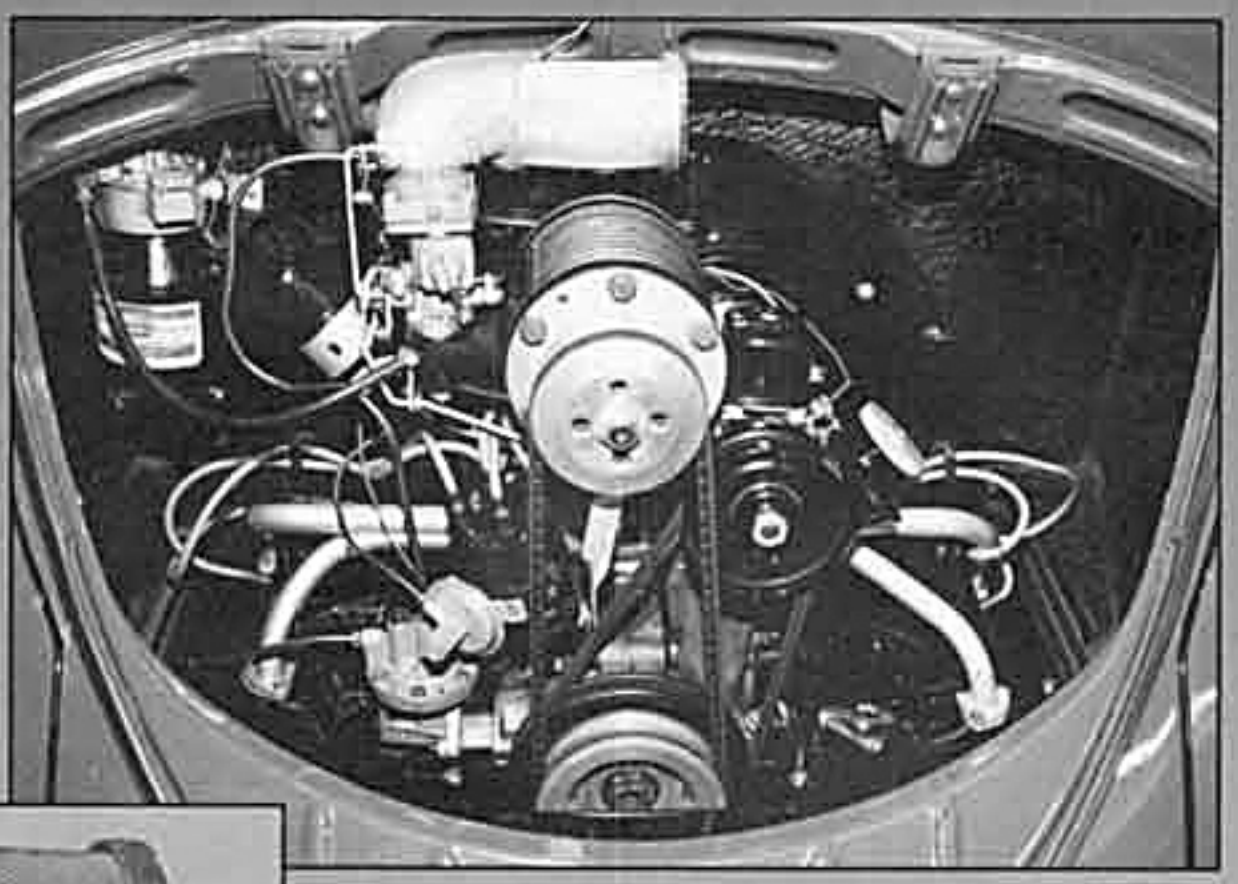
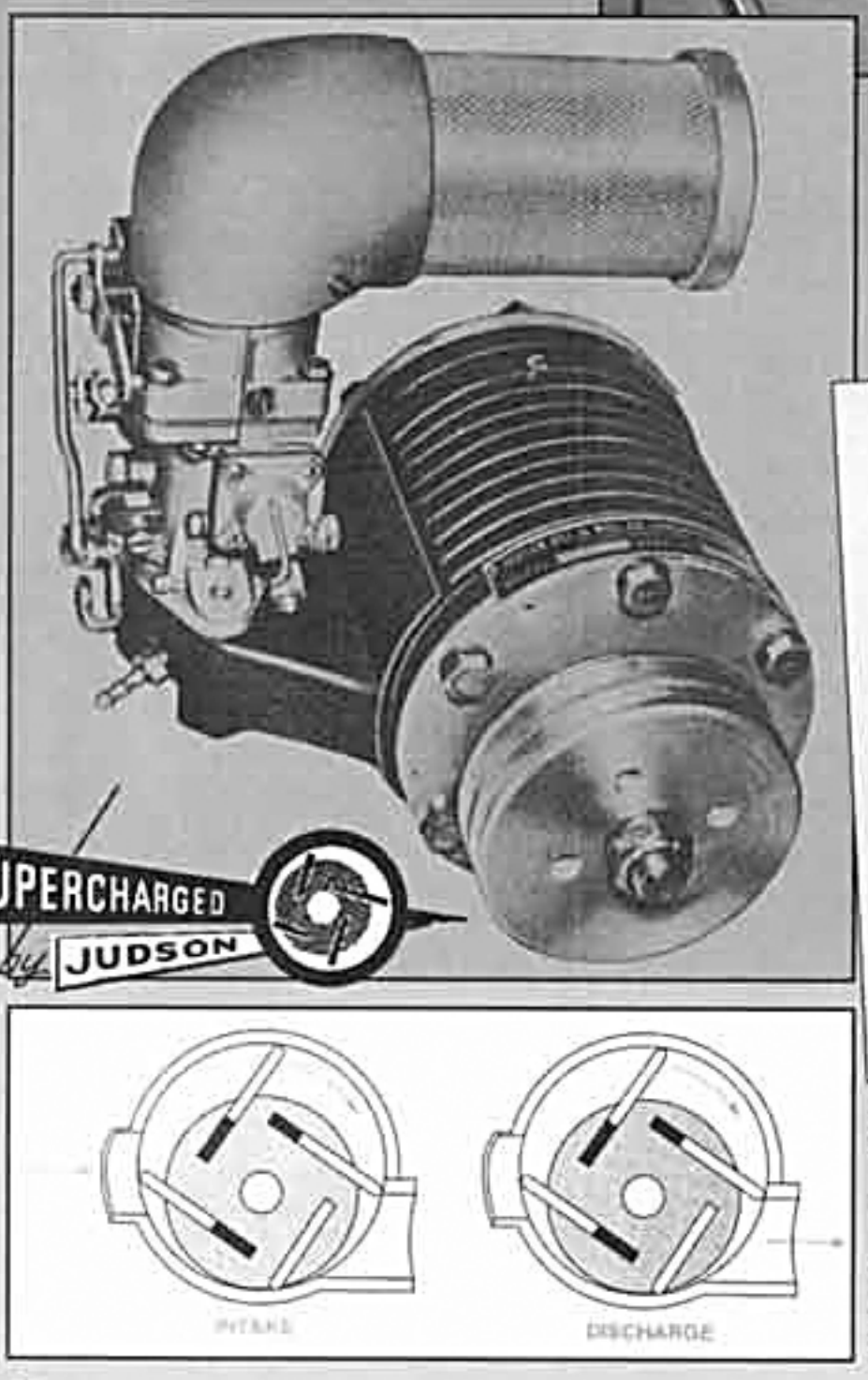
SUPERCHARGING
THE AIR-COOLED VW ENGINE

It has always been the policy of Volkswagen to discourage anyone from modifying the Beetle engine for improved performance. Early technical bulletins even went so far as to suggest that, not only was such hot-rodding unnecessary, it could also be unsafe. Considering that the earliest Porsches were largely based on VW components, this seemed a rather bizarre statement to have made.

However, the fact remains that VW always frowned upon anyone who messed around with their Beetle's engine, pointing out that any unauthorized work would invalidate the manufacturer's warranty. As far as the factory was concerned, the Beetle was intended to provide nothing more than basic transportation, from point A to B, cruising at a steady 100km/h (62mph). But you can't keep a good hot-rodder down, and it was

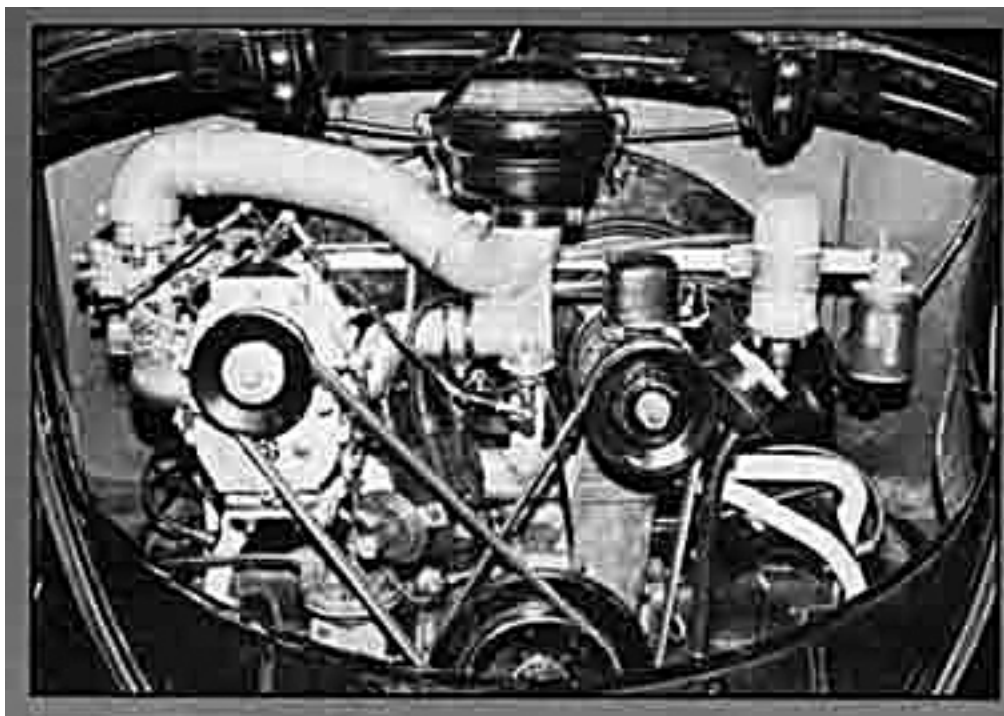


ABOVE, Judson supercharger shown installed on a 36hp engine. Note the bottle of Marvel Mystery Oil located on the firewall to the left of the engine. This provided the lubricant necessary to stop the vanes of the blower from wearing prematurely. LEFT, the Judson conversion was made for a number of different vehicles, ranging from MGs to Fords, but the VW conversion was by far the most popular. This supercharger was compact and easy to install.

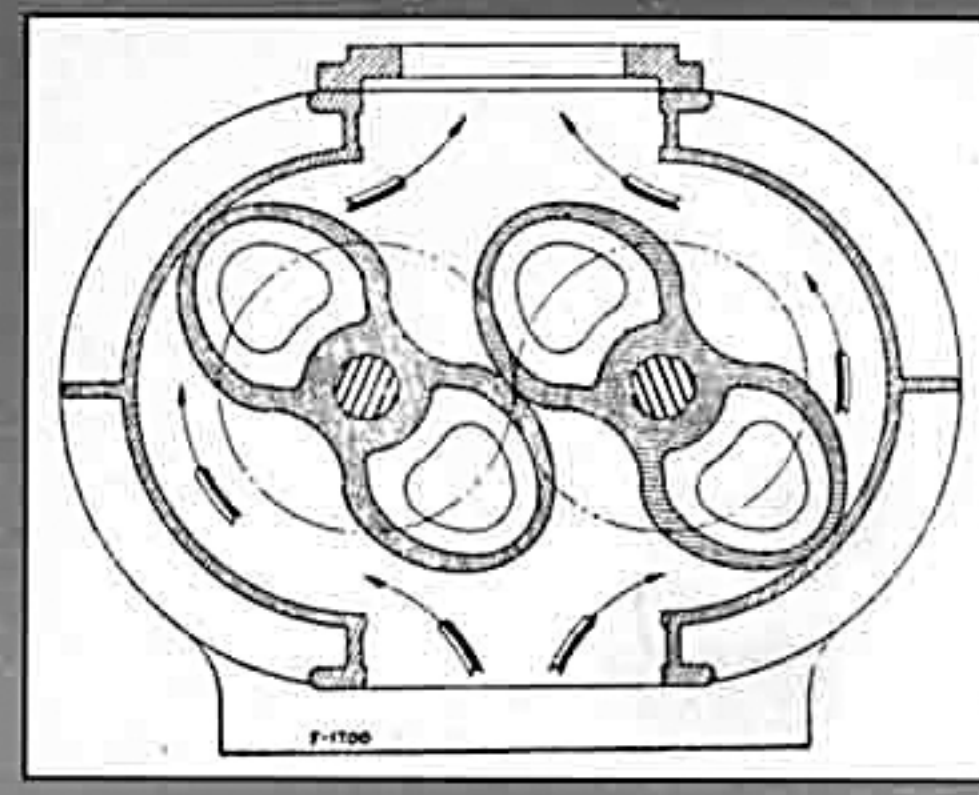


LEFT & BELOW, original 1950s and 1960s advertising for the Judson talked of 50% power increases and turning your ordinary VW into a VW Super! Don't you just love the rocketship imagery?

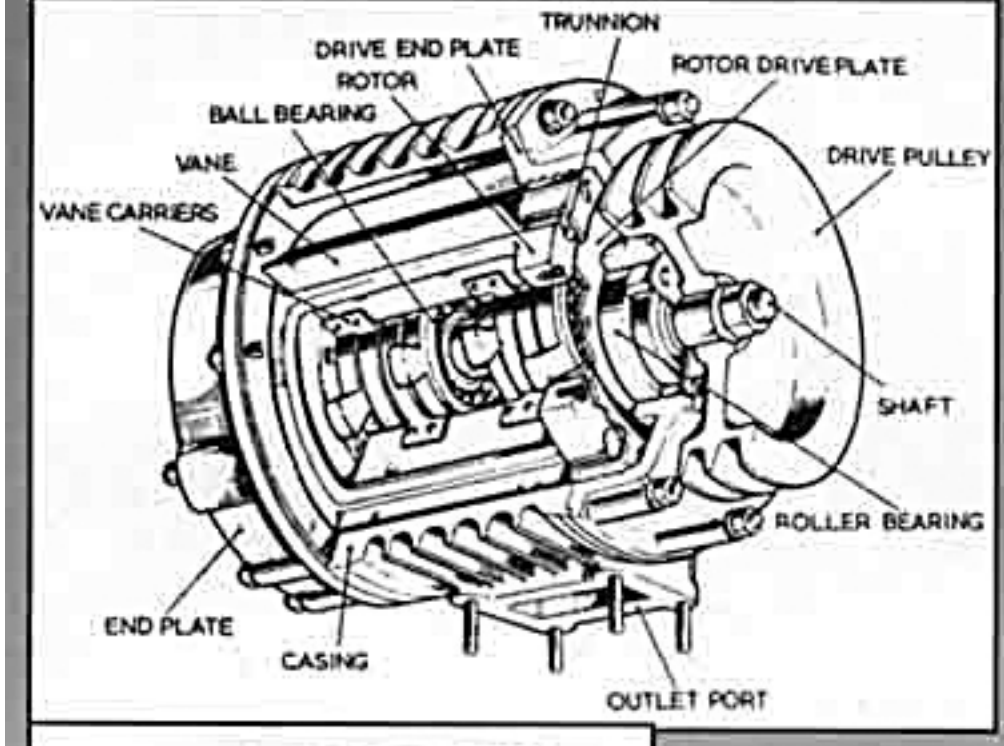
LEFT, vane superchargers consist of a rotating hub which turns inside an eccentric housing. Sliding vanes are thrown out against the sides of the casing, scooping air/gas from the carburetor side and forcing it, under pressure, into the inlet manifold.



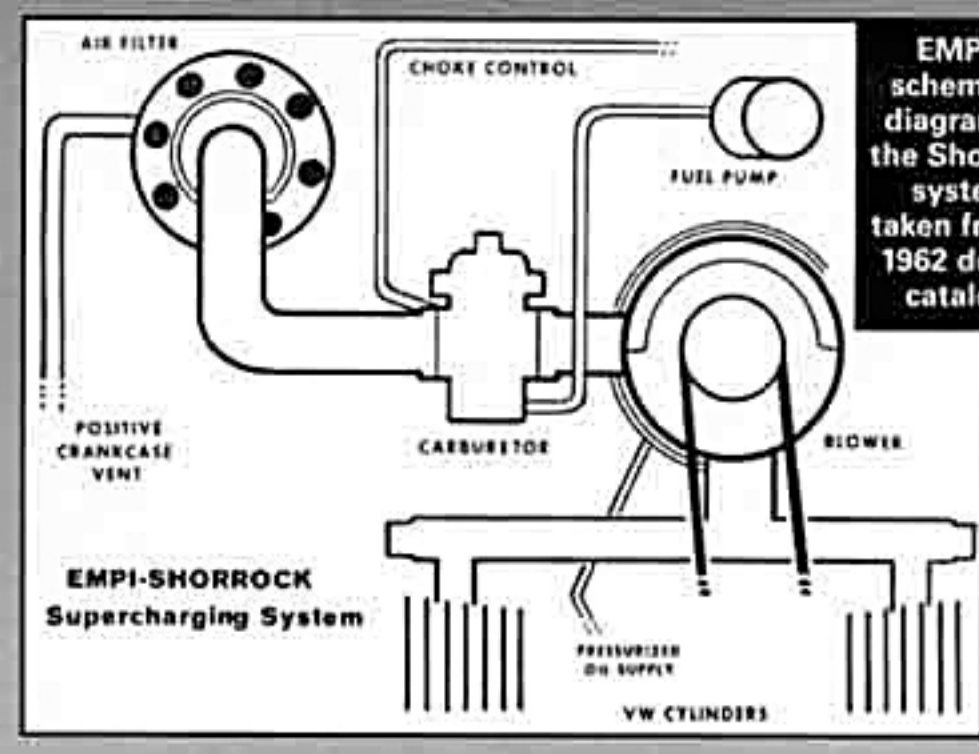
LEFT, MAG supercharger is very rare, and was made by Motosacoche AG of Switzerland. Installation of this lobe-type blower was more complicated than the Judson, and the performance gains were not as high. Check out the neat air filter arrangement, which bolts on to the inlet manifold. BELOW, diagram of the inside of a MAG supercharger showing the rotating lobes which interlock with one another. This style of blower is referred to as a "Roots" type, after the original inventor.



LEFT, Shorrock, in England, produced this sophisticated sliding-vane blower in the 1960s. Built to more exacting tolerances than the Judson, it relied on an oil-feed taken directly from the engine's main oil gallery.



LEFT, EMPI offered a complete Shorrock kit in the 1960s, which included a new electric fuel pump, manifolds, and pressure-relief pop-off valves (rather like today's turbocharger wastegates). Note the Stromberg carburetor in place of the original Solex.



EMPI's schematic diagram of the Shorrock system taken from a 1962 dealer catalog.

only a matter of time before people started playing around with the basic air-cooled flat-four, in the quest for greater power.

In the early 1950s, companies such as Okrasa and Denzel supplied engine kits, which allowed VW owners to boost the power output of their engine by adding a second carburetor and special cylinder heads. Top of the line conversions also included stroker cranks and larger cylinders. These were well-engineered kits, which proved to be very popular, but required the engine to be removed from the car so it could be rebuilt.

On the other side of the coin were the supercharger conversions, such as those by Judson in the U.S.A., and Shorrock and MAG in Europe. The great advantage of these was that it wasn't necessary to remove or rebuild the engine prior to conversion, assuming that the engine was in sound condition to begin with. For the home-mechanic, these bolt-on conversions were certainly an attractive proposition. However, before looking at the conversions that were, and those that are still available, let's take a look at what supercharging is all about, beginning with some basic engine theory.

On a four-stroke engine, when the pistons are moving down the cylinders on the induction stroke, with the inlet valves open, a mixture of air and gas is sucked into the combustion chamber through the inlet manifold and carburetor. If everything in this world was perfect, which sadly it isn't, a cylinder which measures 300cc in volume would draw in 300cc of air/fuel. In real life, though, this situation never exists on a normally-aspirated engine. Due to restrictions in the inlet manifold, carburetor, and the ports (camshaft specification comes into play here, too), an average engine is unlikely to draw in more than about 85% of the maximum possible mixture. This percentage is referred to as the Volumetric Efficiency (or VE for short).

One of the first VW performance modifications • BY KEITH SEUME

SUPERCHARGING

LEFT, Shorrock conversion installed on Richard Windermer's Beetle, featured in our July 1997 issue ("Saved from the Grave"). Installation is very neat. RIGHT, the original Inch Pincher, while in the hands of Dean Lowry, ran with an ear-splitting supercharged engine for a while. In this form, the car ran a best of 12.7seconds/106mph — not bad for a 1600cc engine!

ANOTHER PACKAGE of POWER

The author and pal, Luke Theochari, open a swap meet find — an original Judson Model II Supercharger kit, including the Marvel Mystery Oil equipment.

RIGHT, the same engine shown on EMPI's test stand. Note the use of an SU carburetor and the two pop-off valves mounted either side on the inlet manifolds. Blower was driven 1:1, rather than under-driven as with most street setups. This resulted in more boost, and hence more power, but potentially at the expense of reliability.

Supercharger kit currently available from Dick Landy Industries touts a 43% torque/horsepower increase in an off-road application.

The VE of any engine falls off dramatically at both low and high rpm; look at any dyno readout and you will see that there will always be a peak in the graph, which is where the engine's VE is at its highest. As an engine produces power by burning the air/fuel mixture, any way in which it can be persuaded to burn more should, in theory at least, cause it to produce more horsepower. Obvious ways to achieve this are to improve the ignition system, so that it can make the most of what fuel is in the combustion chamber, or by making the inlet system less restrictive (along with the exhaust, to allow waste gases to be expelled more quickly).

There is a third way, and that is to make more gas available. Increasing the capacity of your engine will immediately cause more air/fuel to be made available to burn. However, what if you could trick the engine into acting like it's bigger than it really is? This is where supercharging comes in. A supercharger, or "blower" in hot-rodding slang, is basically an engine-driven pump which forces air/fuel into the engine under pressure, thus improving the cylinder-filling capability, and hence its VE. Indeed, by supercharging an engine, it is possible to achieve in excess of 100% Volumetric Efficiency, making the engine act as if it was of far greater capacity. Both horsepower and low-rpm torque levels can be significantly increased.

While this may be a somewhat simple explanation of what is, in reality, a very complex subject, it does give you a rough idea of the advantages of installing a supercharger on your engine. So, let's take a look at the three principal designs of supercharger: centrifugal, lobe-type, and sliding vane. Of these, the centrifugal design has proven to be the least popular. It needs to be run at a very high rpm to work efficiently, operating on the same principle as a fan. In real terms, and it doesn't actually pressurize the air/fuel mixture so much as increase its velocity into the port. As the inlet system is restrictive, an increase in pressure does develop within the port, but this inevitably leads to an undesirable rise in the temperature of the mixture.

The lobe-type supercharger (also known as the Roots-type) consists of two interlocking rotating rotors which scoop the air/fuel mixture into the blower housing, compress it, and force it under pressure into the engine. While the induction temperatures still rise significantly, the lobe-type supercharger has proven to be the most popular design of all, and produces boost (increased induction pressure) from the moment the engine starts running. This is the design which was favored by Motosacoche AG (MAG) in Switzerland, as well as by companies such as GMC and B&M, whose blowers are a common sight today in mainstream drag racing.

The third basic design is what is referred to as the sliding vane supercharger. This is slightly more difficult to explain, and illustrate, as it consists of a series of sliding metal vanes which are loosely located in slots machined into a rotating hub, which turns inside an eccentric housing. As the hub rotates, the vanes are thrown out against the outer casing of the blower through centrifugal force, scooping up the air/fuel mixture and compressing it before forcing it into the engine. Anyone who is familiar with the workings of a Holley electric fuel pump will recognize this design for it, too, works on the same principle. This style was used by Judson in the U.S.A., and Shorrock in England (who marketed a blower set-up for 40hp and later engines), both companies claiming that the sliding vane-style kept inlet temperatures down to a more reason-

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able level than that experienced by users of Roots-type blowers. This is due to the fact that the mixture is not compressed between the lobes of two rotating rotors, but allowed to pass more freely through the casing.

Of all the supercharger conversions that have been available — and in the 1950s, there were a number offered from a variety of obscure companies in Europe — by far the most common is the Judson, produced by the Judson Research & Manufacturing Company of Conshohocken, Pennsylvania. The conversion included a belt-driven sliding vane blower, which could be bolted straight onto the stock inlet manifold, an adapter to allow use of the stock carburetor, a cast aluminum air filter, and a separate oil system. The latter consisted of a glass bottle holding a quantity of "Marvel Mystery Oil," which was attached to the firewall on the left side of the engine. Marvel was basically a lubricating oil, which was sucked into the blower by manifold vacuum, designed to prevent premature wear of the tips of the sliding vanes against the outer casing. With their free-moving vanes and crude oil-feed, Judson supercharged VWs always tended to rattle and smoke when cold. Shorrock later overcame these shortcomings by using more exacting machining tolerances, and restricting the movement of the sliding vanes, with oil supplied directly from the oil-pressure take-off on the crankcase.

Installation of the Judson was very straightforward, with the new blower unit being bolted onto the inlet manifold in place of the original carburetor. The carb itself was relocated to the side of the supercharger, where it was attached to an inlet duct cast into the side of the blower casing. The new low-line cast aluminum air filter allowed the conversion to sit happily under the closed hood of a stock Beetle. Conversions destined for use on Karmann Ghias came with a revised air filter assembly, along with a cast aluminum air scoop which bolted across the air intake on the decklid. In each case, a new crankshaft pulley was supplied, which allowed the use of a secondary belt to drive the blower.

The performance gains were quite dramatic for their day, with the stock 36hp Beetle's 0-60mph time being reduced to just 15.5 seconds, according to figures published in a 1962 edition of *The Porsche and Volkswagen Companion*, by Ken Ulyett. British *Autocar* magazine road tested a Judson-blown Beetle in 1957, and came up with a quarter-mile time of 19.8 seconds and a maximum speed of 83mph. By way of comparison, a MAG-supercharged Beetle recorded a 0-60mph time of 22.0 seconds, a standing start quarter-mile of 22.4 seconds, with a maximum speed of 75mph. To put all these figures into perspective, a stock 36hp sedan was timed by Autocar at 28.0 seconds from 0-60mph, 23.2 seconds in the quarter-mile, reaching a maximum speed of 70mph.

Judson claimed a power output of 57hp (SAE) at 4,000rpm from the 36hp conversion, which was a useful increase of some 60% over stock. Conversely, fuel consumption rose by around 5% on average, Judson claiming that this was a small price to pay for the improved performance. And talking of price, the complete kit cost less than $150 in the late 1950s, making it excellent value for money however you looked at it. Later, with the introduction of the 40hp 1200 engine, Judson offered a revised version of its supercharger kit.

If the Judson conversion (and the MAG, for that matter) had a major weakness, it was that the carburetor jetting was always something of a compromise. Judson supplied a richer main jet for use in the stock carb, but this was not really enough to cater for the increased fuel demands of a relatively high-revving supercharged engine. Shorrock, on the other hand, tackled this problem by dispensing with the stock Solex, replacing it with a Stromberg constant-vacuum, or variable venturi, carburetor. This carburetor, along with the similar SU design, proved to be far better suited to use with a supercharger as it provided exactly the right amount of air/fuel mixture, regardless of engine speed or load. To ensure the carb was fed with sufficient gas at all times, Shorrock also supplied an electric SU fuel pump, which came with the kit. Judson made do with a heavy-duty spring to fit inside the stock pump.

A common problem with supercharging the Beetle engine is an acute lack of space under the decklid. The Shorrock unit was somewhat more bulky than the Judson, and proved to be a tight squeeze. However, by some judicious packaging, such as mounting the coil and fuel pump on the blower housing, the Shorrock kit made the best of a difficult job. The lack of space under the decklid was also partly responsible for overheating problems when these early supercharged engines were pushed hard.

Finally, there was also the matter of controlling backfires through the supercharger. On a normally aspirated vehicle, if the engine spits back through the carburetor, there is usually no harm done. On a blown engine, such antics can terminally damage the vanes of the supercharger. To combat this, the inlet manifold of the Shorrock conversion was fitted with two spring-loaded pop-off valves, on either end just above the cylinder heads, which opened to let out excess pressure should a backfire occur.

Joe Vittone's EMPI company offered four different Shorrock conversions for the 1192cc Volkswagen, starting with the basic PSSV-500, which consisted of the full supercharger kit complete with blower, Stromberg carburetor, aluminum intake manifold, SU fuel pump, manual choke control, air filter, and all belts and pulleys. EMPI claimed this to be good for 72hp (SAE) as opposed to 40hp (SAE) from the stock engine. In 1965, retail was $395.00.

Next in line was the PBBV-100, which included the 82mm EMPI big-bore conversion for 1352cc, and an increased power output of 78hp (SAE). The cost? Just $493.50. To this EMPI then added the Okrasa 69.5m crankshaft, for a capacity of 1468cc, and some 82hp (SAE). This, the PSKV-601 kit, sold for $684.50. Finally, there was the PSKV-600 conversion, which used the 74mm Okrasa crankshaft to give 1586cc, and a power output of 85hp (SAE). All this would have set you back $794.50 — double the price of the basic conversion.

So, what could you have expected for your money? EMPI quoted figures from a road test published in the April 10th, 1964, issue of *Autocar* magazine, which reported a top speed of 89mph from a blown 1200 Beetle, along with greatly improved mid-range acceleration. The standard car's 40-60mph time in top gear of 17.2 seconds fell to just 7.4 seconds.

EMPI made much of the conversion in its dealer catalogs, stating that the Shorrock-equipped VW was capable of keeping up with freeway traffic even on hills and against a strong headwind. EMPI also pointed out that at high altitude, where the thinner air results in a fall-off in engine power, a supercharger will more than offset the power loss. A typical drop in power, it claimed, was 20% for every 6,000 feet rise above sea level — a major consideration in mountainous regions of the U.S.A.

In 1966, Dean Lowry fitted a Shorrock supercharger and SU carburetor to the 1600cc engine of the famous Inch Pincher race car. On the dyno, they produced an astonishing 220bhp, running on straight methanol. With this potent combination on board, Inch Pincher ran a best time of 12.7secs/106mph at Carlsbad Raceway. For anyone lucky enough to have seen this legendary car run, one of its most memorable features was the ear-splitting exhaust notes.

Today, the only commercially available supercharger conversion for the Beetle is one manufactured by Dick Landy Industries, which uses a B&M Roots-type blower, with either Dellorto or Holley carburetors. This well-engineered conversion was covered in detail in our October 1991 issue ("Supercharging the VW Engine"). Landy claims some quite considerable power increases using his setup, with a blown 2058cc test engine producing 186hp at 6,000rpm, compared with 122hp at 5,250rpm for the same engine on dual 48mm Dellortos. Although the conversion is aimed primarily at the sand crowd, there have been a number of DLI setups sold to enthusiasts wanting the ultimate in show-with-go street cars.

By and large, superchargers have fallen from favor in the tuning industry, their place being taken by turbochargers and EFI systems. However, there is no denying that there are many benefits to be gained from this relatively simple performance modification. If somebody could adapt a compact, modern design, such as the Sprintex supercharger, to fit a Beetle engine, then we may just see a return to the days when the characteristic whine of a blower drive was a familiar sound at the local cruise. •