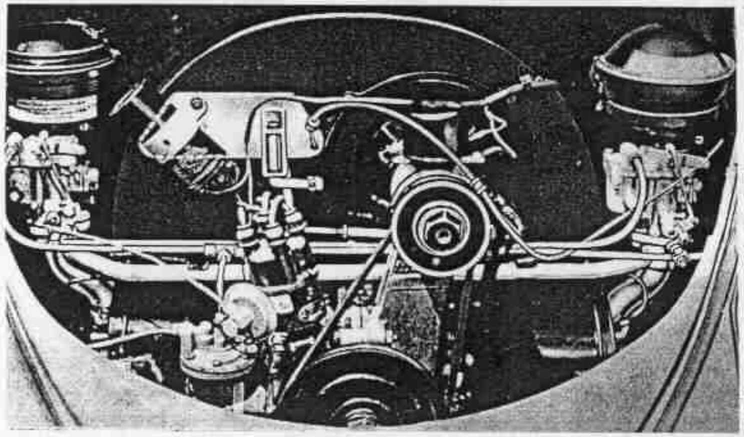
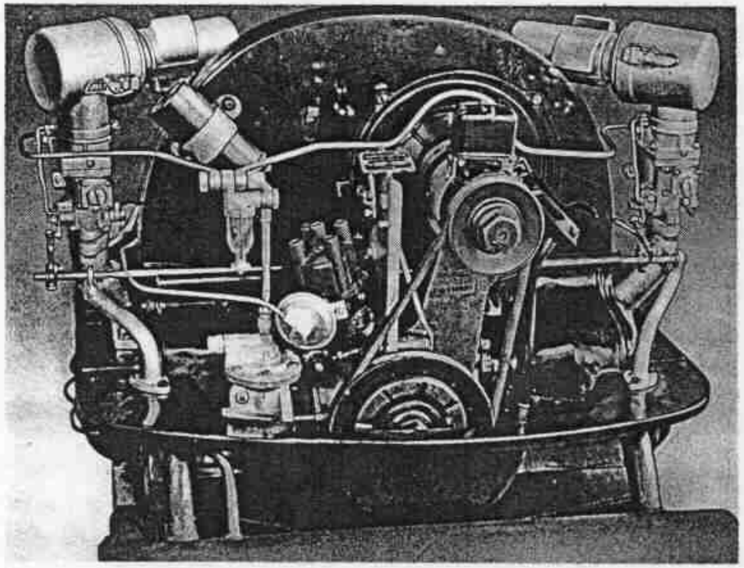


The US-made Dietz manifold employs stock VW carburetors with the factory setting. Note bracket plate for the dual throttle linkage.



The Express dual carburetor kit manufactured in Germany by Autotechnik also employs two Solex 28 carburetors. The hot spot has been retained in this set-up.

Effective Avenues to Power

DUAL CARBURETORS AND MANIFOLDS

One of the easiest and cheapest steps to take in the quest for more horsepower from the VW engine is the installation of a separate carburetor for each of the two cylinder head manifolds. This is a simple conversion which can be completed in a few hours with the engine remaining in the car.

There are several good "bolt on" dual carburetor kits for the VW on the market. The performance increase that can be expected with the aid of one of these kits is from 8 to 10 percent at the top end. Since these manifolds and carburetors are fitted onto the standard heads, one still must contend with the restricted porting in the cylinder head, though the constricting hurdle of the single small venturi is eliminated.

Most conversions duplicate the original *Solex* 28 PCI carburetor. The throttles of these two carburetors are operated simultaneously by linkage supplied by the makers of each twin carburetor kit.

REWORKING STOCK CYLINDER HEADS

The stock VW cylinder head has "siamesed" intake ports, meaning that one intake port branches out into two ports feeding two cylinders. Unfortunately there is insufficient material in the casting to do an effective porting job.

If the speed tuner is not afraid of a little work, however, a worthwhile modification can be achieved by boring through the elbow part of the intake port and threading it to receive a larger intake duct. One successful Australian conversion was made to accommodate a 1¼ in. tube with the ports then enlarged and larger valves fitted. In this case the intake tube was straight and it projected through the valve cover. A special seal arrangement was devised to prevent oil leakage through the valve cover. This engine was fitted in a special tubular chassis and ran successfully on alcohol with a Judson supercharger, in combination with an SU carburetor. The intake port of the Judson supercharger was bored out to 1⅜ in. Further particulars of this modification are given later.

SPECIAL LARGE-PORT CYLINDER HEADS

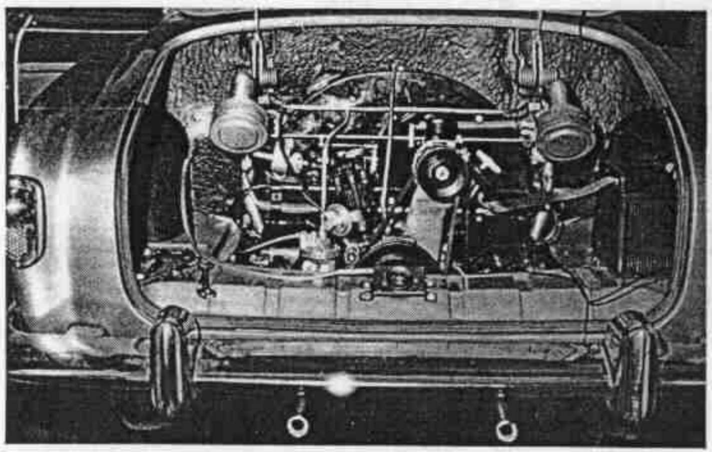
Most effective results of all the power conversions come from the installation of special large-port cylinder heads. The prime reason why the VW engine fails to attain a higher output, restricted port area, is thus attacked and eliminated. The well known *Okrasa* head is one of the most popular pieces of high performance equipment available for the VW engine.

These heads feature separate, large intake ports for the intake valves of each cylinder head. With the undesirable hurdles of the original equipment inlet tract eliminated it is possible to install two larger carburetors. This scores benefits on two counts: 1. Less resistance in the carburetor due to the larger bore and larger venturi. 2. Less resistance in the porting layout due to larger ports and intake valves. All of this helps toward a higher bmep at the top end and, consequently, a higher output. As with the dual carburetor outfits for stock heads, a special throttle linkage is furnished by the manufacturer.

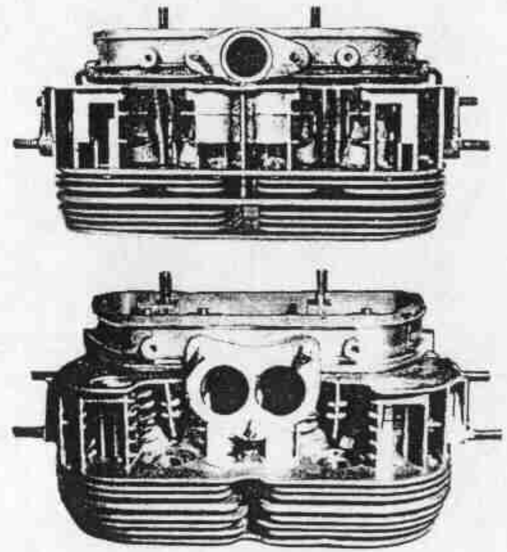
Special large-port cylinder heads are also made in Germany by Heinz Pollmann, who specializes in reworking VW and Porsche engines. The Pollmann cylinder head resembles the Okrasa, also fitting the VW block without far-reaching modifications.

Pollmann also makes a very neat VW conversion for use in light aircraft.

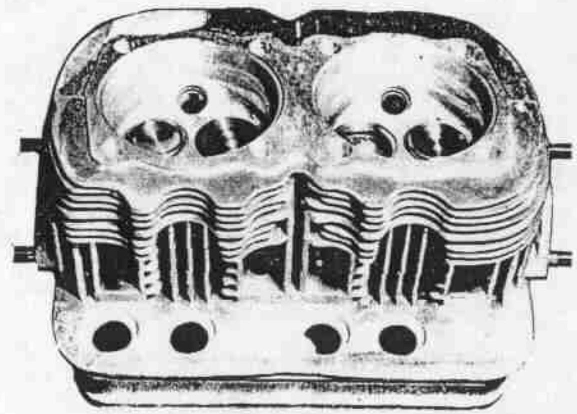
The installation of special cylinder heads is a far-reaching speed tuning measure and, of course, requires removal of the engine from the chassis.



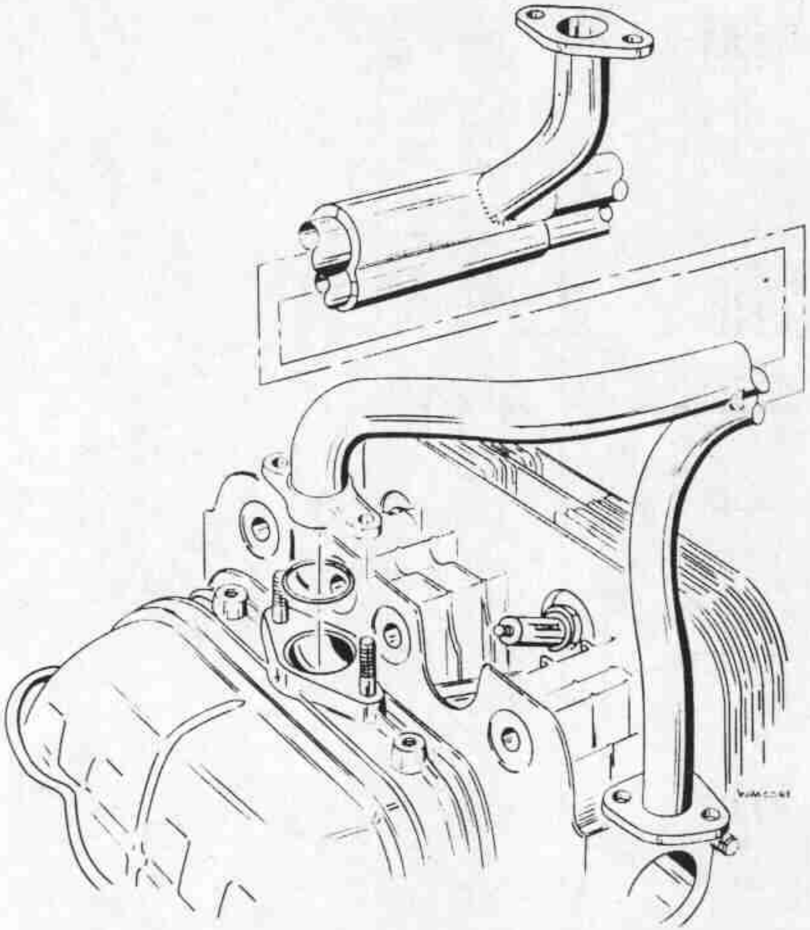
Okrasa-modified engine installed in a Karmann-Ghia coupe. Restricted space required special air cleaner adapters.



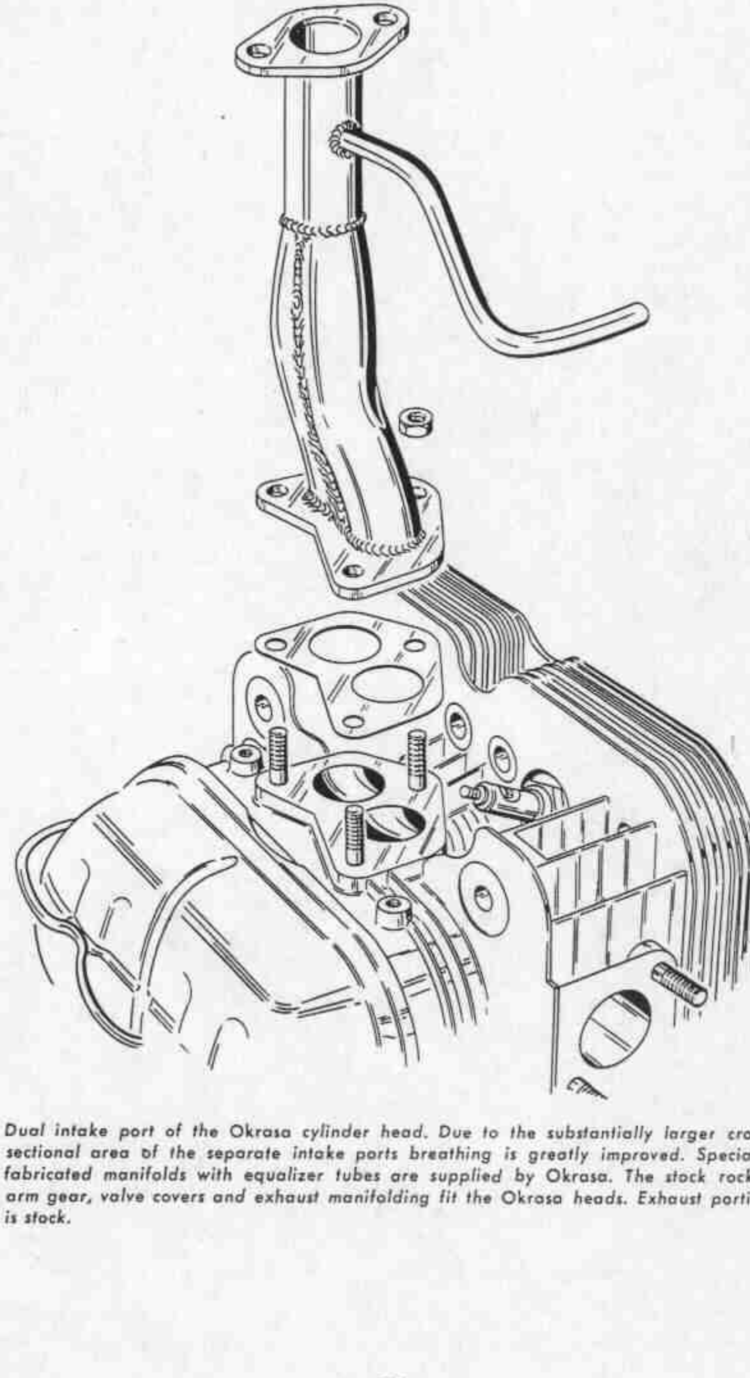
The difference in port area between the stock siamesed intake manifold and the separate dual manifolding of the Okrasa cylinder head is marked. Okrasa exhaust ports are stock size.



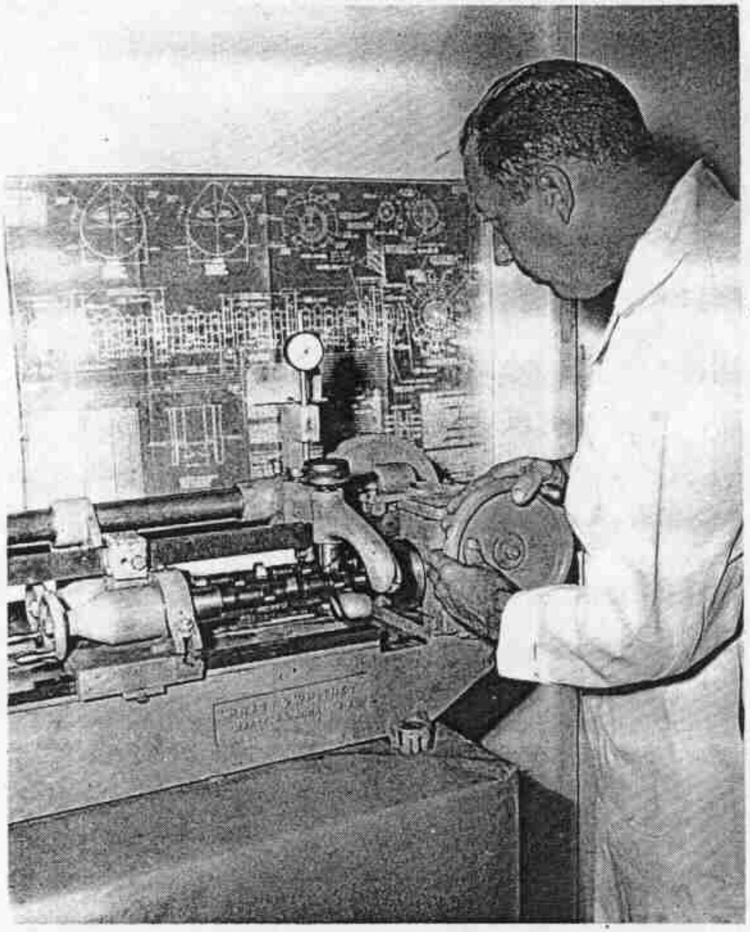
Combustion chamber of Okrasa cylinder head showing larger intake valves which assure good cylinder filling at high rpm. One intake valve is removed. Liberal cooling fins dissipate the heat.



Stock cylinder head and manifold showing long and narrow passages which leave little scope for porting. Compare this with that of the Okrasa cylinder head ⟶



Dual intake port of the Okrasa cylinder head. Due to the substantially larger cross-sectional area of the separate intake ports breathing is greatly improved. Specially fabricated manifolds with equalizer tubes are supplied by Okrasa. The stock rocker arm gear, valve covers and exhaust manifolding fit the Okrasa heads. Exhaust porting is stock.



Checking a reground Volkswagen cam against the master contour on a "Comparator" in Iskenderian's Racing Cams shop. With this method small errors are easily detected.

REGROUND CAMSHAFTS

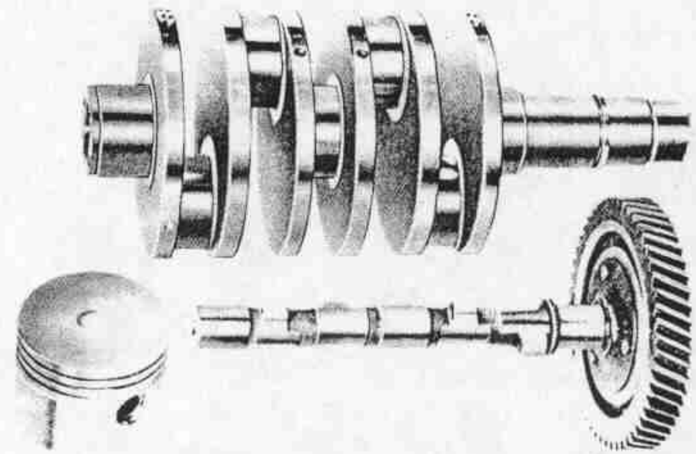
The camshaft and its attendant valve gear—as explained in the section on cam timing—is a vital part of the induction system. The breathing of the VW engine can be considerably improved by the installation of a special camshaft, especially if certain other modifications accompany the fitting of this longer-opening cam.

A number of special grinds are available, each giving good results in the VW. The beneficial effects of a reground cam are especially noticeable when used with large-port cylinder heads, dual carburetion, and increased compression ratio.

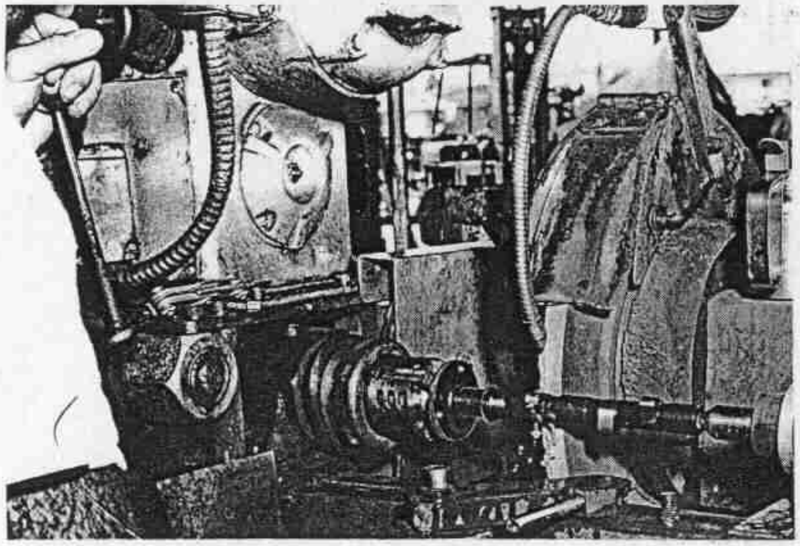
Various manufacturers offer a variety of grinds, from comparatively mild ones, which still retain good idling, to real racing cams which operate efficiently only in the top rpm range.

Installation of the camshaft necessitates the removal of the engine from the frame as well as a complete tear-down in which the crankcase must be split. This should not be regarded as undue labor, however, since the installation of a reground camshaft usually is, and should be, coupled with other inner engine modifications.

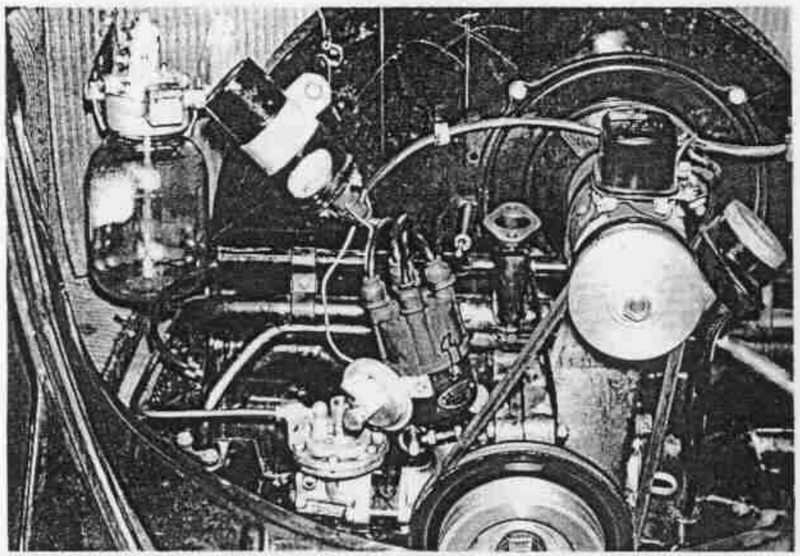
Iskenderian Racing Cams of California has experimented extensively with VW and Porsche engines and probably offers the largest selection of grinds. Iskenderian also furnishes special heavy duty valve springs and retainers for the more severe grinds.



Weber stroker kit for VW with reground camshaft. The Weber company manufactures ¼ in. and ½ in. stroker kits for the VW. The crankshaft is a machined cast billet. On the ½ in. stroker crank the camshaft must be ground to clear the crankshaft webs and the connecting rods also are modified for extra clearance. A set of special pistons giving 8 to 1 compression ratio, when used with the ½ in. stroker cam, also is included in the kit.



Volkswagen camshaft being reground at Iskenderian's Racing Cams shop in Inglewood, California.



Carburetor removed, lubricator mounted to the firewall and pulley fitted to crankshaft prior to fitting the Judson supercharger.

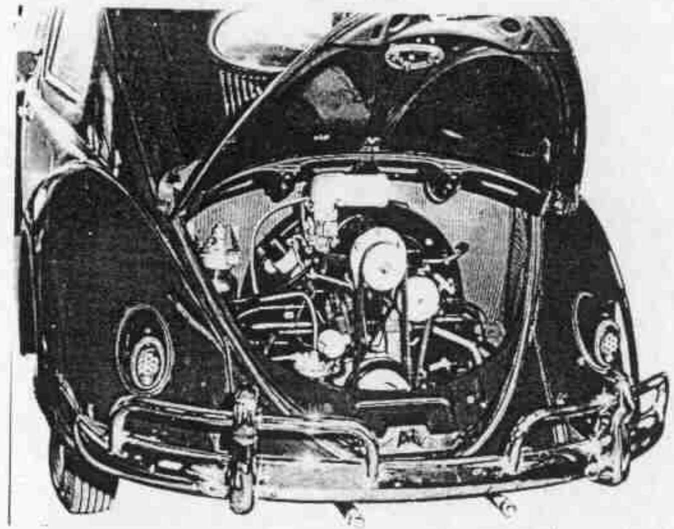
SUPERCHARGING

Here is another efficient bolt-on speed tuning device for the VW owner. The supercharger method is especially attractive because power output increase is considerable while the cost of the boost is relatively low. Installation is attractive because the engine may remain in the chassis, taking only a few hours to complete.

Superchargers made for the VW generally are designed to be used with the standard cylinder heads and manifolding. The resistance in the narrow intake ports still has to be overcome, of course, but as was taken into account when these superchargers were designed, a worthwhile bmep boost is achieved even with the stock heads. If the blower is used in combination with special large-port cylinder heads, then its beneficial effects will be even more emphatic.

Supercharging is mainly a torque boosting procedure and does not rely on excessive rpm to obtain a high power output. This is fortunate in the case of the stock VW engine since this crankshaft is not designed to be run at high rpm for prolonged periods.

Various makes of superchargers available for the VW will be described later.



The Judson supercharger installed in a sedan. Stock carburetion is used with a smaller (size 140) air correction jet. Note also photograph at left.

COMPRESSION RATIO

Increasing the bmep of an engine, as previously established, also proportionately increases the power output of the engine.

The mathematical compression ratio of an engine is the ratio of the piston displacement plus the volume of the combustion chamber to the volume of the combustion chamber. In short: the ratio of the volumes with the piston on bottom and top dead center. This is expressed in the following formula in which V is the piston displacement (swept volume) and V1 the volume of the combustion chamber:

$$CR = \frac{V + V1}{V}$$

Piston displacement V (one cylinder) is easily calculated by multiplying the piston area by the stroke. The volume of the combustion chamber is directly measured by pouring oil from a graduated beaker into the plug hole. Piston should be exactly at top center, both valves should be closed and the plug hole uppermost. Oil should just reach the bottom of the hole.

To give an example, say the amount of oil poured into the combustion chamber (until it reaches the lowest plug hole thread) is 54 cc. The piston displacement in one standard VW cylinder is close to 300 cc (one-quarter of total engine displacement of 1192 cc). The compression ratio of this engine thus works out to be $\frac{300 + 54}{54} = 6.55{:}1$. If the cylinder has been bored, or a long-stroke crankshaft installed, the new dimensions must be taken into account in order to calculate the resulting compression ratio. (When working with cubic inches remember that one cubic inch equals 16.4 cubic centimeters.)

If the cylinders are bored out 2 mm to 79 mm, for instance, the piston displacement of one cylinder will be close to 316 cc and the resulting compression ratio—all else remaining equal—increased to about 6.9 to 1.

The altered compression ratio resulting from an increase in bore size is easily calculated with the formula if one remembers that the displacement is proportional to the square of the bore.

INCREASING COMPRESSION RATIO

The compression ratio can be increased by any of the following methods:

1. Use a crankshaft with a longer stroke. This has the effect of increasing the piston displacement and also decreasing combustion chamber volume.

2. Bore out the cylinders and use an oversize piston. This increases the piston displacement.

3. Machine the cylinders, the cylinder heads (or both), or install high compression heads, hence decreasing the volume of the combustion chamber while other factors remain equal.

4. Use a high compression piston.

5. Indirectly by supercharging. This induces a larger volume of combustible mixture into the cylinder than the theoretical displacement would indicate. The amount of compression ratio increase is dependent upon the degree of supercharge (pressure boost beyond standard).

ADVANTAGES OF A HIGH COMPRESSION RATIO

One has seen that a high compression ratio increases the bmep and thus the maximum output in proportion. In the case of the VW engine, which has a very low compression ratio (6.6:1), a substantial increase, say to 8.5:1, gives a worthwhile increase in power output of about 8%. Gas mileage will also be improved because of the more efficient combustion, although this saving will be partially offset by the higher priced premium gasoline that must be used.

Accompanying illustration shows a high compression *Jahns* piston for the VW. This piston raises the compression ratio to 8.5:1, which will give a stock VW quite a shot in the arm.

High compression piston for VW manufactured by Johns. The Johns company of California has been a piston specialist for many years and can supply custom-built pistons for any type of modified or vintage engine.

Installing high compression pistons requires removal and partial tear-down of the engine, including removal of cylinder heads and cylinders. If the engine has seen a lot of work it would be wise to replace worn parts, bore out the cylinders (to, say, 78 mm), and install oversize high compression pistons. To really make the job worthwhile a mild reground cam, which still allows good idling and flexible engine operation, might also be fitted. Combined with a good dual carburetor set-up this would give a gratifying performance increase, even with the stock heads.

High compression pistons should not be used when supercharging is contemplated—at least not with a road job that has to be tractable. Dual carburetion, however, has proven a natural with this set-up.

SUPERCHARGING BOOSTS COMPRESSION RATIO

With a supercharged engine, as observed, the combustible mixture is admitted to the cylinders at pressures above atmospheric. By pumping in more gas per revolution (with wide open throttle) than the actual displacement of the charged cylinders, supercharging effectively "increases the displacement" of the engine. Since the volume of the combustion chamber remains the same, an *increase in the compression ratio* is the result.

The power output of an engine is directly proportional to both brake mean effective pressure (bmep) and rpm. Due to breathing deficiencies at higher engine speeds (meaning that the bmep falls off), there is a definite limit to the maximum power output of the engine. If bmep falls off at the same rate as engine speed goes up, power output will remain the same. If bmep falls off more rapidly than the rate of increase in rpm, power will fall off despite the fact the engine is spinning faster.

As explained before, it is possible to minimize this tendency toward decreasing bmep by improving the breathing of the engine. Among the more popular avenues used are: opening up the ports, improving cam timing, increasing compression ratio, or a combination of these methods. All these methods, though effective, are costly and time consuming—mainly because the engine must be taken out of the frame, torn down, rebuilt, and reinstalled. That is the reason why installing a supercharger is such an easy method of attaining a higher power output.

Design of the Volkswagen engine is favorably suited to supercharging for several reasons. It has a very low compression ratio and a relatively large piston area. It is rugged and because it is lightly stressed in stock form it can readily absorb increased bearing and thermal loads. Finally, there are a number of good superchargers available which are easily installed.

It has already been established that in the VW engine bmep falls off sharply at high engine speeds due to the small manifolding and small carburetor. This is why, in this speed range, it is very responsive to a mild supercharge effect.

POWER TO DRIVE SUPERCHARGER NOT A LOSS

While a considerable amount of power is required by the engine to drive the supercharger at high rpm, this power is not a total loss, as many people seem to think. The supercharger is nothing more than a pump. The pressure it builds up in the intake manifold actually drives the piston during the intake stroke, so that the breathing task of the engine is considerably relieved. This does away with the greater part of the so-called "pumping losses" of a normally aspirated engine. All the power required to drive the supercharger (mechanical and thermal losses) cannot be offset in this way but a substantial part of the power required to spin the blower is recovered. This small loss of power is amply repaid by the resulting high bmep all along the range, which in turn boosts the power output.

OTHER ADVANTAGES OF SUPERCHARGING

A further advantage of supercharging is found in the worthwhile horsepower output that can be achieved without having to contend with excessive peak bearing loads during the firing of the mixture.

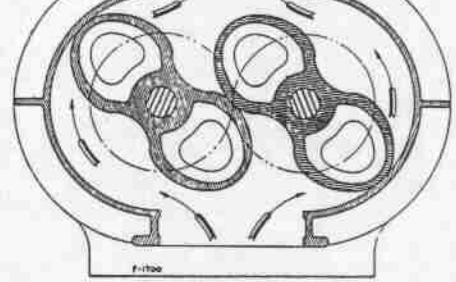
Excessively high peak pressures sometimes occur when compression ratios are raised too high, but the resulting increase in power output would be the same when a supercharger is installed.

Another advantage of supercharging is that a worthwhile gain in output is possible without resorting to excessively high engine rpm.

Supercharging then is a safe, effective, and comparatively cheap method of increasing engine output. For normal, reliable VW engine operation excessive manifold pressures—over 8 psi—are not recommended. Most superchargers available for the VW give a maximum boost pressure (pressure above atmospheric) of about 4 to 7 psi.

SUPERCHARGER TYPES

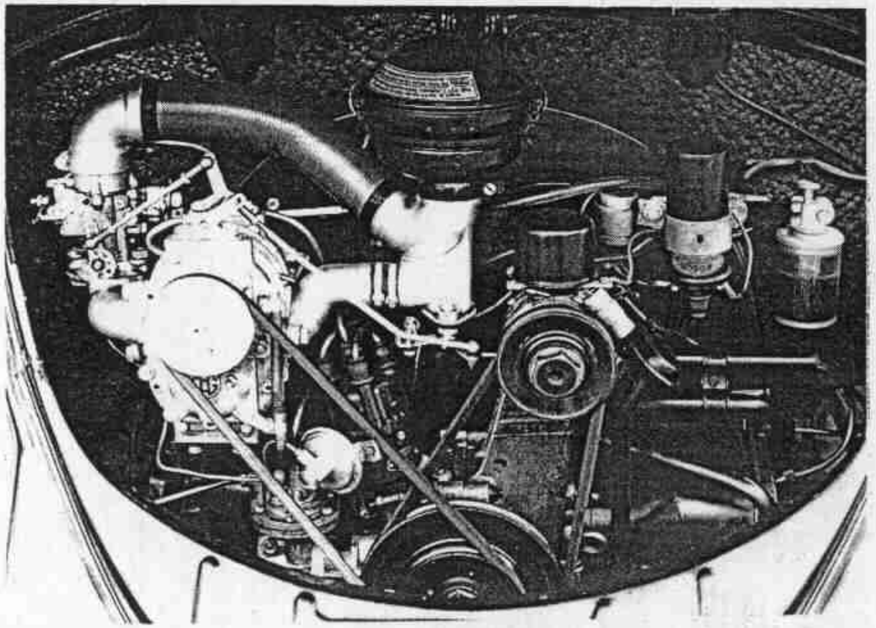
Superchargers available for the Volkswagen include the *Roots* type, and the sliding, or rotary vane type. While both are so-called positive



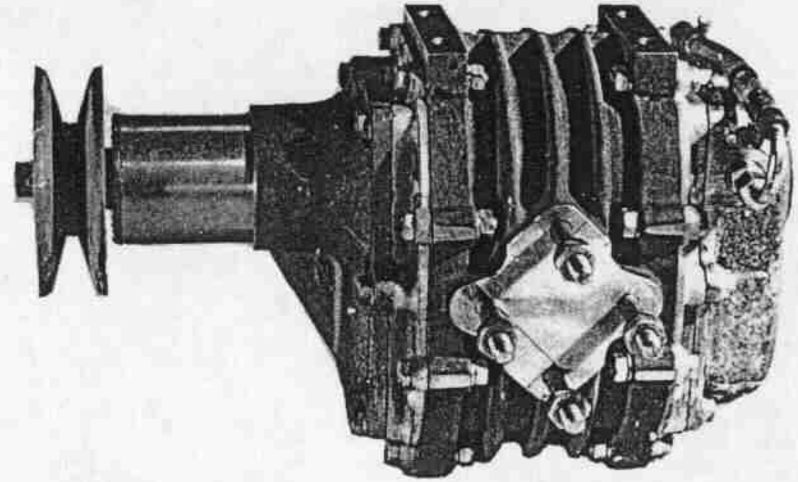
Principle of Roots supercharger. Two lobes are geared together and rotate in exact phase with very little clearance, without actually touching each other. The The Roots supercharges by displacing, not by internal compression.

displacement blowers there is a distinct difference in operation between the two.

The *Roots* type does not operate with internal compression — it merely displaces a certain volume of gas mixture. If this displaced volume is in excess of the normal requirements of the engine, pressure builds up in the manifold. The accompanying illustration shows the principle of a *Roots* type blower. The two-lobe rotors (some have three-lobe or four-lobe rotors) are so shaped that they intermesh without actually touching each other as the supercharger revolves. Efficiency depends on precision in manufacture: the smaller the clearances between the individual rotors (normally between .004 and .008 in.) and between the rotor tips and the housing, the less the gas leakage and blow-back and the higher the efficiency. This type is very popular for its reliability.



The MAG supercharger of the Roots type installed in a sedan. Manufactured by Motosacoche in Switzerland it uses a 32 mm Solex carburetor. Note throttle linkage and lubricator.



The MAG Roots-type supercharger. For VW adaption the driving pulley is closer to the supercharger housing than shown, as appearing below.

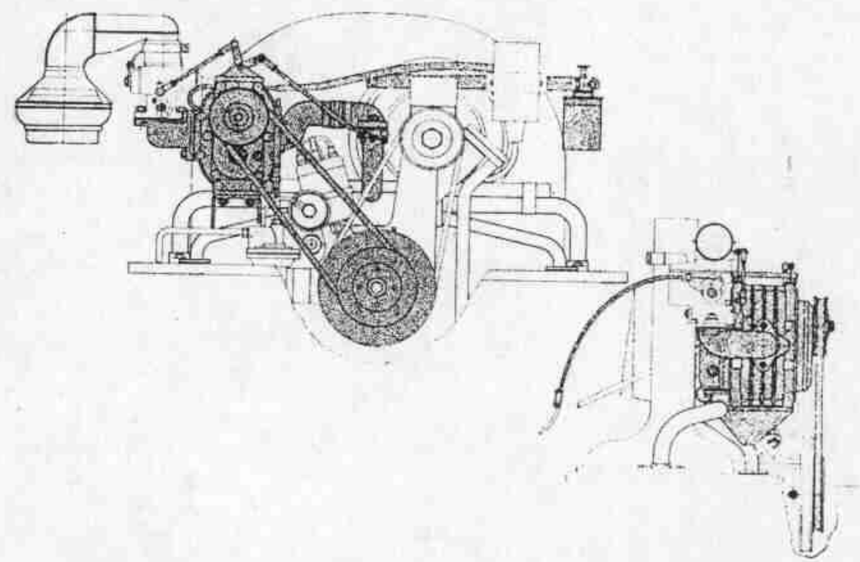
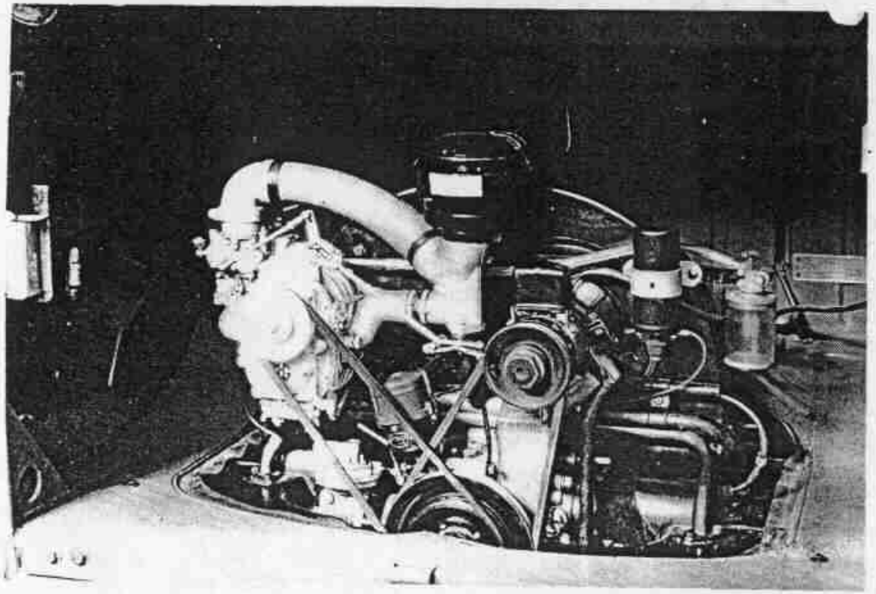


Diagram showing MAG supercharger installation for a Karmann-Ghia. An elbow-type air cleaner adapter is used. Compare this with the sedan installation on page 62.



The MAG installation in a Transporter. A low boost compressor, its use does not affect engine reliability. Note lubricator.

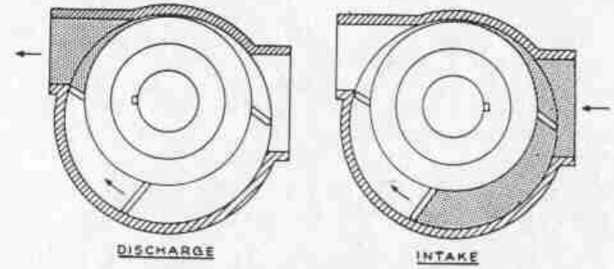
Roots characteristics of delivery are such that a positive manifold pressure can be maintained (with wide open throttle) throughout the usable speed range of the engine. The *Roots* supercharger usually is driven at about engine speed and does not require a great amount of internal lubrication. It is not noisy in operation but does have a characteristic whine, especially at higher rpm. Due to the very close manufacturing tolerances of both the rotors and the driving gears (which have to keep the rotors in exact phase to prevent them touching each other), this supercharger is somewhat expensive.

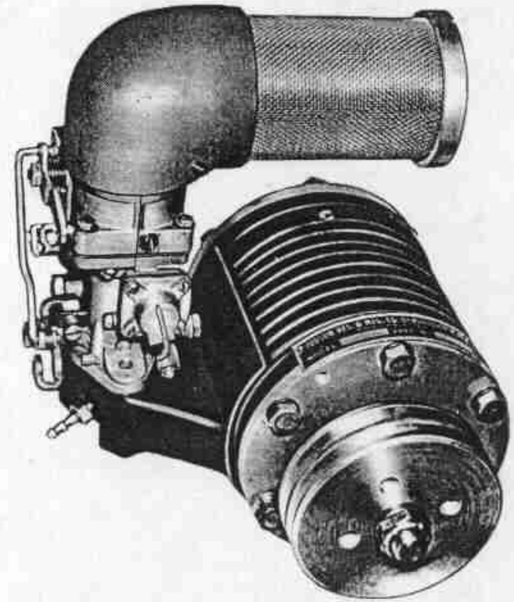
The *sliding-vane* type supercharger, which is also a member of the positive displacement group, is shown in the accompanying illustration. In contrast to the *Roots* type, it operates with internal compression. It is an efficient type especially suitable for high boost pressures and positive delivery at low speeds. The illustration shows how the vanes are driven around by a drum placed eccentrically in the main drum. After being drawn in, the mixture is compressed in the contracting chamber as it is carried around within the main supercharger casing.

These superchargers are especially suitable where high boost pressures are required. Usually driven at engine speed (or slightly higher),

they offer the advantage of being almost completely silent in operation. For trouble-free service and sealing, a certain amount of internal lubrication is required. Most superchargers of this type are built with their own separate lubrication systems.

Centrifugal and *axial flow* supercharges are types which do find some use on other automobiles, but so far have not been marketed for the Volkswagen.





The US-made Judson supercharger is a very popular sliding-vane type blower operating from internal compression as shown above. Carburetor setting is stock except for a smaller air correction jet.