The Little Engine That Could

Like the tiny locomotive in the child's book, the Volkswagen air cooled flat four had to overcome a long mountain of skeptics who said it would never work. But work it did. It powered several million Beetles, and eventually became the guts of an American obsession called the Dune Buggy. Its basic design concept lives on in modern Porsche engines and the Volkswagen waterboxer. Even the Subaru flat four has some of the Beetle's design blood flowing in its veins.

This month's project engine was removed from a 1973 Super Beetle which is currently being returned to running condition after several years of overall neglect. The engine is a 1584 cc dual port version. It has many of the improvements added by VW over the years to improve performance and durability. We've decided to concentrate on returning this engine to its factory condition (or get as close as possible).

Even if you're not doing a complete overhaul on one of these engines, we hope that a better understanding of the little engine's inner workings will help you better diagnose internal mechanical problems. We've also thrown in a number of tips about hang on components and critical adjustments.

To Rebuild or Not to Rebuild

Before we start, let us warn you that this particular engine was definitely worth the rebuild effort. While it did have several serious problems, this was the first time it had been down since the factory. If your engine is on its 357th rebuild, and there's little left to work from, factory rebuilt engines are still available from several sources.

Either way, there are a lot of other things to consider which will ensure a long and happy life for your new or rebuilt engine, and several things to keep in mind which can send it to an early death. It's the little things which make the difference.

Fix This—Fix Anything

Years ago, a fellow student in a VW factory training class referred to the Volkswagen Beetle engine, and said, "If you can't fix one of these, you can't fix anything."

The instructor replied, "If you can fix one of these, and fix it right, you CAN fix anything."

The little engine gives us a chance to review some of our basic skills, without getting snagged in the brambles of the new computer underbrush.

We need to stop and thank a number of folks who helped with our project. SPX Corporation provided most of the hard parts used in our rebuild, and put us in touch with Rick Gable of Gable Machine here in Akron who offered us the fine services of his machine shop.

Rick also put us in touch with Dave Zakikian, an old bug junkie who dusted off his line boring machine and bored the engine case for us. More on that in a moment.

Andy Demrovsky of Euro-Car Service was a great help, as always. In fact, once the reminiscing about the Beetle engine started, little else was accomplished for the rest of the afternoon.

Thanks too, to Schley Products for providing the special tools (seal installer, flywheel lock, piston ring compressor, and lifter clips), used in this overhaul.

To supplement the repair information in this article, you may wish to purchase the factory repair manual, available from Robert Bentley Publishers (800) 423-4595.

—By Ralph Birnbaum

Here's a brief rundown of the Bug engine family tree for vehicles imported to the United States. Similar design engines were used in Porsche cars, and also in Volkswagen Type II and Type III cars. This information is limited to the Beetle's banner years, and spans 20 years of carbureted engines, from 1954 to 1974.

• **From 1954 through 1960, the Beetle was powered by a 36 horsepower 1192 cc engine.** Common problems included broken crankshafts, valve failures, and case wear caused by a camshaft which spun in a bearingless aluminum case bore.

• **A later incarnation of the 1192 cc engine produced an awesome 40 horsepower.** This engine was used in Beetles from 1961-65. VW got fancy and installed a carb with an electric choke, but broken cranks persisted, especially on cars with too much timing advance. Once again, case wear, both at the mains and at the camshaft journals dropped oil pressure to low single digits at idle, and hastened engine failures.

• **In 1966 VW made a number of changes in the Beetle.** In addition to canning the old king and link pin front end in favor of ball joints, they finally addressed the problem of case wear at the cam journals by installing cam bearings. The new 1285 cc engine also included improvements in cylinder head material, larger piston pins, and a bigger carburetor. The increased displacement was achieved by adding 5 mm to the stoke, although 77 mm pistons were still used.

Although the 1285 cc (or 1300 as many called it) was used for only one year, it was a great improvement over previous engines.

• **The 1967 Beetle finally offered a 12 volt electrical system, and a 53 horsepower 1493 cc engine.** The change in the electrical system was significant since the new 12 volt starter worked with a new 130 tooth flywheel. The old 6 volt starter worked with a flywheel having 109 teeth. This caused some problems for the mix and match efforts of home engineers. The 69 mm stroke was carried over from the 1285 cc engine, but the bore was increased from 77 to 83 mm.

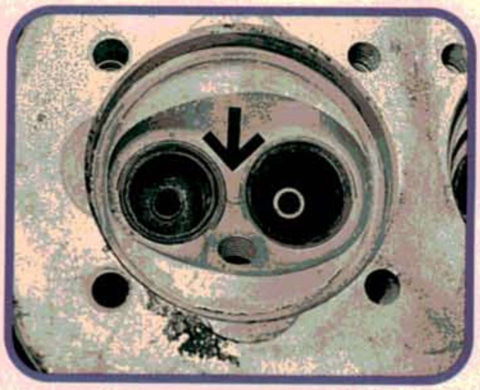
If memory serves me, this was a great little engine, and the 1967 Beetle was an exceptionally good car.

• **The 1485 cc engine lasted until the 1970 model year when a 1584 cc engine replaced it.** The "1600" as we called it, was originally equipped with a single port intake manifold. Once again, VW upped displacement by boring, to a then all time high of 85.5 mm.

This bigger engine was pretty darned lively compared to the old 36 and 40 horsepower versions. But the 1970 Beetles had a tendency to lose their heads. Apparently the added piston diameter was a little more than the head studs could handle.

• **From 1971 through 1974, the 1600 lived on with several modifications and improvements which improved its longevity and performance.** A dual port intake manifold and a Solex 34 PICT-3 carb were fitted. A larger oil pump was installed (in May of 1971), and a second oil control was added to protect the oil cooler from high oil pressures during cold starts.

You'll notice that our 1973 donkey engine has steel inserts in the case for the head studs. This was manna from heaven for technicians who had long lived in fear of the old head studs which screwed directly into the aluminum case. "Pulled studs" meant loose heads. Loose heads meant loss of compression, exhaust leaks, and a river of oil from loose cylinders and push rod tubes.

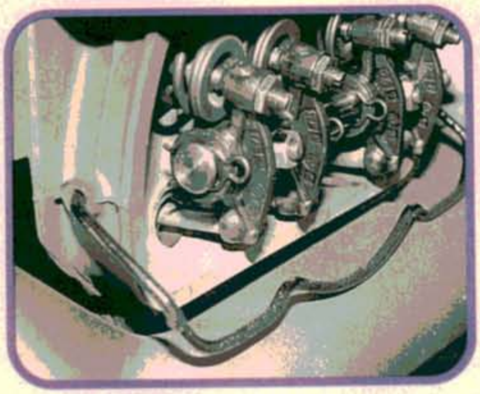


1

Cylinder head work was always a money maker on these. Cracks in the heads were a common problem, especially cracks near the plug hole, and between the valve seats. We'll weld the cracks and install new seats. These heads are certainly usable, although some will be beyond repair.

2

The intake valves need refacing, but a quick check with a micrometer assures us that the stems on the intake valves are within specs. Valve springs, retainers, and keepers all check out okay. The valve guides are shot and the exhaust valves go directly into the scrap bin.



3

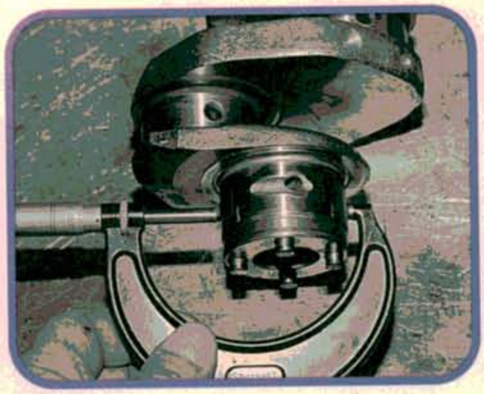
Rocker shaft assemblies are often overlooked during an overhaul or valve job. All of the oil passages in our rocker arms were coked shut. Oil from the lifters passes through the hollow push rods to lube the rocker arm pivots. We clean the shaft assemblies and replace the lash adjustment screws which are shot.

4

Over at the bench we check piston diameters and cylinder bores. Things go well until we get to the last jug which has a nasty taper and is out of spec for out-of-round. If the case and crank check out, we decide that a new jug set is probably the best way to go. The rings are shot anyway.

5

The four main bearing crank likes to thrash around in the aluminum case. Main bearing wear may not be your only problem on a high miler. This case shows signs of the pounding the bearing has given to the case bores. Number 1 main is also the thrust bearing. Wear to the case bore and thrust surfaces can result.



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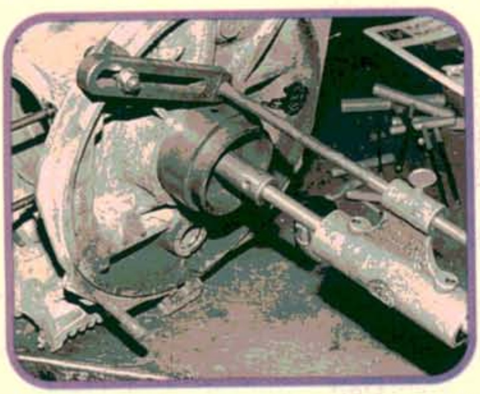
The thrust face of the case is okay. But we've estimated that we'll need to line bore the case and install larger OD bearings. Our crank journals are within specs for diameter, and none are out of round. Bearings are available in both over- and undersized thicknesses for case cutting and crank grinding.



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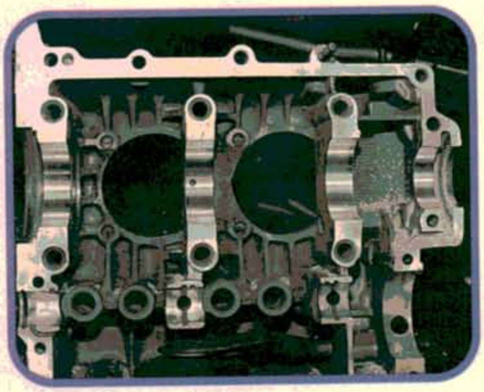
It wasn't easy to find line boring equipment here in Akron. But Dave Zakikian jumped at the chance to dust off his old line boring tool and give us a hand. The case wasn't all that bad, and a first oversize cut (0.50 mm) cleaned up the bores. We ordered first-over bearings with a standard thrust.



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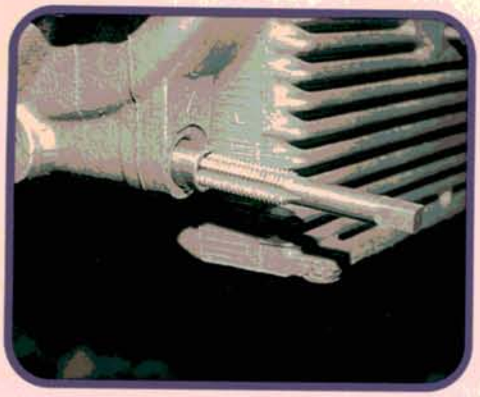
Our case journals come out clean and shiny, but there are chips everywhere. We'll spend some extra time here making sure the inside of the case is spotlessly clean. That includes cleaning all the coke from the oil passages and making sure the oil pickup is clean and fits tight in the case.



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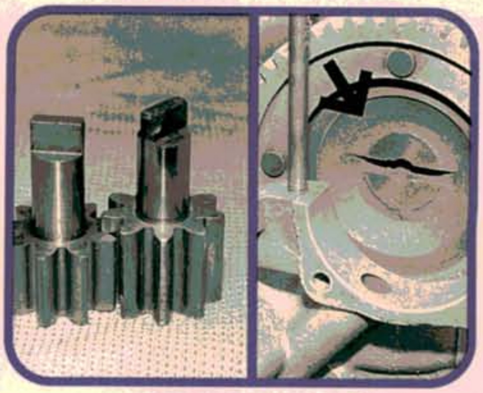
This later style case has two oil pressure reliefs, one which controls oil pressure to the mains, and one which limits oil pressure to the oil cooler. Both of the oil relief pistons are stuck. We screw a 10 mm tap into the pistons to remove them, and clean and polish until both move freely in the case.



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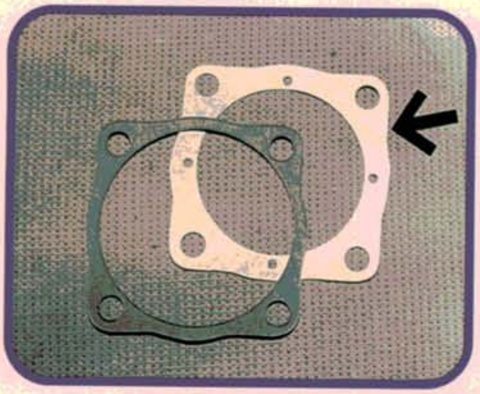
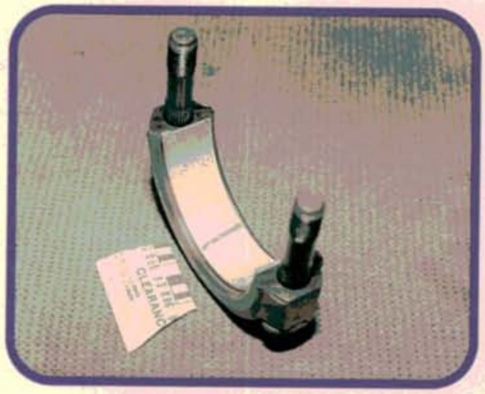
Our engine also has the later style, larger capacity oil pump with taller gears. The use of the deeper pump meant a change in camshafts. The face of the newer cam is slightly dished to accept the taller pump (right photo). Our old pump is worn out. A new one is cheap insurance.



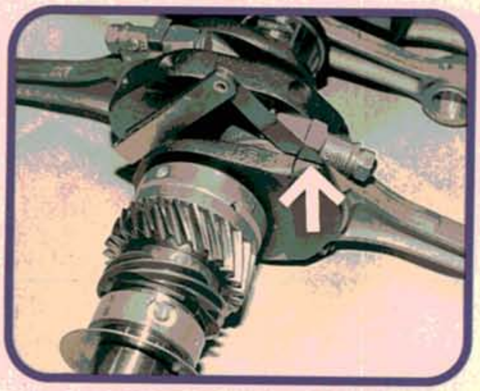
11

Be careful to install the pump gaskets in the correct order. The thicker of the two goes between the pump body and engine case. The thinner gasket (arrow) goes between the pump body and pump cover. Reverse them and you end up with too much clearance between pump gears and cover, reducing oil pressure.



12

Rods. We already used a micrometer to check the rod journals, and a dial bore shows that standard rod bearings will do the trick. We use a plastic clearance checker, just to be sure. Once installed, the rods should turn smoothly without binding. In fact, installed rods should fall smoothly from their own weight.



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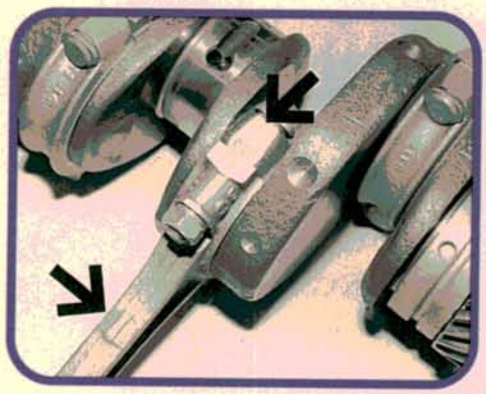
We press in new piston pin bushings and hone them so each new piston pin slides through snugly, but smoothly. We also check rod axial clearance (arrow) and find we're still at the original spec. Too much axial play can result in oil consumption problems when too much oil is thrown against the cylinder walls.



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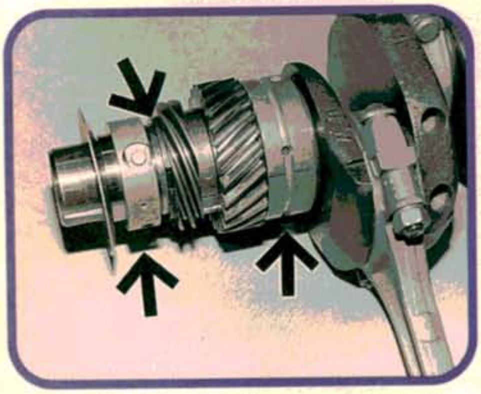
Rods are installed on the crankshaft so the boss on the neck of the rod (left arrow) will point upward when the crankshaft assembly is in the case. Rods and rod caps have matching numbers stamped on them. You can't get the caps on backwards unless you're really determined to do so (right arrow).



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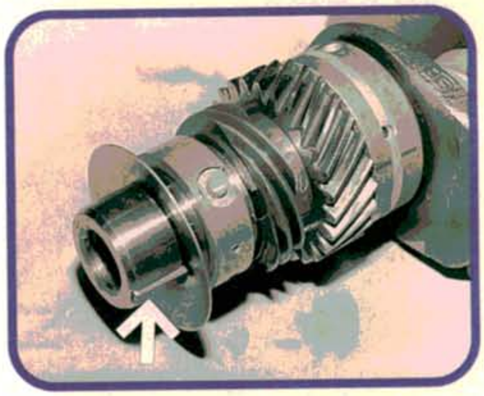
To install new Number 3 and Number 4 bearings on the crankshaft, remove the woodruff key and oil slinger and slide off Number 4 (left arrow). Remove the large snap ring, (top arrow). Press off the distributor, slotted spacer, and cam gear. Install a new Number 3 bearing (right arrow).



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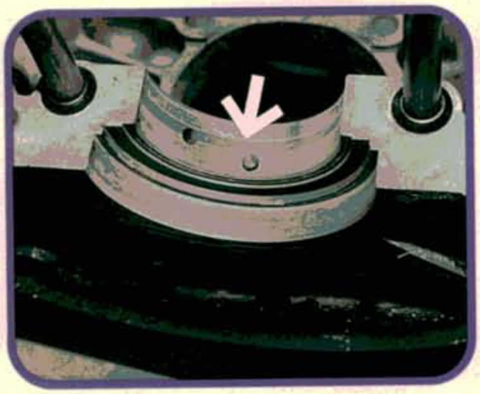
Don't press the gears back on. Make sure the crank area where the gears ride is burr free. Heat the gears in an oil bath (about 180 degrees F) and slide them onto the crank. The timing mark on the cam drive gear faces the slinger. Reinstall the snap ring, Number 4 bearing, oil slinger, and woodruff key (arrow).



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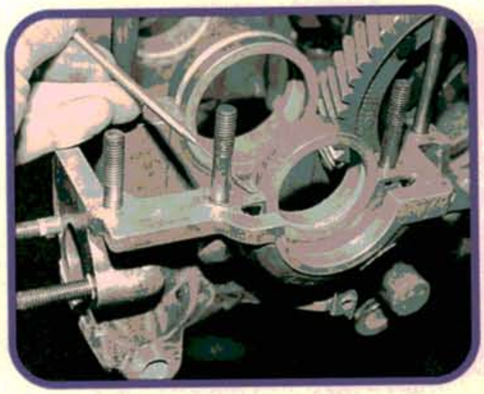
There are locator dowels in one side of the case for each main bearing to keep them from spinning. When you install the crank assembly in the case, be careful to properly index each bearing so its dowel hole fits right over the dowel. Get the holes out of index and you ruin the bearing and lock up the crank.

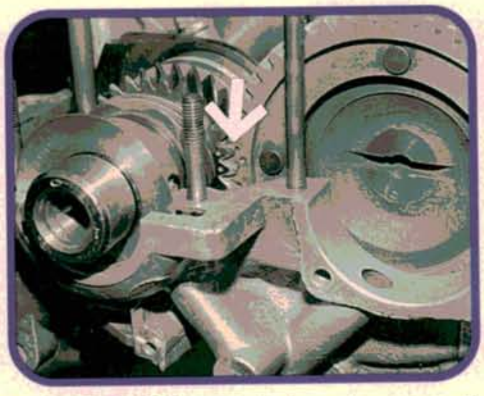


18

One way to be sure the bearings are properly positioned is to install the bearings in the case without the crank. Then take a tiny scribe (a dental pick in this case) and gently mark each bearing for index. Install the bearings on the crank and use the scribe marks to position them as you lower the crank assembly into the case.

19

We install new cam bearings in the case, being careful not to swap the two bearings shown. Note how the narrower bearing shell does not block the oil return passage in the case (arrow). Then we check camshaft end play (bottom photo). The new bearings do the trick, and our end play is within specs.



20

Prelube the lifters and drop them into the case. Install the cam and crank. Timing marks on crank and cam align as shown. Check the backlash between the cam drive and driven gears. Look for zero backlash to a maximum of 0.050 mm. Replacement gears are graded by gear pitch to allow adjustment of backlash.

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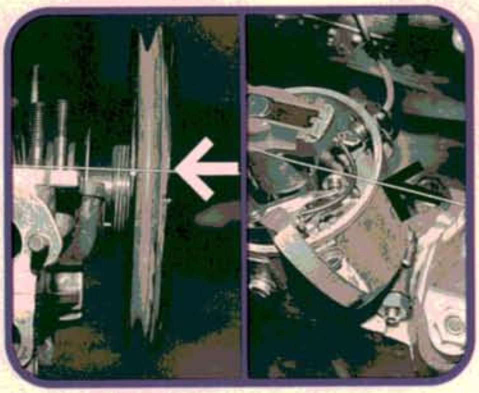
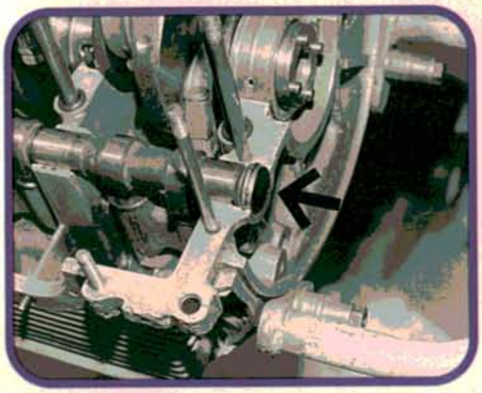


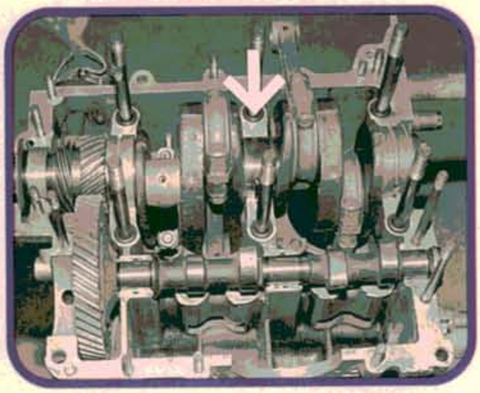
21

Install the distributor drive gear now. Don't forget the washer at the base of the gear. Loosely install the crank pulley and turn the crank until it's at TDC Number 1 (left photo). Install the gear so the distributor rotor faces the notch marking Number 1 when the distributor locks down into the gear.



22

We're almost ready to put the case halves together. Cam and crank are installed, the distributor drive gear is in place. Don't forget to install the cam plug (arrow) or you'll have a massive oil leak. Apply a thin film of sealer to the plug and drop it in place. We check to make sure everything is turning freely.

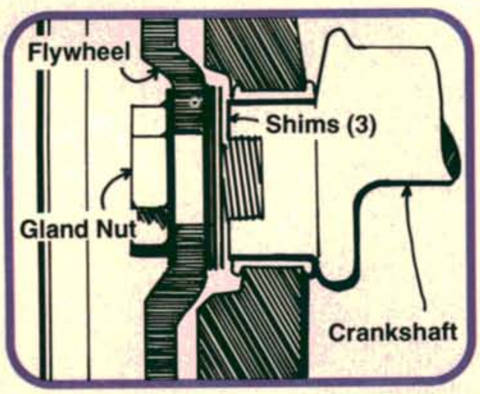


23

We have chosen to use Loctite 518 as our case half sealer, (no blue glue please). We final check for burrs on the sealing surface and apply a thin, thin film to the case half sealing surfaces. We also install a new rubber sealing ring (arrow) on each case stud. We're ready to assemble the case.

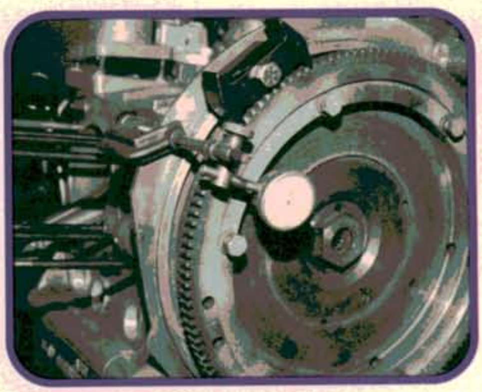
24

Install the other half of the Number 2 bearing in the remaining case half. Guide the rods through the cylinder holes as you lower the case half. Snug the nuts on the main case studs. With the nuts torqued to spec, everything still spins free. Tighten the 8 mm nuts and bolts around the case perimeter.



25

Crankshaft end play is one of the most critical measurements you'll make on this overhaul. End play is set using 3 shims placed between Number 1 main bearing and the flywheel. Do this before installing jug sets. That way you don't fight the added friction when sliding the crank fore and aft.



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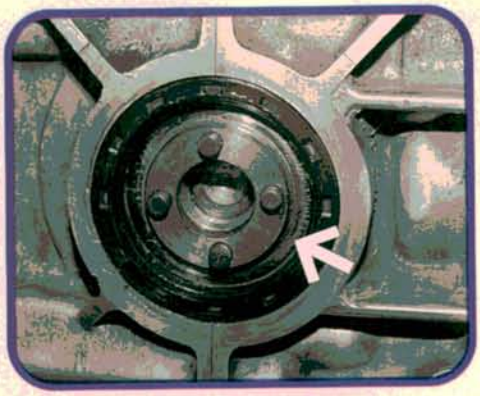
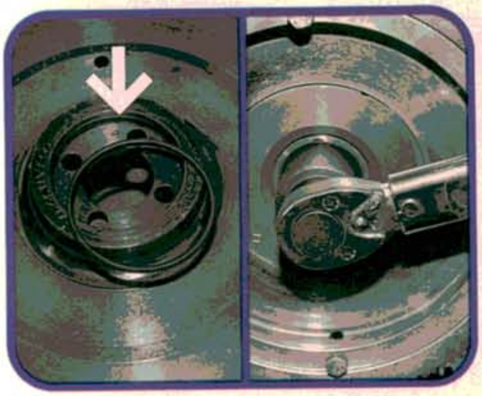
Setting end play. Install two "starter" shims between the flywheel and crank and tighten the flywheel gland nut. Set up a dial indicator on the flywheel as shown. Once you measure total end play with two shims, subtract 0.07-0.13 mm (0.025-0.080 inch). This tells you how thick the third shim needs to be.

27



Remove the flywheel, install a shim of the thickness determined in the last step. Reinstall the flywheel and double check end play. If everything's okay, remove the flywheel one more time and install a new flywheel seal. This photo shows the shims peeking out from behind the new seal (arrow).

28



The crankshaft seal fits into a groove in the flywheel. Pry out the old seal (arrow), and install a new one. Reinstall the flywheel, and lock it so it won't turn. Final torque the gland nut (don't forget the big washer that goes under it) to 343 Nm (a whopping 253 ft-lb). Final check end play (0.07-0.13 mm).

29

The new jug sets came assembled, but we take them apart to check compression ring end gap, just to be safe. We also want to make sure the ring grooves aren't aligned! The new rings are right at the factory new limit. The wear limit on rings is 0.90 mm, but new ones should run between 0.30 and 0.45 mm.

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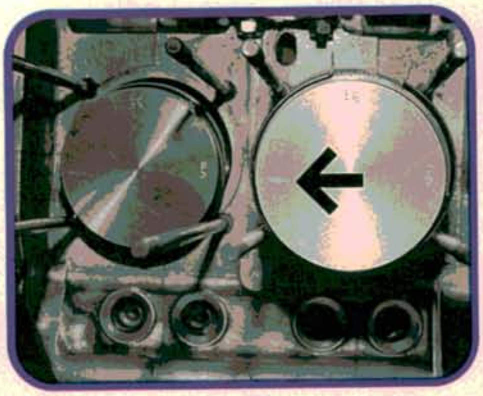
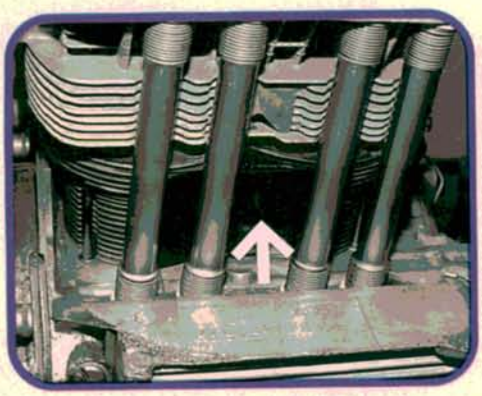


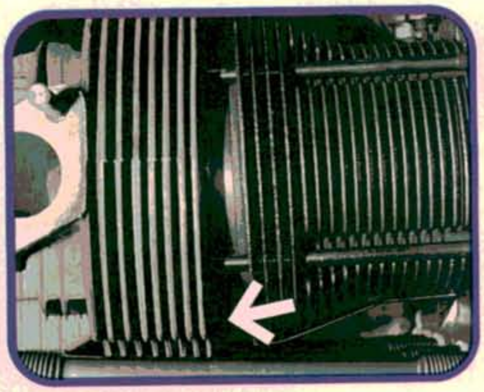
Piston pin bores are slightly offset from the centerline of the piston. As a result, they must be installed with the arrow on the piston head pointing toward the flywheel. Pistons pins are held in place by snap rings (two per piston) which fit in grooves in the piston pin bores.

31



With the jug sets installed, snap the air deflectors into place below the cylinders (arrow). We install new push rod tubes and seals and make sure they're properly seated between the head and case. Push rod tube seams should point upward. The tubes should measure about 191 mm from seal to seal.

32



The push rod tubes are squeezed between the head and case as the heads are torqued. That means they want to push the head outward at the bottom at first (arrow). Tightening the bottom row of head nuts first seats the cylinders squarely in the heads.

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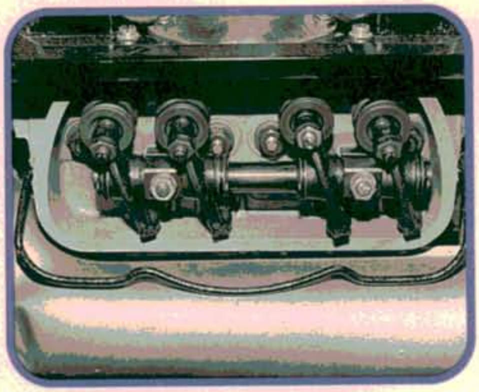

Since the heads hold everything in place (jugs, push rods, heater boxes, muffler, etc.), head torque is critical. This newer style case has stud inserts and is less apt to "pull studs" from the case. Make sure all threads are clean and lightly lubed. Then install the rockers and adjust the valves (cold) to 0.15 mm.

34

The engine is air cooled by a fan bolted to the back of the alternator (or generator). ALL sheet metal must be installed and properly fastened for the cooling fan to do its job. Even the rubber boots on the spark plug wires must fit properly or valuable cooling air will be lost (right photo).

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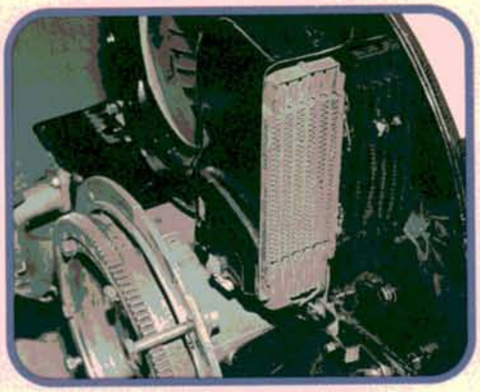

An oil cooler acts like a small radiator to remove excess heat from the engine's puny $2^1/_2$ quarts of oil. Early style oil coolers were mounted inside the fan housing and partially blocked the flow of air to Number 3 cylinder. This later style engine mounts the cooler on an offset mount to correct that problem.

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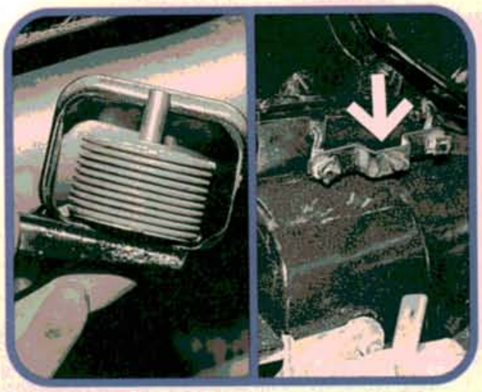

A thermostat mounts to the case below Numbers 1 and 2 to control the air flaps in the fan housing. The flaps stay closed until the thermostat expands and opens the flaps, allowing more air to cool the cylinders. Check all the flaps for free movement before you install and adjust the thermostat.

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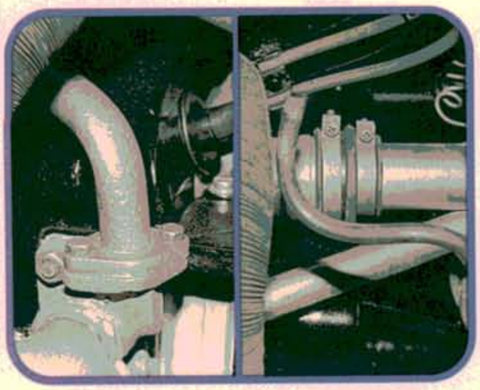

Intake manifold tips. A cross tube runs across the base of the intake manifold and bolts to the muffler. Heat from the exhaust warms the intake to prevent icing in winter. Make sure the tube isn't plugged with carbon. Also check the rubber boots on the intake for cracking which will cause a big vacuum leak.

38

We couldn't show everything in this article. After all, hundreds of books were written about this engine. But we hope this brief article was more than a nostalgia trip. There are still some low-tech opportunities in the auto repair field. And some, like the little engine that could, are fun to boot.