprising oval tubes (130 mm. deep and 90 mm. wide at the largest section), cross-braced with four round tubes. The construction was fully welded in nickel-chrome molybdenum steel 14 mm. thick, and the total weight was approximately 1 cwt.

The rear suspension units, that is to say De Dion cross tube, suspension levers and torsion bars, were identical with the W.125 which have been previously described in detail, and the front suspension system very similar except that whereas the wishbones on the previous car were offset downwards in relation to the wheel centre, on the later model they were raised so as to be almost equally placed above and below the hub centre.

A detail feature of considerable interest used on all the Mercedes-Benz cars has not yet been fully described and is certainly worthy of comment. Prior to 1934 the fastest cars built by the company had been SSK type with rigid front axle and semi-elliptic springs. These suffered from wheel patter and cure was sought in the " kick shackle " popularised by Packard in America. With this arrangement the front axle was given horizontal float by mounting it on two shackles on one side, the degree of float being limited by a spring.

When wishbone type I.F.S. on the 500K model was introduced in 1934 it was thought wise to retain this anti-shimmy device and in due course the 500K design found its way on to the racing cars.

A detail drawing shows how the inner wishbone bearings are mounted on a pivot attached to the frame with fork extension piece running inboard from the bottom of the pivot. This fork embraces a rubber stop which is designed to permit a latitude of plus or minus a quarter of an inch on the king-pin. This movement was determined empirically by *ad hoc* experiment with various coil spring pressures and it is worth noting that the arrangement was used for both front wheels and that it was necessary



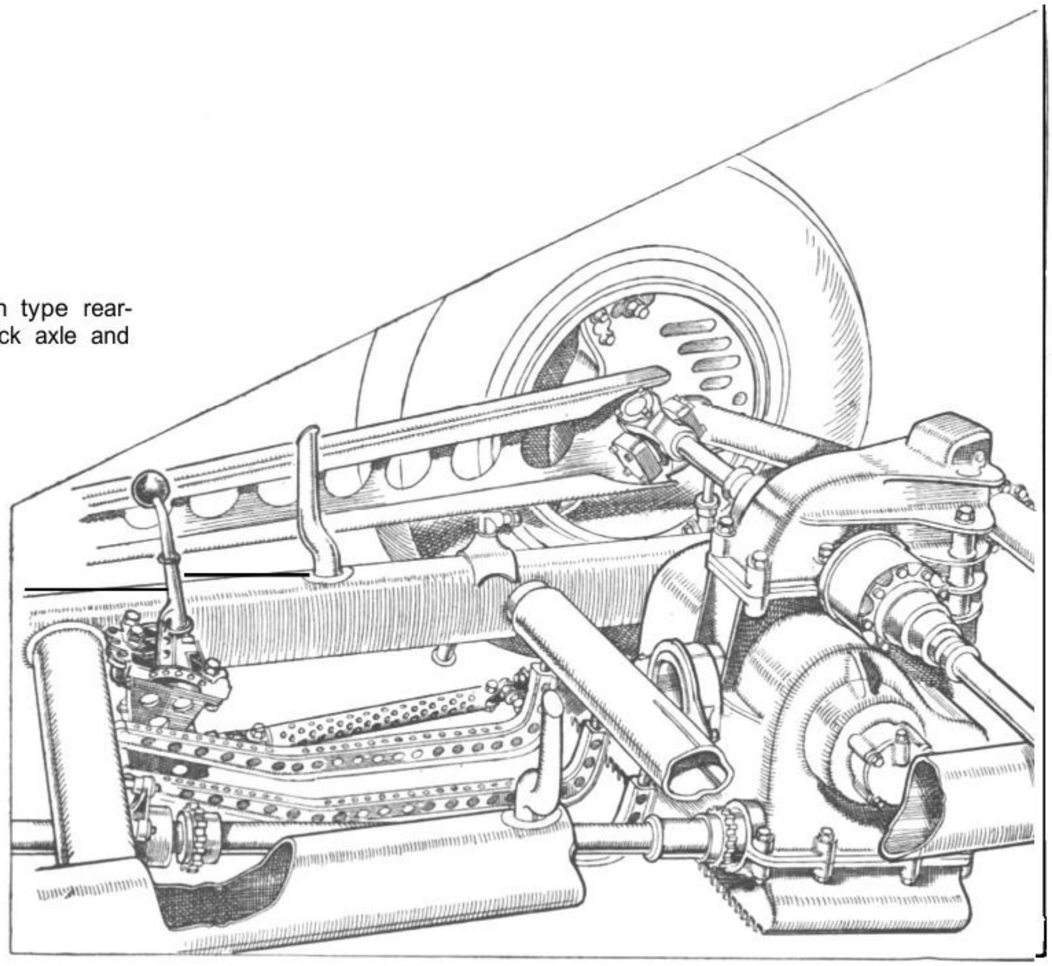
Detail of front suspension referred to on this page.

to mount the hydraulic piston-type shock absorbers so that they, also, could move with the wishbones although restrained in the other planes of motion. The whole assembly was mounted on a round cross tube welded into the main oval frame members, the castor angle of 6 degrees being determined by the welding and machining of the pivot point. At the outer end of the wishbones a particular feature is the extreme length of the king-pin, steering being through a short track rod pivoting around the same centre as the bottom wishbone link. This short track rod was linked to a swinging arm which was mounted on another pivot welded into the frame, this being inclined through the same angle as the king-pin so as to give the utmost accuracy in steering.

Referring to the detail drawing it has to be appreciated that AB and EF are both inclined backwards at 6 degrees and that AB is also inclined in the vertical plane to give an offset of 1¼ in. between the projection of the king-pin and the tyre centres. CD matches the angles of AB.

The type W.163 saw a very marked improvement in the design of the brake drums. Two stiff light alloy shoes, each with its individual operating piston, were used in each drum and the diameter and width of the drum were as large as possible within the limits of rim diameter and unsprung weight. The drum itself was made in light alloy with an inserted steel liner and the novelty in its construction lay in the design of the stiffening and cooling ribs formed around its periphery. On all previous racing cars these ribs had been circumferential, but on the type W. 163 transverse vanes were set at an angle across the rim of the drum and were then encased by a light alloy sheet. By this means air entered, passed from the side of the drum and was expelled centri-

Detail of the De Dion type rear-end with combined back axle and gearbox



fugally through the extreme rim with a considerable lowering of both drum and lining temperature. Air circulation through the inside of the drum was effected by cutting large holes in the side face and arranging that the turbine-like fins had connection with the inner part of the drum and were thus able to draw air right past the friction linings.

The brakes used on the 1939 Mercedes-Benz were an improvement on anything that had previously been used in racing car practice and they contributed not a little to the very high average speeds that these cars could put up on difficult circuits such as the Nürburg Ring.

In addition to improved braking there is no doubt that the measures taken to lower the centre of gravity were effective in increasing the controllability of the cars and the maximum of permissible speed on a given radius curve.

As has been previously mentioned, this low centre of gravity was based upon a major change in the transmission of the car.

On all the eight-cylinder Mercedes-Benz cars the propeller shaft was mounted substantially lower than the wheel hub centres. On the first design (W.25) a pair of step-down gears lowered the shaft by 3½ in. Modification was introduced for 1936

(W25 E) in which the final drive was through a pair of spur wheels, the gears being disposed on each side of the centre line of the car. The drive was thus from the bevels to a primary gear shaft, thence to a secondary gear shaft, and thence to the final spur wheels, and thus lowered the propeller shaft by 9.8 in. The types 154 and 163 saw this expedient carried still further. Five speeds were employed and the bevels were offset by 10.8 in. to the left-hand side of the car, the engine being given a pronounced horizontal inclination so as to provide a straight run for the propeller shaft, which had no universal joints. The engine and propeller shaft line were also inclined downwards so that at the centre point the bevel pinion was 11.2 in. below the centre line of the wheels.

With this arrangement it was possible to bring the seat frame well below the level of the propeller shaft without offsetting the driver in the car and to combine a very low centre of gravity with minimum frontal area and first-class visibility.

The gears were controlled by a right-hand gate and a locking mechanism prevented accidental jumping out of gear. It will be appreciated that the gear ratios could be changed by alteration in the bevel pinions, in all the five gears attached to the primary or secondary gear change, or in the final spur drives. A very large combination of engine to road speeds could thus be provided and a feature of the Mercedes-Benz racing department was a close survey of road circuits leading to an analysis of the required ratios. It is worth setting out in a table some of the principal variations employed during 1939 :

ROAD SPEED AT 7,500 R.P.M. ON W.163

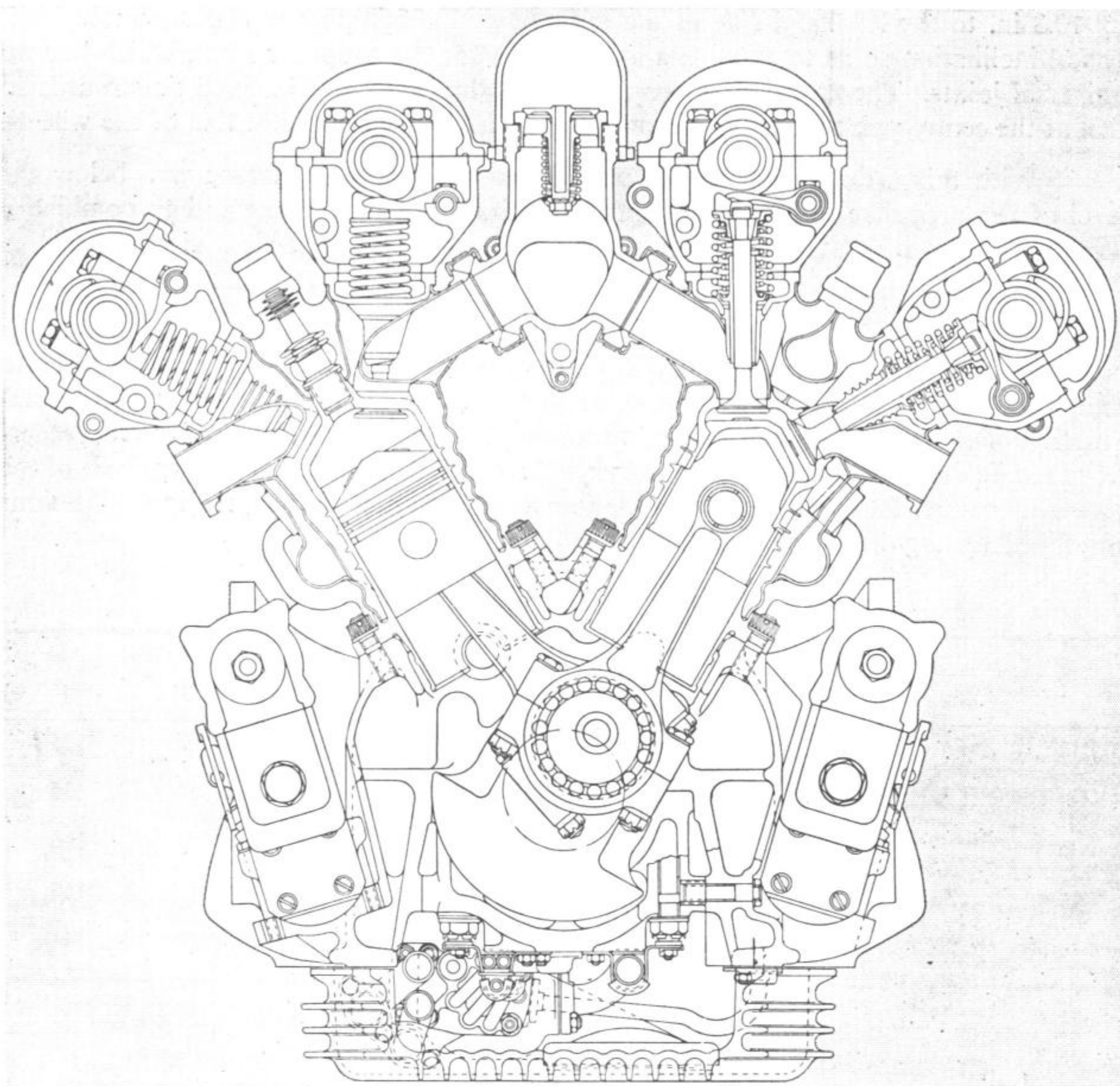
Race	*Tyres*			*M.P.H.*		
		I	*II*	*III*	*IV*	*V*
Pau	7.00-19	37	53	87	107	125
Rheims	7.00-22	77	94	129	150	185
Nürburg	7.00-19	58	104	129	151	188
Berne	7.00-22	59	95	130	152	168
Belgrade	7.00-19	55	89	109	128	141

One can probably add 5 per cent to the above figures as representing the maximum speeds which were possible on any given ratio as the engine peaked at 7,800 r.p.m. and cases were known of 10,000 r.p.m. being realised in the lower ratios.

The reduced height of the engine was matched by a major change in the layout of the cooling services. On the type 154 the height of the radiator was reduced to 27 in. from the ground and the required total cooling area of 1.1 sq. ft. was attained by increasing the width to 31 in.

On the W.163 this process was carried a stage further and the radiator core put forward 3½ in. and reduced in depth from 6 in. to 4 in. From 1937 onwards the coolant was 100 per cent ethylene glycol running in a closed system with blow-off valves set at 7½ lb. above atmospheric pressure. The engines ran at approximately 100 degrees C. and it is computed that the cooling drag was less than 10 per cent of the total. This covers both glycol and oil temperature reduction and a large section of the right-hand part of the radiator core was devoted to oil cooling. A novel feature, present on the type M.163 only, was a fuel radiator mounted separately ahead of the main core.

Throughout 1938 the cars were troubled with difficulty in starting after a pit stop due to vapour lock and boiling of the lighter fractions of the alcohol mixture



As a combination of high power output with compactness and low frontal area the 2.96-litre Mercedes-Benz V.12 represents the highest pinnacle of the designer's art. This quarter-scale cross-section shows the principal features of the construction.

(8.8 per cent acetone and 0.8 per cent sulphuric ether), one reason for this being the very high proportion of under-bonnet space occupied by the engine and consequently extremely rapid rise in under-bonnet temperature once the car was brought to rest.

When this design was introduced in 1938 (Ml54) a great deal of trouble was experienced with " frothing " and consequent loss of oil from the crankcase. This was undoubtedly caused by greater r.p.m., which led in turn to piston ring flutter and blow-by into the crankcase. This was cured relatively easily, but with the more complicated internal construction of the V12 engine, scavenging of the crankcase, and return

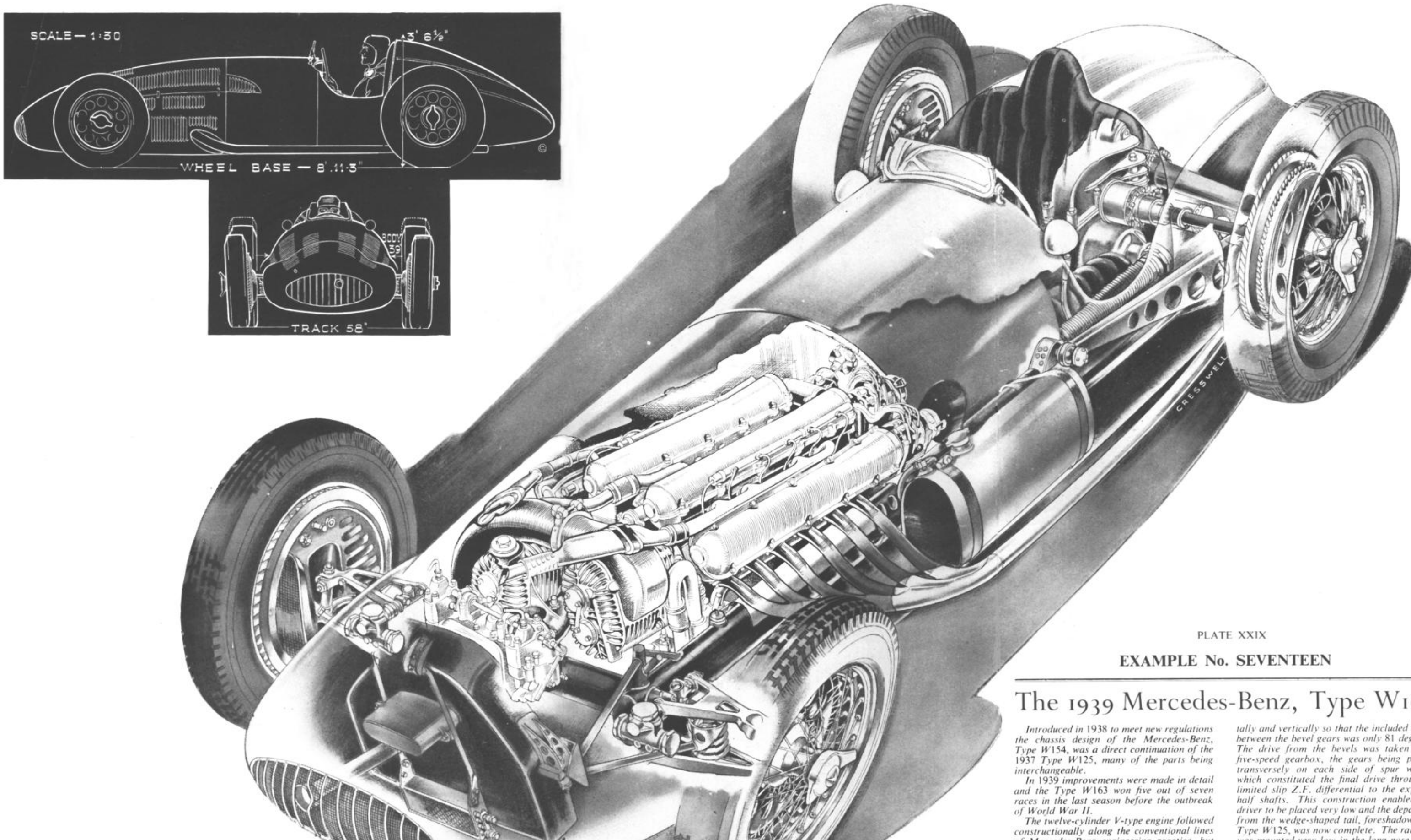


PLATE XXIX

EXAMPLE No. SEVENTEEN

The 1939 Mercedes-Benz, Type W163

Introduced in 1938 *to meet new regulations the chassis design of the Mercedes-Benz, Type W*154, *was a direct continuation of the* 1937 *Type W*125, *many of the parts being interchangeable.*

In 1939 *improvements were made in detail and the Type W*163 *won five out of seven races in the last season before the outbreak of World War II.*

The twelve-cylinder V-type engine followed constructionally along the conventional lines of Mercedes-Benz engineering practice, but owing to the small size of the cylinders it was possible to raise the crankshaft speed to 7,800 *r.p.m. In conjunction with a high supercharge pressure from two Roots blowers working in series it was possible to obtain* 483 *b.h.p. at maximum engine speed. In order to make the utmost use of this speed the engine was installed at an angle in the frame and the propeller shaft offset both horizontally and vertically so that the included angle between the bevel gears was only* 81 *degrees. The drive from the bevels was taken to a five-speed gearbox, the gears being placed transversely on each side of spur wheels which constituted the final drive through a limited slip Z.F. differential to the exposed half shafts. This construction enabled the driver to be placed very low and the departure from the wedge-shaped tail, foreshadowed in Type W*125, *was now complete. The radiator was mounted very low in the long nose cowling, and frontal area and drag co-efficient reduced to the minimum possible for a road-racing car. In consequence, despite a reduction in maximum power enforced by the* 3*-litre capacity limit this* 1939 *design was little inferior to the* 1937 *predecessors on fast courses and on exceptionally twisty courses could actually show better circuit speeds.*

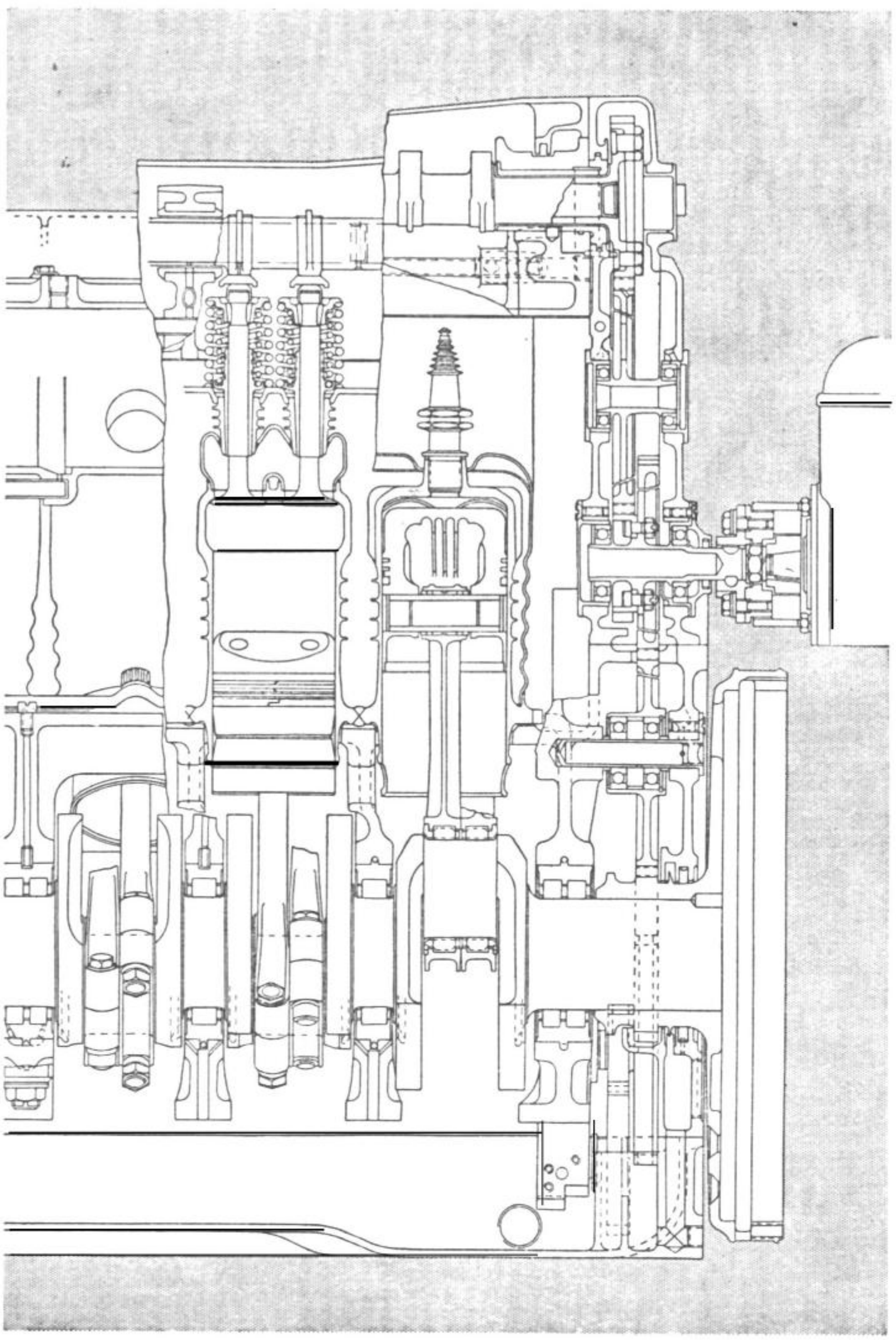
of oil into the external tanks, presented many serious problems which persisted during the first half of the 1938 season. Detail changes brought relief, whilst the problem was entirely cured in the 1939 engines, which were equipped with no fewer than nine separate oil pumps, detail application being carried so far that even the supercharger gear casing had its own individual scavenger pump.

Reduced engine size and increased supercharged pressures resulted in very heavy specific road consumption, it being something under 3 m.p.g. In order, therefore, to traverse, say, 200 miles non-stop with a certain margin in hand a minimum capacity of, say, 70 gallons was required. In point of fact, on the type W.163 the tank capacity was 88 gallons, and in order to accommodate this it became absolutely essential to use more than the space available in the tail of the car which offered a maximum of 50 gallons. In fact, on these cars the tail tank carried 48 gallons, a further 40 gallons being contained in a large saddle tank which formed virtually the dash structure. In view of the disastrous results likely to result from a leak in a tank placed so close to the ignition apparatus and exhaust system it was three-point mounted in order to relieve it from strain due to flexing of the chassis. The tanks had a common filler orifice at the back. It will be observed that the weight of the car would vary by more than 5 cwt. as between the car leaving the starting line with the tank full and running nearly empty before the replenishment stop, this figure being over 20 per cent of the all-up weight. In consequence weight distribution was bound to vary and the 60 per cent carried on the rear wheels on the starting line would drop 52-53 per cent. To mitigate the consequences of this change in trend the driver was provided with a " ride control " whereby the damping of the rear shock absorbers could be varied as the level of the tanks fell.

A scale drawing illustrates the extremely compact engine installation, although the drawing, in fact, is an early project and does not represent either the body lines or radiator mounting which was finally used. In particular, on the 1939 car the radiator core was very closely cowled by the forward part of the bonnet, which projected well ahead of the leading edge of the front tyre. A ram effect was achieved in this way at high speeds, which would improve both cowling efficiency and give a slight boost on the air intake, which would be balanced by the small flexible pipes running to the sealed float chambers. The carburetter was of the Mercedes-Benz Schiebervergaser type. This consisted of a single casting embracing two jet and choke assemblies, two float chambers and accelerator pump. The horizontal choke assemblies were separated by a third passage containing a barrel-type throttle, which was opened from shut to fully open with the least fraction of an inch of movement on the accelerator pedal.

A jet 3 mm. diameter was then disclosed giving a substantial enrichment of the alcohol mixture, which was a Standard Oil Co.'s W.W., as used on the 1937 vehicles.

On the 3-litre engines two superchargers were mounted horizontally and driven by spur wheels from the nose of the crankshaft. The supercharge drive was through a spring drive and a friction clutch, having thirteen plates, through which the mass of the rotors acted as a damper to the crankshaft. The drive location of the blowers were identical as between the 1938 type M.154 and the 1939 type M. 163, but whereas the former had two equal-sized blowers working in parallel, the latter had two unequal-sized blowers working in series. On the 1938 car the rotor dimensions were 106 mm. diameter by 150 mm. long, each having a theoretical delivery of 1.07 litres and being driven at 2.78 times the engine speed. Thus, the total delivery of both blowers was 5.65 litres per crankshaft revolution, or 3.8 times the engine swept volume. With a volumetric efficiency of 60 per cent, this is the equivalent to a boost pressure of *circa* 18 lb. sq. in., which is very much higher than is theoretically desirable for a Roots-type blower, which has no internal pre-compression. The power absorbed in the blowers was, in fact, over 150 b.h.p., and in 1939 a development programme was initiated to reduce this loss. Experiments with Vane-type superchargers with an internal compression ratio proved that developments were required to achieve mechanical reliability, and this led to the use of a pair of Roots blowers working in two stages. The first stage comprised a blower with rotors 125 mm. diameter and 220 mm. long with a capacity



This drawing reveals the widespread use of roller bearings on the Type M.163 engine, the use of split housings, and a one-piece crankshaft, being a well-tried feature of these cars. This drawing also portrays the welded-up construction used for the cylinders.

of 1.73 litres. This was driven at 2.55 times engine speed, at which ratio the delivery was equal to 18 lb. boost at a volumetric efficiency of 75 per cent. The intermediate-stage blower was driven at the same speed and had rotors 125 x 125 mm., the capacity thus being approximately 0.55 that of the first stage. By this means the pressure rise across each blower was kept below 15 lb. On all Mercedes-Benz engines the top speed of the supercharger rotors was limited to approximately 400 ft. per second, and this factor may be considered to set a limit on the blower r.p.m. There are obviously considerable advantages to be derived from gearing up of the blowers, both in respect of obtaining maximum output for a given size and weight, and also in keeping a flat delivery curve and avoiding a fall in boost pressure leading to reduced b.m.e.p. in the lower part of the speed range curve. On the Ml54 and Ml63 the b.m.e.p. curve was, in fact, almost flat from 3,000 up to 5,000 r.p.m., but it must be admitted that on these high speed V12 engines carburation defects gave irregular response to wide throttle opening below 4,000 r.p.m. The normal operating speeds for these engines lay, therefore, between 4,500 and 7,500 r.p.m.

Conjointly with the change in supercharging arrangements valve timing was modified, the differences between 1938 and 1939 being as follows :

VALVE TIMING ON 3-LITRE MERCEDES-BENZ CARS

	Type 154	*Type* 163
Inlet open	28 degrees b.t.d.c.	40 degrees b.t.d.c.
Inlet closes	58 degrees a.b.d.c.	67 degrees a.b.d.c.
Exhaust opens	53 degrees b.b.d.c.	47 degrees b.b.d.c.
Exhaust closes	33 degrees a.t.d.c.	31 degrees a.t.d.c.

Together these changes resulted in a marked increase in engine output which is disclosed in some curves. The percentage gains as between the engine as originally tested and as finally run in 1939 were as follows :

PER CENT GAIN IN ENGINE OUTPUT OF 1939 M.163 OVER 1938 TYPE M.154

R.P.M.	*Per Cent Gained*
3,000	134
4,000	10
5,000	9
6,000	9½
7,000	14.35
7,500	12

During the 1939 racing season it was rumoured that the type M.163 was using direct fuel injection into the cylinders. A design was, in fact, prepared as early as 1937, using two of the well-known Bosch fuel-pump injectors into the inlet ports, but owing to disappointing results on a single-cylinder test rig no full-scale engine trials were carried out. The tests showed that with fuel injection, 146.3 h.p. per litre was realised at a piston speed of 3,450 f.p.m., whereas with normal fuel-air aspiration through a blower 166.5 h.p. per litre was obtained at 2,600 f.p.m.

The general structure of the 1938 and 1939 engines was identical and showed no great departure from previous Mercedes-Benz practice, except that, in order to raise the piston area to a maximum in relation to cylinder volume, twelve cylinders in V formation were used. The company had prior experience of this type on record breaking engines of 5.57-litre capacity built in 1936, but the 3-litre engines were, of course, an entirely new design. They weighed substantially more than the type M. 125 eight-cylinder of nearly twice the cylinder capacity, the exact figures being 5.66-litre type M.125, 486 lb. ; twelve-cylinder 3-litre type M.154, 558 lb. ; twelve-cylinder 3-litre type M. 163, 603 lb.

The imposition of a capacity limit, it will be noted, increased the weight of the engine from 0.7 lb. per b.h.p. to 1.25 lb. per b.h.p., but with the change from a maximum to a minimum weight limit this was not a decisive factor. The general arrangement drawing shows how the cylinders were built up in blocks of three, the general construction being exactly similar to the previous models, including a deep spigot into the crankcase.

The latter followed the lines of the last of the eight-cylinder type, being split very much below the centre line and having tie-bolts threaded into the main-bearing caps in order to assist lateral rigidity of the crankcase. The six-row crank ran in seven-roller main bearings, the journals being 60 mm. diameter and the crankpins 54 mm. The cylinder centres were offset by 18 mm. and the connecting rods were mounted side by side on the pins, the big ends being split, as were the cages for the rollers. The two halves were connected by a pair of big-end bolts for each rod, the joint between them being serrated so as to provide for maximum accuracy in assembly and the reduction of distortion when pulling up the big-end bolts, a point of particular importance when the rollers were running direct in hardened tracks in the eye of the big end.

The main bearings used 10 mm. by 14 mm. rollers, the big ends being smaller, viz., 8 mm. by 12 mm. At the very high rotational speeds of which these engines were capable (up to 9,000 r.p.m.), fretting of the roller-bearing cages and break-up of the big ends was a not uncommon trouble, and the design department had in mind a radical change in policy embracing the use of one-piece big ends and cages, with built-up crankshaft on the Hirth system.

The drawing shows the very careful design of the rod, and the diameter of the gudgeon pin (20 mm. or 30 per cent of the cylinder diameter) shows a definite increase as compared with the earlier cars running on a much lower boost pressure.

The rod measured 151 mm. between centres, that is stroke x 2.15. It was thus a good deal longer in proportion than on the eight-cylinder engine, in which the connecting rod measured 168 mm. between centres or stroke x 1.62.

The steeply domed light-alloy pistons were constructed by Mahle and the very low mounting of the piston rings in relation to the crown was a point of particular interest and shows that the designers had appreciated the very large gas loading which can be imposed with comparatively high supercharged pressures.

The total mass of the reciprocating parts was approximately 2.8 lb., and although the connecting rod is obviously designed for minimum weight, it is equally obvious that in the piston considerations of rigidity and heat dissipation have been regarded as being of primary importance.

The lubrication of the system consists of jets feeding the main bearings at low pressure with further passages drilled on a tangent to oil-collector rings machined in cheeks of the crank webs. At this point centrifugal force passes the oil through the hollow crankpin to the big ends, gudgeon pins being lubricated solely by splash.

The dry sump system was employed, a large oil tank being mounted on the near side of the car.

In the early stages of development serious trouble was experienced with oil being blown out of the crankcase through the breather pipes. High output V-type engines are liable to this trouble, due to the exceedingly small cubic content of the crankcase in relation to that of the cylinders.

There were separate systems covering the crankshaft, camshafts and super-charger drive, and very great care was taken throughout the design to meter the oil through the crankshaft so that each bearing received the same quantity. Equal attention to detail can be observed in the fine-gauze filters which are embodied in the camshaft delivery system.

The intermediate timing wheels provided a drive for the two Bosch magnetos, which were mounted on an overhanging bracket attached to the rear of the timing cover. The final gears were bolted to the camshafts, which were supported in plain bearings and opened the valve through trailing fingers. The valve lift was approximately 8 mm., the valves being 30 mm. diameter inclined at an included angle of 60 degrees. With four valves per cylinder, the total inlet-valve area thus came to 26.2 sq. in., the power developed being 18.6 b.h.p. per sq. in. of valve area. The sparking plug was mounted directly upon the apex of the pent-roof-type cylinder head, and 18 mm. Bosch plugs were used. These were generally type No. 490.

The forward end of the engine carried gears giving a right-angle drive to the fuel pump on the near side of the coolant pump on the off side of the engine. The former was a fully mechanical aviation type and the latter of the conventional centrifugal form, supplying Glycol to external manifolds and to the base of the steel cylinder blocks. Individual coolant off-take pipes were mounted on the top of the cylinder heads, the radiator header tank being just high enough to avoid the necessity for any separate tank above the level of the head.

Despite every technical endeavour the 1939 3-litre cars were not able to match the 1937 models in power per sq. ft. or per laden ton. They were thus inevitably slower in respect of acceleration, but owing to the improved form of the body there appeared to be little difference in the maximum speeds actually realised on the road. The earlier cars, moreover, had really too much surplus power for the mental comfort of their drivers, and the 1939 models were certainly superior in the important matters of stability and braking. As a consequence the 1939 Mercedes-Benz cars may claim to have been the fastest cars in the world on a road circuit.

DETAILS OF CAR

MAKE.-Mercedes-Benz
TYPE.-W. 163
YEAR OF CONSTRUCTION.-1939
YEAR RACED.-1939
DESIGNER.-Oberings Wagner and Hess under Dir. Max Sailer
WHEELBASE.-8 ft. 11.3 in.
TRACK FRONT.-4 ft. 10 in.
TRACK REAR.-4 ft. 7 in.
HEIGHT TO SCUTTLE.-34½ in.
HEIGHT TO DRIVER'S HEAD.-42½ in.
FRONTAL AREA.-12.5 sq. ft.
UNLADEN WEIGHT.-17.6 cwt.
ALL-UP STARTING LINE WEIGHT.-24.1 cwt.
MAXIMUM SPEED.-195 m.p.h. at 7,800 r.p.m.
SPEED ON GEARS.-According to circuit. For German G.P. Nürburg Ring.-195 m.p.h. on Fifth ; 157 m.p.h. on Fourth ; 133 m.p.h. on Third ; 109 m.p.h. on Second ; 60 m.p.h. on First at 7,800 r.p.m.
H.P. PER SQ. FT.-39
H.P. PER TON UNLADEN.-550
H.P. PER TON ALL-UP.-405
BORE.-67 mm.
STROKE.-70 mm.
S./B. RATIO.-1.045 : 1
NO. OF CYLINDERS.-Twelve
CAPACITY.-2,962 c.c.
PISTON AREA.-65.5 sq. in.
B.H.P.-483 at 7,800 r.p.m.
H.P. PER SQ. IN.-7.95
B.M.E.P.-270 lb. sq. in.
PISTON SPEED FT. PER MIN.-3,600
CYLINDER HEAD.-Integral steel
VALVES No.-Four per cylinder
VALVES ANGLE.-60 degrees
VALVES AREA-Inlet 26.8 sq. in.
VALVES AREA EXHAUST.-26.7 sq. in.
CYLINDER BLOCK.-Forged steel barrels welded together into four sets of three with sheet water jackets and mounted in V formation with two sets per bank at an included angle of 60 degrees
FUEL.-86 per cent Methyl Alcohol mixture
CARBURETTERS.-One Mercedes-Benz with triple choke tube, and twin float chamber
SUPERCHARGERS.-Two Roots in series giving two-stage boost.
SUPERCHARGE PRESSURE.-26.5 lb. boost (2.86 ata.)
IGNITION.-Two Bosch magnetos
PLUGS NO.-Twelve
PLUGS LOCATION.-Centre of head
CRANKCASE.-Two-piece light alloy split below centre of main bearings.
CRANKSHAFT.-One-piece counterbalanced
MAIN BEARING NO.-Seven
MAIN BEARING TYPE.-Roller
BIG END TYPE.-Roller in split housing
LUBRICATION.-Dry sump
CAMSHAFT NO.-Two per bank
CAMSHAFT LOCATION.-In head
CAMSHAFT DRIVE.-Train of gears
CAMSHAFT DRIVE LOCATION.-Rear of crank
CLUTCH.-Single plate
GEARBOX LOCATION.-In unit with bevel box
GEAR RATIOS.-Varied with circuit. For German G.P. 4.0, 4.97, 5.8, 7.2, 10.6:1
TRANSMISSION.-Open propeller shaft inclined downwards to bring bevels 11.2 in. below hub centre line and inclined sideways to end transmission line 10.8 in. offset to nearside of car. All indirect gearbox with shafts mounted transversely driving exposed half-shafts with double universal joints with spur wheels and Z.F. differential
FRAME.-Oval tube
FRONT SUSPENSION-Independent to each wheel with wishbones and open coil springs
REAR SUSPENSION.-De Dion type with torsion bar springs
SHOCK ABSORBER TYPE.-Hydraulic
BRAKE SYSTEM.-Lockheed hydraulic
BRAKE DRUM DIAMETER.-16½ in. internal
BRAKE DRUM WIDTH.-3 in.
SQ. IN. PER TON LADEN.-510 sq. in.
STEERING.-Worm and nut, 2¼ turns lock to lock
WHEELS TYPE.-Rudge
TYRES FRONT.-525 by 17 Continental
TYRES REAR.-7 by 19 Continental

RACING RECORD MERCEDES-BENZ TYPE W.163

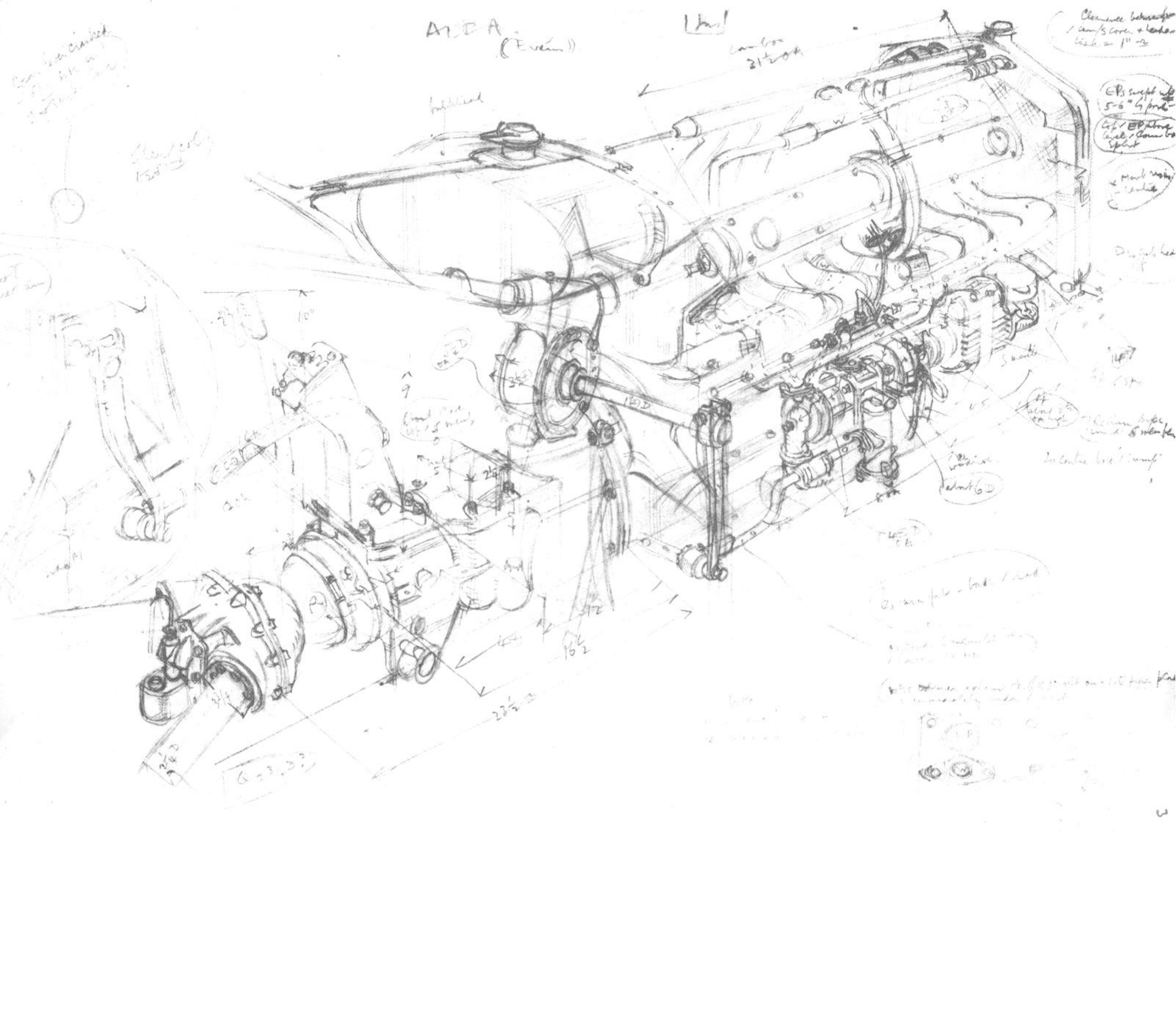
Date	*Event*	*Course*	*Average Speed*	*Lap Speed*
2/4/39	Pau Grand Prix ..	Pau	56.09 m.p.h.	57.83 m.p.h.
21/5/39	Eifel Races	Nürburg	84.14 m.p.h.	86 m.p.h.
26/6/39	Belgian Grand Prix ..	Spa	94.39 m.p.h.	109.12 m.p.h.
9/7/39	French Grand Prix ..	Rheims	Non-finisher	117.5 m.p.h.
23/7/39	German Grand Prix ..	Nürburg	75.12 m.p.h.	87.5 (P) m.p.h.
20/8/39	Swiss Grand Prix ..	Berne	96.02 m.p.h.	106.23 (P) m.p.h.
3/9/39	Yugoslav Grand Prix ..	Belgrade	81.03 m.p.h. (2nd)	83.9 (P) m.p.h.

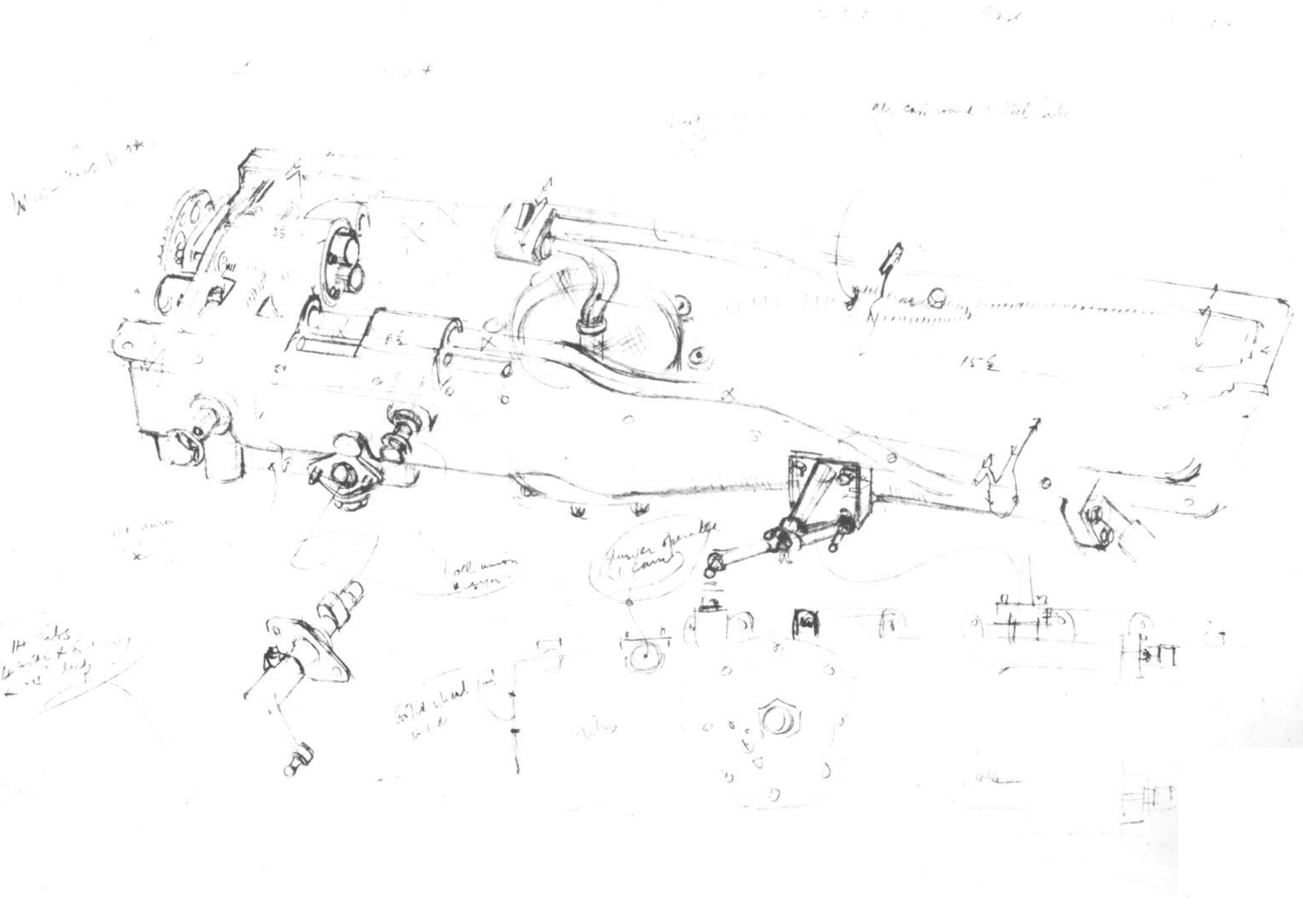
PORTFOLIO OF SKETCHES BY L. C. CRESSWELL

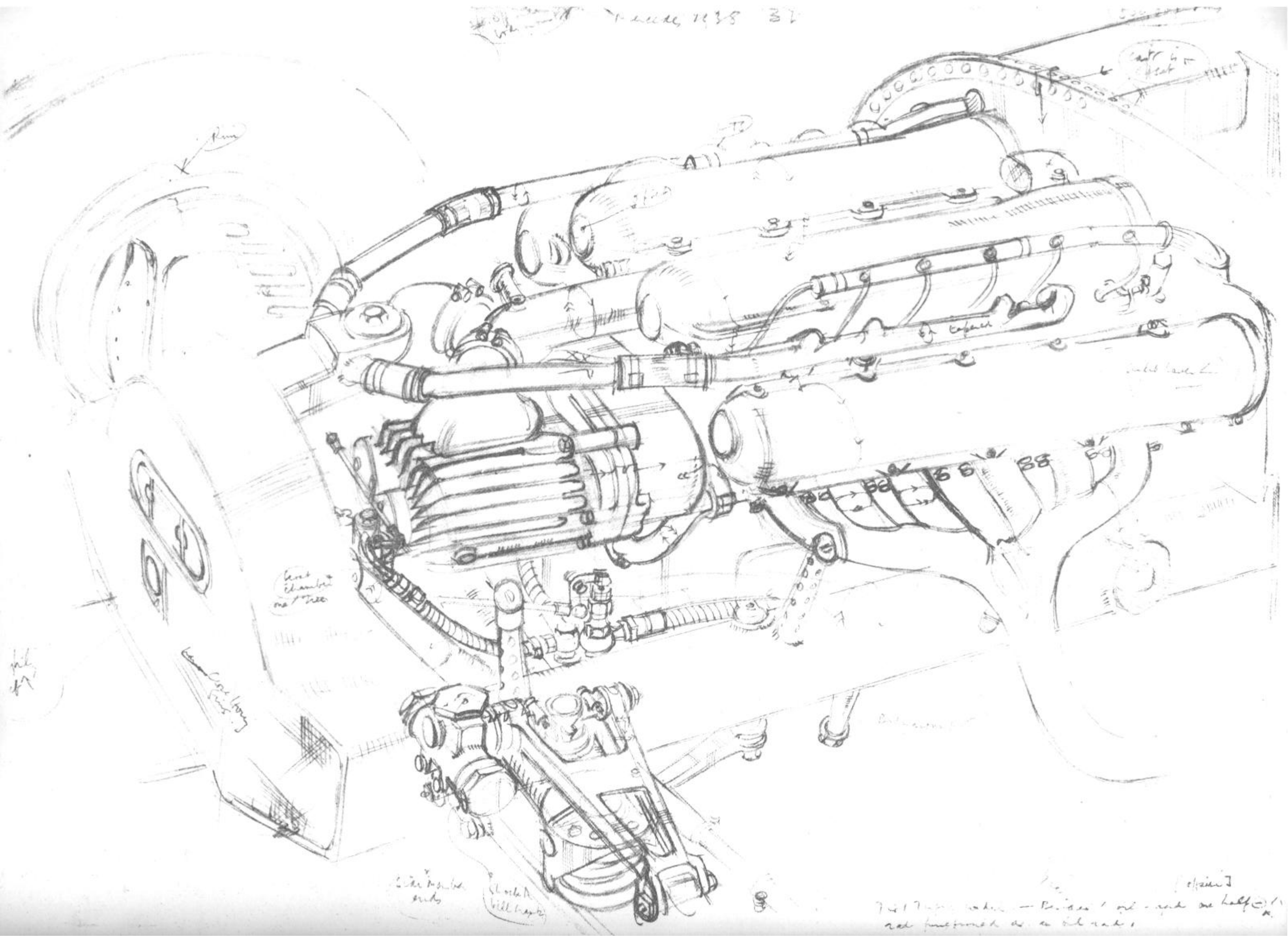
This portfolio of twelve original sketches by the artist who has illustrated this book is included in compliment to his skill.

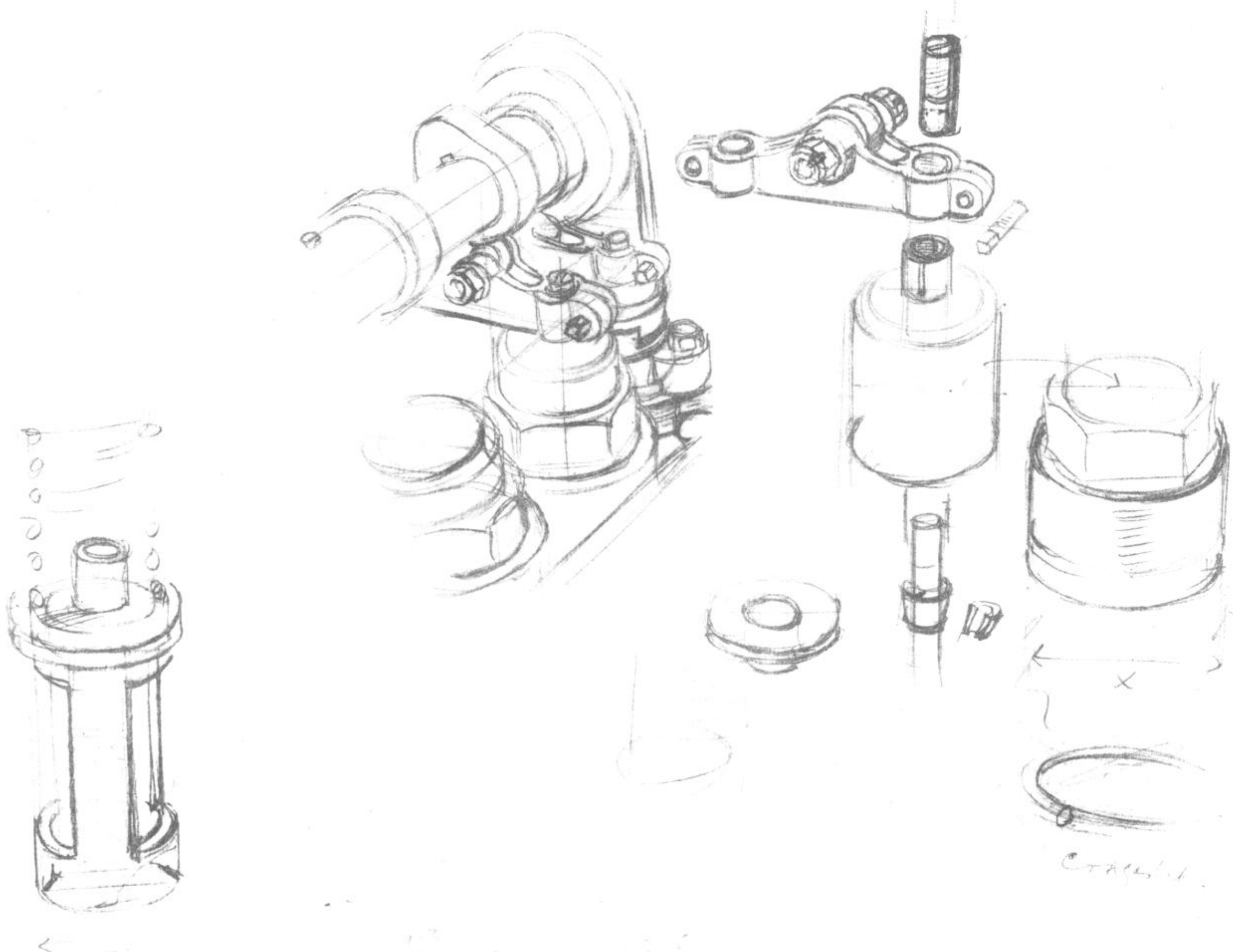
These sketches show the nature of his original "note-taking " which is done by the artist from the actual vehicle, and it is from these that he builds up the magnificent tone and line drawings which are included in this volume in the form of double page plates in Part II.

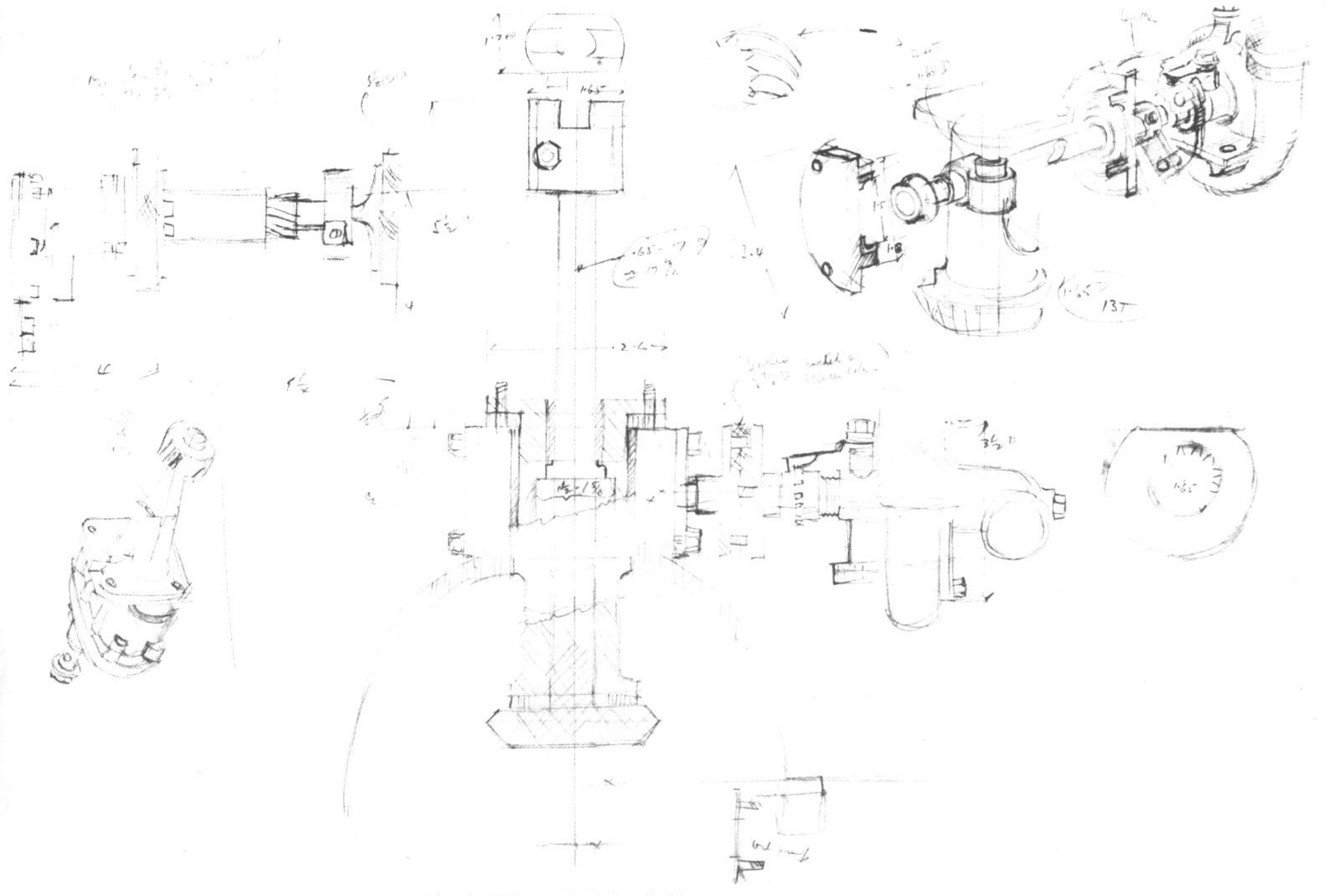
It will be of interest to note that all the illustrations in this book are the product of some 5000 hours work on the part of the artist, and it cannot be denied that he brings a refreshing touch to mechanical drawings which combine the meticulous accuracy of the drawing board with the essential character of the vehicle which is his subject.

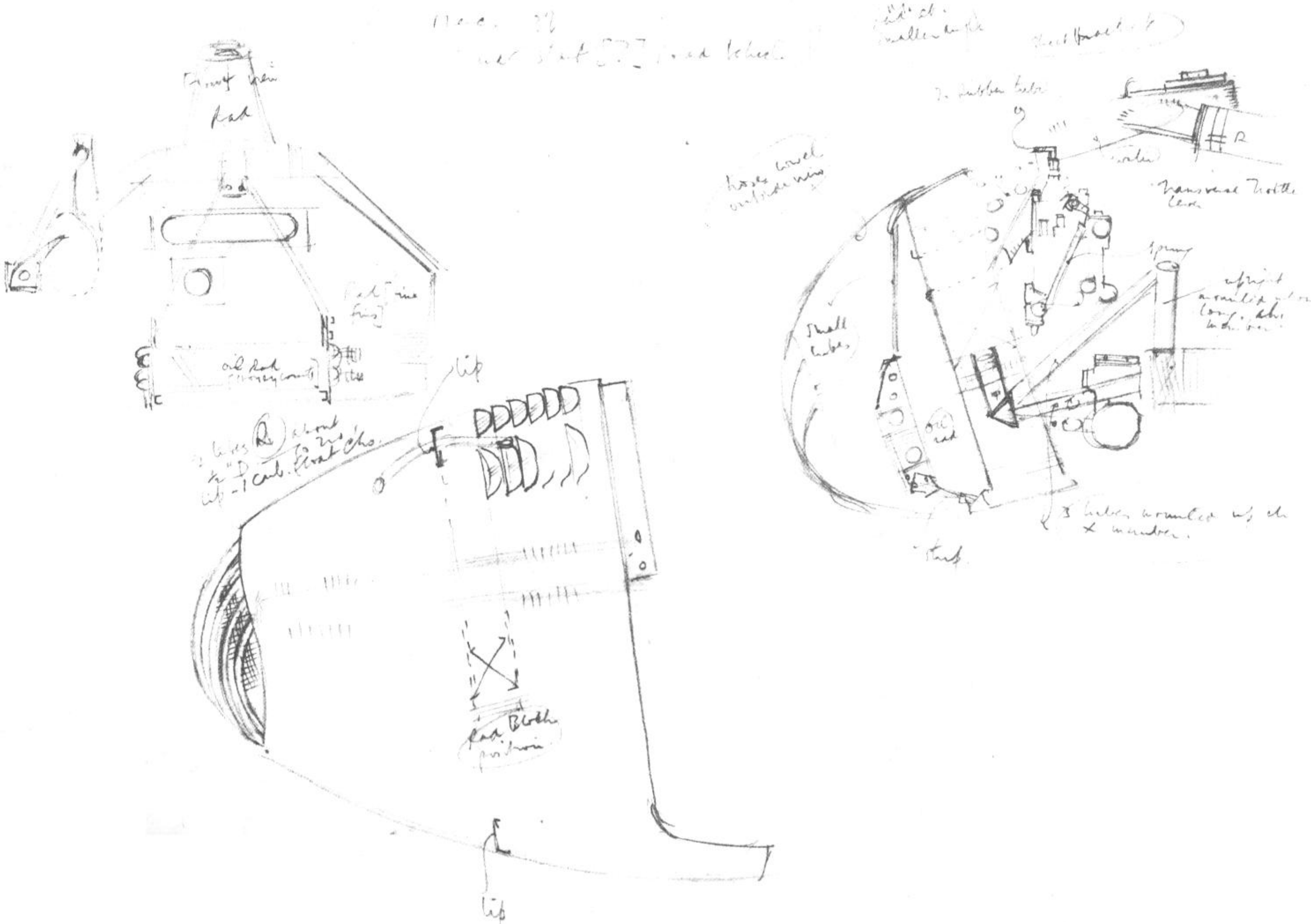

16½
28½



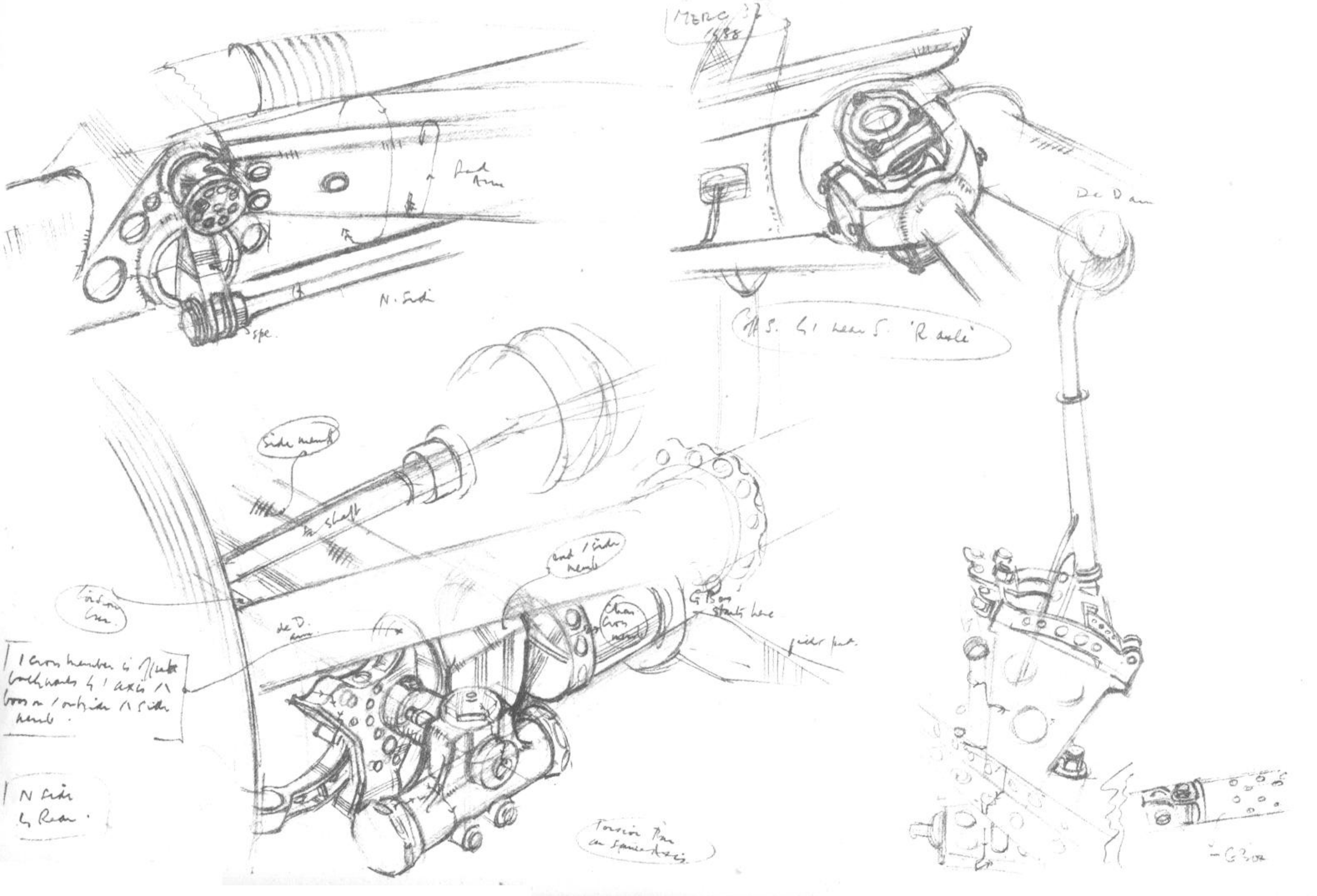




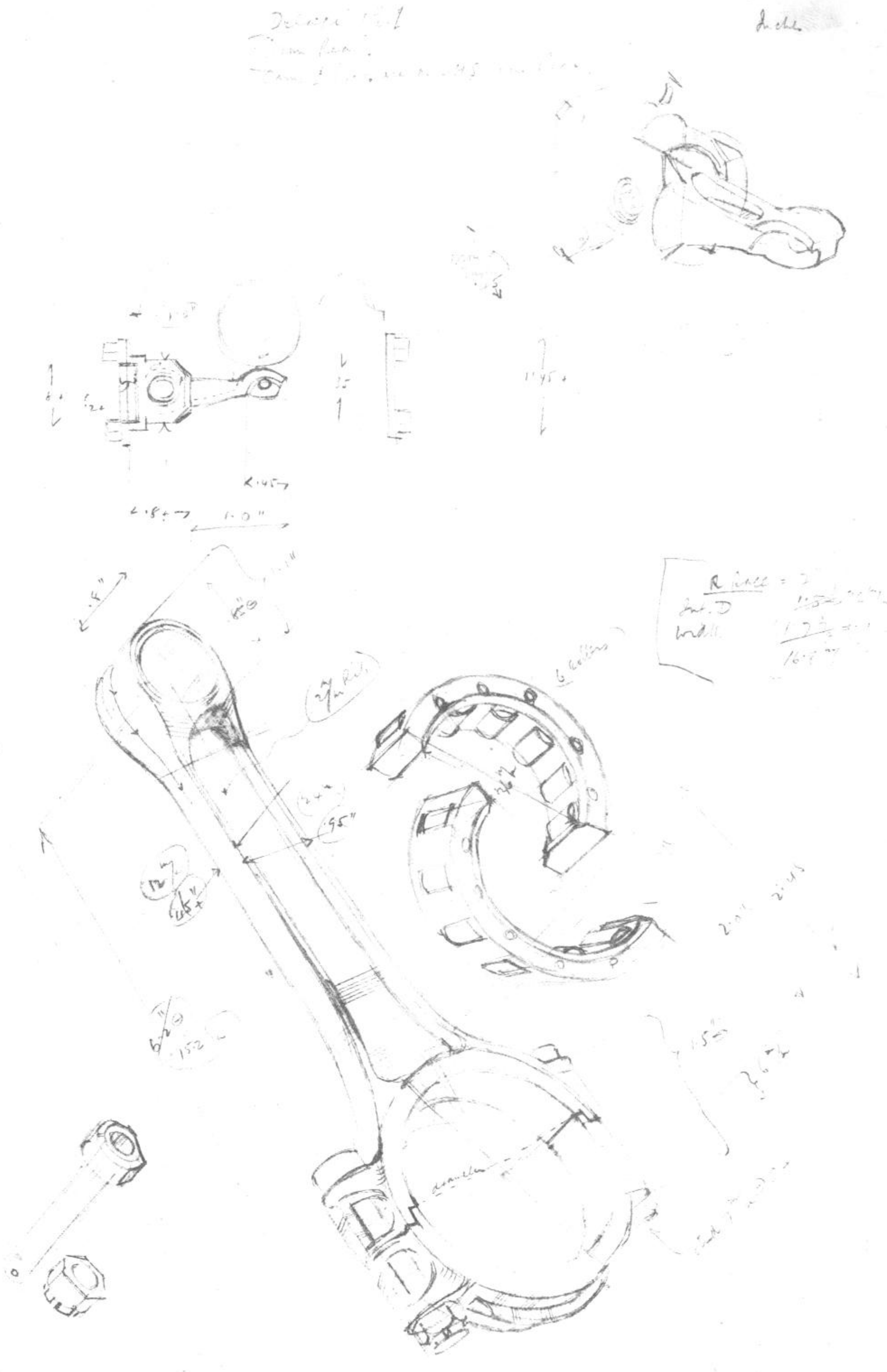

1.65
1.8
13T

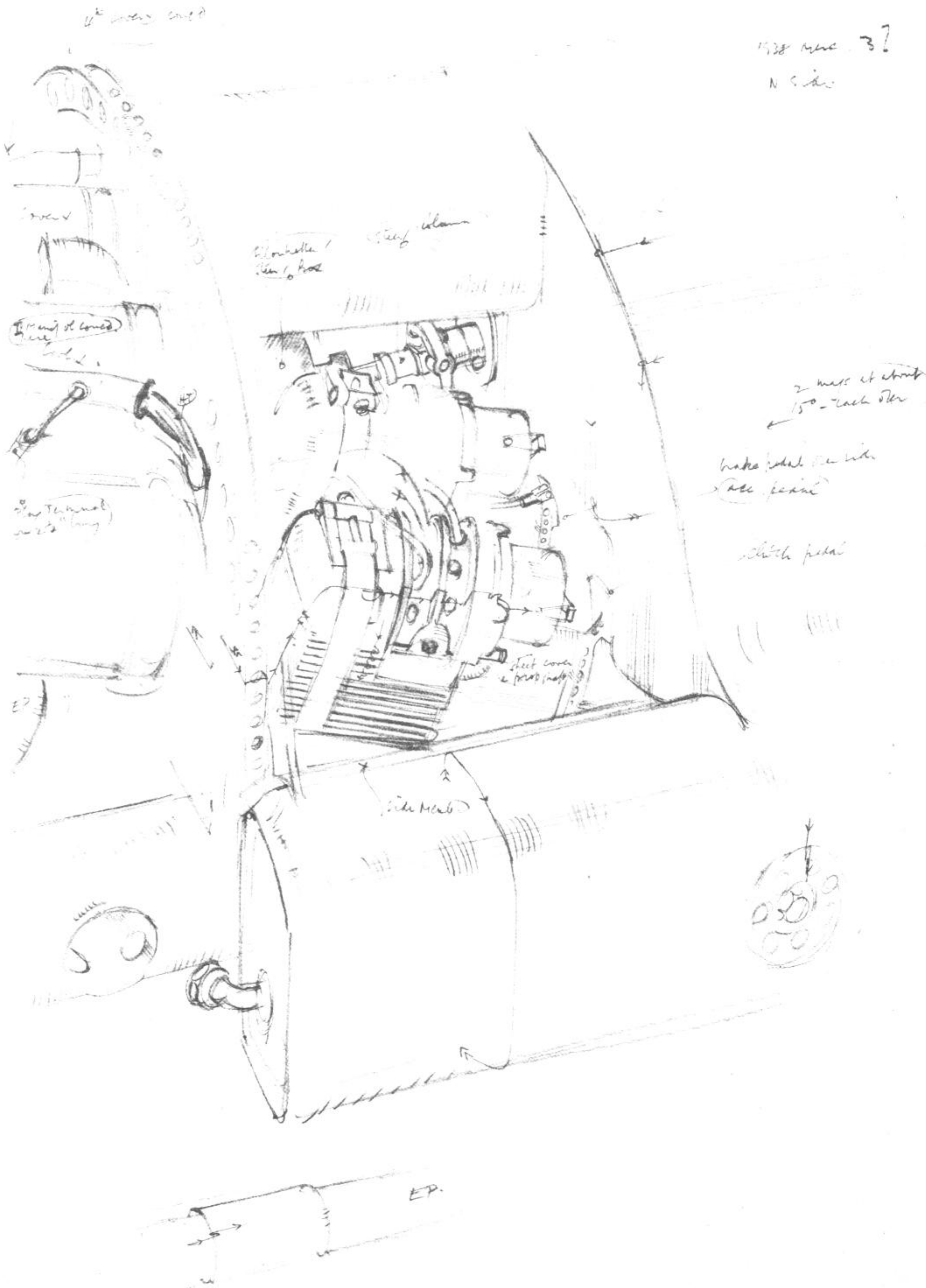


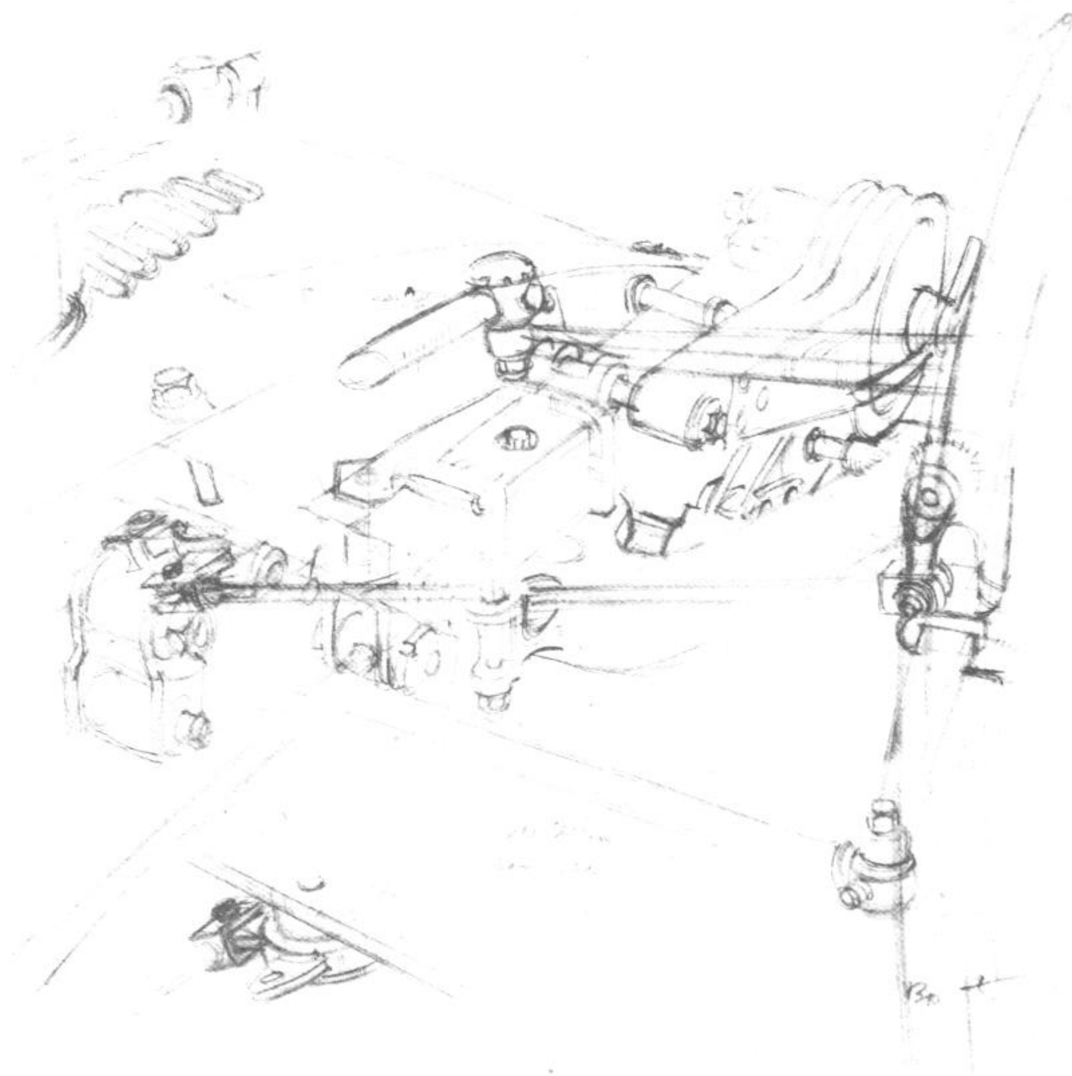
Rad
lip
Transverse Throttle Lever
Small tubes
spring
lip

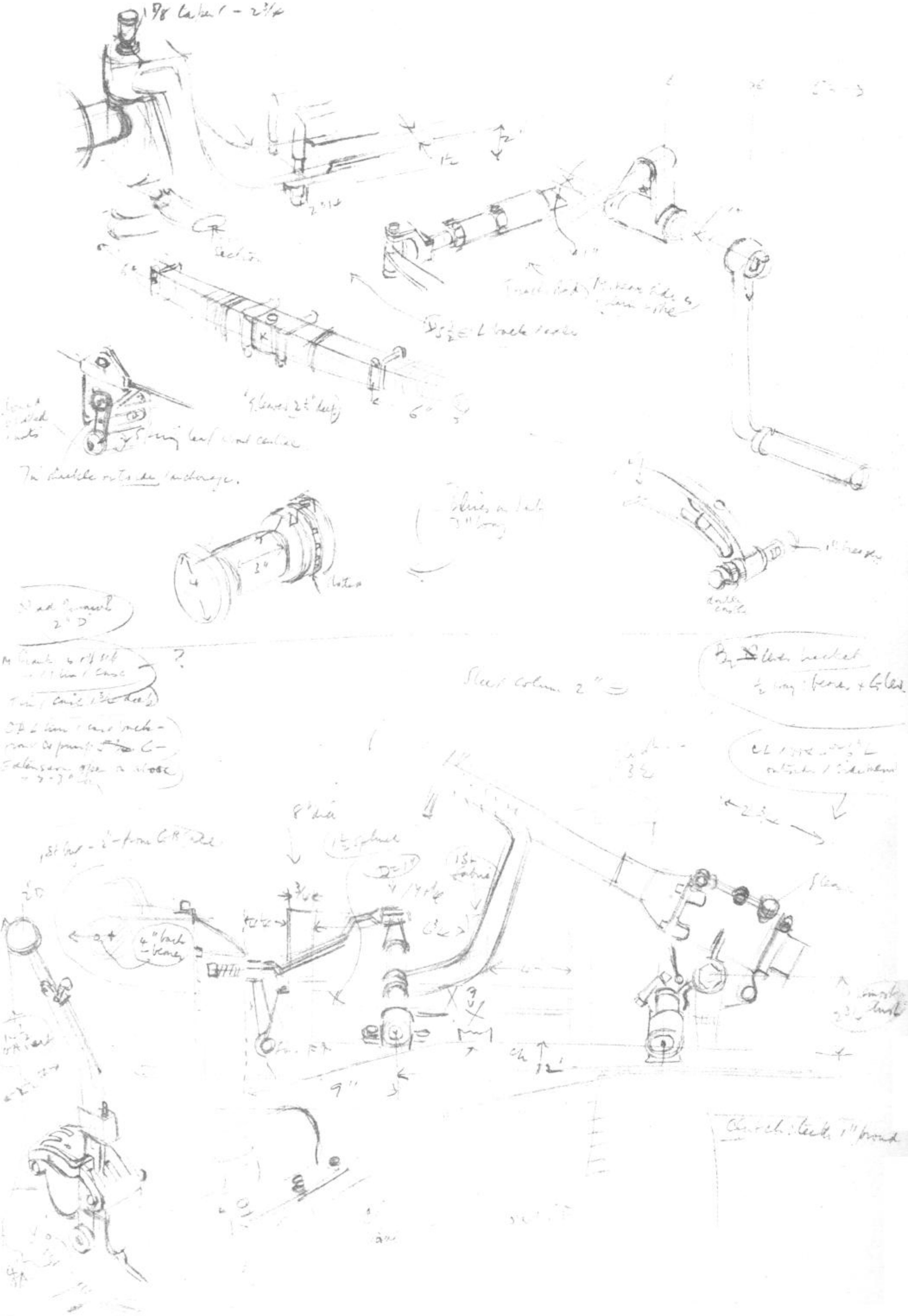


MERC
shaft
N Side


1.0"
.95"
6 rollers
R Race
Int. D
Width


clutch pedal
EP.




Section
4 leaves 2½" leaf
6"
Steer column 2"
Clutch stick 1" round
8" dia
9"

APPENDIX A
RESULTS OF THE 200 MOST IMPORTANT RACES 1906-1939

Date	*Course*	*Driver*	*Car*	*Index No.*	*Winning Speed m.p.h.*	*Lap Speed (Rec'd*)*
AMERICAN GRAND PRIX						
30/11/11	Savannah	D. Bruce Brown	Fiat	110	74.75	—
ARDENNES PRIZE						
13/8/06	Ardennes Circuit	L. Duray	De Dietrich	102	65.8†	—
,,	,,	L. Wagner	Darracq	103	—	70*
25/7/07	,,	J. T. C. Moore Brabazon	Minerva	106	59.5	—
,,	,,	A. Lee Guinness	Minerva	106	—	67
,,	,, (G.P. Class)	Baron de Caters	Mercedes	107	57.3	—
,,	,, (G.P. Class)	C. Jenatzy	Mercedes	107	—	66.6
ASTOR CUP						
30/9/16	Sheepshead Bay Track	J. Aitken	Peugeot	116	104.8	—
AVUSRENNEN						
2/8/31	A.V.U.S.	R. Caracciola	Mercedes-Benz	140	115.39	121.65*
22/5/32	,,	M. von Brauchitsch	Mercedes-Benz	140	120.07	—
,,	,,	R. Dreyfus	Maserati	147	—	130.39*
21/5/33	,,	A. Varzi	Bugatti	148	128.48	—
,,	,,	Count Czaykowski	Bugatti	148	—	137.77*
27/5/34	,,	G. Moll	Alfa Romeo	146A	127.57	—
,,	,,	A. Momberger	Auto-Union	151	—	140.33*
26/5/35	,,	L. Fagioli	Mercedes-Benz	150	148.83	—
,,	,,	H. Stuck	Auto-Union	151	—	161.88*
30/5/37	,,	H. Lang	Mercedes-Benz	158	162.61	—
,,	,,	B. Rosemeyer	Auto-Union	156	—	172.75*
BELGIAN GRAND PRIX						
28/6/25	*(See European Grand Prix)*					
20/7/30	*(See European Grand Prix)*					
12/7/31	Spa	W. Williams and Count Conelli	Bugatti	143	82.04	—
,,	,,	L. Chiron	Bugatti	143	—	88*
9/7/33	,,	T. Nuvolari	Maserati	149	89.23	92.33*
29/7/34	,,	R. Dreyfus	Bugatti	152	86.9	—
,,	,,	A. Brivio	Bugatti	152	—	96.38*
14/7/35	,,	R. Caracciola	Mercedes-Benz	150	97.8	—
,,	,,	M. von Brauchitsch	Mercedes-Benz	150	—	103.7*
11/7/37	,,	R. Hasse	Auto-Union	156	104.87	—

†Not as text on Page 24.

Date	Course	Driver	Car	Index No.	Winning Speed m.p.h.	Lap Speed (Rec'd*)
BELGIAN GRAND PRIX (*cont'd.*)						
11/7/37	Spa	H. Lang	Mercedes-Benz	158	—	108.8*
26/6/39	,,	H. Lang	Mercedes-Benz	164	94.39	109.12
BORDINO PRIZE						
22/4/28	Alessandria	T. Nuvolari	Bugatti	139	63.45	—
,,	,,	E. Materassi	Talbot	137	—	64.3*
21/4/29	,,	A. Varzi	Alfa Romeo	131	68.24	68.6*
20/4/30	,,	A. Varzi	Alfa Romeo	131	67.7	70.7*
BRESCIA GRAND PRIX						
12/9/21	Brescia	J. Goux	Ballot	121	90.4	—
,,	,,	P. Bordino	Fiat	124	—	96.31*
500 MILE CHICAGO DERBY						
26/5/15	Chicago Board	D. Resta	Peugeot	116	97.58	—
CHICAGO DERBY						
11/6/16	Chicago Board	D. Resta	Peugeot	116	98.61	—
100 MILE RACE, CHICAGO						
7/8/15	Chicago Board	D. Resta	Peugeot	116	101.86	—
COPPA ACERBO						
17/8/30	Pescara	A. Varzi	Maserati	142	75.35	—
,,	,,	L. Fagioli	Maserati	142	—	78.3*
16/8/31	,,	G. Campari	Alfa Romeo	144	81.68	—
,,	,,	T. Nuvolari	Alfa Romeo	144	—	83.4*
14/8/32	,,	T. Nuvolari	Alfa Romeo	146	86.89	90.3*
13/8/33	,,	L. Fagioli	Alfa Romeo	146	88.03	—
,,	,,	T. Nuvolari	Maserati	149	—	90.4*
15/8/34	,,	L. Fagioli	Mercedes-Benz	150	80.26	—
,,	,,	G. Moll	Alfa Romeo	146A	—	90.5*
15/8/35	,, with chicane	A. Varzi	Auto-Union	153	86.6	90.9*
15/8/36	,,	B. Rosemeyer	Auto-Union	156	86.48	—
,,	,,	A. Varzi	Auto-Union	156	—	89.04
15/8/37	,,	B. Rosemeyer	Auto-Union	156	87.61	92*
14/8/38	,,	R. Caracciola	Mercedes-Benz	160	83.69	—
,,	,,	L. Villoresi	Maserati	161	—	87.79
COPPA CIANO						
21/7/29	Montenero	A. Varzi	Alfa Romeo	131	54.17	—
,,	,,	T. Nuvolari	Alfa Romeo	131	—	55.3*
3/8/30	,,	L. Fagioli	Maserati	142	54.47	

Date	Course	Driver	Car	Index No.	Winning Speed m.p.h.	Lap Speed (Rec'd*)
COPPA CIANO (*cont'd.*)						
3/8/30	Montenero	T. Nuvolari	Alfa Romeo	131	—	57.2*
31/7/32	,,	T. Nuvolari	Alfa Romeo	146	53.91	54.5
30/7/33	,,	T. Nuvolari	Maserati	149	54.18	55.38
4/8/35	,,	T. Nuvolari	Alfa Romeo	154	55.18	56.22
2/8/36	Leghorn	T. Nuvolari	Alfa Romeo	155	74.8	77.05
7/8/38	,,	H. Lang	Mercedes-Benz	160	85.94	89.17*
,,	,,	M. von Brauchitsch	Mercedes-Benz	160	—	89.17*
COPPA FLORIO						
6/9/08	Bologna	F. Nazzaro	Fiat	109	74.1	—
,,	,,	V. Lancia	Fiat	109	—	82.3*
CORK GRAND PRIX						
23/4/38	Carrigrohane	R. Dreyfus	Delahaye	159	92.5	95.71*
COUPE DE L'AUTO						
21/9/13	Boulogne	G. Boillot	Peugeot	115	63.15	—
,,	,,	J. Goux	Peugeot	115	—	65.5*
CIRCUIT OF CREMONA						
9/6/24	Cremona	A. Ascari	Alfa Romeo	131	98.3	100.8*
CREMONA PRIZE						
24/6/28	Cir. of Cremona	L. Arcangeli	Talbot	137	101.31	—
,,	,,	G. Campari	Alfa Romeo	131	—	108.6*
1/7/29	,,	A. Brilli-Peri	Alfa Romeo	131	114.41	—
,,	,,	A. Maserati	Maserati	141	—	124.4*
CZECHOSLOVAK GRAND PRIX						
27/9/31	Brno	L. Chiron	Bugatti	143	73.26	75.36*
4/9/32	,,	L. Chiron	Bugatti	143	67.67	73.73
17/9/33	,,	L. Chiron	Alfa Romeo	146	63.57	70.8
30/9/34	,,	H. Stuck	Auto-Union	151	79.21	—
,,	,,	L. Fagioli	Mercedes-Benz	150	—	82.29*
29/9/35	,,	B. Rosemeyer	Auto-Union	153	82.39	—
,,	,,	A. Varzi	Auto-Union	153	—	85.21*
26/9/37	,,	R. Caracciola	Mercedes-Benz	158	85.97	94.89*
DONINGTON GRAND PRIX						
2/10/37	Donington	B. Rosemeyer	Auto-Union	156	82.86	85.62*
,,	,,	M. von Brauchitsch	Mercedes-Benz	158	—	85.62*
22/10/38	,,	T. Nuvolari	Auto-Union	162	80.49	83.71
EIFEL RACES (*For lap records see also German Grand Prix*)						
2/6/31	Nürburg Ring	R. Caracciola	Mercedes-Benz	140	67.67	—

Date	*Course*	*Driver*	*Car*	*Index No.*	*Winning Speed m.p.h.*	*Lap Speed (Rec'd*)*
EIFEL RACES (*cont'd.*)						
29/5/32	Nürburg Ring	R. Caracciola	Alfa Romeo	146	70.7	72.8*
3/6/34	,,	M. von Brauchitsch	Mercedes-Benz	150	76.12	79*
10/6/35	,,	R. Caracciola	Mercedes-Benz	150	72.8	75.6
14/6/36	,,	B. Rosemeyer	Auto-Union	156	72.71	74.46
13/6/37	,,	B. Rosemeyer	Auto-Union	156	82.95	85.13
21/5/39	,,	H. Lang	Mercedes-Benz	164	84.14	86*
ENGLISH GRAND PRIX						
7/8/26	Brooklands with chicanes	R. Senechal and L. Wagner	Delage	136	71.61	—
,,	,,	H. O. D. Segrave	Talbot	137	—	85
1/10/27	,,	R. Benoist	Delage	136A	85.59	—
EUROPEAN GRAND PRIX						
9/9/23	Monza	C. Salamano	Fiat	129	91.06	—
,,	,,	P. Bordino	Fiat	129	—	99.8*
3/8/24	Lyons	G. Campari	Alfa Romeo	131	71	—
,,	,,	H. O. D. Segrave	Sunbeam	132	—	76.7*
28/6/25	Spa	A. Ascari	Alfa Romeo	131	74.56	81.5*
18/7/26	San Sebastian	J. Goux	Bugatti	135	70.4‡	81.5
4/9/27	Monza	R. Benoist	Delage	136A	90.04	94.31
9/9/28	,,	L. Chiron	Bugatti	139	99.4	—
,,	,,	L. Arcangeli	Talbot	137	—	103.2
20/7/30	Spa	L. Chiron	Bugatti	139	72.1	—
FRENCH GRAND PRIX (*For lap records on Rheims circuit see also Marne Grand Prix*)						
26/6/06	Le Mans	Szisz	Renault	100	63	—
,,	,,	P. Baras	R. Brasier	101	—	73.3*
2/7/07	Dieppe	F. Nazzaro	Fiat	104	70.5	—
,,	,,	L. Duray	De Dietrich	102	—	75.4*
7/7/08	Dieppe	C. Lautenschlager	Mercedes	108	69	—
,,	,,	O. Salzer	Mercedes	108	—	78.5*
25/6/12	Dieppe Circuit	G. Boillot	Peugeot	111	68.45	—
,,	,,	D. Bruce Brown	Fiat	112	—	76.8
12/7/13	Amiens	G. Boillot	Peugeot	113	72.2†	—
,,	,,	P. Bablot	Delage	114	—	76.6*

†Not as text on Pages 29 and 34; Goux 2nd at 71.8 m.p.h.

‡Not as table on Page 56.

Date	Course	Driver	Car	Index No.	Winning Speed m.p.h.	Lap Speed (Rec'd*)
FRENCH GRAND PRIX (*cont'd.*)						
5/7/14	Lyons	C. Lautenschlager	Mercedes	118	65.3†	—
,,	,,	M. Sailer	Mercedes	118	—	69.95
26/7/21	Le Mans	J. Murphy	Duesenberg	123	78.1	84.0*
16/7/22	Strasbourg	F. Nazzaro	Fiat	126	79.2	—
,,	,,	P. Bordino	Fiat	126	—	87.75*
2/6/23	Tours	H. O. D. Segrave	Sunbeam	128	75.3‡	—
,,	,,	P. Bordino	Fiat	129	—	87.75*
3/8/24	(*See European Grand Prix*)					
26/7/25	Montlhery	A. Divo and R. Benoist	Delage	134	69.7	—
,,	,,	A. Divo	Delage	134	—	80.3*
27/6/26	Miramas	J. Goux	Bugatti	139	68.2	79.4*
3/7/27	Montlhery	R. Benoist	Delage	136A	77.24	81.43*
30/6/29	Le Mans	W. Williams	Bugatti	139	82.66	52.7*
21/9/30	Pau	P. Etancelin	Bugatti	139	90.4	—
21/6/31	Montlhery	L. Chiron and A. Varzi	Bugatti	143	78.21	—
,,	,,	L. Fagioli	Maserati	142	—	85.6*
3/7/32	Rheims	T. Nuvolari	Alfa Romeo	146	92.26	99.5*
11/6/33	Montlhery	G. Campari	Maserati	149	81.52	86.6*
1/7/34	,,	L. Chiron	Alfa Romeo	146A	85.55	91.44*
23/6/35	,, with chicanes	R. Carracciola	Mercedes-Benz	150	77.39	—
,,	,,	T. Nuvolari	Alfa Romeo	154	—	85*
3/7/38	Rheims	M. von Brauchitsch	Mercedes-Benz	160	101.3	—
,,	,,	H. Lang	Mercedes-Benz	160	—	105.87*
9/7/39	,,	H. Muller	Auto-Union	163	105.25	—
,,	,,	H. Lang	Mercedes-Benz	164	—	114.87*
GERMAN GRAND PRIX (*For lap records see also Eifel Races*)						
15/7/28	Nürburg Ring	R. Caracciola	Mercedes-Benz	140	64.6	69.34*
14/7/29	,,	L. Chiron	Bugatti	139	66.79	69.97*
19/7/31	,,	R. Caracciola	Mercedes-Benz	140	67.4	—
,,	,,	A. Varzi	Bugatti	143	—	72.6*
17/7/32	,,	R. Caracciola	Alfa Romeo	146	74.13	—

†Not as text on Pages 29 and 37; Wagner 2nd at 65.1 m.p.h.; Salzer 3rd at 64.6 m.p.h. ‡Not as text on Page 48.

Date	Course	Driver	Car	Index No.	Winning Speed m.p.h.	Lap Speed (Rec'd*)
GERMAN GRAND PRIX (*cont'd.*)						
17/7/32	Nürburg Ring	T. Nuvolari	Alfa Romeo	146	—	77.55*
15/7/34	,,	H. Stuck	Auto-Union	151	76.39†	79.29*
28/7/35	,,	T. Nuvolari	Alfa Romeo	154	75.43	—
,,	,,	M. von Brauchitsch	Mercedes-Benz	150	—	80.73*
26/7/36	,,	B. Rosemeyer	Auto-Union	156	81.8	85.52*
25/7/37	,,	R. Caracciola	Mercedes-Benz	158	82.77	—
,,	,,	B. Rosemeyer	Auto-Union	156	—	85.57*
24/7/38	,,	R. Seaman	Mercedes-Benz	160	80.75	83.76
23/7/39	,,	R. Caracciola	Mercedes-Benz	164	75.12	81.66
HARKNESS TROPHY						
28/10/16	Sheepshead Bay Track	J. Aitken	Peugeot	116	105.95	—
HUNGARIAN GRAND PRIX						
21/6/36	Budapest	T. Nuvolari	Alfa Romeo	155	69.1	71.84*
500 MILE SWEEPSTAKE						
30/5/13	Indianapolis	J. Goux	Peugeot	111	75.92	—
,,	,,	P. Zuccarelli	Peugeot	111	—	93.5*
30/5/14	,,	R. Thomas	Delage	114	82.47	—
,,	,,	G. Boillot	Peugeot	113	—	99.5*
30/5/15	,,	R. de Palma	Mercedes	118	89.84	98.6
30/5/16	,,(300 mls.)	D. Resta	Peugeot	116	83.26	—
30/5/19	,,	H. Wilcox	Peugeot	116	87.95	—
,,	,,	R. Thomas	Ballot	119	—	104.7*
30/5/20	,,	G. Chevrolet	Monroe	120	88.5	—
,,	,,	R. de Palma	Ballot	121	—	99.15
30/5/21	,,	T. Milton	Frontenac	122	89.62	—
,,	,,	R. de Palma	Ballot	121	—	100.75
30/5/22	,,	J. Murphy	Murphy Special	—	94.48	100.5
30/5/23	,,	T. Milton	H. C. S. Miller	127	90.95	108.17*
ITALIAN GRAND PRIX						
3/9/22	Monza	P. Bordino	Fiat	126	86.89	91.3*
9/9/23	(*See European Grand Prix*)					
19/10/24	Monza	A. Ascari	Alfa Romeo	131	98.76	104.24*
6/9/25	,,	Count G. Brilli-Peri	Alfa Romeo	131	94.76	—
,,	,,	P. Kreis	Duesenberg	—	—	103.21

†Not as table on Page 76.

Date	Course	Driver	Car	Index No.	Winning Speed m.p.h.	Lap Speed (Rec'd*)
ITALIAN GRAND PRIX *(cont'd.)*						
5/9/26	Monza	Sabipa	Bugatti	135	85.87	—
,,	,,	M. Costantini	Bugatti	135	—	98.3
4/9/27	*(See European Grand Prix)*					
9/9/28	*(See European Grand Prix)*					
24/5/31	Monza	G. Campari and T. Nuvolari	Alfa Romeo	144	96.17	105*
5/6/32	,,	T. Nuvolari	Alfa Romeo	146	104.13	—
5/6/32	,,	L. Fagioli	Maserati	147	—	112.22*
10/9/33	Full Monza	L. Fagioli	Alfa Romeo	146	108.58	115.82*
9/9/34	2.68 Miles at Monza	R. Caracciola and L. Fagioli	Mercedes-Benz	150	65.37	—
,,	,,	H. Stuck	Auto-Union	151	—	72.59*
8/9/35	2.68 Miles at Monza	H. Stuck	Auto-Union	153	85.17†	—
,,	,,	T. Nuvolari	Alfa Romeo	155	—	90.77*
13/9/36	Monza with chicanes	B. Rosemeyer	Auto-Union	156	84.59	87.18*
12/9/37	Leghorn	R. Caracciola	Mercedes-Benz	158	81.59	84.5*
11/9/38	Monza with chicanes	T. Nuvolari	Auto-Union	162	96.7	—
,,	,,	H. Lang	Mercedes-Benz	160	—	101.38
KAISER PRIZE						
14/6/07	Taunus Mountains	F. Nazzaro	Fiat	—	52.5	—
MARNE GRAND PRIX *(For lap records see also French Grand Prix)*						
5/7/28	Rheims	L. Chiron	Bugatti	139	82.5	91.4*
14/7/29	,,	P. Etancelin	Bugatti	139	85.5	88.6
29/6/30	,,	R. Dreyfus	Bugatti	139	88.5	91
5/7/31	,,	P. Lehoux	Bugatti	143	89.49	92.78*
2/7/33	,,	P. Etancelin	Alfa Romeo	144	90.59	—
,,	,,	G. Campari	Maserati	149	—	96
8/7/34	,,	L. Chiron	Alfa Romeo	146A	90.71	—
,,	,,	A. Varzi	Alfa Romeo	146A	—	97.65
7/7/35	,,	R. Dreyfus	Alfa Romeo	146A	98.03	102*
MILAN GRAND PRIX						
4/9/27	Monza	P. Bordino	Fiat	138	94.57	96.59

†Not as table on Page 83.

Date	*Course*	*Driver*	*Car*	*Index No.*	*Winning Speed m.p.h.*	*Lap Speed (Rec'd*)*
MILAN CIRCUIT						
28/6/36	Milan	T. Nuvolari	Alfa Romeo	155	60.02	—
,,	,,	A. Varzi	Auto-Union	156	—	62.26*
MONACO GRAND PRIX						
14/4/29	Monte Carlo	W. Williams	Bugatti	139	50.23	52.7
6/4/30	,,	R. Dreyfus	Bugatti	139	53.63†	56.01*
19/4/31	,,	L. Chiron	Bugatti	143	54.09	56.01
17/4/32	,,	T. Nuvolari	Alfa Romeo	144	55.81	—
,,	,,	A. Varzi	Bugatti	143	—	58.3*
3/4/33	,,	A. Varzi	Bugatti	143	57.04	59.77*
2/4/34	Monte Carlo	G. Moll	Alfa Romeo	146A	55.86	—
,,	,,	Count Trossi	Alfa Romeo	146A	—	59.7*
22/4/35	,,	L. Fagioli	Mercedes-Benz	150	58.17	60.08*
13/4/36	,,	R. Caracciola	Mercedes-Benz	157	51.69	—
13/4/36	,,	H. Stuck	Auto-Union	156	—	56.01*
8/8/37	,,	M. von Brauchitsch	Mercedes-Benz	158	63.25	—
,,	,,	R. Caracciola	Mercedes-Benz	158	—	66.99*
MONTENERO PRIZE						
19/8/28	Montenero	E. Materassi	Talbot	137	52.77	—
,,	,,	T. Nuvolari	Bugatti	139	—	53.8*
MONZA GRAND PRIX						
15/9/29	2.8 Mile Circuit of Monza	A. Varzi	Alfa Romeo	131	116.83	—
,,	,,	A. Maserati	Maserati	141	—	124.2*
7/9/30	4.3 Mile Lap Monza	A. Varzi	Maserati	142	93.55	100,6*
6/9/31	,,	L. Fagioli	Maserati	142	96.6	—
,,	,,	T. Nuvolari	Alfa Romeo	144	—	101.23*
11/9/32	Monza	R. Caracciola	Alfa Romeo	146	110.8	—
,,	,,	T. Nuvolari	Alfa Romeo	146	—	113.7
10/9/33	2.8 Mile Lap Monza	P. Lehoux	Bugatti	143	108.99	—
,,	,,	Count Czaykowski	Bugatti	148	—	116.81
PAU GRAND PRIX						
10/4/38	Pau	R. Dreyfus	Delahaye	159	54.64	—
,,	,,	R. Caracciola	Mercedes-Benz	150	—	57.86*
2/4/39	,,	H. Lang	Mercedes-Benz	164	56.09	—
,,	,,	M. von Brauchitsch	Mercedes-Benz	164	—	57.83

†Not as table on Page 62 and text Page 66.

Date	Course	Driver	Car	Index No.	Winning Speed m.p.h.	Lap Speed (Rec'd*)
PENYA RHIN						
17/6/34	Mont Juich	A. Varzi	Alfa Romeo	146A	64.24	—
,,	,,	L. Chiron	Alfa Romeo	146A	—	66.25*
17/6/35	,,	L. Fagioli	Mercedes-Benz	150	66.99	—
,,	,,	R. Caracciola	Mercedes-Benz	150	—	68.94*
7/6/36	,,	T. Nuvolari	Alfa Romeo	155	69.21	71.85*
RIO DE JANEIRO GRAND PRIX						
6/6/37	Gavea	C. Pintacuda	Alfa Romeo	155	51.5	—
ROME GRAND PRIX						
10/6/28	Trefontana	L. Chiron	Bugatti	139	78.55	80.4
26/5/29	,,	A. Varzi	Alfa Romeo	131	80.2	—
25/5/30	,,	L. Arcangeli	Maserati	142	83.6	—
,,	,,	G. Bouriat	Bugatti	139	—	86.6*
SARTHE GRAND PRIX or G.P. de FRANCE						
23/7/11	Le Mans	V. Hemery	Fiat	110	56.71	67.75*
9/9/12	,,	J. Goux	Peugeot	111	74.56	—
,,	,,	G. Boillot	Peugeot	111	—	80*
5/8/13	,,	P. Bablot	Delage	114	76.8	82.5*
SAN SEBASTIAN GRAND PRIX						
25/9/24	San Sebastian	H. O. D. Segrave	Sunbeam	132	64.12	—
,,	,,	M. Costantini	Bugatti	133	—	69.79*
19/9/25	,,	A. Divo	Delage	134	76.4	—
,,	,,	M. Costantini	Bugatti	133	—	82.75*
28/7/28	,,	L. Chiron	Bugatti	139	80.58	88.25*
SPANISH GRAND PRIX						
31/7/27	San Sebastian	R. Benoist	Delage	136A	80.52	85.41*
4/10/30	,,	A. Varzi	Maserati	142	86.82	91.09*
24/9/33	,,	L. Chiron	Alfa Romeo	146	83.32	—
,,	,,	T. Nuvolari	Maserati	149	—	96.59*
23/9/34	,,	L. Fagioli	Mercedes-Benz	150	97.13	—
,,	,,	H. Stuck	Auto-Union	151	—	101.96*
22/9/35	,,	R. Caracciola	Mercedes-Benz	150	101.92	—
,,	,,	A. Varzi	Auto-Union	153	—	108.11*

Date	*Course*	*Driver*	*Car*	*Index No.*	*Winning Speed m.p.h.*	*Lap Speed (Rec'd*)*
SWISS GRAND PRIX						
26/8/34	Berne	H. Stuck	Auto-Union	151	87.21	—
,,	,,	A. Momberger	Auto-Union	151	—	94.42*
25/8/35	,,	R. Caracciola	Mercedes-Benz	150	89.95	—
,,	,,	L. Fagioli	Mercedes-Benz	150	—	99.5*
23/8/36	,,	B. Rosemeyer	Auto-Union	156	100.45	105.42*
22/8/37	,,	R. Caracciola	Mercedes-Benz	158	98.61†	107.14* (P)
21/8/38	,,	R. Caracciola	Mercedes-Benz	160	89.44	—
,,	,,	R. Seaman	Mercedes-Benz	160	—	95.35 103 (P)
20/8/39	,,	H. Lang	Mercedes-Benz	164	96.02	106.23 (P)
,,	,,	R. Caracciola	Mercedes-Benz	164	—	104.32
TARGA FLORIO						
23/11/19	Madonie	A. Boillot	Peugeot	117	34.19	—
27/4/24	,,	C. Werner	Mercedes	130	41.02	42.4*
3/5/25	,,	M. Costantini	Bugatti	133	44.5	45.1*
25/4/26	,,	M. Costantini	Bugatti	139	45.68	46.8*
24/4/27	,,	E. Materassi	Bugatti	139	44.61	—
,,	,,	F. Minoia	Bugatti	139	—	46.78
6/5/28	,,	A. Divo	Bugatti	139	45.65	—
,,	,,	L. Chiron	Bugatti	139	—	46.2
5/5/29	,,	A. Divo	Bugatti	139	46.21	—
,,	,,	F. Minoia	Bugatti	139	—	47.3*
4/5/30	,,	A. Varzi	Alfa Romeo	131	48.48	49.1*
10/5/31	Long Madonie	T. Nuvolari	Alfa Romeo	144	40.39	—
,,	,,	A. Varzi	Bugatti	143	—	43.8*
8/5/32	New Short Madonie	T. Nuvolari	Alfa Romeo	144	49.27	50.7*
28/5/33	,,	A. Brivo	Alfa Romeo	144	47.56	—
,,	,,	I. Borzachini	Alfa Romeo	144	—	49.6
R.A.C. T.T.						
10/6/14	Isle of Man	A. Lee Guinness	Sunbeam	115A	56.44	59.3*
22/6/22	,,	J. Chassagne	Sunbeam	125	55.78	—
,,	,,	H. O. D. Segrave	Sunbeam	125	—	62.5* (P)
TRIPOLI						
7/5/33	Mellaha	A. Varzi	Bugatti	143	104.7	110*
6/5/34	,,	A. Varzi	Alfa Romeo	146A	115.67	—

†Not as table on Page 92.

Date	Course	Driver	Car	Index No.	Winning Speed m.p.h.	Lap Speed (Rec'd*)
TRIPOLI (*cont'd.*)						
6/5/34	Mellaha	L. Chiron	Alfa Romeo	146A	—	124.48*
12/5/35	,,	R. Caracciola	Mercedes-Benz	150	123.03	136.81*
10/5/36	,,	A. Varzi	Auto-Union	156	129.01	141.29*
9/5/37	,,	H. Lang	Mercedes-Benz	158	134.42	—
,,	,,	H. Stuck	Auto-Union	156	—	142.44*
15/5/38	,,	H. Lang	Mercedes-Benz	160	127.4	139.7
,,	,,	Count Trossi	Maserati	161	—	131.2 (P)
TUNIS GRAND PRIX						
5/5/35	Carthage	A. Varzi	Auto-Union	153	101.2	105.17*
17/5/36	,,	R. Caracciola	Mercedes-Benz	157	99.62	—
,,	,,	B. Rosemeyer	Auto-Union	156	—	103.79*
VANDERBILT TROPHY						
12/10/36	Roosevelt Speedway	T. Nuvolari	Alfa Romeo	155	65.99	69.92*
5/7/37	Roosevelt Field	B. Rosemeyer	Auto-Union	156	82.56	— (P)
,,	,,	R. Caracciola	Mercedes-Benz	158	—	84.5*
YUGOSLAV GRAND PRIX						
3/9/39	Belgrade	T. Nuvolari	Auto-Union	163	81.21	83.9*
,,	,,	M. von Brauchitsch	Mercedes-Benz	164	—	83.9*

NOTE.—*The INDEX NUMBER refers to a table of specifications included in the Appendices of Vol. II.*

MAKES AND TYPES OF CAR WITH MORE THAN THREE WINS IN MAJOR EUROPEAN ROAD RACES LISTED ABOVE

Bugatti Types 35B and C and Type 39	21
Alfa Romeo P3	16
Alfa Romeo P2	12
Mercedes-Benz W25	11
Bugatti Type 51 Auto-Union Type C	10
Mercedes-Benz W154/163	9
Maserati 2.5/2.8-litre Alfa Romeo 2.3-litre Monza	6
Alfa Romeo 3.8-litre Mercedes-Benz Type W125 Delage 1½-litre	5
Auto-Union Type D	4
Auto-Union Type A Mercedes-Benz SSK Maserati 2.9-litre	3

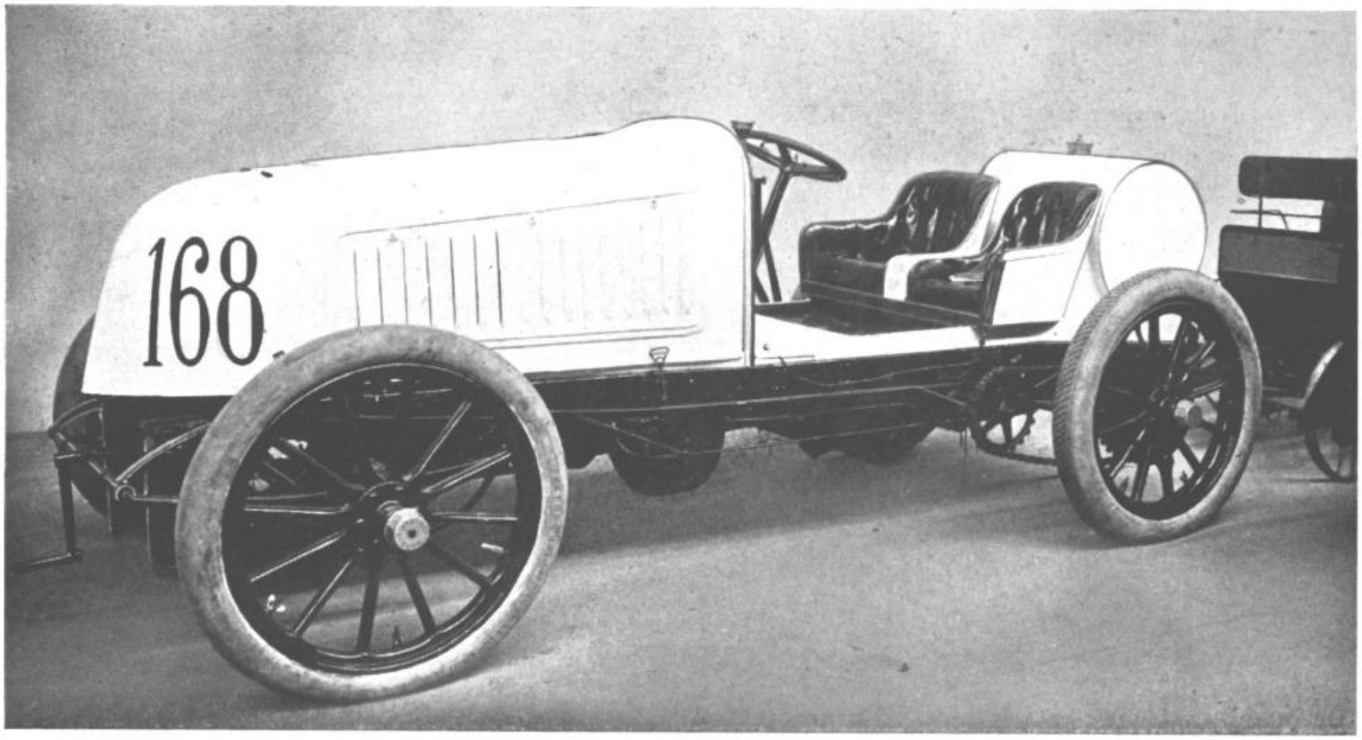
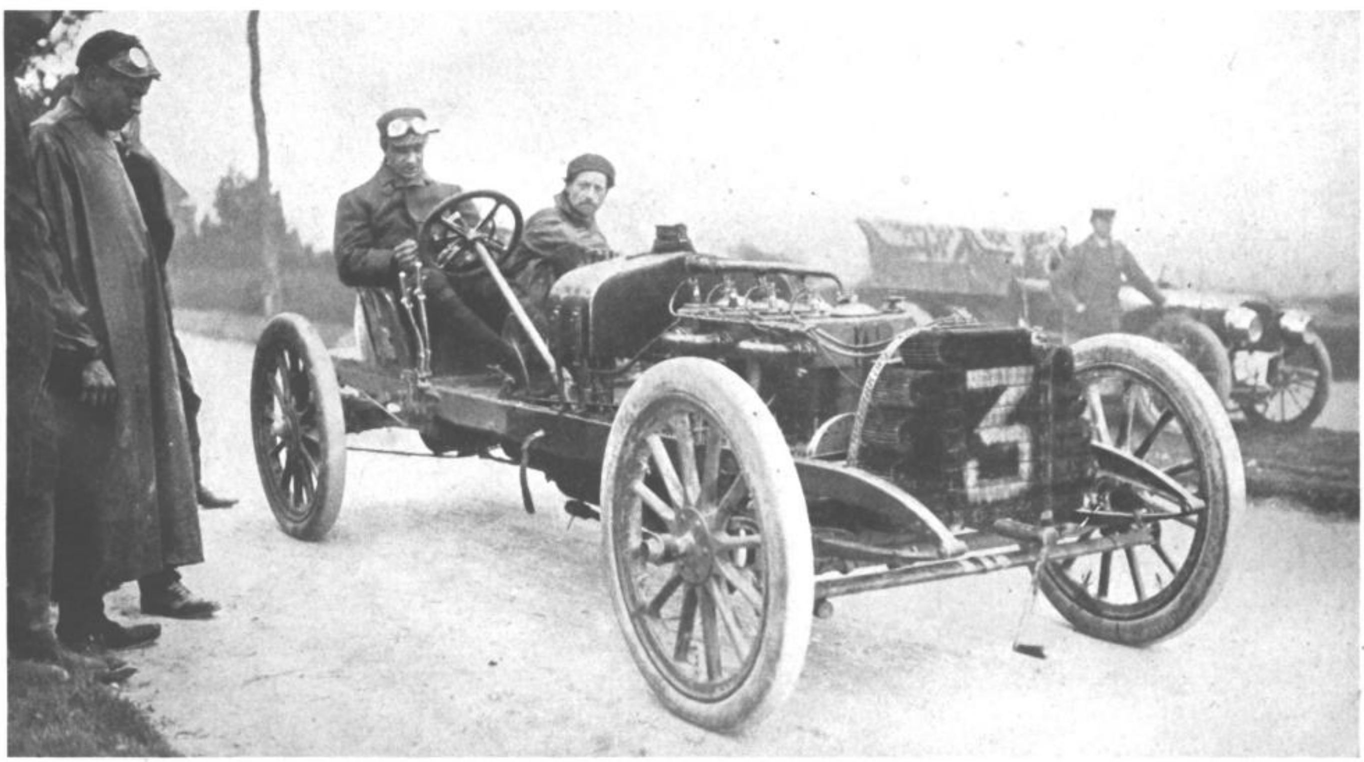
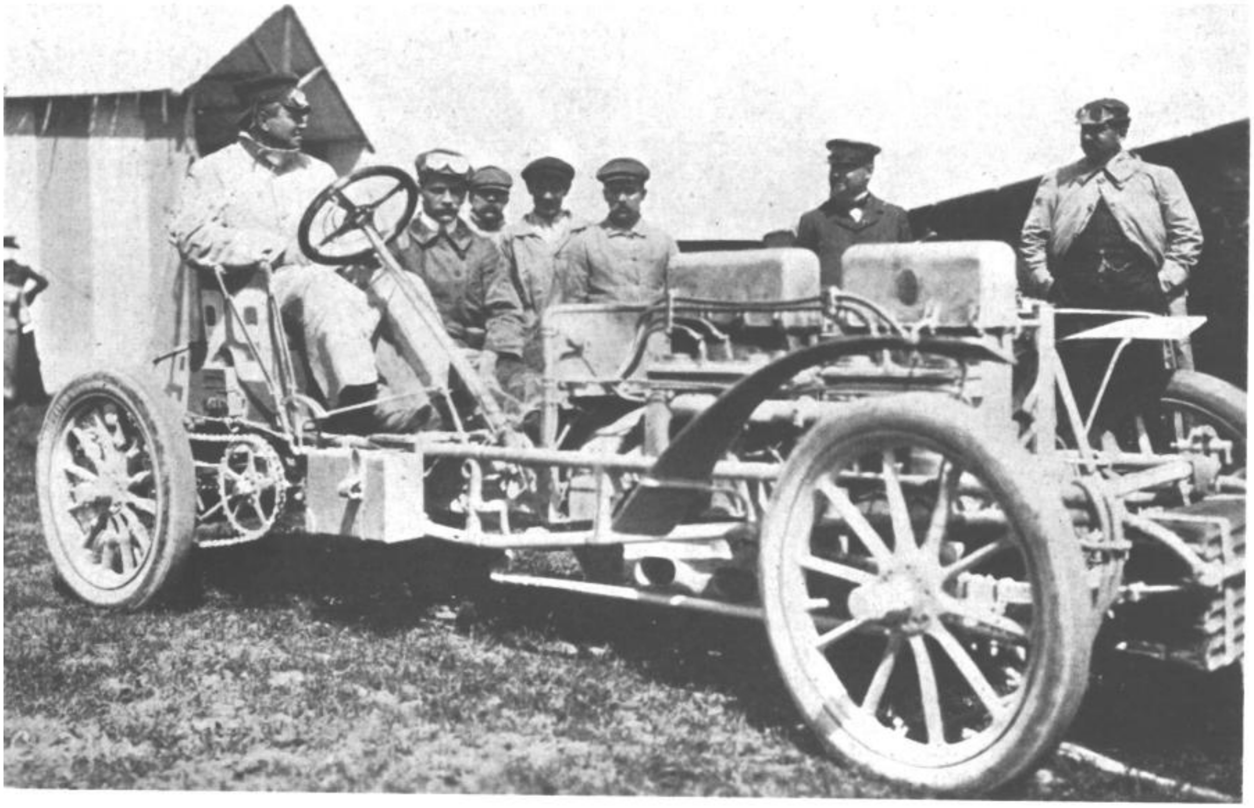


PLATE XXX

LAST OCCASION - The 1903 Dauphin Mors won the last town to town race, the famous Paris-Madrid which was stopped by authority at Bordeaux. This car had a four-cylinder, 11.5-litre, engine developing 70 b.h.p. and technical features disclosed in this photograph include the low mounted radiator, placed outside the tapering bonnet, and the struts running beneath the frame to give this component increased beam stiffness.



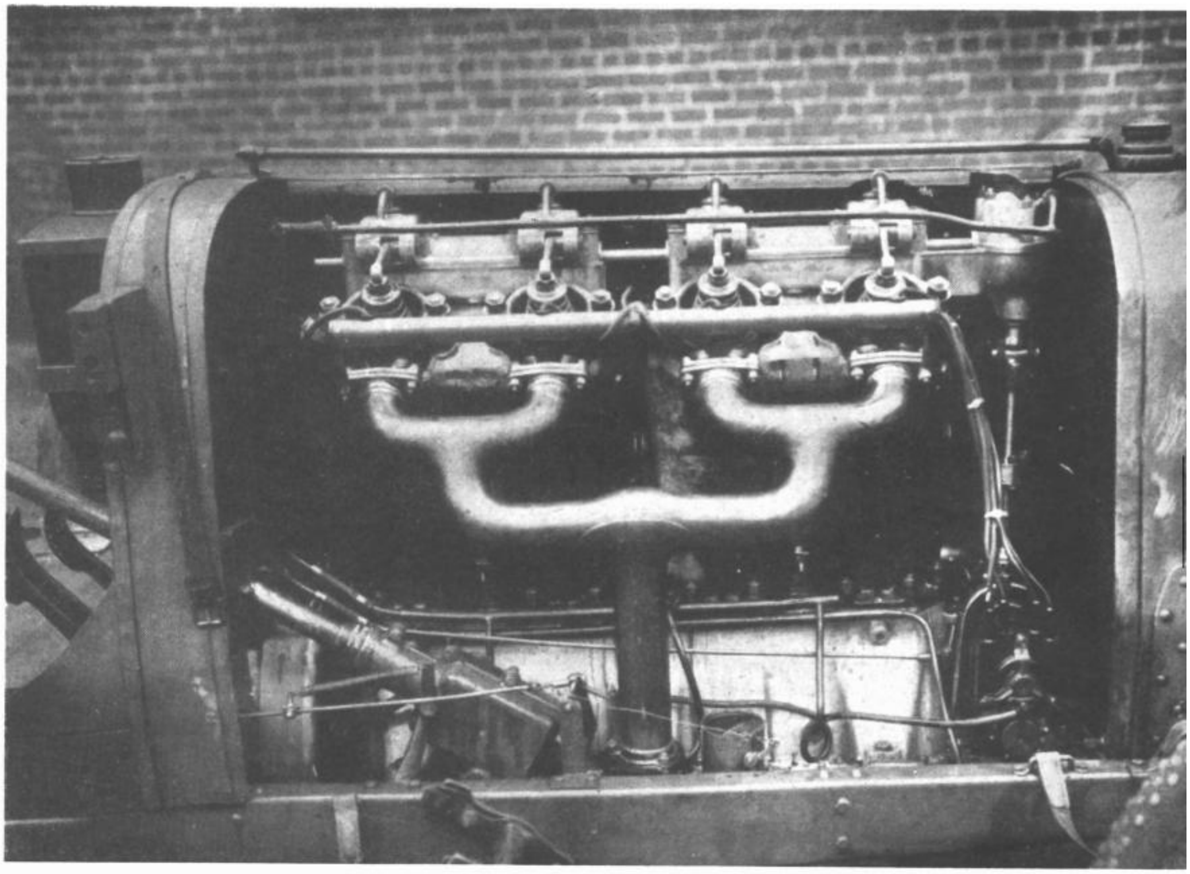
REDUCING WIND RESISTANCE - This 1904 Clement Bayard shows an early attention to low wind resistance. The picture of the car in chassis form indicates the header tank mounted behind the cylinder block with low-level radiator tubes ; the fairing over the track rod and front axle is also interesting. It is instructive to compare the rake on the steering column with the Mors shown above.



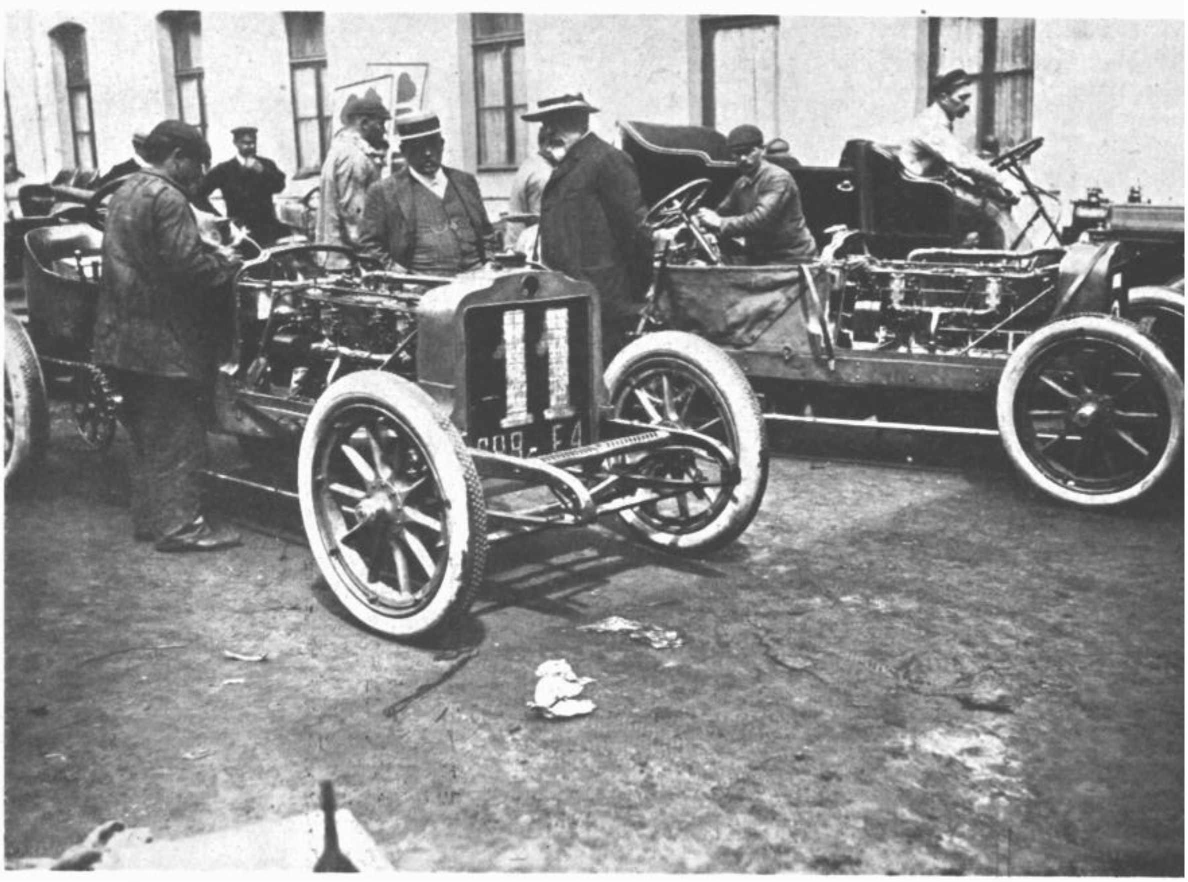
HETERODOX COMBINATION - Probably the fastest car of the pre-Grand Prix period was the opposed piston Gobron Brillié which in 1904 was the first I.C. engined car officially to exceed 100 m.p.h. Alcohol mixture was used and other advanced features included the girder-type tubular frame and forward mounted radiator element mounted at the position of maximum pressure.

EARLY INCLINATION - Early use of inclined overhead valves operated by pushrods with two camshafts at crankshaft level is exemplified by this Pipe car driven by Jenatzy in the 1907 Circuit des Ardennes. The design was originally employed by this Company in 1904.

PLATE
XXXII



FASTEST KILOMETRE - The highest speed achieved over a flying km. during the 1908 French Grand Prix was 104.8 m.p.h. achieved by Rigal driving a four-cylinder (155 mm. by 185 mm.) Clément Bayard developing 135 h.p. from 11.7 litres. Engine design:was notable for the use of inclined overhead valves and an overhead camshaft and driven from a vertical shaft and bevel gears at the front of the engine,



STEADY PROGRESS - Amongst the fastest road racing cars in the 1908 G.P. were the Richard Brasiers shown in this picture. One of these cars was timed to cover a measured distance in the race at 101.3 m.p.h. The engine was a four-cylinder of 12 litres capacity giving 120 b.h.p. The general similarity in design between 1903 and 1908 is shown clearly by these first six photographs.

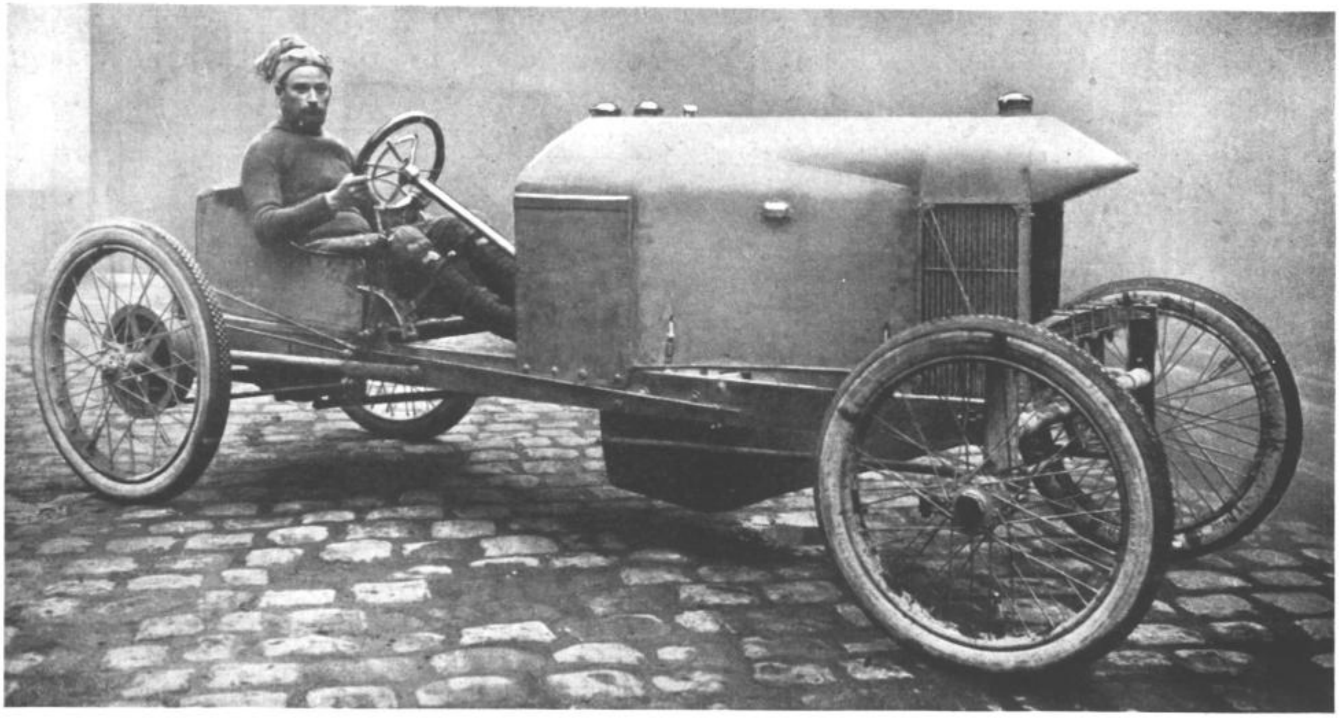
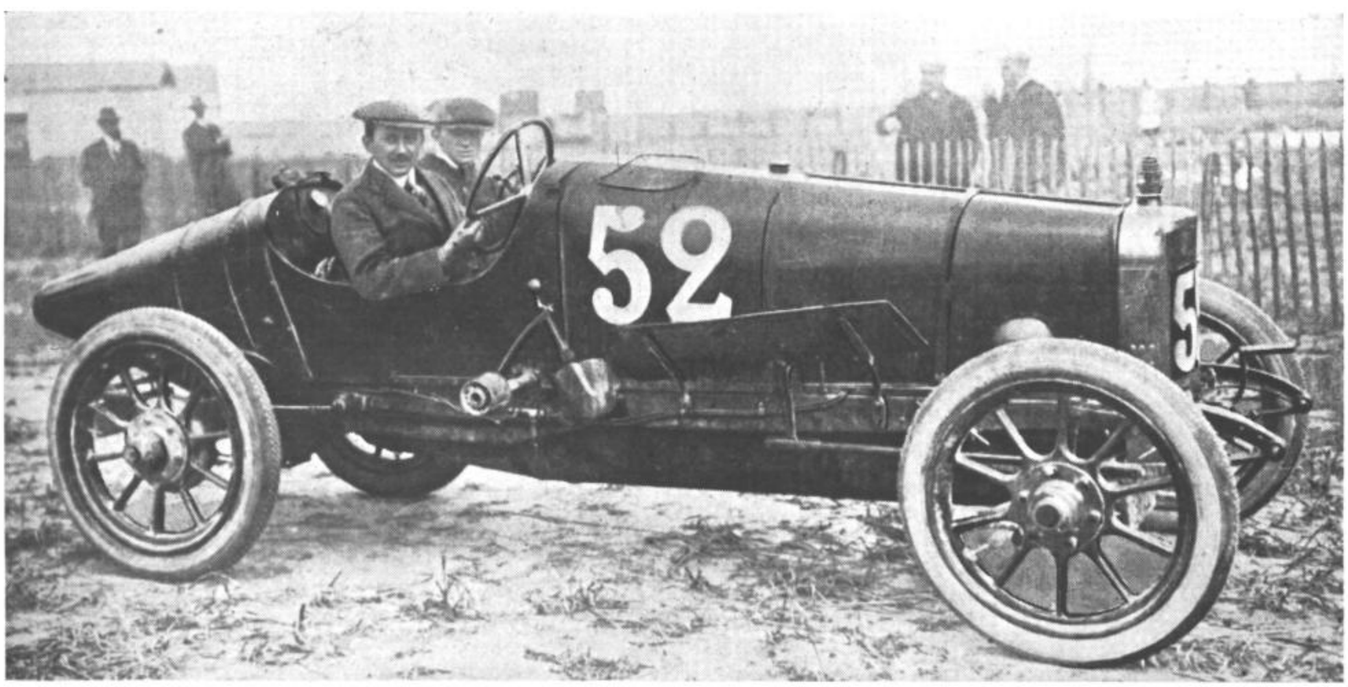


PLATE XXXIII

INNOVATION - Independent suspension to the front wheels was first used for racing in the Voiturette cars built by Sizaire-Naudin in 1906. The wheels were attached to sliding members which connected to a transverse leaf spring, an arrangement providing vertical rise and fall of the wheels with elimination of gyroscopic reactions. The abnormal bonnet height of' the 1908 car here shown was the result of piston area limitations leading to an S/B ratio of' 2.5 : 1.



FIVE YEARS' DEVELOPMENT - By 1912 progress in small car design had been so great that in the French Grand Prix of that year the British cars using 3-litre engines running at 3,000 r.p.m. and developing 65 and 75 h.h.p. were but little slower than cars running in the class in which there were no limits on engine capacity. In a two-day race a Sunbeam similar to the car pictured above finished third at an average speed of 65.3 m.p.h. (and was timed at 84.73 m.p.h.) and during the first day Vauxhall cars of basically similar conception had also challenged their larger rivals.

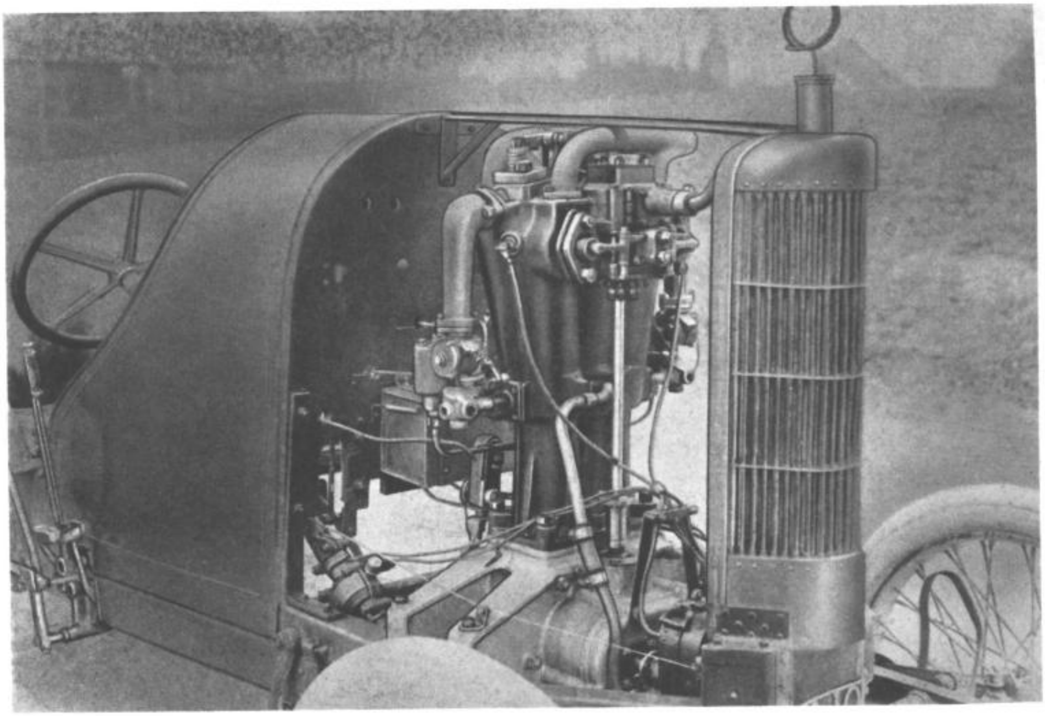
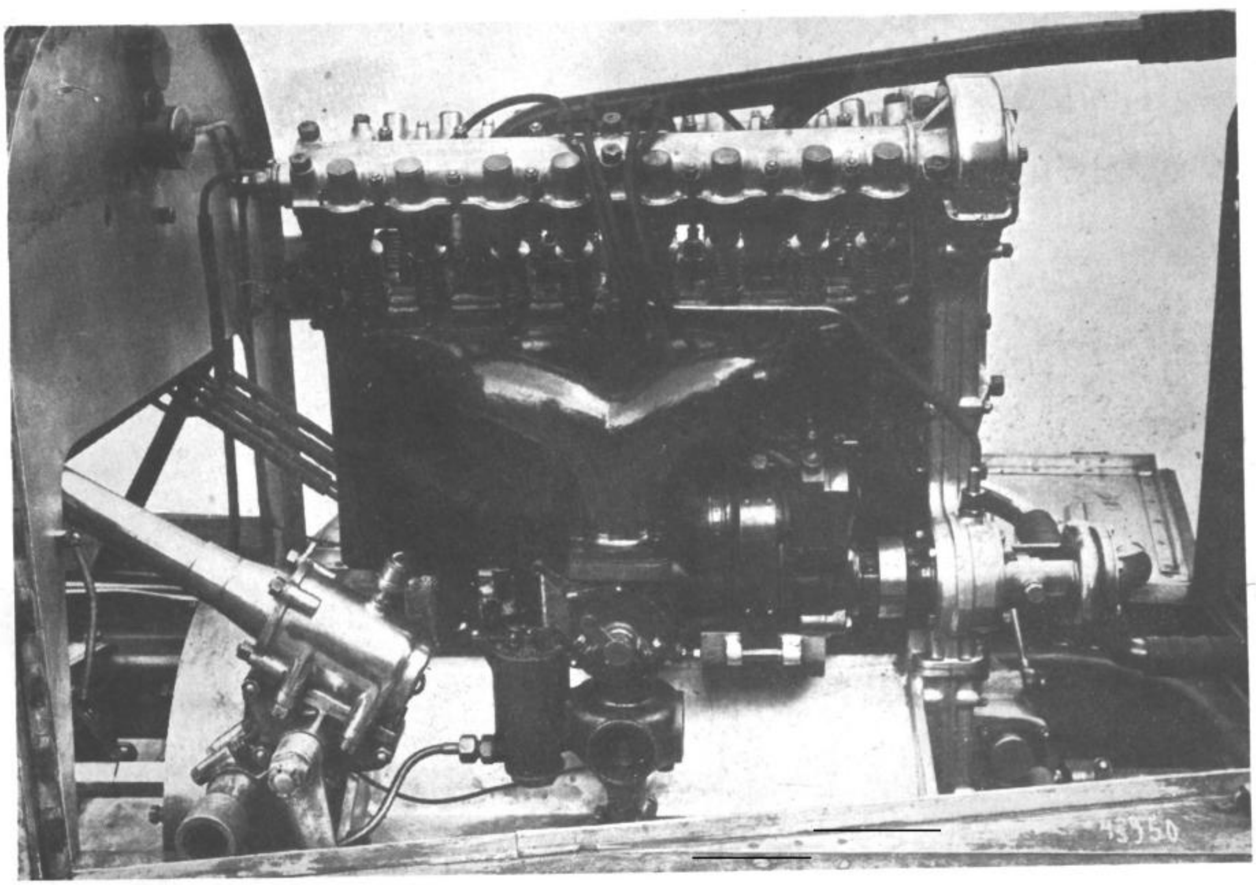
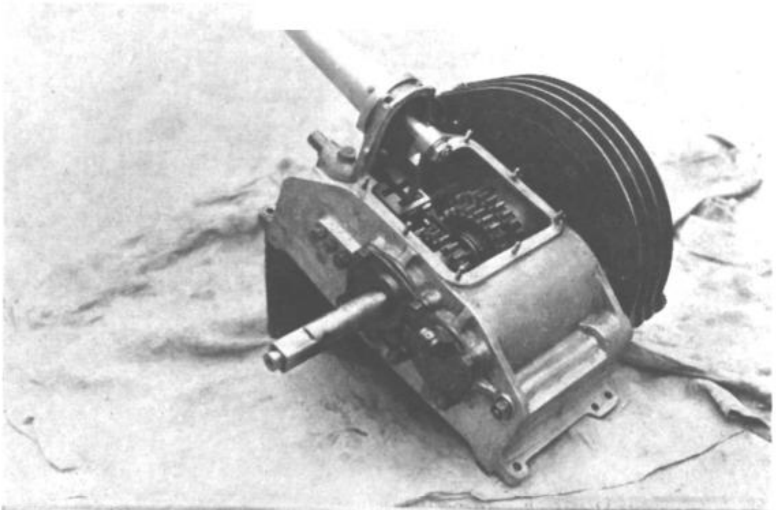


PLATE XXXIV

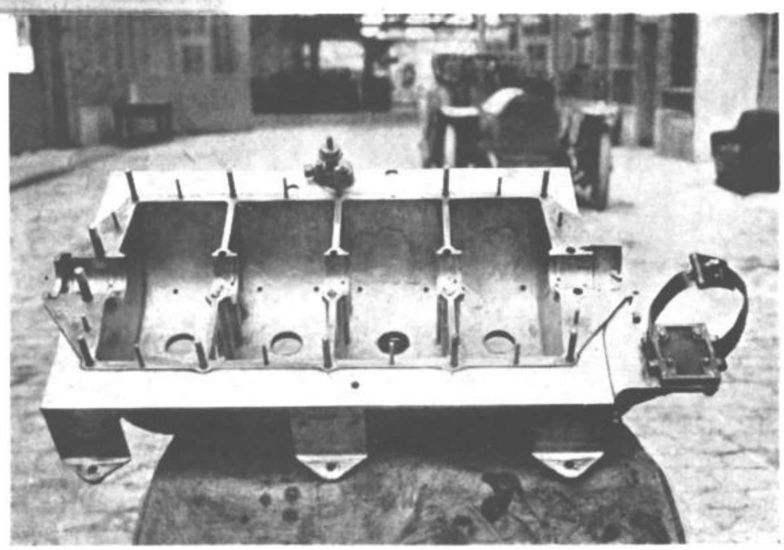
IN EXTREMIS - As a result of successive annual regulations limiting piston area, the Lion-Peugeot voiturette racing cars of 1910 were fitted with this Vee-twin engine with a bore and stroke of 80 mm. by 280 mm. and a capacity of 2.8 litres. Having three valves per cylinder, this engine developed approximately 40 h.p. at 2,200 r.p.m. the equivalent of the very high piston speed of 4,000 ft./min.



PRIME EXAMPLE - Probably the most efficient engine built before 1914 was this 1913 3-litre Peugeot with bore and stroke of 78 mm. by 156 mm. Having four valves per cylinder, operated by two overhead camshafts gear driven from the front of the engine, it developed approximate(v 90 b.h.p. at 2,900 r.p.m.



BASIC ENGINEERING - The 1912, 7.6-litre, Grand Prix Peugeot which won the French Grand Prix was very carefully designed and these two photographs show the compact four-speed gearbox with large ribbed transmission brake and the bottom half of the crankcase showing support for five main crankshaft bearings.



RADICAL CHANGE - Racing car performance, and indeed the whole technique of race driving, was much affected by front-wheel brakes which were first used on the road in the French Grand Prix of 1914. The Perrot design employed by Delage is illustrated in this picture: this basic type was continued on many racing cars for a further 20 years.

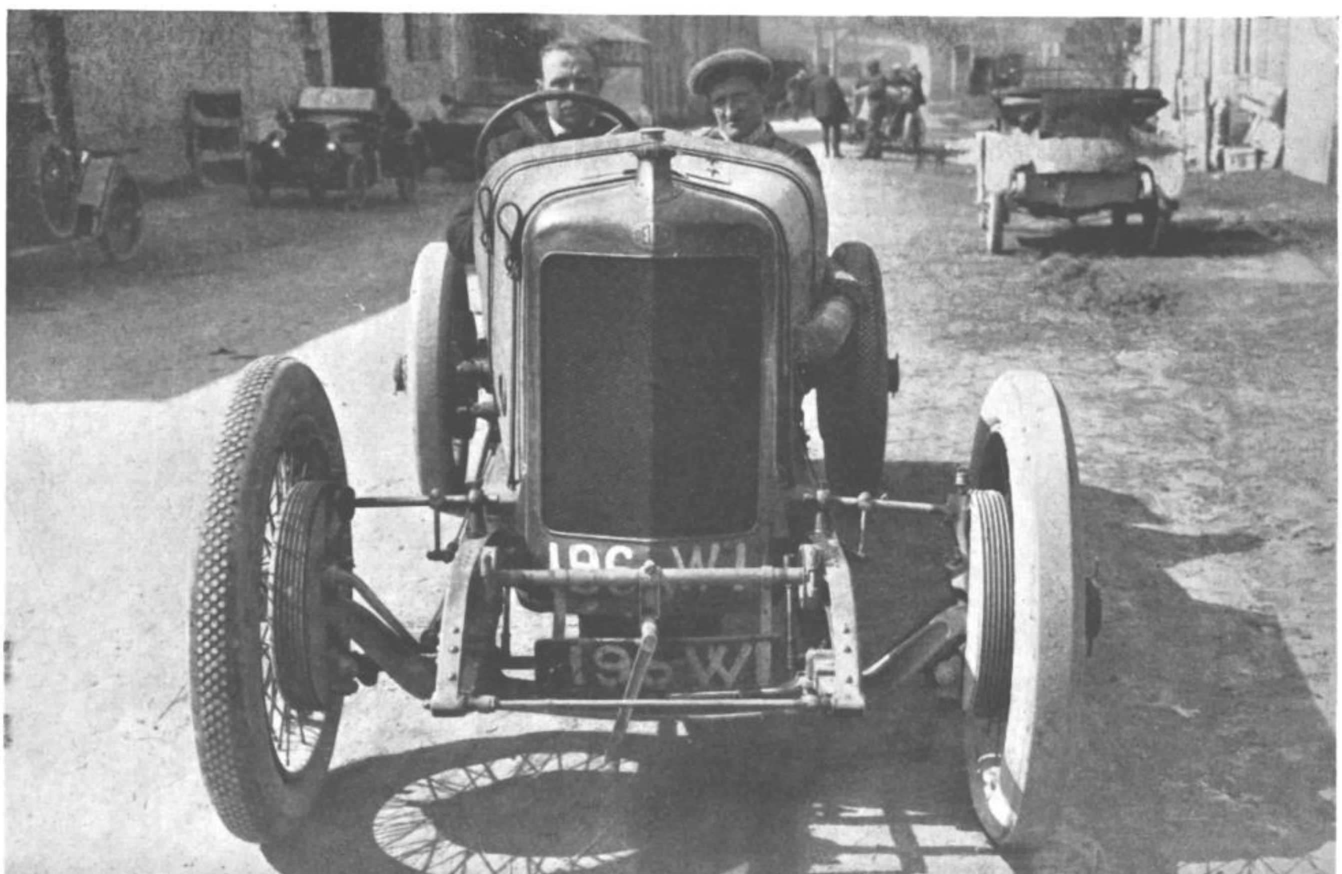
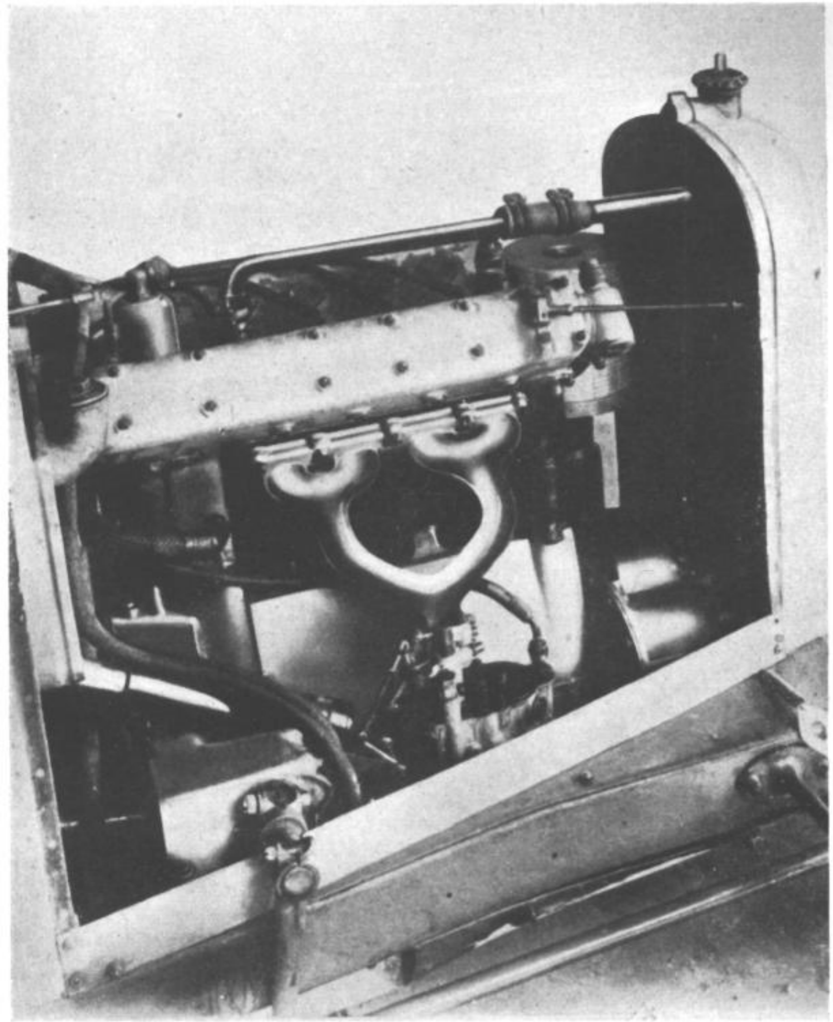
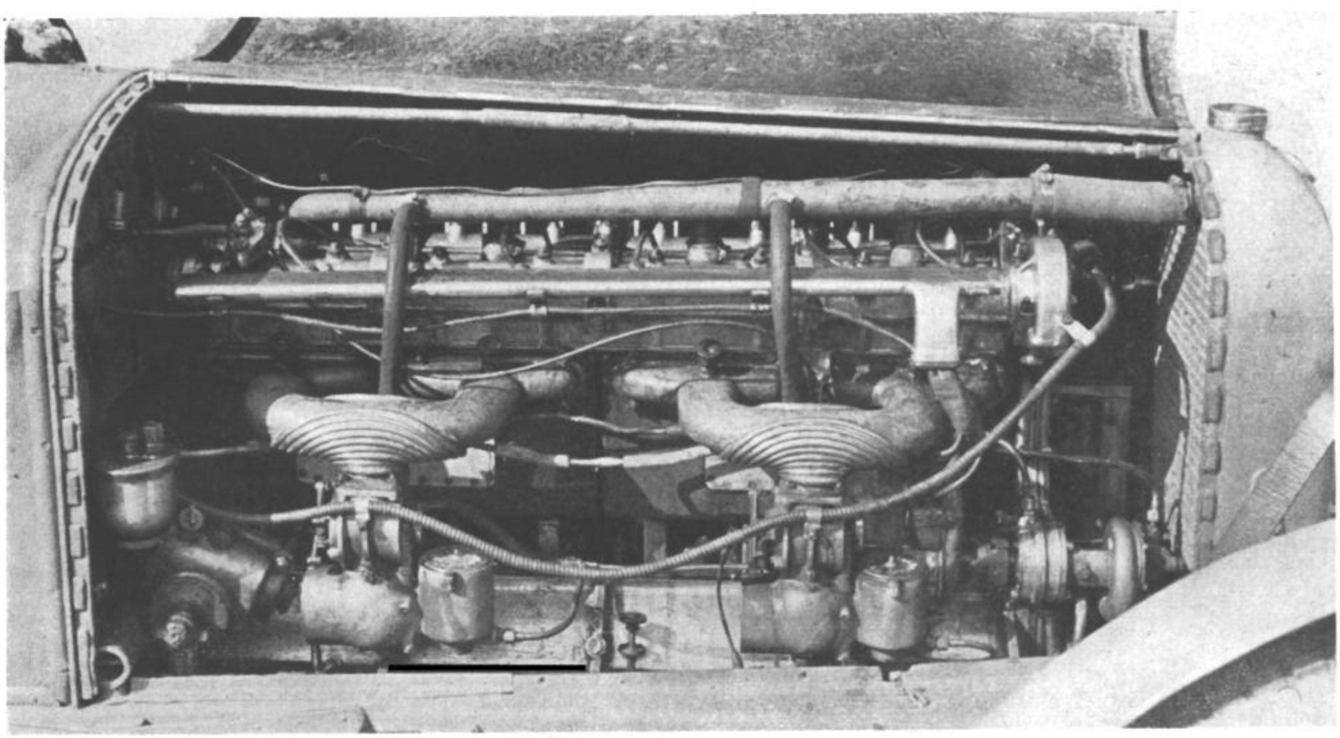


PLATE XXXVI

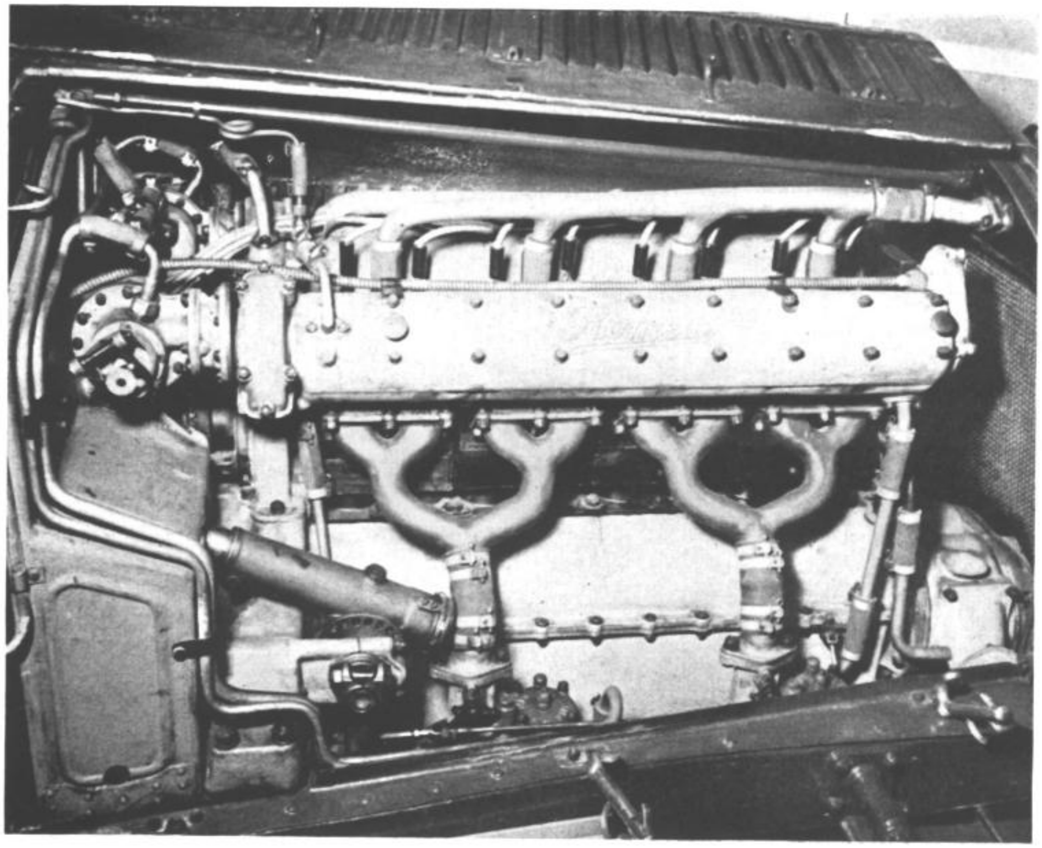
POWER BOOST - The earliest road racing cars to use supercharging were the Chadwick in 1907, in the U.S.A. and Mercedes (1921) in Europe. The first successful Grand Prix car to employ forced induction was the 2-litre Fiat which won the Italian Grand Prix of 1923. This photograph shows the very similar four-cylinder, 1½-litre, Fiat jirst built in 1922 and supercharged in 1923. The Roots blower was driven directly from the nose of the crankshaft and inspired air through a large air filter ; the carburetter received air under pressure of circa 5 lb. per square inch.



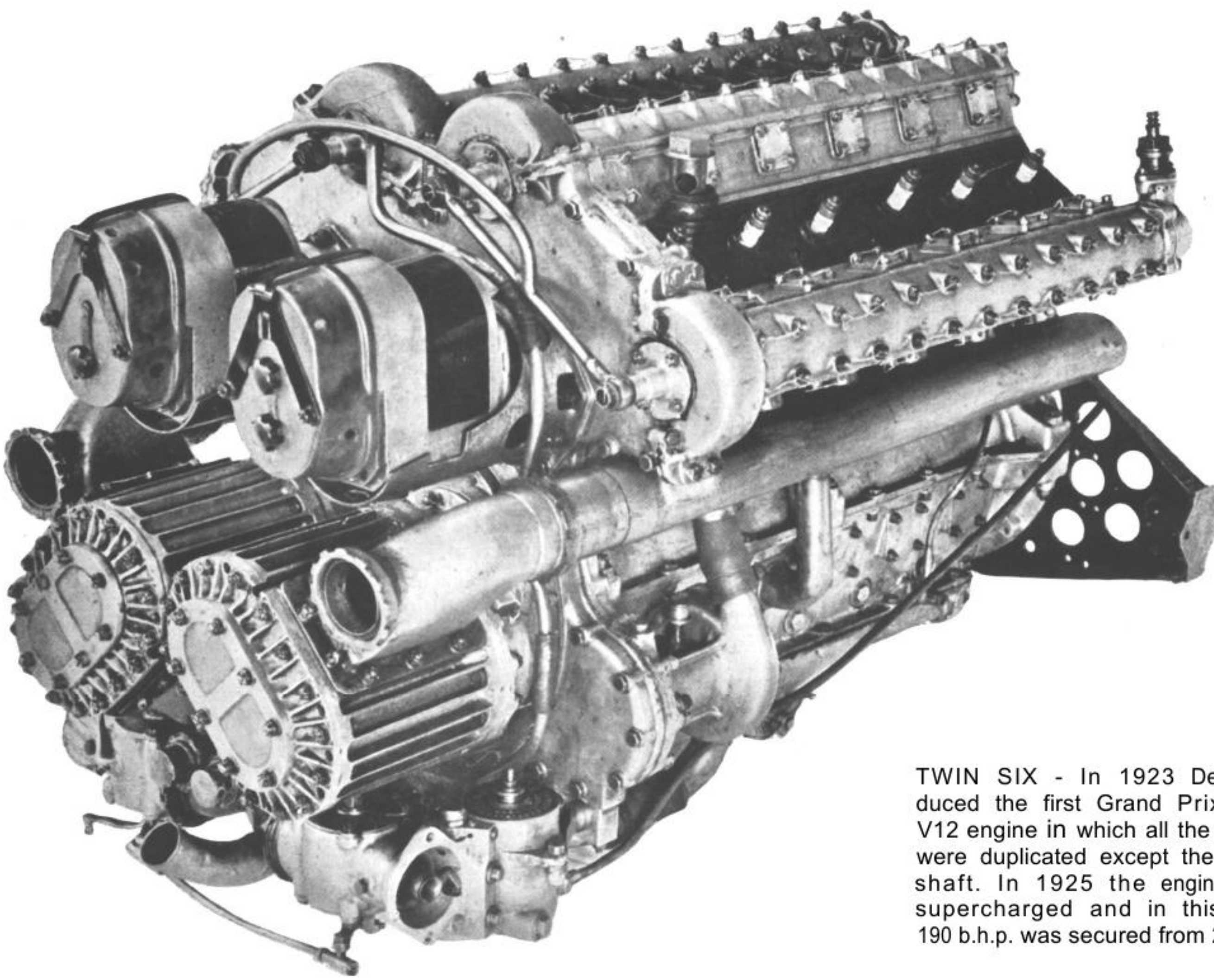


MULTI-CYLINDER - Eight-cylinder, in-line, engines were first used in Grand Prix racing in 1908 but eleven years elapsed before success attended this arrangement with the production by Ballot of a Henri-designed 4.9-litre car in 1919. After being designed and built in 101 days this car raised the lap record on the Indianapolis circuit by nearly 5 m.p.h.

PLATE XXXVII



STRAIGHT-EIGHT DEVELOPMENT - The 2-litre P2 Alfa Romeo first raced in 1924 was a brilliant example of the Italian school of design and was the most successful road racing car in Europe for the next five years. This photoqaph shows the welded steel cylinder block (formed in sets of two) with 100 degree angle valves worked by rear-positioned timing gears. The Roots type blower can be seen at the front of the crankcase, pressure air being delivered to the carburetters. At its peak this engine developed 165 b.h.p.



TWIN SIX - In 1923 Delage produced the first Grand Prix type V12 engine in which all the organs were duplicated except the crankshaft. In 1925 the engine was supercharged and in this form 190 b.h.p. was secured from 2 litres.

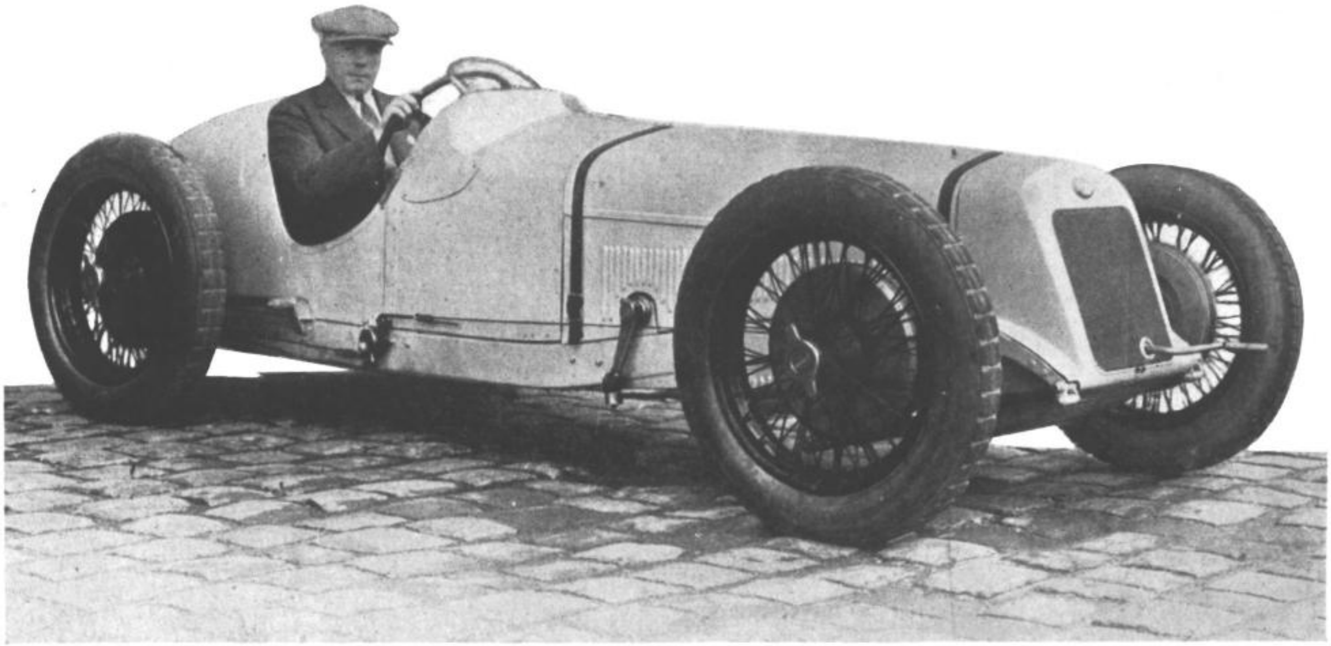
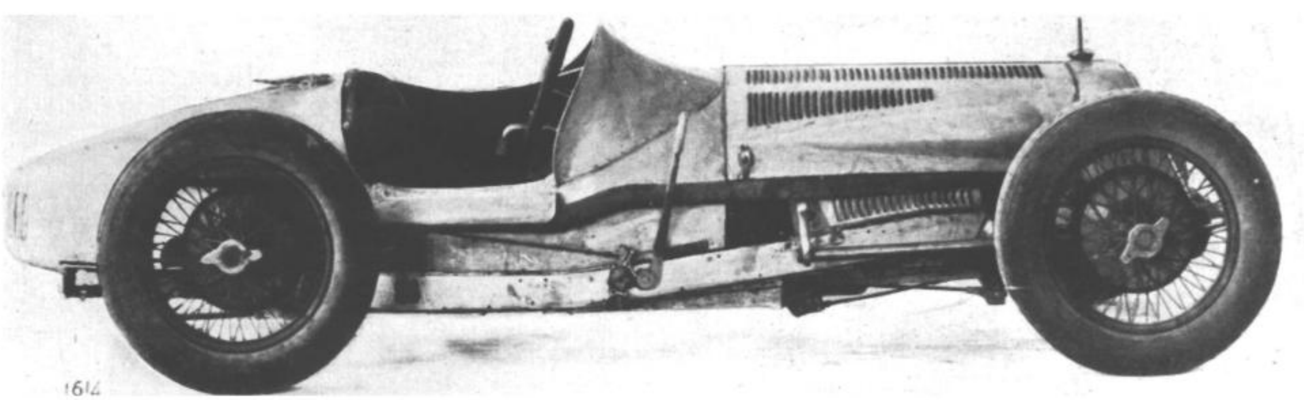


PLATE XXXVIII

LOW LEVEL - Designers counter-attacked the restriction of engine capacity to 1½ litres in the 1926/7 period by reducing windage and frontal area to a minimum. As the regulations for these years did not require a mechanic to be carried on the car the driver was placed very low to one side with offset transmission lines and double drop frames. The pictures on this page show the eight-cylinder, in-line, Delage, above, and the twelve-cylinder Fiat with geared crankshafts, below.



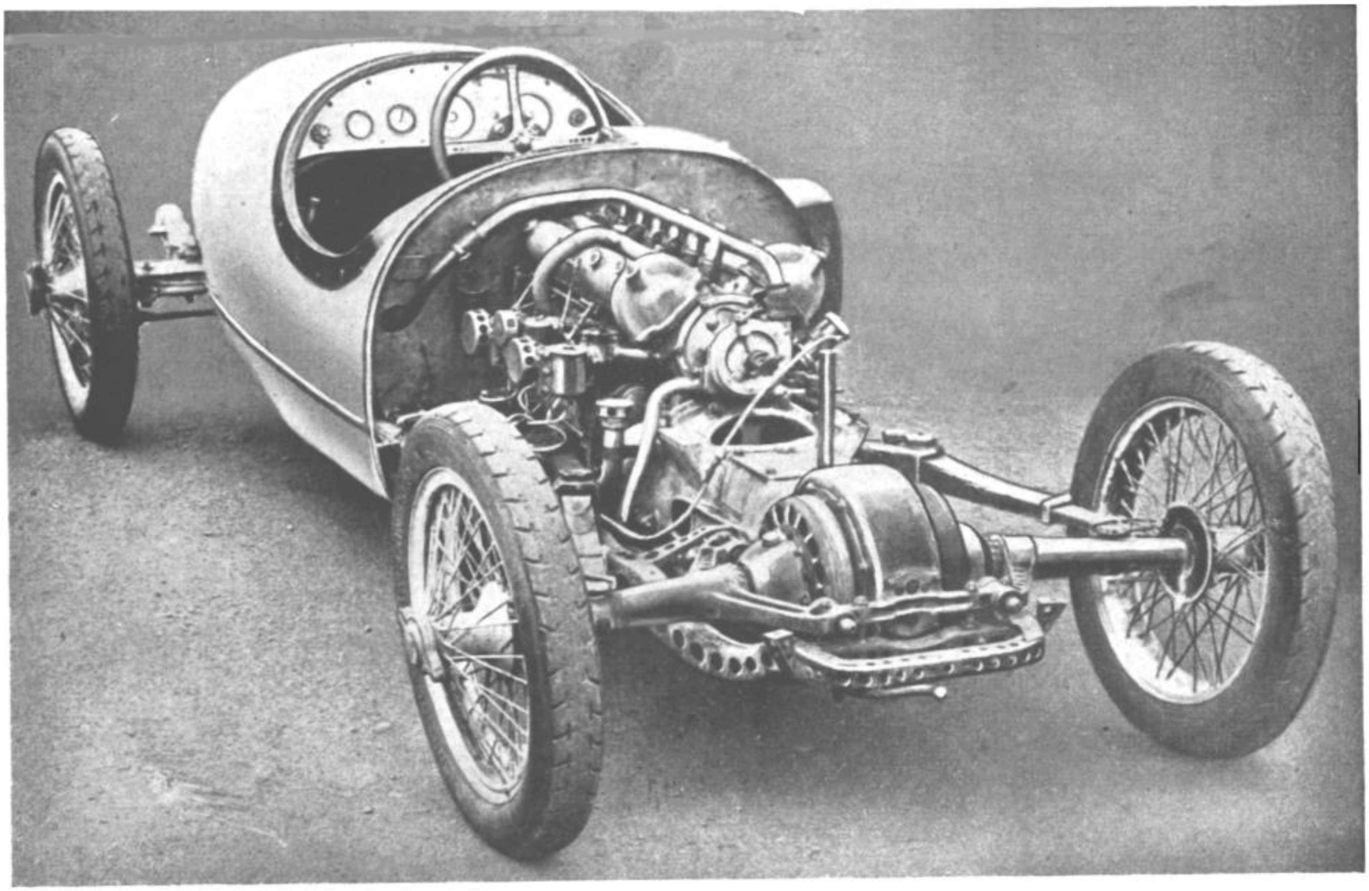
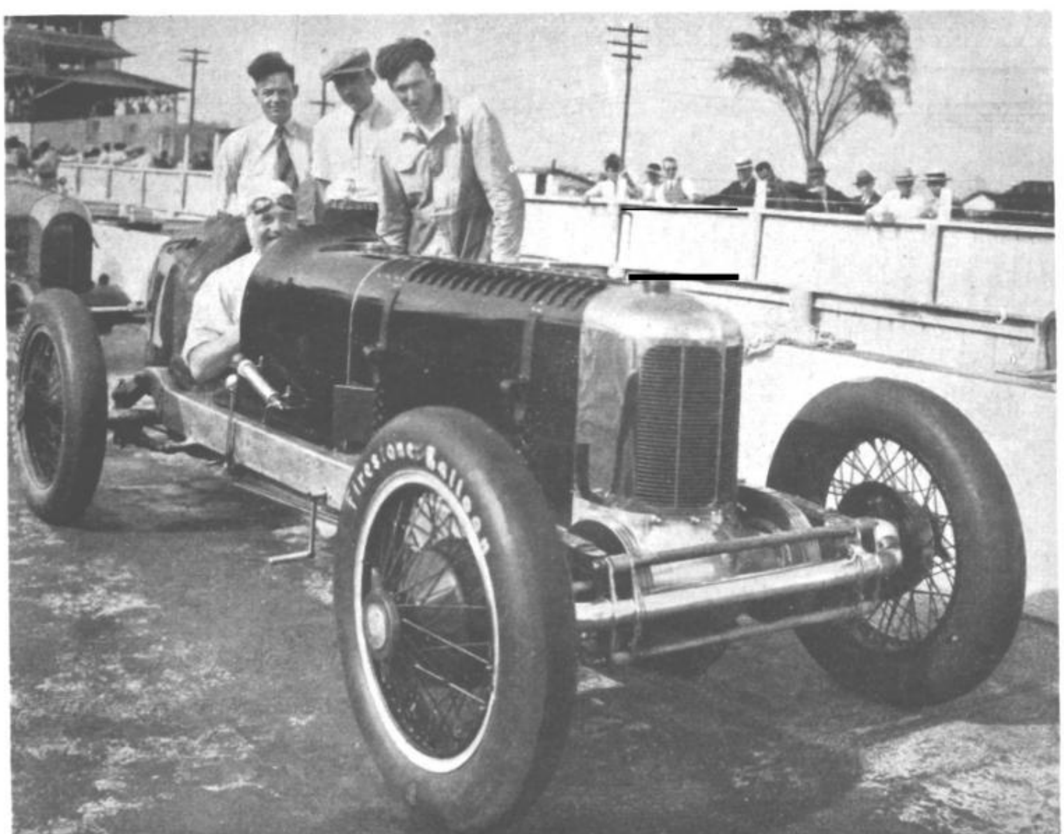


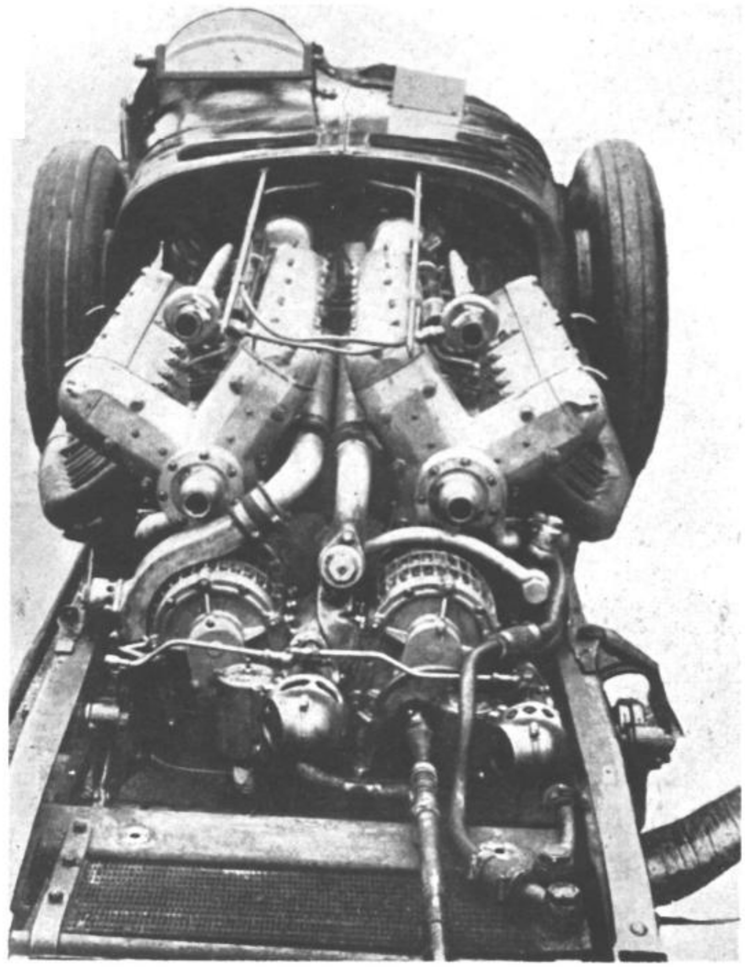
PLATE XXXIX

REAR-END FORECAST - In 1923 the Benz Company built a six-cylinder, 2-litre car to the designs of Professor Rumpler. This was the first rear-engined road racing car and also pioneered the use of independent rear suspension on the swing axle system, as shown in the above photograph.

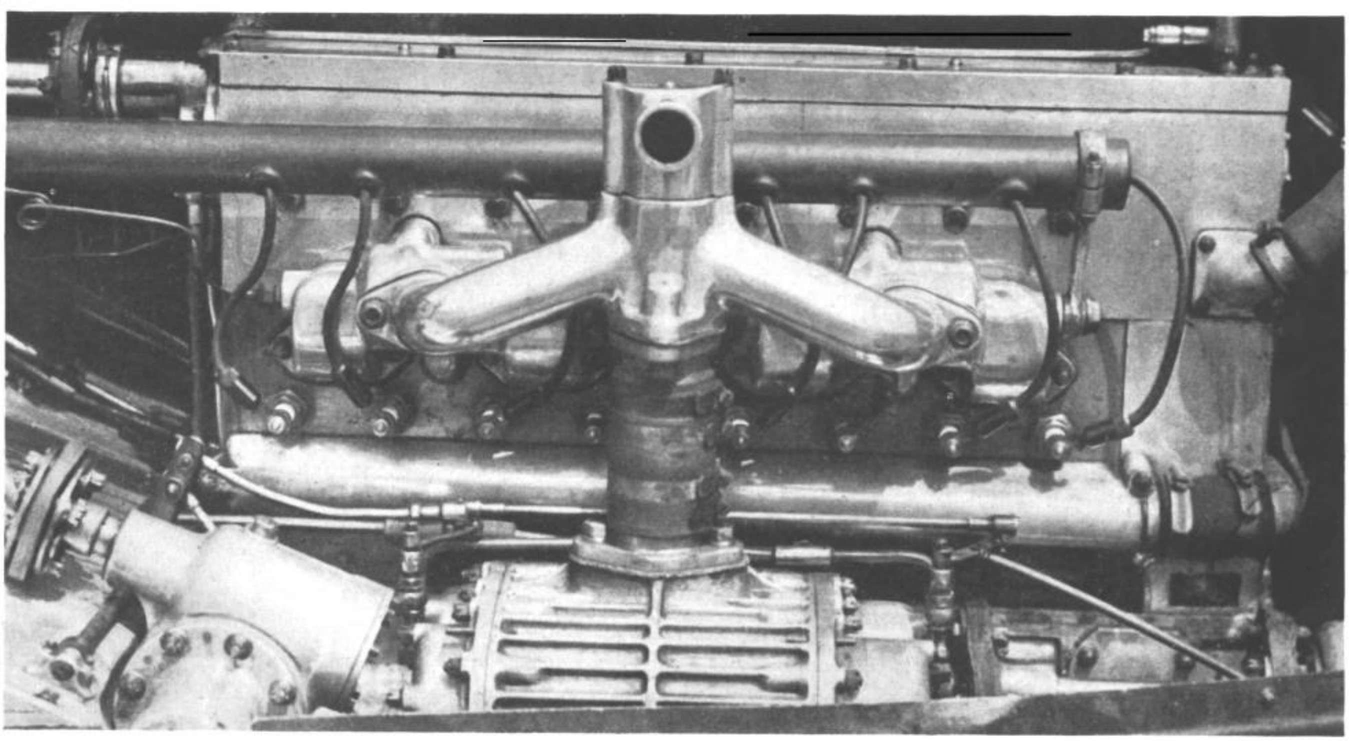


FRONT TO BACK - In 1925 Miller, in America, used the De Dion axle arrangement .for the front end of his .front-wheel drive Indianapolis cars, a 1926 version of which is shown in this picture. In 1931 the same arrangement was adapted for use on a rear-drive Miller which thus hecame the first racing car to have a De Dion type rear axle.

PLATE XL



OVER POWERED - In 1929 Maserati built a twin-engine racing car using two supercharged eight-cylinder blocks each of 2 litres capacity and thus produced a car with a sixteen-cylinder, 4-litre, engine developing approximately 300 b.h.p. Although timed on the road at over 152 m.p.h. this car was not successful in normal road racing.



BALANCED QUALITY - The Type 35 Bugatti was by far the most successful racing car judged by sheer number of wins. The straight-eight engine had two cast iron blocks, four cylinders in each, with a single overhead camshaft driven by bevel gears at the front end of the engine. This pjcture also shows the central mounted Roots blower which gave approximately 10 lb. boost, the engine developing approx - imately 135 b.h.p.

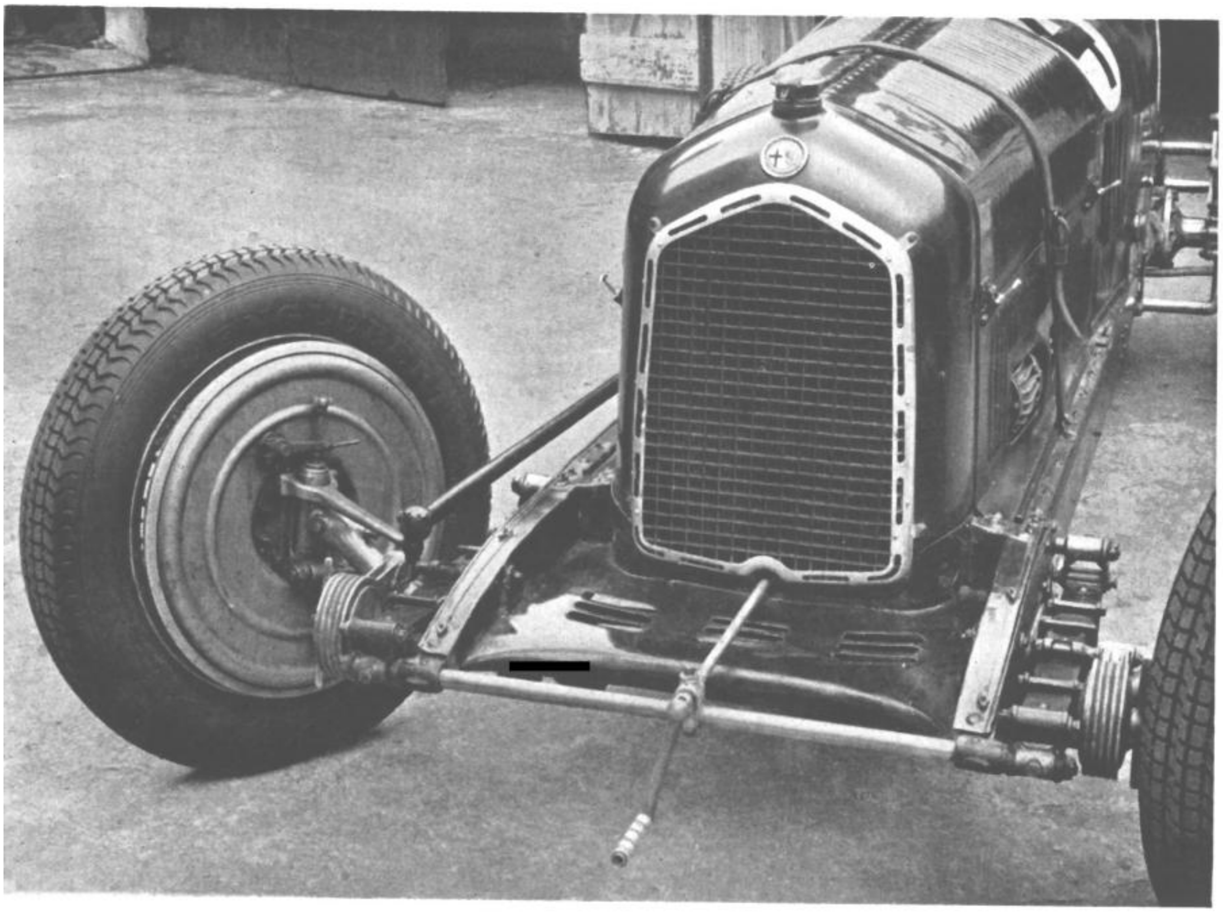
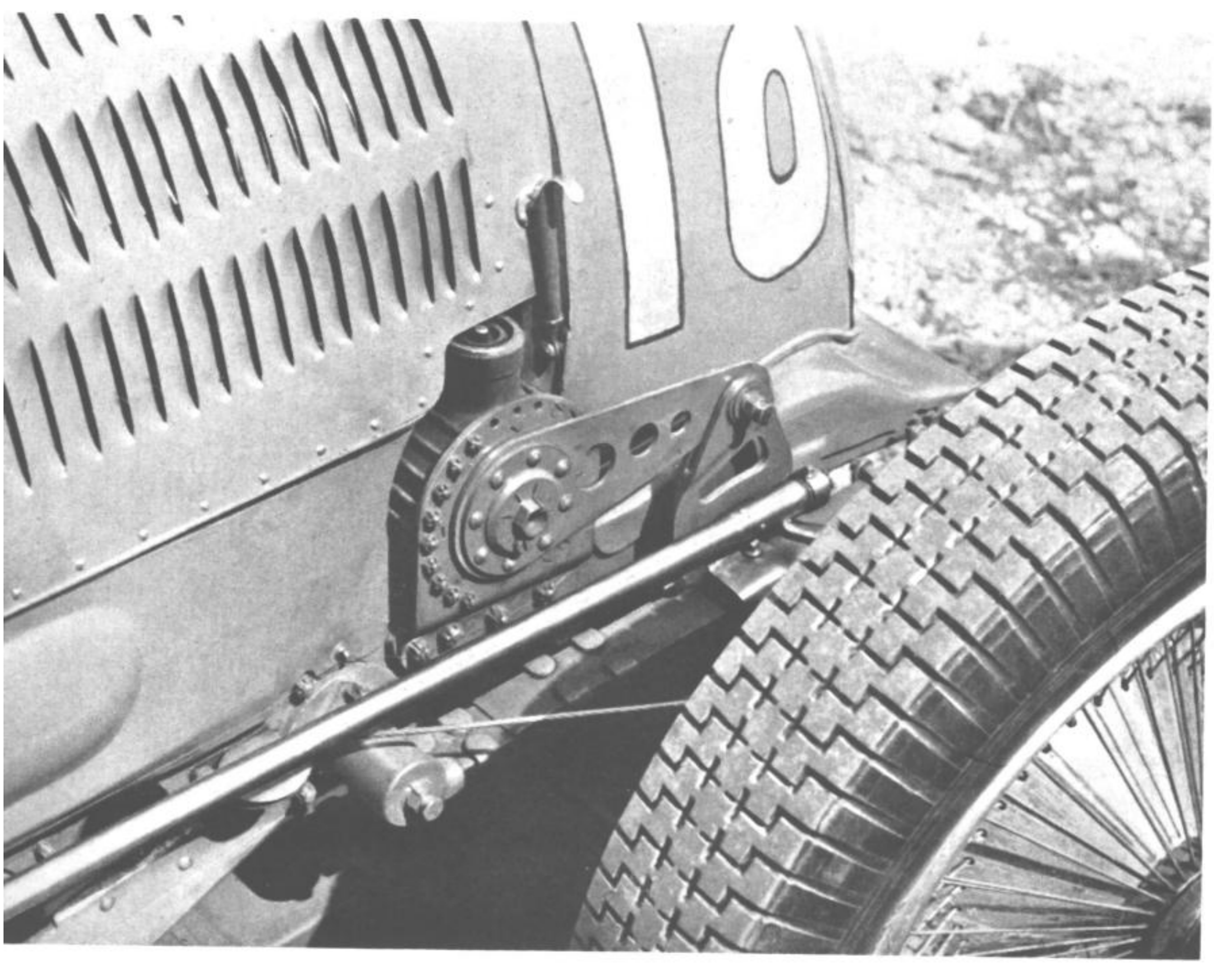


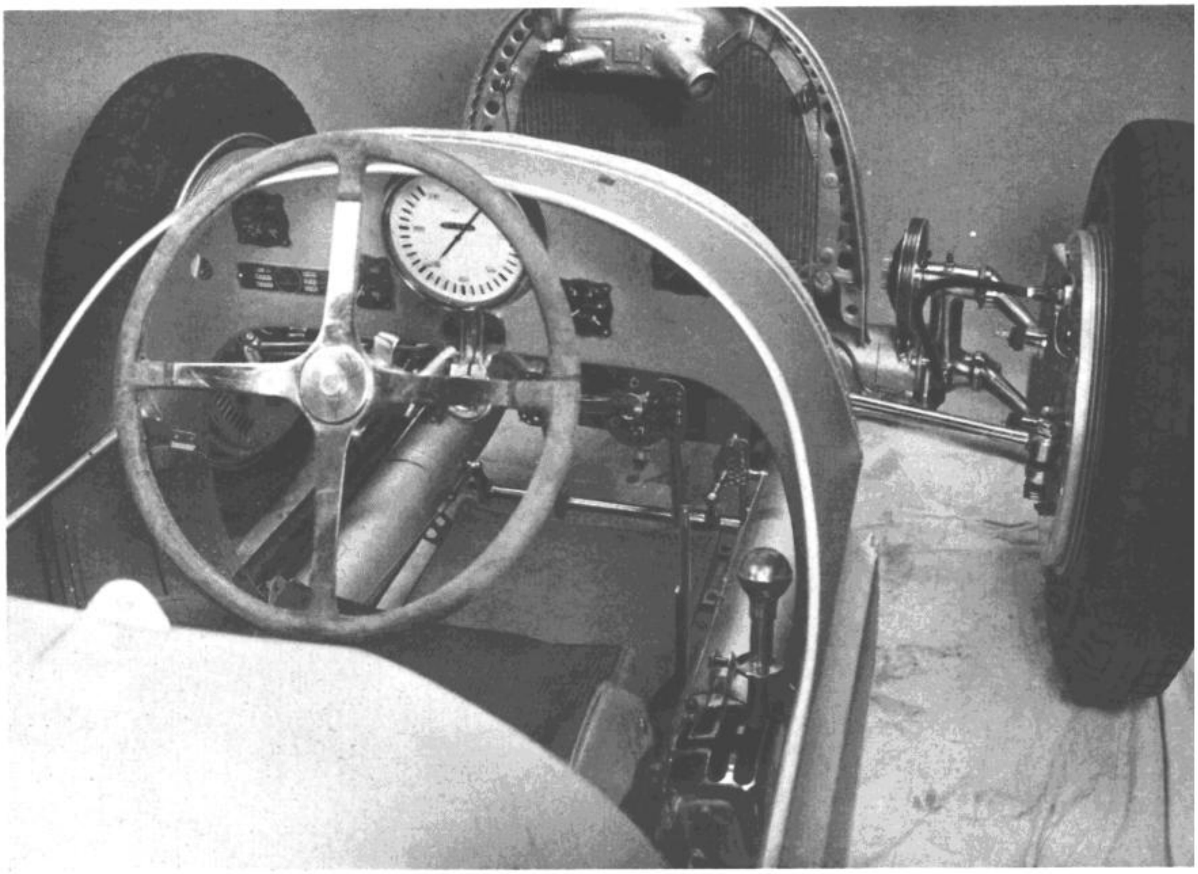
PLATE XLI

END POINT — The Alf'a Romeo and Bugatti cars produced, between 1932 and 1934, the highest standards of road worthiness achieved by any cars with rigid axles and leaf springs. This photograph shows the out-rigged front springs and comparatively wide track of the 1932 P3 Alfa Romeo, whilst at the back one can see the out-riggers for the widely spaced, rear springs ; also part of one of the twin bevel housings which join the triangular drive embodying double propeller shafts. The low frontal area and clean lines are also well exemplified.

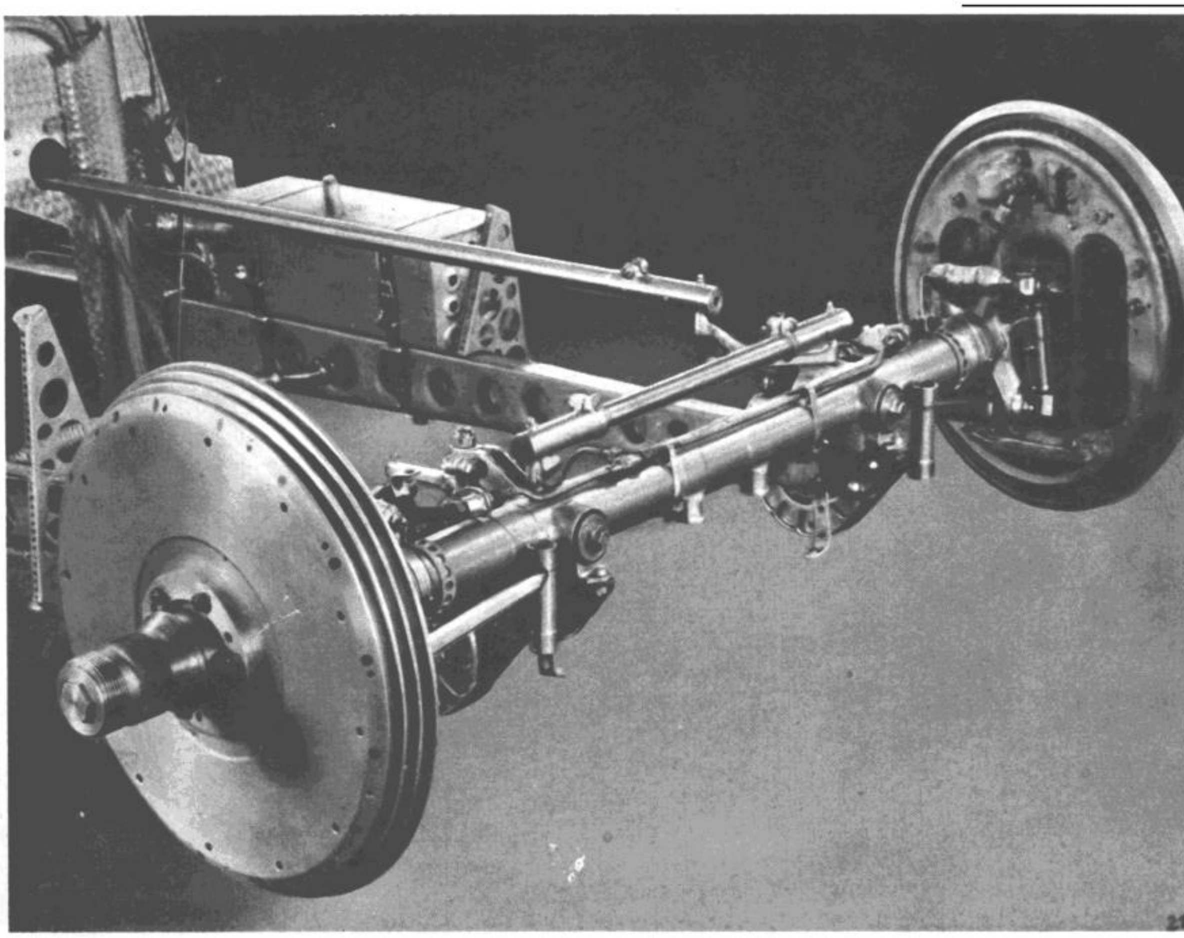


DETAILED REFINEMENTS - The 1938 3-litre Bugatti retained semi - elliptic front springs but these were freed from brake torque by a radius arm connecting to the De Ram shock absorber which combined friction damping with hydraulic loading of the surfaces. This picture also shows the specially designed Bugatti wheel which replaced the cast light alloy type used in previous years.

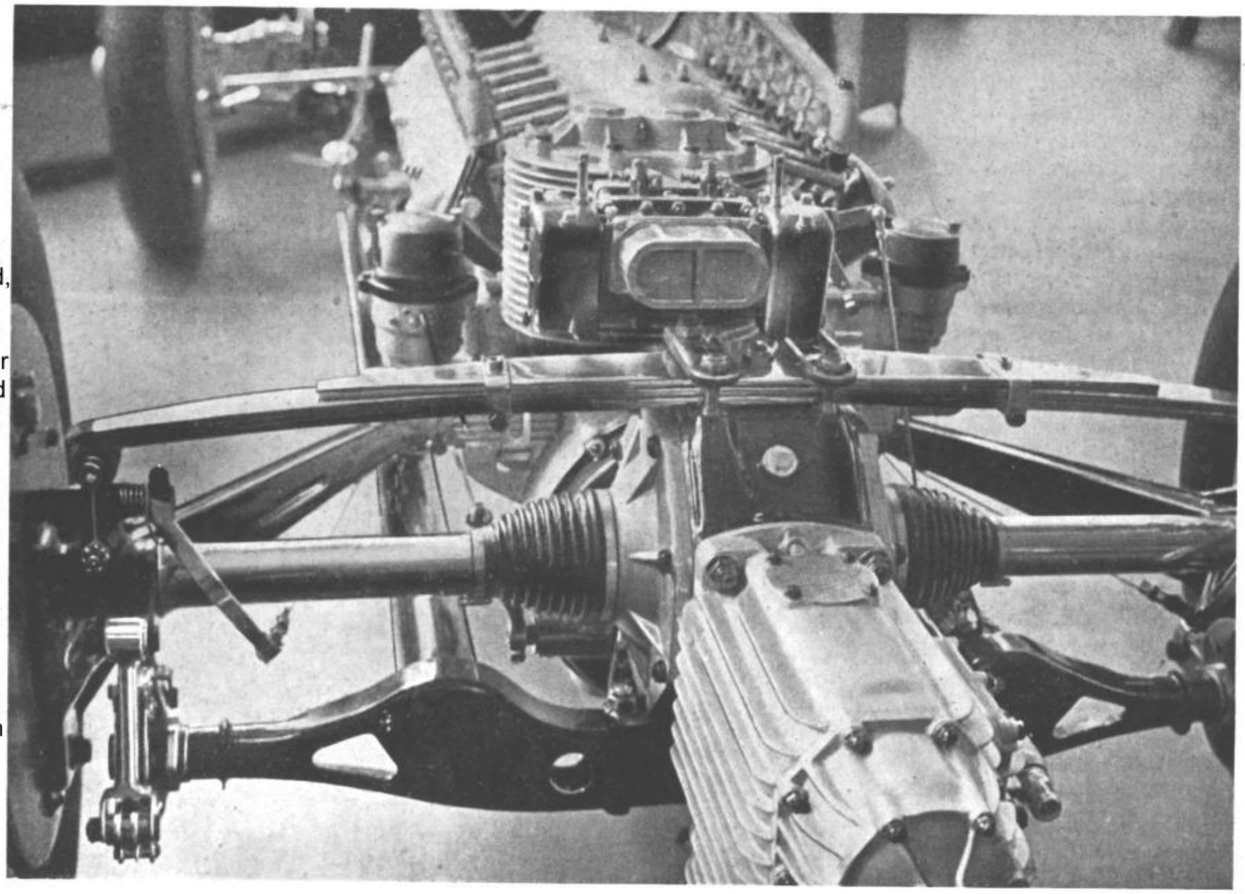
SIMPLICITY -
In 1934 independent front suspension was first used in Grand Prix racing. The Auto-Union car designed by Dr. F. Porsche used his patented suspension layout in which the wheel was supported through spherical joints on two trailing arms. The bottom arm of each wheel was connected to a torsion bar concealed in the front cross member and running the full width of the car, there being a slight offset so that the bars could be staggered one to the other. The centrally mounted steering box made possible by the rear engine location led to a simple, divided, track rod. Other features made clear by this drawing are the tubular frame and forward mounting of the radiator.



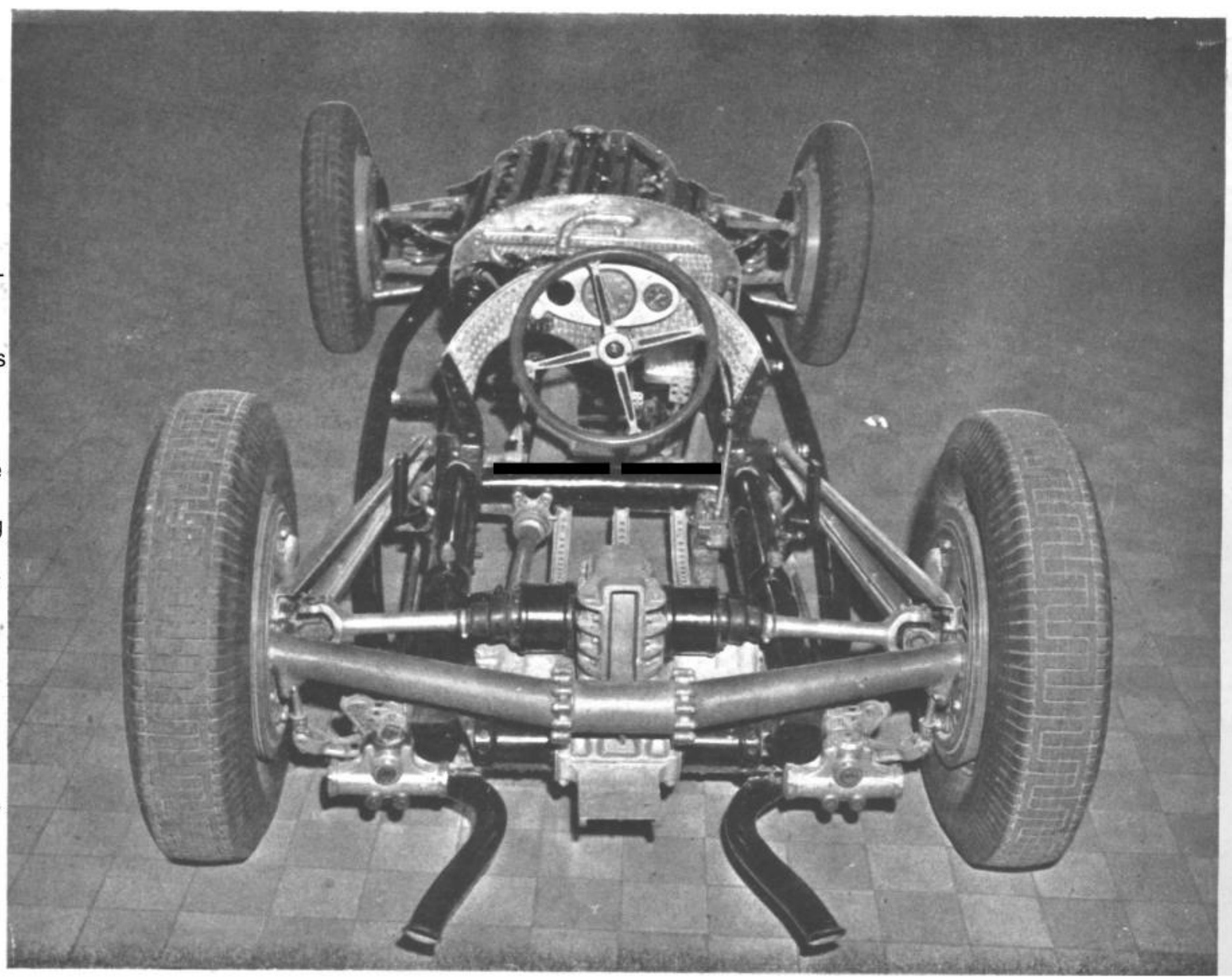
COMPLEXITY -
The 1934/6 Mercedes-Benz 750 kg. formula had independent suspension to the front wheels in which coil springs were concealed in the front cross member. These were actuated by a bell crank and the wheels located by short wishbones of approximately equal length. The relatively complex steering link layout imposed by the front engine mounting is also shown in this picture.

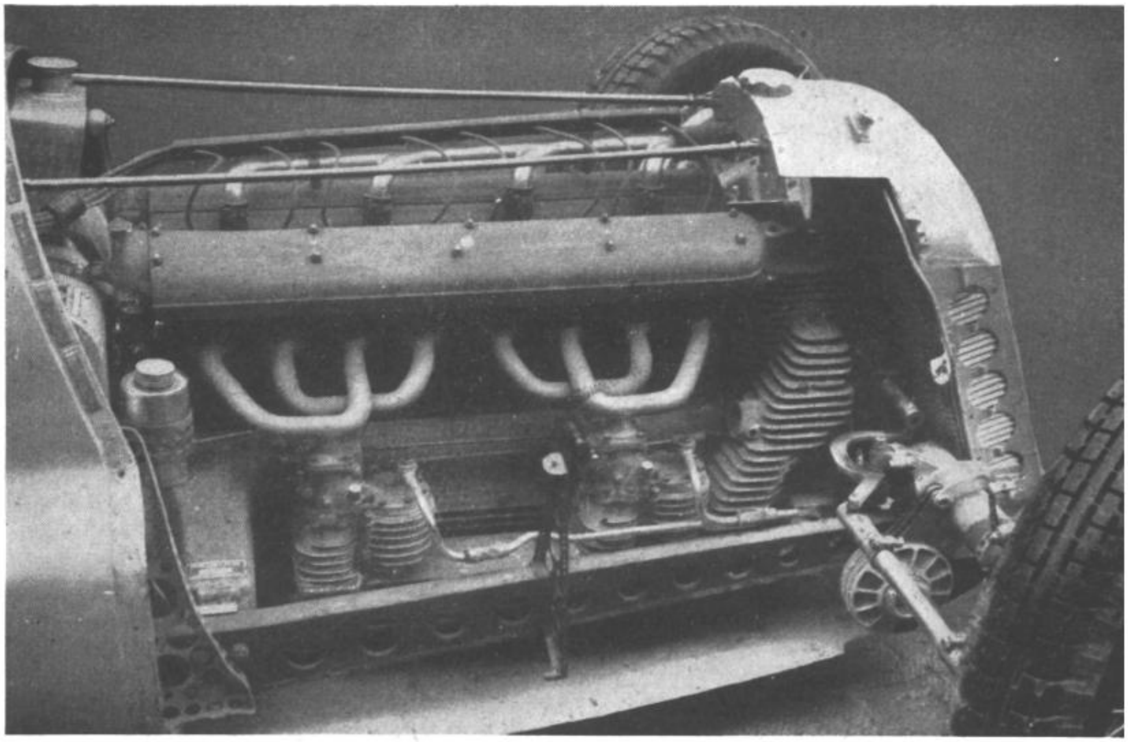


SWING AXLE REVIVAL — Independent suspension for the rear wheels of racing cars was first used on the 1923, rear engined, Benz cars, which employed the swing axle type. Eleven years later this layout was revived by Mercedes-Benz and Auto-Union and the arrangement used on the latter car is shown here. The simple transverse leaf spring was replaced on the 1935/6/7 cars by torsion bars but the basic layout remained unchanqcd with radius arms controlling the movement of each rear wheel.



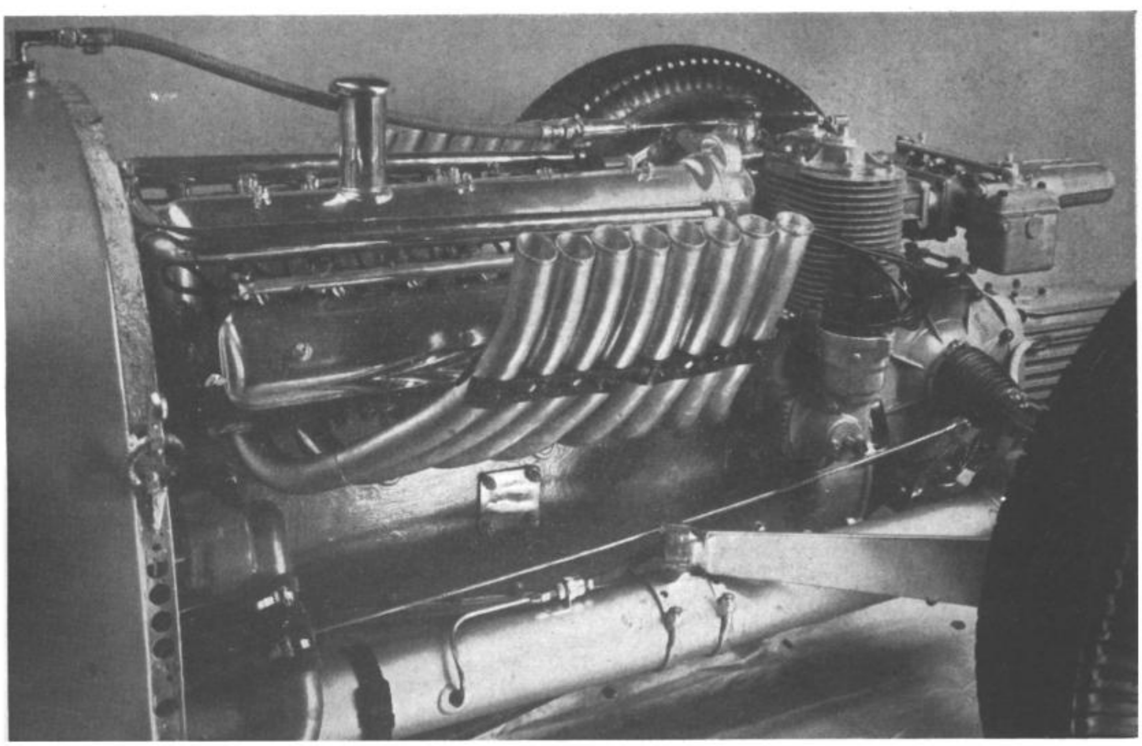
DE DION REVIVAL - The De Dion type of axle was first used in 1894 and was revived for road racing by Mercedes - Benz in 1937, the same components being used during 1938 and 1939. This photograph shows the 1938, 3-litre, car, the cross tube (which is split internally and located sideways in the vertical slot shown in the bevel housing) being a prominent feature. On each side of the car is a radius arm. The drive being taken independently to each wheel through exposed half-shafts with two universal joints on each side. This illustration also shows clearly the marked offset of the propeller shaft and the deep oval tube frame.



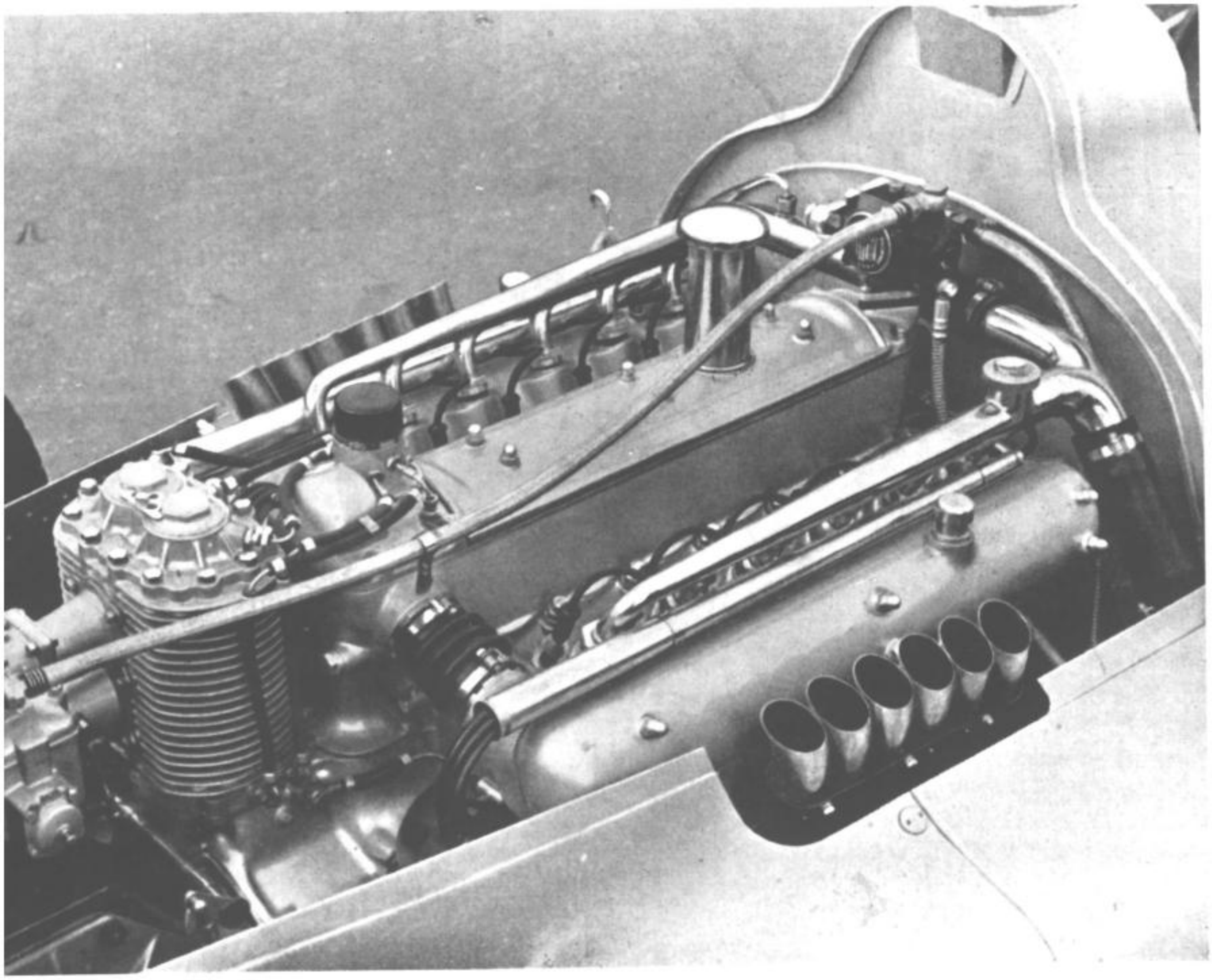


LIGHTWEIGHT CONSTRUCTION - The Mercedes-Benz M.25 series of engines built between 1934 and 1936 varied between 3.36 litres and 4.14 litres capacity with a weight of between 449 and 465 lb. and an output varying between 345 and 494 b.h.p. This illustration shows the 1935 version with bore and stroke 82 mm. by 94.5 mm. (3.99 litres) having an output of 430 b.h.p. at 5,800 r.p.m. The ribbed pipe feeding pressure air to the carburetters should be noted, also the spill valve on the vertical pipe which controlled the inlet manifold pressure.

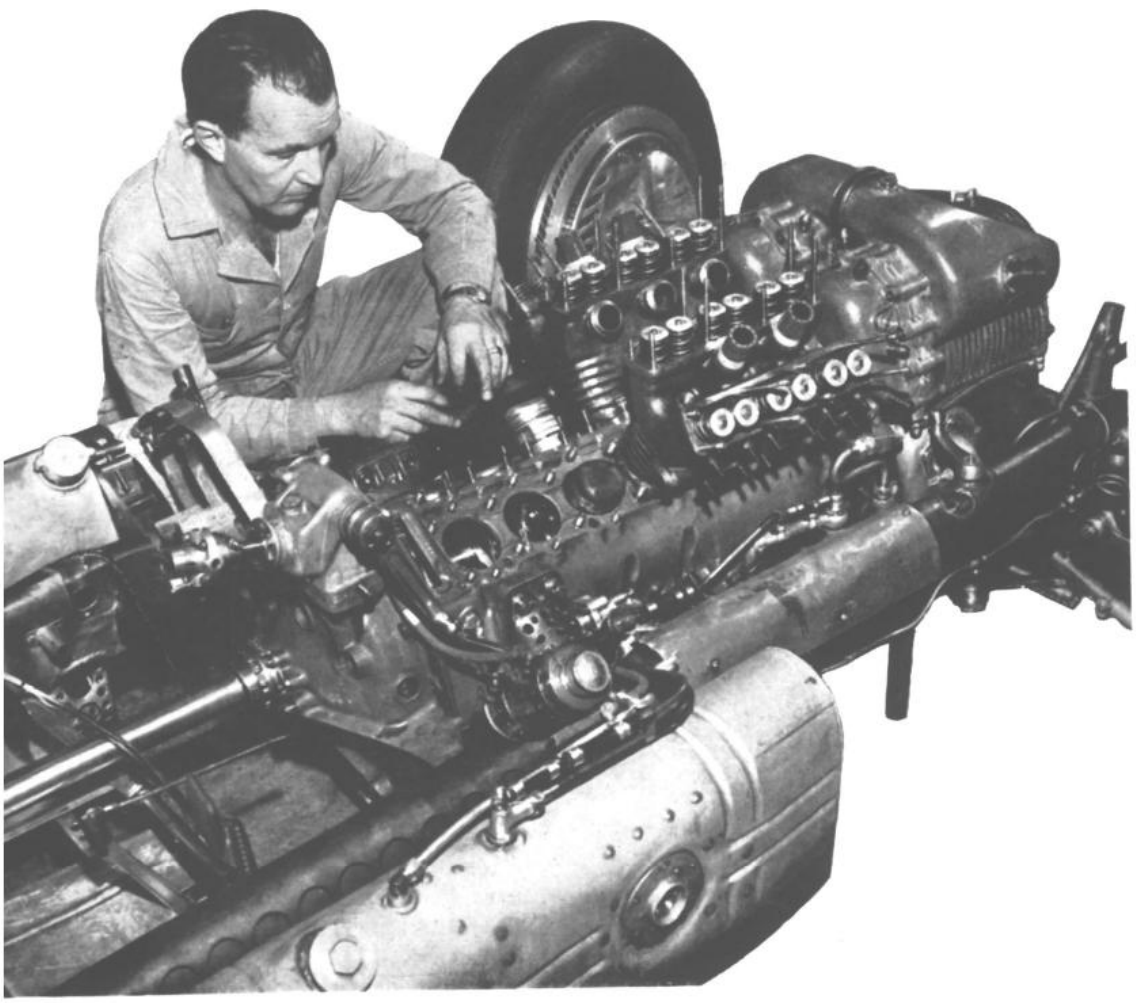
PLATE XLIV



UNIQUE ARRANGEMENT - The 1934/1937 Auto-Union engines were unique in combining rear mounting with sixteen cylinders in Vee formation, the mixture being fed into a central manifold from a supercharger mounted just ahead of the rear axle as shown in this illustration. The picture also shows the water pipe connecting to the forward mounted radiator and the vertically-rising grouped exhaust pipes used from 1935 onwards.



NEAT LAYOUT — The 3-litre Auto-Unions built for 1938/9 were designed by Dr. Werner. The cylinder ases were inclined at 60 degrees and each detachable head carried an exhaust camshaft driven by a short cross-shaft engaging with a vertical drive at the back qf the engine. A single, central camshaft operated all the inlet valves and ran in the same casting used for the inlet manifold. This connected at the back of the engine to a Roots type blower drawing mixture through multiple Solex carhuretters. In 1939 two Roots blowers operated in series drew mixture from floatless D.U.M. carburetters and in this guise the engine gave approximately 500 b.h.p.



CHARACTERISTIC CONSTRUCTIO N — From 1914 onwards all Mercedes-Benz racing cars used forged steel cylinders with integral heads carrying four valves, the ports and water jackets being welded on. The layout of the 1939 V12, 3-litre,engine is shown here. The picture also gives a clear view of the turbine-like fins which shrouded the brake drum and which promoted cooling by a positive air blast. The Roots supercharger seen on the right-hand side of the car is the first-stage delivery being made through the cast pipe into a second, smaller blower, on the left-hand side, the inlet manifold running between the V of the cylinder block.

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ILLUSTRATIONS