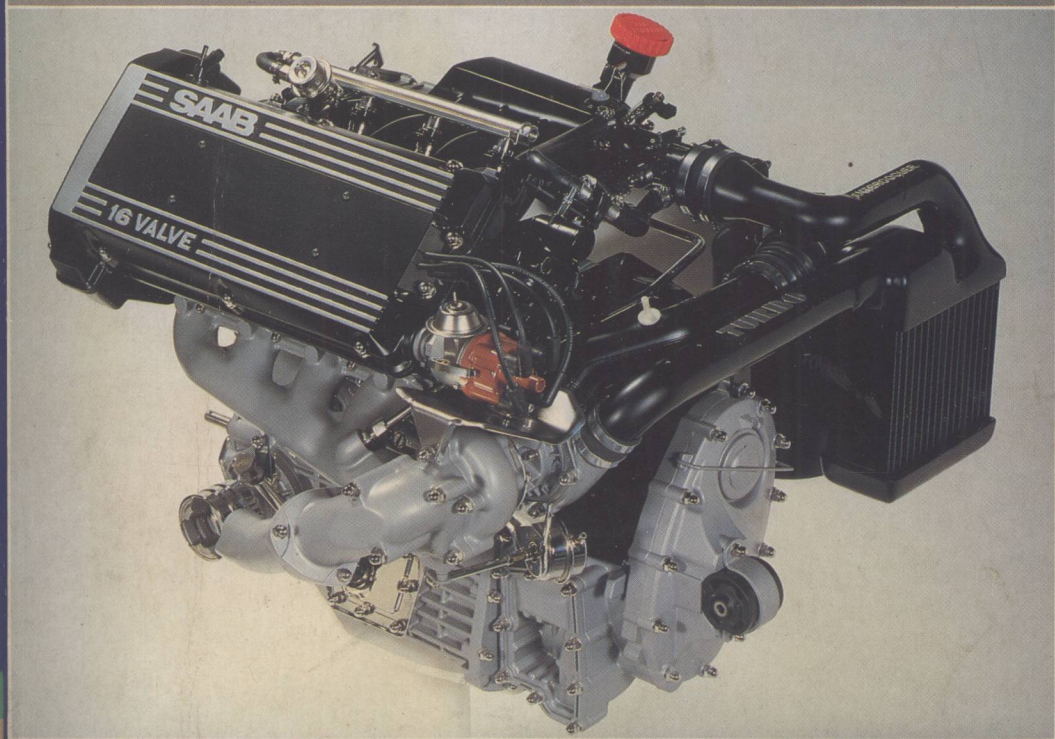
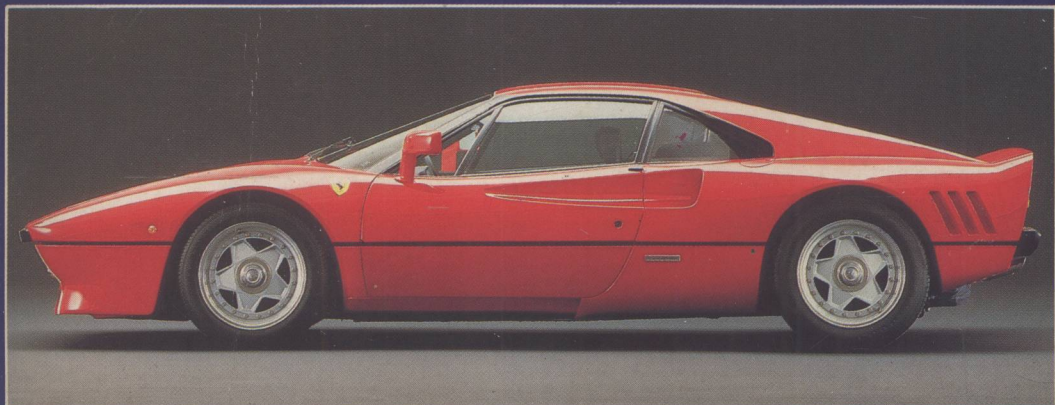


TURBOCHARGING & SUPERCHARGING



ALAN ALLARD

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TURBOCHARGING & SUPERCHARGING

A practical guide to supercharging and turbo-charging car, motor cycle and small diesel engines for road and competition use.



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TURBOCHARGING & SUPERCHARGING

ALAN ALLARD



Patrick Stephens, Wellingborough

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Introduction

It is no exaggeration to say that in the automobile world there are few subjects which conjure up so much interest as supercharging or turbocharging. Yet, despite this, there are very few books available on the subject, although magazine articles and technical papers abound. I have, therefore, with this book, set out to cover an outline of the history and development of the art of forced induction from the beginnings of blowing in the early 1900s to the sophisticated turbocharged vehicles of the 1980s.

However, as it was my intention to make this book of practical value and interest to as wide a range of readers as possible, I have attempted to include a large percentage of practical information, laced with sufficient technical detail to give adequate technical back-up. There are chapters covering almost all aspects of forced induction, from carburation to exhaust systems, together with sections on diesel turbocharging, motor cycles, high performance turbocharged manufacturers' cars and other specialised applications.

In a subject which is so far-ranging and ever-changing, it is not possible to cover all aspects in every detail, without resorting to writing a volume on each, but wherever possible, facts and figures, together with supporting photographs or diagrams are given.

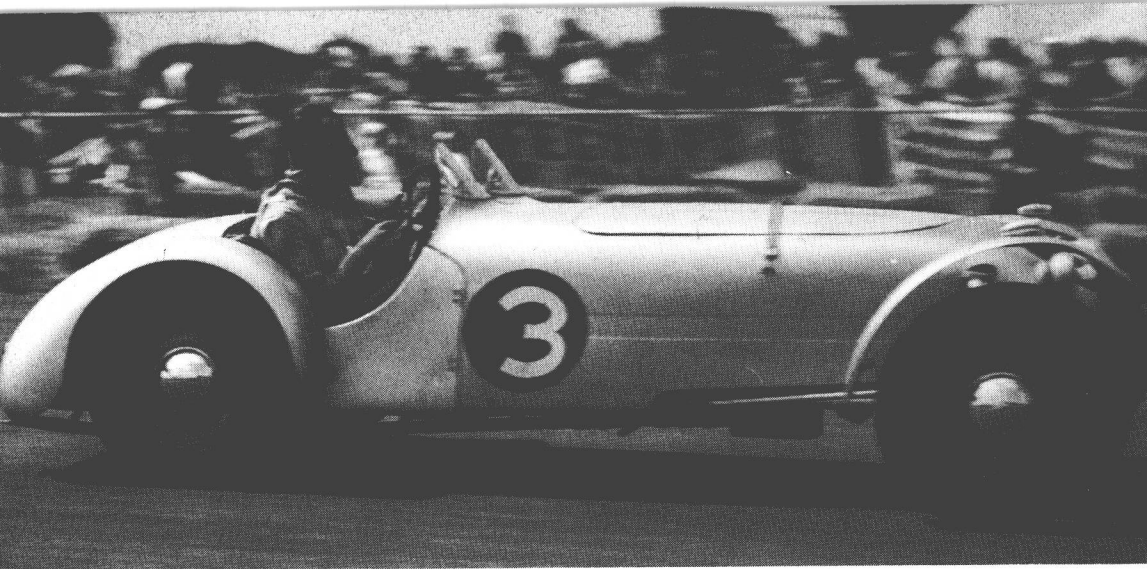
I originally started compiling information for this book some six years ago, yet even now, such is the rapid development of turbocharging, that more information and details of new developments are coming to hand all the time, so that a new chapter could be written each month.

Unlike most other books concerned with supercharging, I have written in detail about all types of supercharging, whether it be positive displacement mechanically-driven or 'turbo' turbine-driven, showing the relative merits or pitfalls of each and their practical and theoretical application, together with details of design and construction of each type.

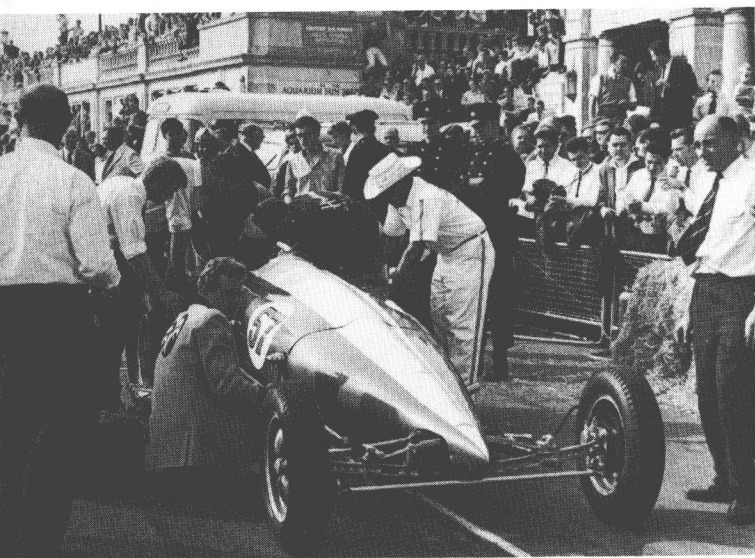
As has been said before, one of the most difficult things in producing a book is to sit down and actually write it, but after over twenty years' involvement with the practical application of supercharging and turbocharging, I felt that the time had come when I should put pen to paper. I hope you will find this book as interesting to read as I have to compile and write.

The Allard connection

Those mature readers amongst you who may well remember the past days when my father, Sydney Allard, produced, raced, hillclimbed, rallied and even drag-raced his own



Above Sydney Allard in the supercharged J1 Allard at Silverstone in August 1949.



Left The first Allard Dragster, Brighton speed trials 1962. Built by Sydney Allard, John Hume and Dave Hooper to establish drag racing in this country. Chrysler 350 CI Hemi-head engine with Potvin front mounted blower. Ran on methanol and achieved a best time over the quarter mile of 10.24 seconds. UK rules insisted on front wheel brakes for a 'racing car' in those days. This machine has been carefully restored and is now on display in the National Motor Museum at Beaulieu (Freddie Grevett).



Left Alan Allard with co-driver Rob Mackie in the Shorrock Supercharged Allardette Anglia on the Col du Turini, Monte Carlo Rally 1963. Finished 56th overall out of nearly 400 starters.

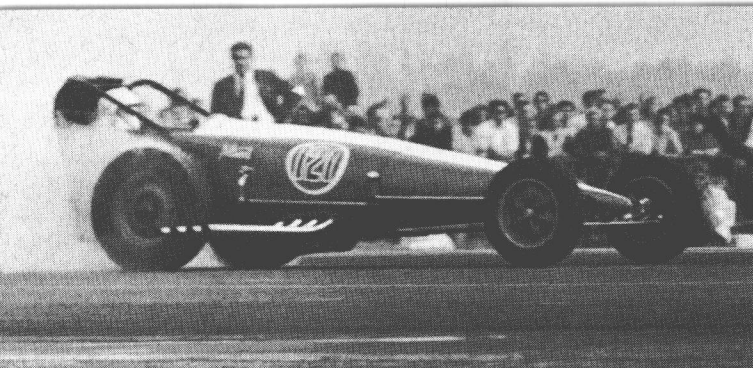


Above Goodwood chicane 1963. Alan Allard's Shorrock Supercharged Allardette Anglia sandwiched between the Lotus Cortina of Doc Merfield and the incredibly quick Austin A40 of Willie Cave.

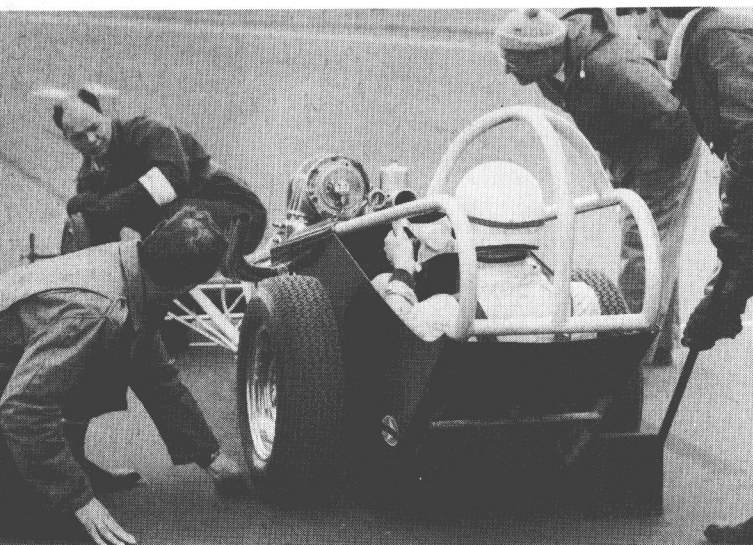
cars, might be interested to know how it evolved that Allards were to get so involved with supercharging. Indeed, the Allard connection with supercharging dates way back to the days of the J1 Allard, about 1947. My father had two J1 Allards fitted with Marshall superchargers. I believe he was looking for methods to increase substantially power and torque at low and medium engine speeds. There are really only two ways to achieve this: one is by some form of forced induction and the other is by fitting a larger capacity engine. Up until recent times fitting a larger engine had been the normal step, but my father, never a man to tackle a project in a certain manner just because it has always been done that way, decided to supercharge. He always had a passion for engine muscle power, as opposed to what might be termed rpm power, so I suppose supercharging falls quite naturally into this category.

After production of Allard cars had ceased in 1957, the Allard Motor Company branched into engine tuning, motor accessories and various other associated activities. About this time my father met Chris Shorrock of Shorrock Superchargers and came to an agreement to handle the distribution and marketing of these units. Shortly afterwards I too became enthusiastic about supercharging as a method of obtaining big engine performance from a small capacity engine. To both my father and I it seemed the logical way to obtain a 'quart from a pint pot', but generally very few others agreed with this and indeed many of the purists tended to see it almost as a form of cheating, at least when using supercharged cars in competition, even though supercharged cars were often competing in a larger capacity class. I had been convinced that forced induction was the right way to go about it for many years, but until such a time as a larger manufacturer was convinced sufficiently to invest money to develop an efficient supercharging system and the engine to handle it, and by producing in numbers to break through the homologation barrier, it was not possible to bring supercharging back into the limelight.

It may be interesting for readers to know that my father and I competed in the 1960 and



Left Alan Allard competing in the Allard Dragster at Blackbushe in the 1964 Drag Festival (Geoffrey Willson).

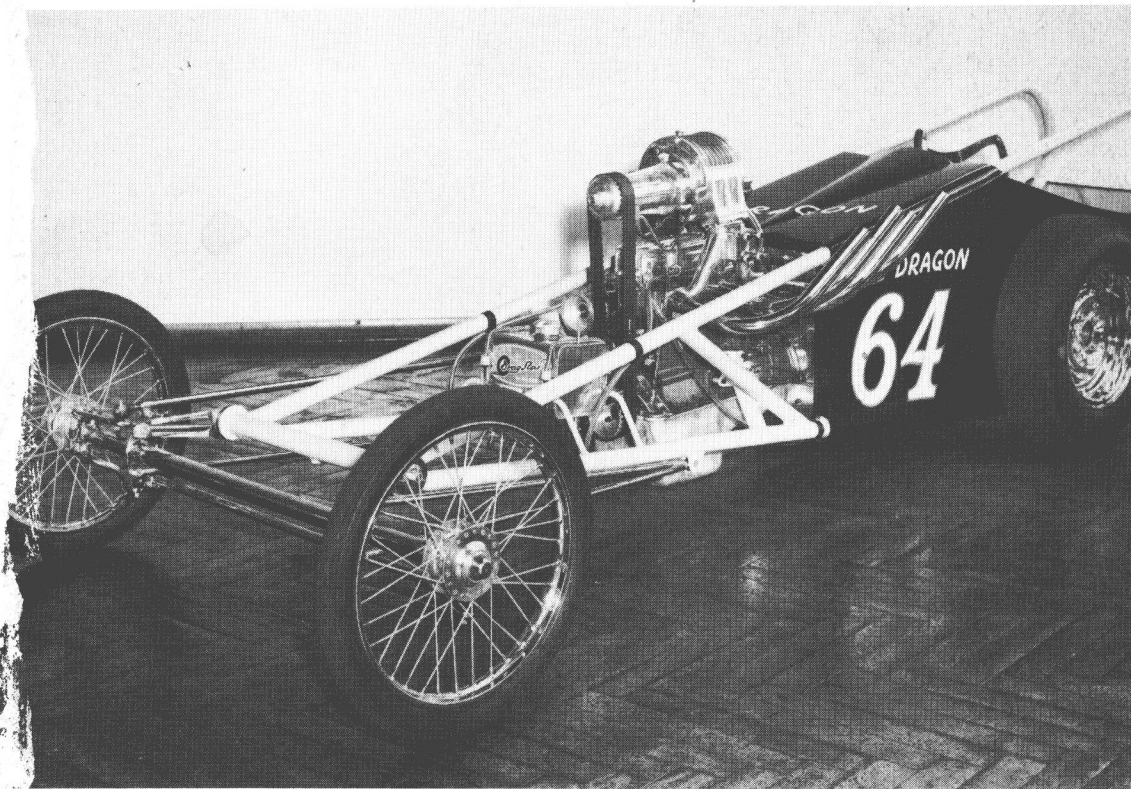


Below left The author waits to start his record attempt in Dragon Dragster for the standing-start kilometer. The engine reached maximum revs approximately halfway down the course at a speed of around 145 mph. Even so, the time was a creditable 21.53 seconds.

Right Allard Dragon Dragster built to foster the sport of drag racing in the UK. Powered by a Shorrock supercharged Ford Cortina 1,500 cc engine, it produced 175 bhp with a single 2-in SU, running on methanol, and achieved a best elapsed time for the quarter mile of 10.9 seconds with a top speed of 129 mph.

1961 Monte Carlo rallies with Shorrock supercharged 997 cc Ford Anglia 105Es. I can always remember how the Anglias really got 'into their stride' when hillclimbing. On one such occasion in very thick snow, we had just caught and passed a Russian team (their first event outside Russia) in a Moskvitch, whereupon we got a little too far sideways, a wheel dug into soft snow, the steering was wrenched from my hands and we suddenly found the car on its side blocking the road. Luckily the Russians did not hit us, but we imagined they were somewhat horrified by such wild antics of these capitalists. At least with their help we managed to get the car on its wheels once more.

On another occasion, when competing in the round-the-town race, which was normal for many years at the end of the Monte Carlo rally, we were racing with—amongst others—Vic Elford and Raymond Baxter in a Sunbeam Talbot and a German-entered Mercedes. I recall following the Mercedes around the circuit. With all his extra power he would pull away on the flat and straighter parts of the course, but when we came to the hill up past the Beau Rivage Hotel on the sea front, the blower really started its characteristic whine and our blown Anglia accelerated past the Mercedes up the hill. It was sweet medicine indeed and left the surrounding crowds of people with a stunned look of amazement on their faces.



About this time my father became interested in the American sport of drag racing. Indeed, most of the fastest dragsters and funny cars were supercharged. Early in 1960 he imported from the Moon Equipment Company of Los Angeles, California, what was probably the first GMC 6-71 supercharger in this country. This, complete with Hillborn Fuel Injection, was fitted on to a specially-prepared Chrysler Hemi engine and installed in the Allard Dragster: the first big-engined American-style dragster outside the USA. This machine was built primarily to establish the sport of drag racing in this country and from this to generate a market for competition and hot rod equipment. The blown Chrysler engine with blower gear driven directly from the nose of the crank churned out about 17.0 psi boost and produced around 750 bhp on straight methanol. The machine turned 10.2 seconds for the standing quarter-mile. No doubt this nowadays sounds slow compared to the times which are being produced in the States, but remember this was back in 1961 and, for the first European dragster produced, was very impressive.

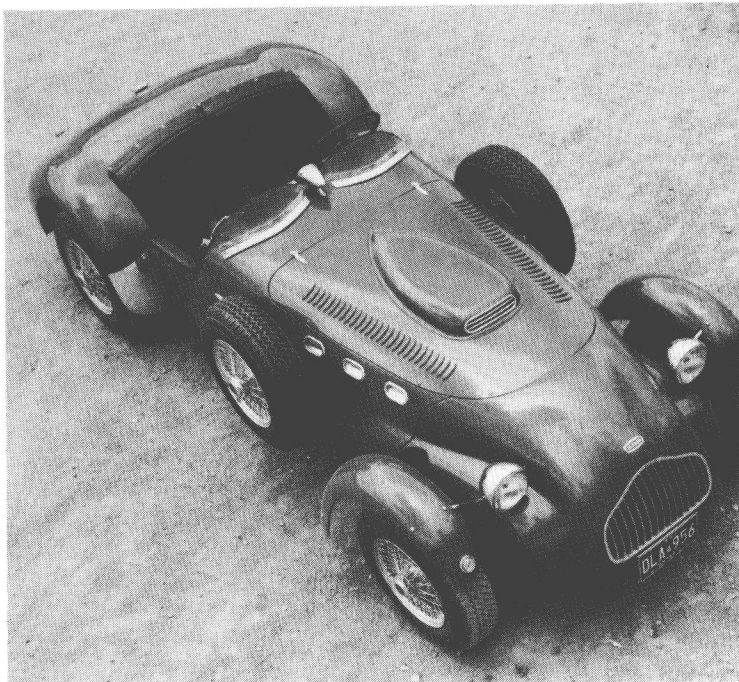
I can recollect driving this projectile for the very first time, I believe, at North Weald airfield. I had obviously driven many fast cars prior to this, but the sheer acceleration of this machine almost took my breath away—and all in top gear too! At that time, dragsters were virtually unknown outside America. In fact, it must have been the fastest-



Left Allard's Shorrock Supercharged Twin Cam Escort flying high on the 1971 International Scottish Rally (Foster & Skeffington).

Below left Allard-Wade Supercharged Escort RS2000 on the 1972 Scottish Rally (Foster & Skeffington).

Right Allard J2X2 reborn and now in production in Canada after a lapse of over 25 years. The reason for including this photo is that one or two of the early J-type Allards were supercharged and the latest example is to be available with a turbocharged engine option.



accelerating vehicle up to 150 mph ever seen in Europe until that time, having a better power-to-weight ratio than the hairiest Auto Union and Mercedes Grand Prix car.

Acceleration in a dragster tends to be the reverse of that in a normal car; or at least, it feels that way. By this I mean the faster you go, the faster it accelerates. So that if you thought 0-100 mph was fast, then 100-200 was faster! With the Mk 2 Allard dragster I held the official world record in 1967 for the standing quarter-mile with a two-direction average of 9.3 seconds. The times could have been in the 8.0 seconds region, but the engine was running on only seven cylinders for one run. The noise of the eight exhausts was deafening and if you stood on the line for too long the exhaust fumes gassed you, or your leg gave out holding the clutch pedal down. All-in-all a definite case of the 'agony and the ecstasy'.

The American dragsters were running in the mid-7.0 seconds region at that time, so obviously they were not interested in quarter-mile records. I competed in the second drag festival which my father organised, in the same machine, and as we were about to take a run it rained. I was staged with Norman Barclay in the ex-Dos Palmas Chevy-engined dragster in the other lane. No-one had ever run slick-shod dragsters in the rain before and I do not for one moment imagine that they have ever tried the same experiment again! Anything but a faint touch on the rather insensitive throttle produced a massive amount of wheel spin; it felt like sliding on sheet ice as I used opposite lock, rally-style, to prevent the dragster slewing from side to side. With each burst of violent wheelspin a high pressure stream of water was shot back into my goggles from the skinny front wheels. At

least we both managed to stay on the track and reach the other end, and this was a record in itself.

The Allard Dragon Dragster was designed to foster the drag racing and hot rod market, but although it was not a commercial success, probably due to the fact that the market had not grown sufficiently for that type of equipment at that time, it was successful competitively. Powered by a Shorrock supercharged Ford Cortina 1,500 cc engine, it produced 175 bhp with 12.0 psi boost. It used a 2-in SU carburettor and methanol fuel and accelerated from 0-130 mph in 10.9 seconds over a quarter mile, and also covered the standing-start kilometer in 20.5 seconds.

When the rules permitted supercharging, I always used a supercharged rally car, but homologation regulations stifled much development in this direction. Only large-volume manufacturers are able to make use of these regulations as they are the only people able to produce a sufficient number of identical vehicles to meet the homologation requirements.

As I write this chapter, it appears as though things may have turned a full circle. Arrangements have recently been made with a new Allard Motor Company situated in Mississauga, Canada, to produce a new Allard based on the original J2X model. Outwardly it will appear the same as the original, but under the skin up-to-date mechanicals will give it new refinement in handling and ride. Adequate performance expected of such a machine will be provided by a 318 CID Chrysler V8 and, this is the link with this book, a turbocharged option package will be available to be produced by Allard Turbochargers in the UK.

Indeed, it seems to be the time for nostalgia, but I cannot help but think how very much my father would have approved of such a venture. Generally, with the climate well into turbo-supercharging at this time, I can only imagine my father's comment would be 'what took them so long?'.

Chapter 1

The beginnings of supercharging

At the turn of the century it became evident to several engineers that the power output of an internal combustion engine could be raised by increasing the weight of air charge breathed in by the engine, together with the required amount of fuel. The obvious way to increase the weight of charge entering the cylinder was to use some form of pump to increase mechanically the mass flow, to 'overcharge' or supercharge as the process later became known.

All engines at this time were severely restricted in their breathing ability due largely to very inefficient induction system design, resulting in low power output for a given displacement or swept volume, and low maximum rpm. The power output of a piston engine is determined by the piston area and stroke, the number of engine revs per minute and the mean effective pressure exerted on the pistons. Supercharging is a very effective method of increasing the breathing ability of an engine and thereby the mean effective pressure on the pistons and volumetric efficiency which is directly related to it. It can be seen, therefore, that the basic function of supercharging, by whatever means, is to artificially supply the engine cylinders with more air/fuel mixture than would be taken in under normal atmospheric conditions.

For many years the idea of using a pump or blower to pump air had been employed in the engineering industry, principally in foundry work. However, in 1901 Sir Dugald Clark discovered that if he used a device to increase artificially the volume of air charge entering a cylinder, the engine produced more power. In 1902 Louis Renault used this idea when he patented a system in which a centrifugal fan blew air into the mouth of a carburettor. In 1907 Lee Chadwick, in the USA, developed the idea of putting the carburettor under pressure to increase volumetric efficiency.

Initially a single-stage centrifugal blower was used, driven at nine times engine speed by a flat belt from the flywheel. Because the results were so good, the next development was to install a three-stage blower, again driven at nine times engine speed by a 2-in wide leather belt. Three impellers with 12 blades were employed, each of the same 10-in diameter, but of varying widths to provide the three-stage compression. The carburettor received air under pressure. (It is interesting to note that the use of a blower driven by the engine's exhaust gas was also considered, although the idea of using an exhaust gas-driven supercharger is usually credited to Buchi, a Swiss engineer who applied it to a diesel engine in 1909.)

On May 30 1908, Chadwick's car entered the Wilkes Barr hillclimb, this being the first

event in which a blown car was entered—and it won. Over the next two years the car won many events, the most notable being the 200-mile road race at Fairmont Park in 1910. Replicas of this car, which was capable of well over 100 mph, were sold to the public and it became the first catalogued car to exceed 100 mph.

In 1911 Chadwick abandoned his automobile interest despite his obvious success and it is surprising that such a good idea was not developed further in the USA until taken up by Miller and Duesenberg in 1923. In Europe in 1911 and 1912 Sizaire and Birkigt in Paris carried out experiments with centrifugal blower and piston-type displacer, respectively.

The 1914-18 war terminated all racing in Europe and therefore any further supercharging development in this field. At that time the development of aviation was gaining momentum and the war highlighted the need for more power from aero engines. It soon became apparent that the power output of a normally aspirated engine decreased as altitude increased, so that at approximately 18,000 ft above sea level, the full throttle power output is reduced by 50 per cent and this is progressively reduced further as altitude increases. This is simply due to the decrease in atmospheric pressure and therefore air density with the resultant reduction in mass of air being drawn into the engine, so that there is less available for combustion with the fuel. This in turn leads to a decrease in cylinder pressures and corresponding decrease in engine power output.

As supercharging is purely a mechanical means of artificially increasing the air density drawn into the cylinders, it did not take long for the idea to be taken up by the newly

The renowned 1928 4½-litre 'blower' Bentley with 'roots' type supercharger drawing through two 2-in SUs, mounted between dumb irons and gear driven from the nose of the crankshaft (National Motor Museum).

