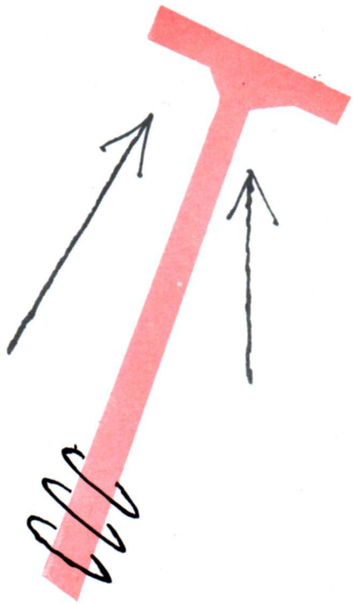
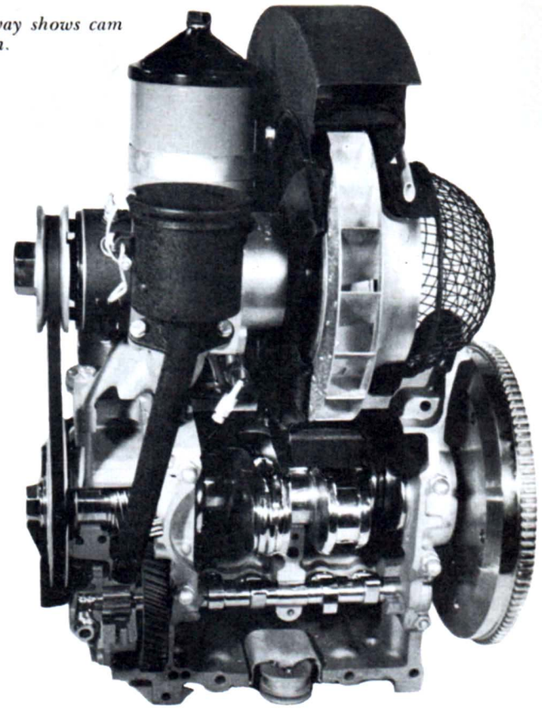
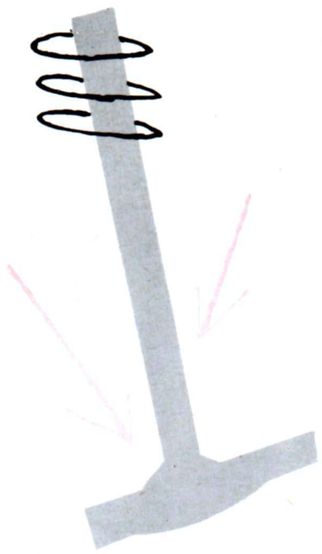


Standard engine cutaway shows cam and crankshaft operation.

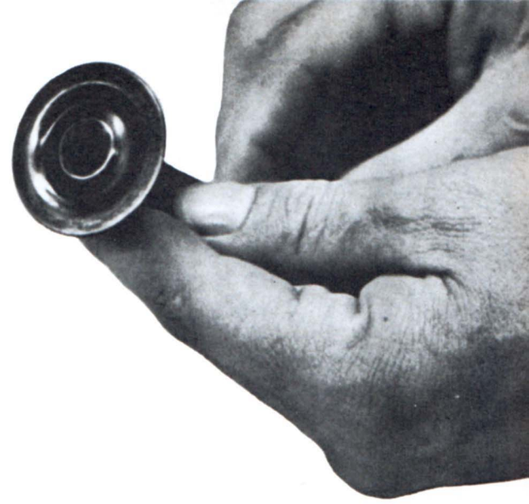


Four Cylinders Opposed



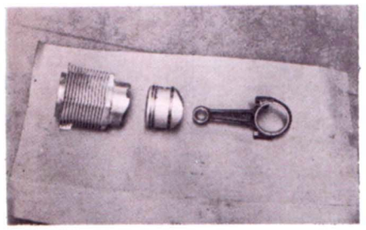
A sort of ultimate simplification, Porsche's flat fours are among the hottest in the world.

THE large, varied line of Porsche engines represents a series of evolutionary refinements based on the humble VW power plant which also, of course, is an original Porsche design. When the full range of variations on this unorthodox theme is viewed from its People's Car beginning to its present competition-car culmination, we can begin to appreciate the really earth-shaking significance of the Porsche *boxer motor*. It's an amazing device from the standpoints of originality, versatility, simplicity, durability, efficiency, and performance. Its many forms are naturally confusing to anyone who has not been able to

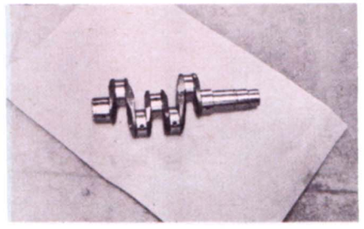


Exhaust valve has high center so that if piston strikes valve, it will close it, not bend stem.

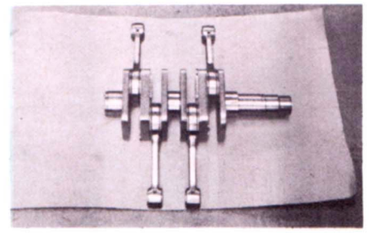
By GRIFF BORGESON



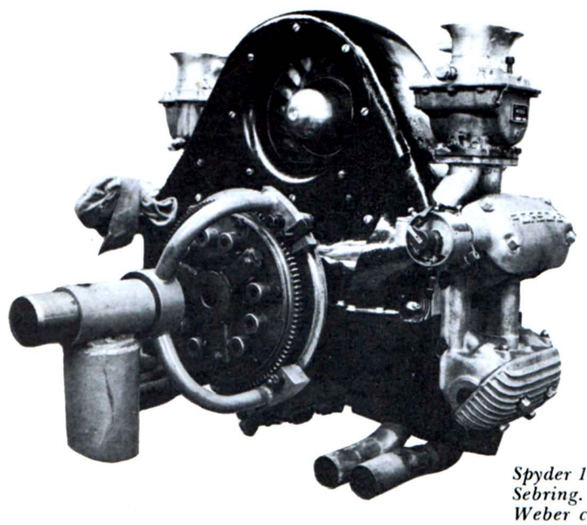
Cylinder, piston and rod assembly from 1600 engine. This is not a roller bearing connecting rod. Note oil ring below wrist pin.



Standard crankshaft journals are narrow but massive, with the mains running just under two inches. Bearings are hardened.



Hirth built-up roller-bearing crankshaft. Con rods are one piece and hand finished. Replacement price of unit—$513.

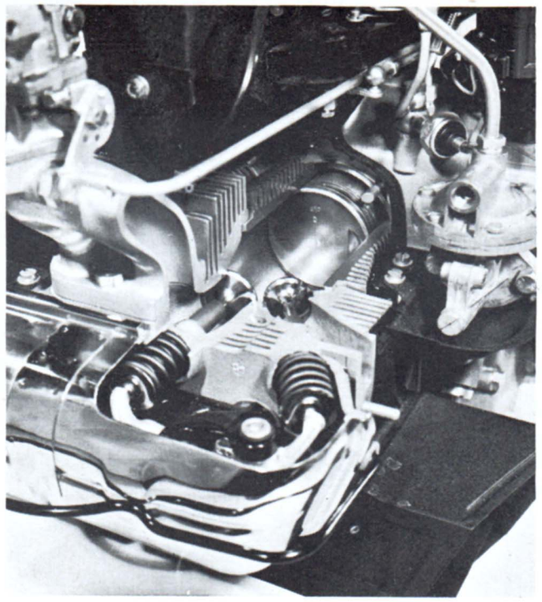


Spyder 1500 RS engine being prepared for Sebring. The dohc engine uses dual-throat Weber carburetors, and two separate ignition systems. Note small flywheel.

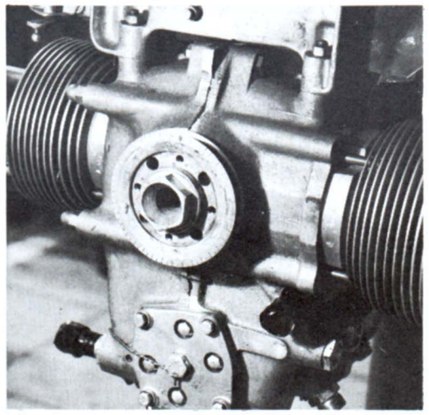
make a study of the subject and so we present here, for the first time, a survey of the whole spectrum of Porsche power plants.

The current line of engines manufactured by the firm called Dr. Ing. h. c. F. Porsche KG consists of the types shown in the accompanying table, the popular 1500 and 1500S having been replaced by the more lustily-endowed 1600 series. The 1100, 1300, and 1300S are paired with the coupe and convertible bodies. In addition to this choice of coachwork, the 1600 and 1600S also are supplied in the Speedster, a roadster or open two-seater. The same applies to the 1500GS Carrera. The appallingly potent 1500RS, with its unique ahead-of-rear-axle mounting, lives only in the Spyder, an all-out competition two-seater.

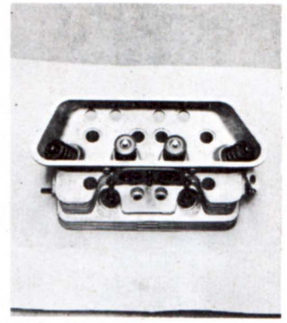
All of these engines share many of the same components. Some of these are crankcase, cylinder barrels, and cooling system. All of the "normal" engines — the 1100, 1300 and 1600 — share the same crankshaft, connecting rods, camshaft, and valve train. The S or Super engines all have Hirth roller-bearing crankshafts and special, ground-all-over connecting rods. The 1500GS and RS also have these organs, plus dual overhead camshafts, twin-throat carburetors, two-



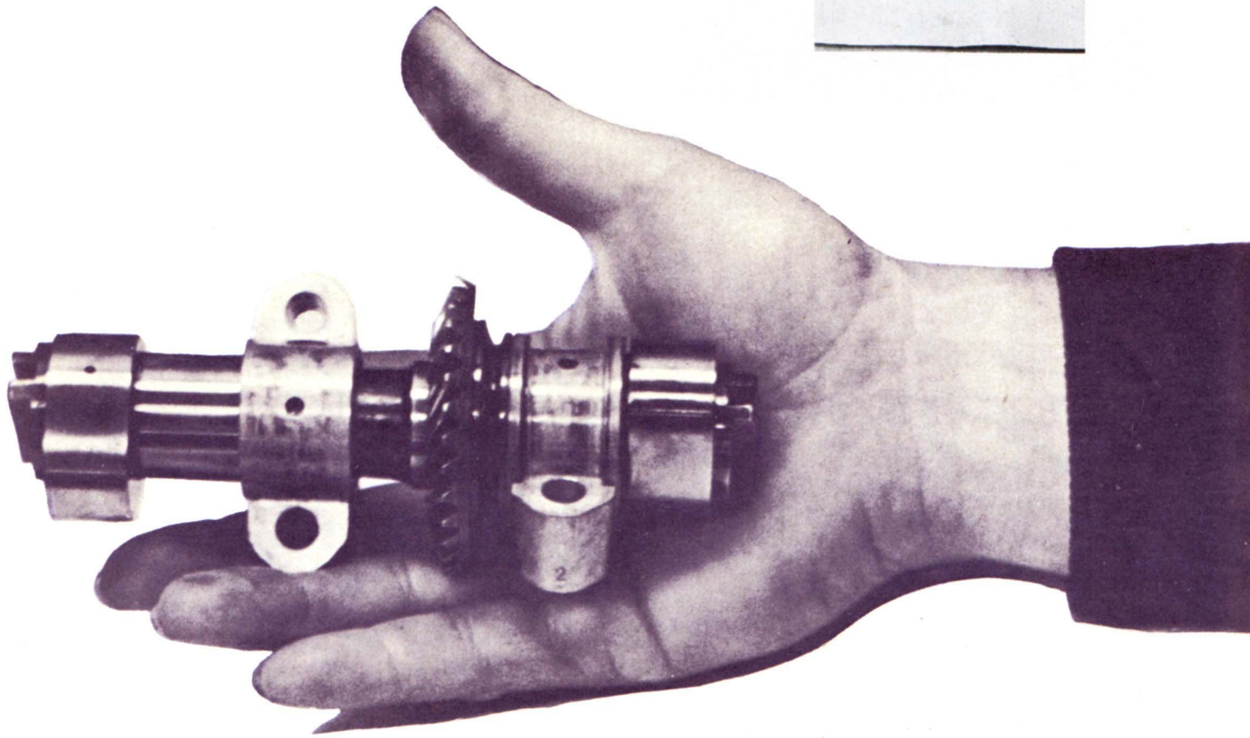
Partial cutaway of the 1600S engine shows intake and exhaust ports. Intake valve is .28 inches larger than the exhaust. Piston has flat top, bevelled edges, and exhaust valve relief.



View of Spyder engine from fan pulley end. Timing degree marks can be seen on pulley. Engine is timed statically with 24° advance for each bank of cylinders. Advance marks must be at top center and aligned with vertical casing line.



Top view of standard head. Note, deep and all around finning for optimum heat dissipation. Head is light alloy, easily removable.



Part of overhead camshaft showing cam lobe, bearing, bevel gear, bearing, and second cam lobe. This cam operates the exhaust valves.

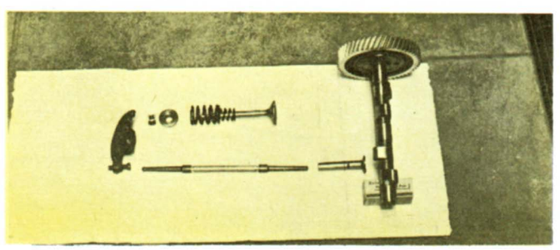
plugs-per-cylinder heads, and a separate ignition distributor for each set of plugs.

A moment's contemplation of the table shows the fantastic range over which this engine of such modest beginnings has been made to perform and, as the world knows, to perform well. Every forward step in the performance of Porsche cars has caused endless bother and embarrassment to the people who build the engine in its most economical form. From the earliest days of the Porsche the VW factory was assailed with customer complaints, all hewing to this line: "If Porsche can get more speed and acceleration from the VW engine, why can't the VW factory do the same?" The answer, of course, lies in the difference in price between VW and Porsche cars.

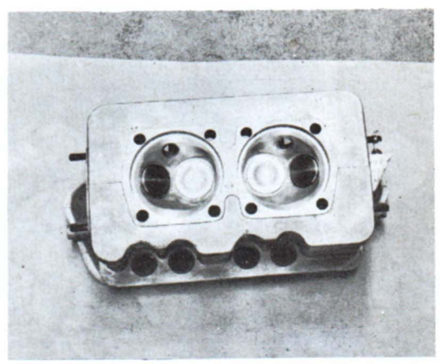
In the Porsche 1600 road test I mentioned that calculations based on pulling power and tractive resistance indicated that the test car was delivering more horsepower to the flywheel than its builders claimed for it — a very unusual occurrence. This caused me to doubt my own slipstickery and make inquiries. I learned from several owners who have had their cars on chassis dynamometers that they have run into the same surprising situation: power output was "a lot more than it ought to be." Finally I met Mr. Rolf Wuetherich, master mechanic from the Porsche factory who looks after company affairs in the American southwest. "Sure," he said. "It's our policy to keep all statement concerning performance on the conservative side. We've made quite a few solid friends that way."

Results are a more compelling argument for the sale of a small car than exaggeration of miniature horsepower figures. And when these brilliant little engines are coupled with chassis and bodies that actually *contribute* to their effective urge, the results pour in. Except for a rare, supercostly semi-prototype, Porsches dominate their classes in competition. The fact of consistent superiority gets the job done in the sales room.

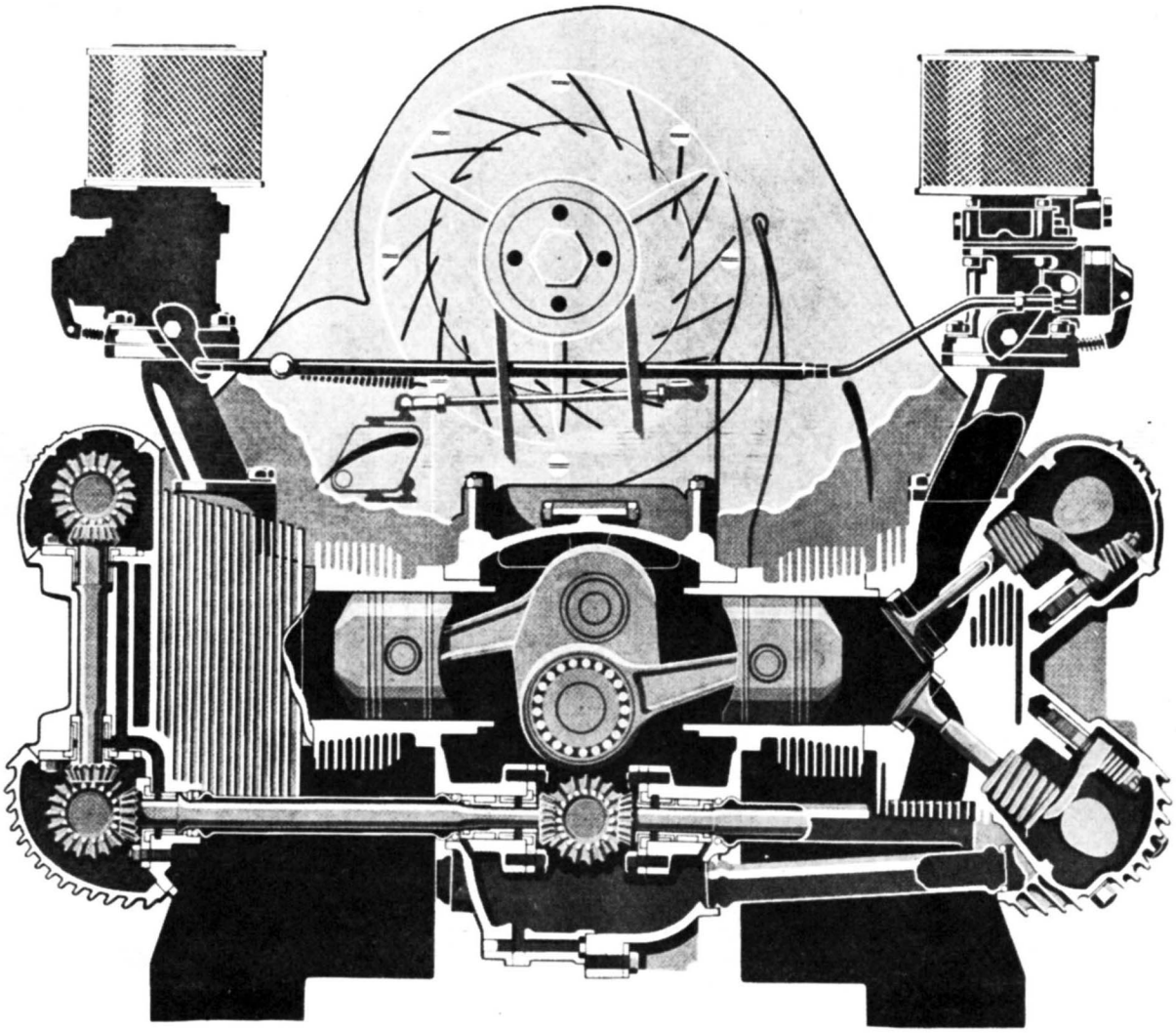
Now let's talk engines. Basically, the Porsche is an air-cooled flat four with overhead valves. There are two cylinders on each side of the crankcase, which is mounted on



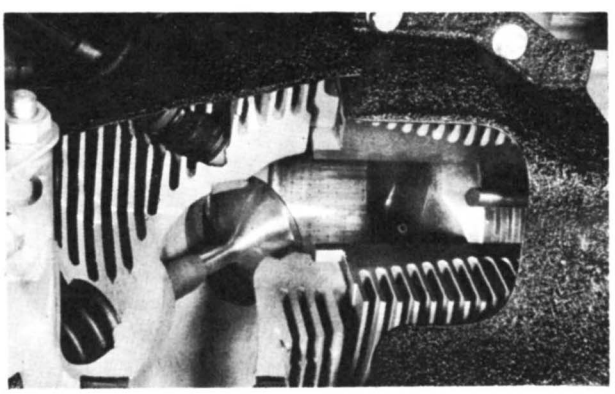
Valve train of standard engine. Pushrod is of light alloy with steel center section. Rods have same coefficient of expansion as cylinder-head assembly. Note blunt ends of camshaft. Valve clearances are .006 int. and .008 exh.



Bottom view of standard cylinder head which carries steel or bronze valve seats, valve guides, and plug bosses.



Cutaway showing working parts of dohc engine. Bevel gears drive camshafts. Con rods run on roller bearings at crank end. Note, domed pistons with oil ring below wrist pin.



Partial cutaway shows intake valve, piston, and cylinder. Cylinders of all engines are of light alloy casting and do not use ferrous liners. Bores are chromium plated and lightly scored to hold oil film. Pistons are inverted-Vee type and do interfere with valves.

rubber blocks. Each engine is painstakingly hand-fitted and assembled and bears the initials of the skilled technician who performed the job.

The rigid, box-shaped crankcase is made of light alloy. It's in two pieces, split down the vertical center line. The main bearing bulkheads are narrow but massive and the mains are just under two inches in diameter — huge for such a small engine. There is a main bearing between each pair of crank throws, plus another main at the forward end of the crankshaft. Each of the main journals runs in solid, circular inserts except the No. 2 main, located between the front and rear cylinders. This runs in a split insert.

On older Porsche engines it was necessary to dismantle the crankcase in order to remove the camshaft. On the current engines this operation can be performed merely by removing the light-alloy cam-drive cover at the front of the case. If part of a crankcase is damaged both halves must be

Adavanced characteristics of the Porsche enabled car to cruise at peak rpm indefinitely without injury to engine.

THE CURRENT PORSCHE ENGINES

	1100	1300	1300S	1600	1600S	1500GS (Carrera)	1500RS (Spyder)
Piston displacement	1086 cc 66 cu. in.	1290 cc 79 cu. in.	1290 cc 79 cu. in.	1582 cc 96.5 cu. in.	1582 cc 96.5 cu. in.	1498 cc 91.4 cu. in.	1498 cc 91.4 cu. in.
Bore & stroke	73.5x64mm 2.89x2.52 in.	74.5x74mm 2.93x2.91 in.	74.5x74mm 2.93x2.91 in.	82.5x74mm 3.25x2.91 in.	82.5x74mm 3.25x2.91 in.	85x66mm 3.35x2.60 in.	85x66mm 3.35x2.60 in.
BHP (SAE)	47 @ 4000	51 @ 4200	70 @ 5500	70 @ 4500	88 @ 5000	115 @ 6200	137 @ 6200
Torque (DIN), lb-ft	54 @ 3300	60 @ 2800	65 @ 3700	82 @ 2700	86 @ 3700	94 @ 5500	95.5 @ 5500
Compression ratio	7.0	6.5	8.2	7.5	8.5	8.7	9.5
Valve drive	Pushrod	Pushrod	Pushrod	Pushrod	Pushrod	DOHC	DOHC
Valve timing: In. opens BTC In. closes ABC Ex. opens BBC Ex. closes ATC	 2° 30′ 37° 30′ 37° 30′ 2° 30′	 2° 30′ 37° 30′ 37° 30′ 2° 30′	 19° 54° 54° 19°	 2° 30′ 37° 30′ 37° 30′ 2° 30′	 19° 54° 54° 19°	 38° 78° 78° 38°	 38° 78° 78° 38°
Valve diameter: Inlet Exhaust	 1.50 in. 1.22 in.	 1.50 in. 1.22 in.	 1.50 in. 1.22 in.	 1.50 in. 1.22 in.	 1.50 in. 1.22 in.	 1.875 1.5625	 1.875 1.5625
Carburetor throat diam.	1.26 in.	1.26 in.	1.26 in.	1.26 in.	1.58 in.	1.58-in. dual	1.58-in. dual
Spark plugs per cyl.	1	1	1	1	1	2	2
Connecting rod bearings	Plain	Plain	Roller	Plain	Roller	Roller	Roller
Lubrication	Conv.	Conv.	Conv.	Conv.	Conv.	Dry sump	Dry sump
Bore: stroke ratio	0.87	0.99	0.99	0.89	0.89	0.78	0.78
Piston speed @ max. bhp	1680	2040	2670	2180	2425	2690	2690
Bhp per sq. in. piston area	1.79	1.89	2.60	2.11	2.65	3.26	3.89
Bhp per cu.in.	.71	.65	.89	.73	.91	1.26	1.50

replaced; they come as fitted parts.

All con rod small ends contain bronze bushings. The 1100, 1300 use VW big-end inserts, and 1600 engines use lead-bronze big-end inserts which are interchangeable with the 1500. The 1300S, the 1600S, and the 1500RS and GS use normal main bearings but the rod big ends run on rollers. This is accomplished by means of built-up crankshafts and special, hand-finished, one-piece con rods. The roller-bearing shaft with a set of fitted rods packs a replacement price of about $513. In the case of either standard or Hirth roller crank, the flywheel is located by means of a single, central hollow bolt and eight locating dowels — an excellent, simple and handsome arrangement. The standard con rods are stubby H-section forgings with huge big ends. The bearing surfaces of all cranks are hardened.

The pistons in all Porsche engines are of the full-floating type, the wrist pins being secured by lock rings. Pistons for the various engines differ widely. All use two compression rings and one oil ring and these are arranged conventionally on the 1100 and 1300. The other engines use pistons on which the oil ring is mounted below the wrist pin and close to the bottom of the skirt. The 1100 piston has a domed crown with flyout clearance for the exhaust valve. The 1300's piston has a narrow, inverted-vee crown which requires no valve relief. The 1500 GS and RS use hairy, domed pistons with pronounced valve relief on two sides of the dome. The 1600 piston has a flat top and the pistons for the 1300S and 1600S have high flat tops with bevelled edges and exhaust valve relief.

The cylinders of all these engines are light alloy castings which do *not* use ferrous liners. Instead, the bores are chromium plated, then lightly scored to give a foothold to the oil film. This novel procedure is not as radical as it may

(Continued on page 55)

Four Cylinders

(Continued from page 43)

sound, having been developed and proved in German motorcycle practice. The hard chrome finish is amazingly wear resistant. I know of one Porsche owner who now has 82,000 miles on his engine and it still shows no sign of requiring a rebore. If it should reach that stage as it must eventually, he will not have to invest in new cylinders. Lockheed will rechrome the original ones for a modest price. Each Porsche cylinder, new or replacement, comes with its own piston, tailored to fit. The sloppy clearances popularly associated with air-cooled engines don't apply to the Porsche. The 1300 and 1300S, for example, use pistons that are only six-tenths of a thousandth of an inch smaller than their cylinder bores.

Each bank of two cylinders carries a common, removable light-alloy head which, like the barrels, is deeply finned for optimum cooling. The head contains steel or bronze valve seats, valve guides and spark plug bosses. The cylinders are spigoted to permit the heads to fit down around them and no head gaskets are required.

The overhead valves of all but the 1500GS and RS are pushrod operated and are arranged in a wedge-shaped variation on the vee-inclined theme. The camshaft rides in three bearings and is driven by a light-alloy helical gear. With admirable simplicity, each lobe on the camshaft alternately operates one valve of two opposed cylinders, by means of pushrods and rocker arms. Mushroom-type cam followers act on the pushrods, which are of light alloy with a steel center section. This bimetal combination has a coefficient of expansion practically identical with that of the head and block assembly. Valve lash is adjusted conventionally at the rocker arms.

The 1500 GS and RS are full-race versions of the foregoing engines, as a glance at the table shows. The heads of these engines have true hemispherical combustion chambers, classically vee-inclined valves, two spark plugs per cylinder, and dual overhead camshafts. That adds up to four camshafts for the engine.

These cams are driven by shafts and bevel gears. Instead of using conventional, somewhat clumsy Oldham-type couplings, the main cam-drive shafts are jointed by means of male and female splines. These permit changes, including compression ratio and cylinder height, to be made with no modification of the cam drive.

The lobes on these d.o. cams are enough to quicken the pulse of any roller tappet devotee. They're as blunt as the end of a broom handle and act upon radiused finger-type cam followers.

The followers are heavily spring-loaded and ride on adjusting buttons placed over the valve stems. The exhaust valves are sodium cooled and their heads are higher at the center than at the periphery so that, if a piston should hit a valve, it will close it, not bend it. Double-nested valve springs are used in all the Porsche engines.

The cylinders and heads are cooled by means of ducted air that is forced-fed by a powerful fan driven by an adjustable v-belt pulley on the crankshaft. An oil cooler also is mounted in the path of cool air flow and all lubricant must pass through it before it reaches the engine's bearing surfaces. Correct viscosity of the oil is maintained in cold weather by means of a by-pass valve ahead of the cooler.

All oil passages in the crankcase, blocks and heads are lined with copper tubing. The lube system delivers pressure oil to all friction surfaces with the exception of cylinder walls and wrist pins, which are splash-lubed. On the 1500GS and RS engines a single pump handles both oil feed and scavenging. In addition to a conventional cartridge-type oil filter the system includes a large "magnetic filter" in the bottom of the sump for extracting ferrous particles from the oil.

The Porsches use a single-plate dry clutch built into the flywheel; the clutch pressure-bearing requires no maintenance. If there is an Achille's heel to these engines, the clutch is it. This is not necessarily because of any defect inherent in the robust 7.13-inch clutch but is more a function of driving conditions and techniques. Protracted drag racing from traffic light takes its toll and changes a delightfully soft and easy clutch into a rough one. The Porsche is built to tolerate hard use but leadfoot owners will do themselves a favor by not expecting the clutch to live out its life constantly slamming into a flywheel spinning at 4000 revs or more.

The pair of Solex carbs fitted to Porsches have generous acceleration pumps. The engine can be brought to life on the coldest morning with just a couple of tromps on the throttle pedal before the starter button is pressed. Throttle priming should be done with restraint; it's an easy engine to flood if you're careless.

Although the two carbs are nearly a yard apart, the linkage that joins them is tight, positive and substantial. All engines but the hot 1500's have single-throat carbs. The GS and RS come with Solex-twin-throat units and are often fitted with twin-throat Webers for competition; with linkage and manifolding they cost about $900. The Webers make little difference in ultimate power output but they do make for a marked improvement in acceleration and prompt, smoothly continuous throttle response.

Dual ignition on the GS and RS engines is credited with increasing their total power output by better than ten percent. One distributor feeds the juice to one plug in each cylinder. Thus, if one distributor should fail, you can stay in the fray on the remaining, separate ignition system.

When laying down the specifications for the original VW engine, Dr. Porsche chose air cooling largely because of its indifference to climate: "air neither freezes nor boils." Air cooling was a must for the projected universal car that could be left in the open in any climate, but that would always be reliably ready to go.

There are other advantages to air cooling, including nicer control in the casting process and elimination of the costly, heavy, superfluous bulk of water jacketing and radiator. The one disadvantage seems to be noise: a water jacket around an engine is a highly effective sound deadener. But the problem of noise has been adequately coped with in latter-day production of the Porsche family of engines, as far as the Porsche-VW market is concerned. If customers should ever begin to complain seriously, it could be coped with even more. Aside from this one objection, everything is in favor of retiring the water jacket along with the whip socket.

Dr. Porsche's *boxer motoren* are a revolution in power plant design, a sort of ultimate simplification. The basic design is a modern, intensely rational solution to the problem of propelling a car by means of a piston engine. It probably will retain its excellence as an answer to this problem as long as piston engines are being made. #