

Top to Bottom

Part Two

Welcome to the second half of our top to bottom look at a 1987 BMW 535 iS engine overhaul. We thought we had finished our top end coverage last month, but it turned out we were just getting started. This elevator is going to be stuck at the penthouse a little longer.

After removing the camshaft, rocker shafts and rocker arms, we took the cylinder head to Ray English at AADCO in Solon, Ohio to solicit his advice. AADCO specializes in the repair and remanufacture of aluminum cylinder heads. One look around the AADCO shop might convince you that they were trying to corner the world market on alu-

minum cylinder heads. Cylinder heads waiting to be remanufactured are neatly stacked to the ceiling along one wall.

Ray's eyes lit up when I showed him the BMW cylinder head and box of parts I had brought him. If you believe in fate or destiny, you probably would not be surprised to learn that Ray had the factory franchise for BMW cylinder head repair in his native Australia. He reckoned this would be more fun than the average Ford Escort head.

One part of the job that we had been dreading was the reassembly of the camshaft, rocker shafts, and rocker arms. Last month we managed to disassem-

ble these parts without the aid of the special factory fixture mentioned in the service manual (Robert Bentley, **Circle No. 140**), but it didn't look like it was going to be easy to get everything back together again. We were looking at an awful lot of new parts that had to go back together in the right order.

Ray put our fears to rest. He didn't have the factory fixture either, but quickly tired of putting heads together without it. He may describe his homemade fixture as ugly, but it certainly gets the job done. We'll describe Ray's easier camshaft and rocker shaft assembly procedure in our photo captions. If you would like more information about AADCO's services, call (216) 498-9420, or **Circle No. 141** on the Reader Service Card.

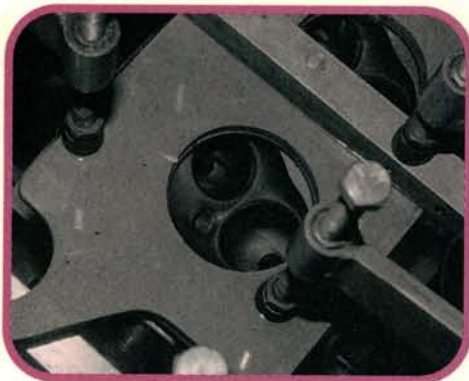
Once we got the elevator moving again, we stopped to see Rick Gable at Gable Machine and Engine Shop in Akron, Ohio for help with our lower engine

repairs. We took most of the preliminary cylinder block and crankshaft measurements ourselves, then relied on Guy and Dale at Gable's to work their magic with the machine shop equipment.

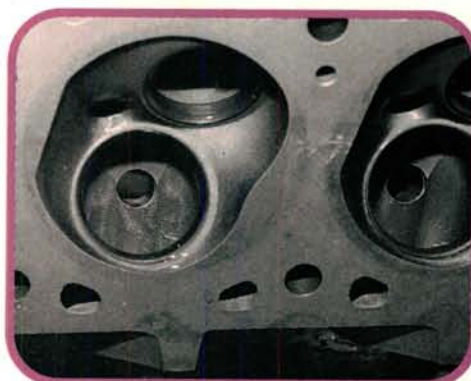
Guy honed the cylinder walls to the first oversize dimension, then reconditioned the connecting rods. Dale magnafluxed the crankshaft to check for cracks. Our measurements indicated that the crankshaft was still within specifications, so he finished the job by polishing the journals.

All of the heavy work is done, but there's still quite a bit of work to do before this thing is ready for the road. We won't bore you with final engine assembly information, however. There are service manuals for that if you're unclear on any of the details.

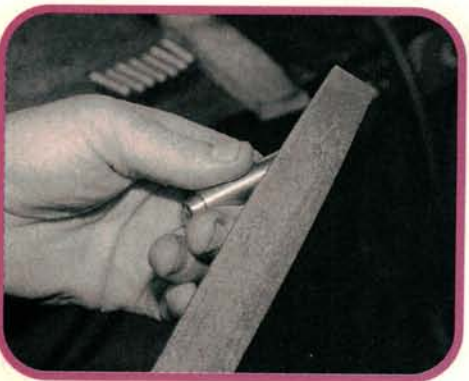
— By Karl Seyfert



We didn't suspect that the head was cracked or porous, but a quick pressure test seemed like good insurance. We clamped this plate over the bottom of the head to block the cooling passages. After submerging the head, we pumped compressed air into the head. No bubbles, no leaks.



The new valve guides were oversize (14.1 mm), to compensate for any damage to the holes during guide removal and installation. Ray assured us that if the head was heated before removal and installation, standard diameter guides (14 mm) could be installed. The holes looked fine after guide removal.

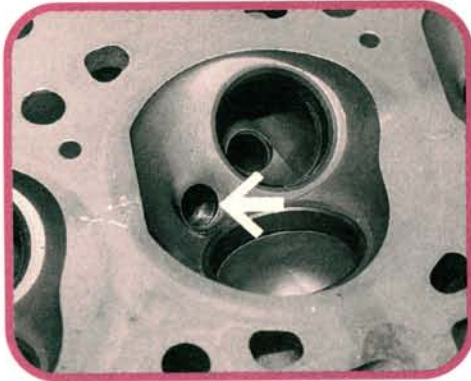


This extra step assures a tight guide fit with minimum damage to the guide holes. Even though the new guides are tapered, a few minutes spent with a file will remove the rough edge at the end of the taper. This keeps the guide from picking up any aluminum and broaching the hole as it is installed.



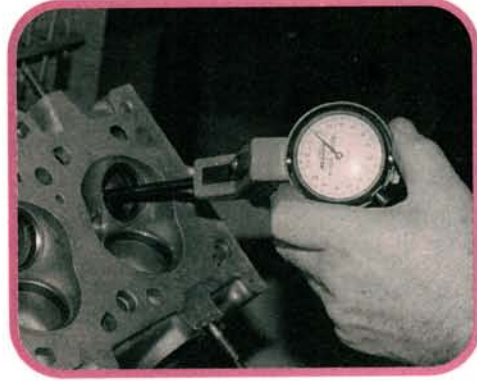
Before installing the new valve guides, chill them in a freezer and reheat the head in an oven. Ray prefers to install the guides by hand - no air tools. This homemade tool installs each guide to the correct height. The tool's recessed head directs the impact to the guide shoulder, preventing mushrooming.

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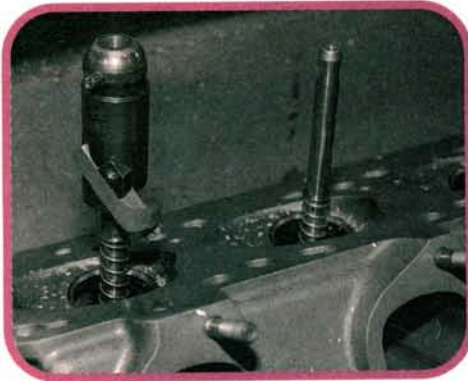
5

Damaged spark plug hole threads had caused the engine to spit out its number two spark plug a while back. The threaded insert that was installed at the time didn't reach the combustion chamber. We removed the insert, prepped the hole, reinstalled the insert, then machined the spark plug seating surface.



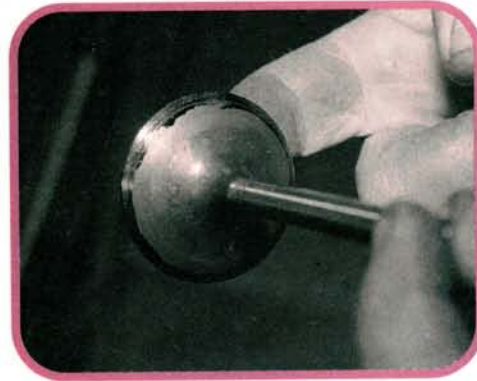
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Careful installation had prevented any damage to the interior diameter of the valve guides. A few strokes with a diamond hone brought the guides to the specified clearance. Using a new valve as a guide, we set up this dedicated inside diameter dial indicator to measure the clearance.



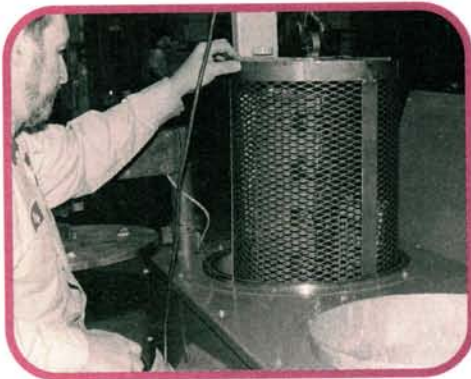
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The job is always easier when you have the right tools. This valve seat refacing tool cuts all three valve angles, adjusts the seat width, and sets the seat height; all at the same time. Very little material was removed. Valve installed height remained within specifications.



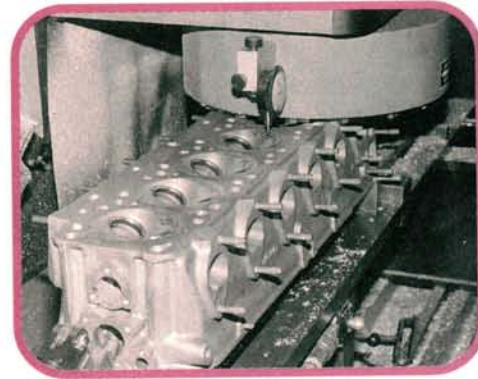
8

After placing a thin coating of machinist's bluing on the face of a new valve, we checked the results of our seat refacing work. The valve is making even contact with the seat. However, to our eyes the valve appeared to be sitting low in the seat. Ray assured us that this is the correct contact point.



9

Baking the head in an oven destroys the factory's original resin coating. Aluminum castings are naturally porous, so it's necessary to reapply the coating to prevent oil or coolant leaks once the head is reinstalled. This machine uses a three-step process to force a special resin into the pores of the aluminum.



10

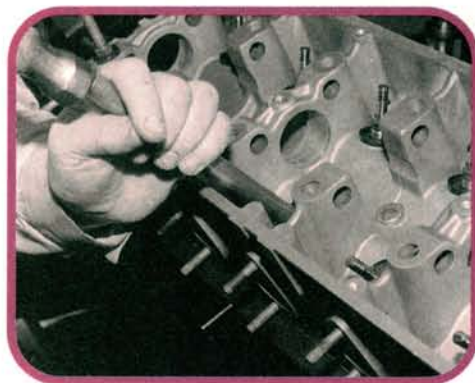
A straight edge revealed that the head was unwarped. Even with a flat head, Ray recommends a very light cut to provide the proper surface finish for the new head gasket. The maximum cut for this head is only 0.4 mm. A 0.3 mm thicker head gasket is available from BMW for use with machined heads.

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After giving the head a final pressure wash to remove the chips, we move to the head assembly bench. Foam rubber and sheet metal plates will hold the valves in position when we flip the head over. No more chasing the head all over the bench. Luxury like this can spoil you in a hurry.



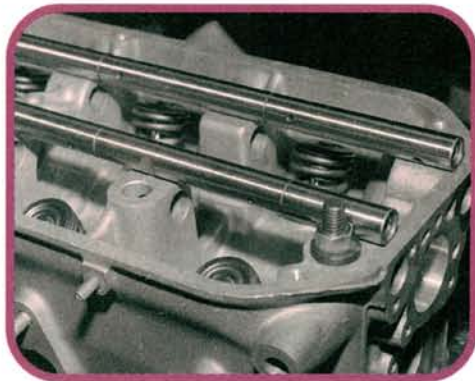
12

We've seen all sorts of inappropriate tools used to install valve seals. Valve seals are fragile, and can be easily torn or pushed out of shape with rough handling. This hollow punch pushes on the outside edge of the seal, assuring positive engagement on the guide shoulder.



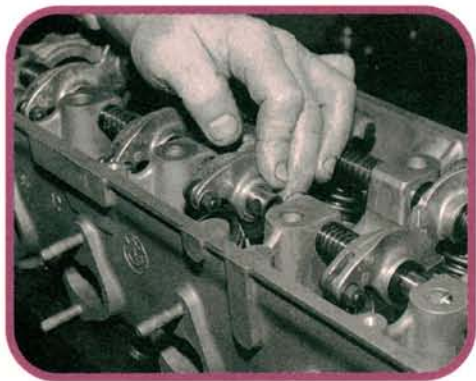
13

We're using all new rocker arms, eccentrics, and hardware. To properly install the eccentrics, place the rocker arm in front of you as shown. The eccentric's adjusting hole should be to the right of the mounting hole as shown. Turn the eccentric up for maximum clearance, then tighten the nut.



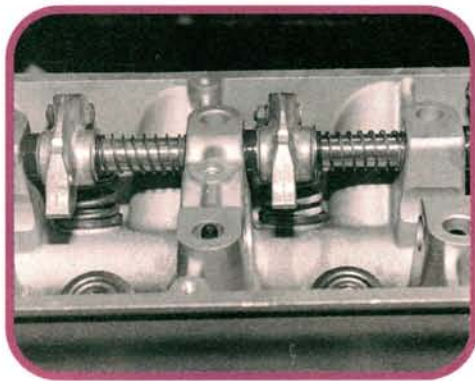
14

All four rocker shafts are different. The following tips will aid proper assembly. Longer shafts go toward the front of the head. The hex end plugs on all shafts must face out. Notches in the shafts line up with the head bolt holes. Lube holes in the rocker shafts line up with the rocker arms.



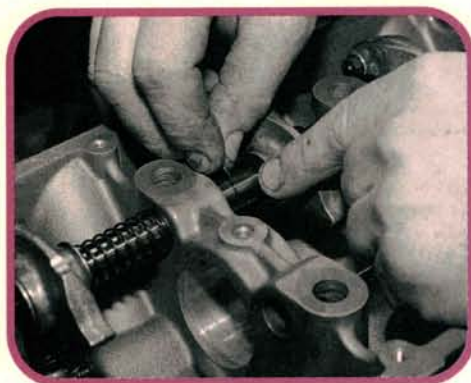
15

We're going to install the rocker arms and rocker shafts before the camshaft. Working from both ends of the head, slide the rocker shafts into position; adding rocker arms, spacer washers, springs, and thrust rings as you go. Hold the assembled shaft with a pin through a head bolt hole.



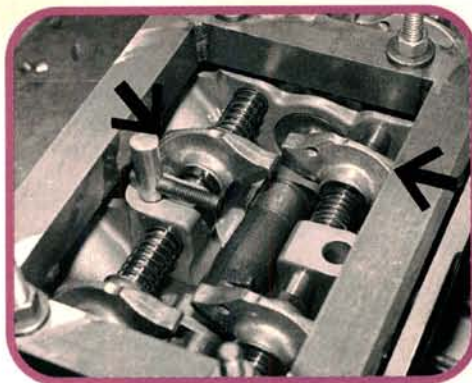
16

All intake valve rocker arm springs push the rockers toward the rear of the head. All exhaust valve rocker arm springs push from the rockers to the front of the head. A washer separates each spring and rocker arm. The thrust ring flanks the other side of the rocker arm. Its recessed side faces out.



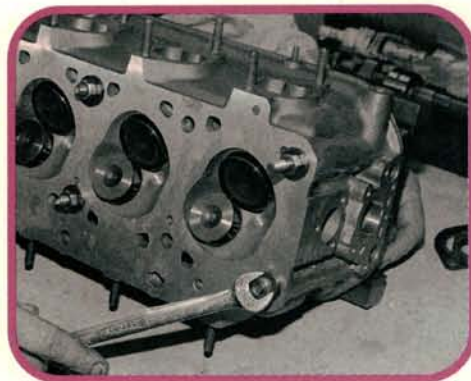
17

The pins keep the rocker shafts from rotating and also keep them from sliding back out of the head during the next step. Push the rocker arms and thrust rings aside, then install the rocker arm retaining ring. The rings wear on the thrust ring side and should be replaced during an overhaul.



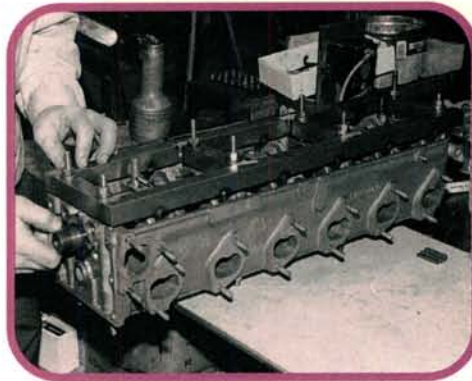
18

Not wanting to pay \$800 for the factory head fixture, Ray constructed his own. The fixture tabs index each of the rocker arms (arrows). By gradually tightening the fixture to the head, we can depress all of the valves, move the rocker arms out of the way, and reinstall the camshaft.



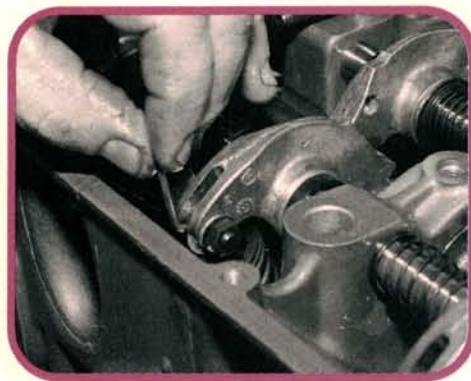
19

It's trickier than it sounds. Begin by gradually tightening the fixture bolts on the exhaust side of the fixture. After the exhaust valves have opened, begin tightening the fixture bolts on the intake side to open the intake valves. Watch for interference between the intake and exhaust valves.



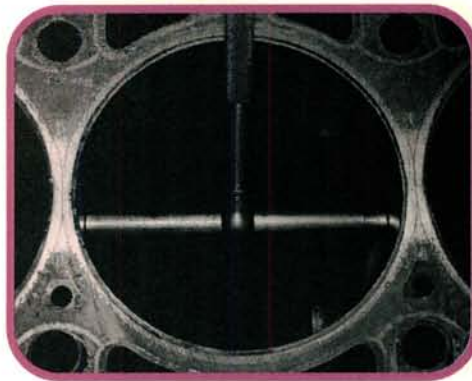
20

After tightening the fixture bolts, there is room to spare under the rocker arms. Slide the cam into position, then gradually loosen the fixture bolts to relieve the spring pressure. Keep your rocker arm locating pins in position until the fixture has been removed. This sure beats the hammer and punch method.



21

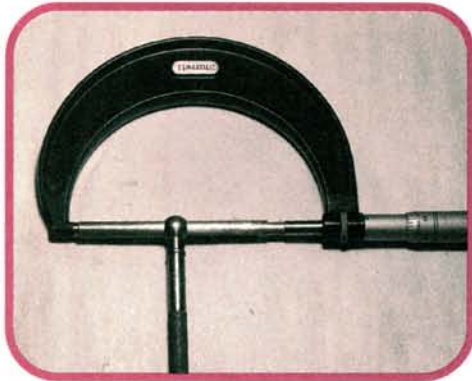
We'll give the valves a preliminary adjustment before we say goodbye to the head. Rotate the cam until both number 1 valves are lapping, then adjust the six valves that are closed to 0.30 mm (0.012 in). Rotate the cam until both number 6 valves are lapping, then adjust the remaining six valves.



22

We didn't have a bore gauge, so we used a telescoping gauge to determine the extent of the cylinder wall wear. We checked at several depths and positions to check for taper, barrel and other cylinder distortions. Piston thrust had caused the greatest wear at 90 degrees to the crankshaft centerline.

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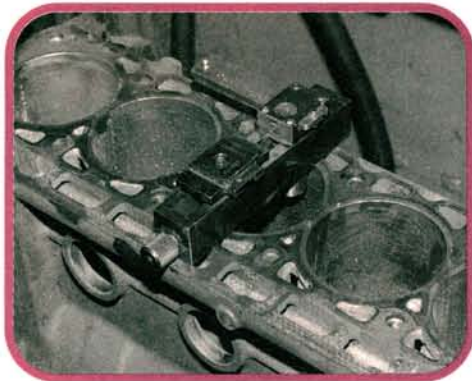
23

We transferred several telescoping gauge readings to an outside micrometer. Measurements ran 92.014-92.024 mm. Maximum out of round and conicity for the 92 mm bores is 0.01 mm (0.004 inch). Our gauge readings indicated that a 0.25 mm oversize bore would clean up our wear problems.



24

The box says these pistons are for a 92.25 mm oversize bore, but Guy at Gable Machine and Engine Shop wasn't taking any chances. Recommended piston-to-cylinder wall clearance is 0.02-0.05 mm (0.0008-0.0020 in). At the prescribed measuring height, our new pistons measure 92.22 mm — just right.



25

Guy double checked our bore measurements while setting up the machinery to hone the cylinders. We're enlarging the cylinder bores a relatively small 0.25 mm (approximately 0.010 inch) beyond their original diameters, so we can skip an appointment with the boring bar.



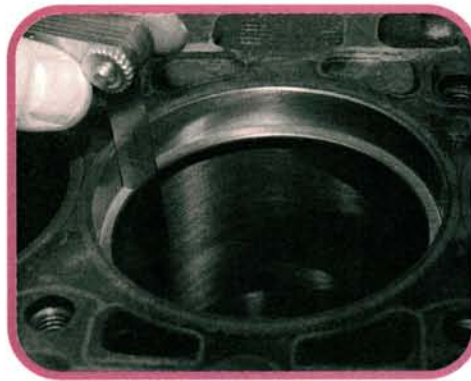
26

The block was honed in a three-step process. Starting with a diamond hone, we took the bores half way to their ultimate size. Progressing to a medium, then a fine hone, the bores were gradually enlarged to their finished dimension. Guy stopped several times along the way to check his progress with the bore gauge.



27

Overlooking this simple task can spell disaster for any aspiring engine builder. After we finished honing the cylinders, we carefully scrubbed the whole block with soap and water. All traces of the cylinder wall grit and hone material must be removed to assure proper ring performance.



28

Check the ring end gap 15 mm from the top of the cylinder, using a feeler gauge. Use an inverted piston to square the ring in the cylinder bore. All three rings have different clearance requirements. They also vary according to engine size, so check a manual for the proper specs.



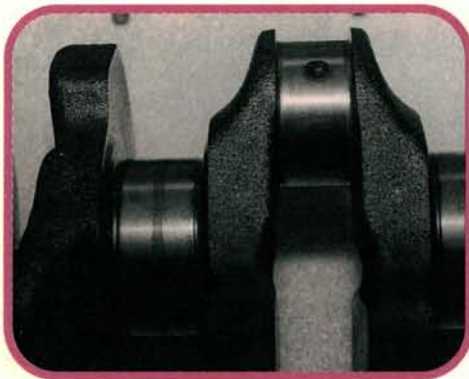
29

As a final bore check, lower a new piston into the freshly honed cylinders to measure piston-to-cylinder bore clearance. Hold the piston steady while inserting a feeler gauge between the piston and cylinder bore. If the bore has been properly honed, nothing bigger than a 0.03 mm feeler gauge should fit.



30

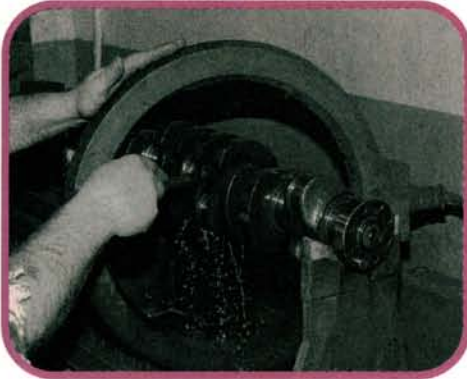
The crank looked relatively clean and undamaged. We used an outside micrometer to measure each of the journals at several different points to check for wear, taper and out-of-round. The rods showed a little wear, but were still in the middle of the recommended specs. The mains were even better.



31

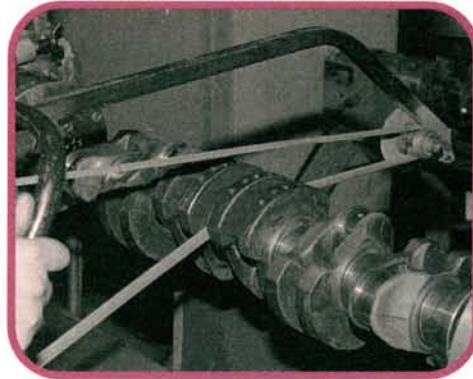
BMW uses a colored paint dot classification system to identify the original dimensions and clearance specifications for their crankshaft main bearing journals. This crank has red dots next to the journals, so we used the red classification chart when selecting bearings and measuring clearances.

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As a safety measure, Dale at Gable Machine magnafluxed the crank. After bathing the crank in a special fluid and magnetizing it with the ring shown here, he checked for cracks using a black light. Cracks usually appear near the connecting rod pins. Our crank received a clean bill of health.



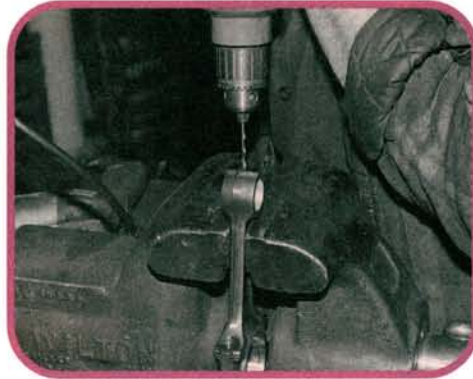
33

BMW doesn't recommend regrinding their crankshafts to repair damaged or undersized journals. As our earlier measurements indicated that the crank was still within acceptable limits, we settled for a simple polishing job. Measurement after polishing indicated we were still within specs.



34

After 200,000 miles of pounding, the big ends of the connecting rods weren't as round as they used to be. This would cause uneven wear and clamping on the new bearings. After removing a small amount of material from the rod caps, we honed the rods until the original inside dimension was reached.



35

We can't forget the little ends. These are full floating pistons, so piston pin bushing clearance is especially important. After driving out the old rod bushings, we pressed new bushings into place. A small oil lube hole must be drilled in the top of the bushing before honing the bushing to size.



36

Guy transferred his new piston pin micrometer measurement to the hone gauge. Even though we had this sophisticated equipment to measure our progress, there's still no substitute for the human touch. When properly honed, the lubricated pin just barely slid through the bushing under its own weight.



37

The crankshaft journals measured good, but we measured the rod and main bearing clearances with Plastigauge™ as a final quality check. Allowable clearances are listed according to the classification system. Our "no classification" rod journals called for a clearance of 0.030-0.070 mm (0.0012-0.0028 inch).