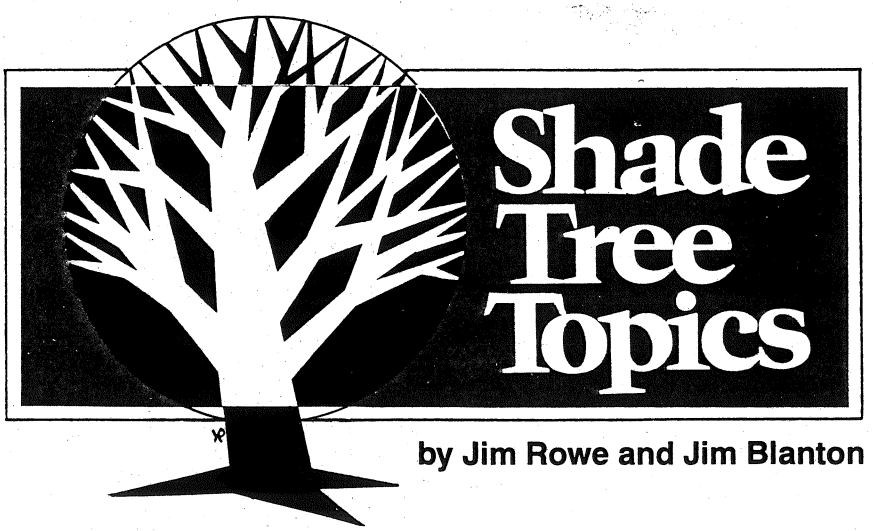


by Jim Rowe and Jim Blanton

Disassembling the BMW Head

Part I

Introduction

Now that winter is here, many of us will put our BMWs into hibernation. We, that like to work on our BMWs, will think about those loose rocker arms and tail pipe smoke or how tired and worn out our engines are. The winter represents the ideal time to take on a major project such as rebuilding a head or engine. This series of articles will tell you how to assemble and fit a BMW engine together correctly. These articles are not intended to be a manual, but rather a complement to a manual. We want to tell you the information that the manuals didn't cover. We will cover the following:

I. Disassembling the BMW head
II. Reconditioning the head
III. Assembling the head
IV. Disassembling the lower unit
V. Reconditioning the lower unit
VI. Assembling the engine

We hope you find this series of articles enlightening.

The Captain

Pre-disassembly to the rocker arms and shafts

To remove the head from your BMW refer to the factory or Haynes manual. Once the intake and exhaust manifolds are removed from the head you are ready to rebuild it. Rebuilding a BMW head is rather difficult until you learn to master the correct way to disassemble and assemble the cylinder head.

Tools needed:

1.) 4 — ½″ bolts, 1½″ to 2″ long
2.) 9/16″ steel rod 3′ long
3.) 2 or 3 lb. hammer
4.) Composite hammer or brass hammer
5.) Valve spring compressor ('C' clamp type)
6.) 10mm combination wrench
7.) 13mm combination wrench

With the head placed, valve cover side down, you will notice that some of the valves will be protruding out from the surface of the head. Take the 4 — ½″ bolts x 1½″ or 2″ long and put them in the head bolt holes on each corner of the head. The function of thes bolts is to keep you from bending the valves while the head sits upright on the work bench. Now, turn the head over and proceed:

1.) Loosen all eccentric cam locking nuts with a 10mm wrench.

2.) Remove the cam sprocket by bending back the lock tabs and removing the 4 bolts using a 10mm wrench.

3.) For 4 cylinders only: Using the same wrench remove the 2-6mm bolts that hold the cam thrust plate and then lower the plate enough to clear the slots in the shafts (do not try to remove it).

4.) Go to the back of the head and remove the distributor housing (on 6 cyl. heads remove the back cover plate). With your 10mm wrench or socket remove all the 6mm bolts (take note that the bolt by the oil pressure sending unit uses a special sealing washer. Make sure this washer is replaced when reassembling the head or you could get a leak at this point.) Using a 13mm wrench or socket, remove the last bolt (8mm) and remove the distributor housing.

Freeing up the rocker arms for disassembly

5.) From this point on you will need to be able to rotate the cam, so, take two of the front cover bolts and screw them in two of the holes (opposite each other) that hold the cam sprocket on to a depth of about of 8mm. Using a large screwdriver or wrench, stick it between and to the base of the bolts (to avoid bending the bolts). This should now allow you to lever the camshaft into any position.

6.) Looking at the cam, notice which rocker arms are not riding on the cam lobes. Slide one of the rocker arms and side retainers, that is not under load. That can be removed against the rocker arm spring. You will now see a "C" clip that you can remove with your fingers or a small screwdriver. After you have removed the "C" clips from all the rocker arms that are not under load, rotate the cam to unload the remaining rocker arms and remove their "C" clips.

7.) You are now ready to remove the rocker arms and shafts. Start with the intake rocker arm assembly first. Rotate the cam so that the first two rocker arms (cyl. #1 & #2) are not under load.

8.) Before driving out the rocker shaft make sure the cam thrust plate is not locked into the rocker shaft. (Remember the thrust plate should be dropped down.)

Driving out the rocker shafts

9.) This is a critical point where skill counts, so listen up. When driving out the rocker shafts, here is the correct technique:

a.) Have someone hold on to the head very tightly, so that it doesn't move, or wedge a 2 foot 2" x 4" the long way between the back of the head and a wall while driving out the shafts.

b.) When using the 2 or 3 lb. hammer to strike the 3' long 9/16" steel rod, use good hard firm blows. Do not use any form of tapping, this will only mushroom the end of the rocker shaft, making it even more difficult to remove.

Remember, steady the head and use good, hard, firm blows.

10.) Starting at the cam sprocket end and using the technique outlined above, drive the rocker arm shaft out far enough to remove the first rocker arm. If you are working on a 6 cylinder head, rotate the cam so that one of the cut-outs in the cam sprocket drive lines up with the rocker shafts on the exhaust side. Turn the cam to the cut-out that puts the rocker arms on the first three cylinders under the least load. If the rocker shafts will not slide out or they hang up on the first rocker arm, then you will have to reverse direction and drive the rocker shafts from the distributor housing side. If this happens, drive the rocker shaft backwards using a composite or brass hammer directly on the rocker shaft until it is flush with the head. If you don't have a composite or brass hammer, then use a vise grips to hold a piece of aluminum or brass on the backside of the rocker shaft to dampen the hammer blows and avoid mushrooming the rocker shaft end. Unload the rocker arms from this direction (#4 & #3 cylinders) and drive the shafts backwards. If you still are having problems, you either need to press the shafts out because the shafts are too tight in the head (rarely the case) or de-burr the end of the rocker shaft that is blunted (usually the case). To de-burr the end of the rocker shaft take a die grinder or drill with a small grinding stone and grind the blunted end of the shaft until it is below the surface of the shaft and you can easily slip a rocker arm over the shaft. If you are having trouble grinding the end of the rocker shaft on the bottom side, then put a rag on the rocker shaft and grab it with a vise grips or a small monkey wrench and rotate the rocker shaft.

11.) After you have driven the rocker shaft back to the point where you can remove the first rocker arm, slide the driving shaft back and remove the retainer, rocker arm, washer, and spring. Now, put the driveshaft back in the rocker shaft holes and drive out the second rocker arm assembly. Then turn the cam shaft to unload the last two rocker arms (#3 & #4) and drive them out.

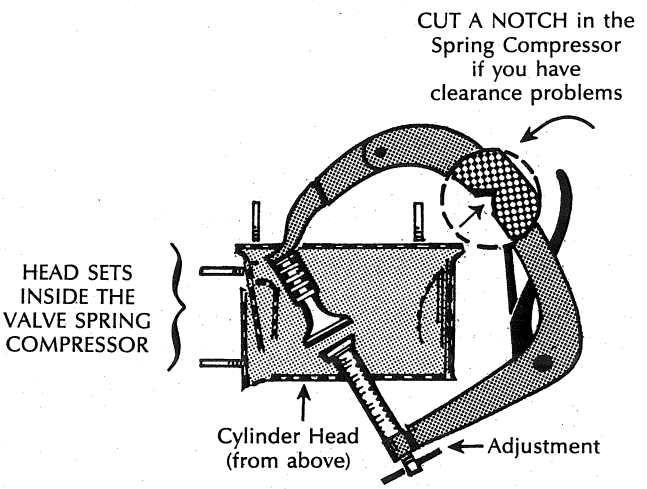
12.) Now, go the exhaust side and drive out the rocker shaft by following steps 10 and 11.

Removing the cam

13.) Slide out the cam and remove the thrust plate. On a 6 cylinder head, using a 10mm wrench remove the 2 bolts that hold on the cam thrust plate and remove the cam.

Removing the valves

14.) Using a valve spring compressor ("C" clamp type), position the head on the intake studs (or exhaust studs) with the combustion chambers facing you. The bulk of the head is sitting on the inside of the "C" clamp. You may need to cut a notch in the valve spring compressor. (See diagram)



Adjust the clamp to where the spring compressor will compress the spring just enough to remove the valve spring keepers. Before compressing spring, however, tap the retainers to initially unseat the keepers. Now, remove all keepers, retainers, valve springs and valves.

15.) Using a screwdriver remove the valve guide seals and valve spring seats.

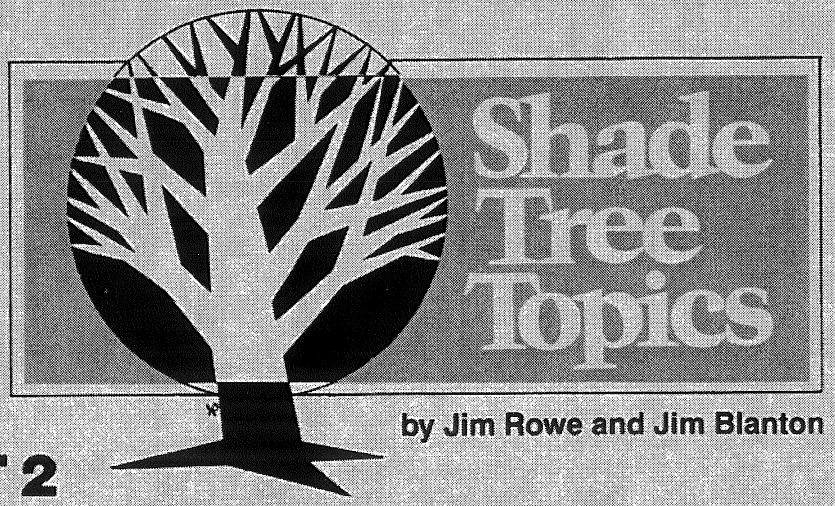
Clean-up

16.) Using a wire wheel, clean the carbon off the valves.

17.) Have the head dunked in carburetor cleaner or have it professionally cleaned. You may want to have the ports glass beaded.

18.) Clean the rocker arm and valve assembly in carburetor cleaner.

This should get you ready for Part II "Reconditioning the head".



by Jim Rowe and Jim Blanton

PART 2
Evaluating the cylinder head and related parts

At this point you should have the cylinder head completely dismantled and ready for inspection. Before discarding parts or whisking them off to the local machine shop it will be to your advantage to determine what specifically needs to be rebuilt and/or replaced and what can legitimately be salvaged for reuse.

CYLINDER HEAD — Checking for Cracks and End-to-End Straightness

Use a sanding block or scraper to clean the bottom surface of deposits and residual head gasket material. You're not trying to resurface the head, so just clean it enough to expose the aluminum, especially around the circumference of the combustion chamber. Now use a penlight and carefully inspect the area between the exhaust valves and the nearest water passage. Sight along the surface and the inner wall of the water passage for hairline fractures concentrating most on the area where the distance from exhaust valve to passage inner wall is shortest.

You are most likely to find cracks on six cylinder heads at the two middle combustion chambers. Occasionally they appear at #2 and #4, but rarely at #1 and #6 chambers. If, however, you are looking at a head manufactured after 1980 the likelihood of head cracks falls dramatically because of the greater amount of aluminum in this same area. Whereas with four-cylinder heads, although the incidents of cracks are low, they are still more likely to occur at the middle chambers. While you are here also check for cracks running between the valve seats and into the spark plug holes.

If you have discovered any cracks you might as well stop right here and make a judgement call concerning the head. On the one hand, a good welding or machine shop can weld and resurface the head, and if done correctly it will be stronger *at that spot,* than when it was new; but on the other hand it costs approximately $75 to $150 per crack. Granted, a new late-style head is expensive, but having a head with three or more cracks repaired wouldn't make sense either. If your head has one or two cracks occuring at one or both of the middle exhaust valve seats have both of them welded even if one has no crack.

In our experience we haven't seen welds crack; instead the crack moves to another cylinder. However, if one or both of your cracks occur at any of the other combustion chambers treat it as a multi-crack head. The rule of thumb is if you must economize, weld at the two middle chambers only, otherwise the odds are still against you. Peace of mind is worth the difference in price.

Those of you that can find no cracks locate a 7/16" Drill Rod (the type used to drive out rocker shafts), a straight edge, rocker shaft or something similar and place it so that it rests over all the combustion chambers directly over the spark plug holes. Now take your feeler gauge and see if your smallest blade (usually .001" or .0015") will slip under the rod in the very middle of the head. Find the blade of the thickness that will just slide under the rod with a slight amount of drag. Now rotate the rod 90

degrees and verify that you have the correct blade. If the gap measures differently you will have to use the average of the two measurements. If even your thinnest blade will not slip under the straight edge your head is either not warped or at least not warped enough to matter. Actually as long as your final measurement does not exceed .003", you can get by without resurfacing the head.

Note: Before having the head resurfaced bolt the cam sprocket cover back on the head to insure a level valve cover gasket sealing surface.

Valves and Valve Guides

With the head still in the upside down position, insert one of the intake valves into one of the intake guides and let it drop onto the seat. Reach under the head and push the valve up off the seat just enough to grab the circumference of the valve head between your thumb and forefinger. Keeping the valve head as close to the seat as possible wiggle it sideways, i.e., perpendicular to its normal line of movement. You should either feel no movement or just enough to be detectable. Intake valve guides are very seldom so worn as to require replacement and for this reason you can usually use their fit as the standard to measure the amount of exhaust guide wear.

Now insert this valve into all the remaining intake guides and test them. They should all feel just about the same, with no significant variations. Should any feel much 'sloppier' than the rest you had better put valve guide replacement on your machinist list.

Now take this same intake valve and test all the exhaust valve guides for wear. The reason for this is that not only valve guides but also valve stems wear. If you have a micrometer you can verify this by calculating the difference between the diameter of the top and bottom of the valve stem. If this difference is .001" or more you need to replace the valve. So, since most of the wear occurs on the exhaust side of the head, you want to use the valve with the least prospect of having a worn stem. As you check the exhaust guides what you will probably discover is that there is a significantly greater side-to-side movement of the valve head, and if this is so, replace all of the exhaust guides even if you find some that seem to be all right.

Although determining worn valve stems is strictly empirical (as long as you have a micrometer), deciding whether or not your guides need replacing is more subjective. If the head has 100,000 miles or more, we suggest that you strongly consider replacing the exhaust valves and valve guides. Therefore if you have doubts either have the machinist decide or rest easier and replace them all (the cost is minimal).

Rocker Arms and Shafts

BMWs are notorious for upper valve train noise caused by worn rocker arms and shafts, especially on the exhaust side of the head (as you might expect), because this is one of the last places in the engine to receive oil. Lugging the engine as an automatic transmission tends to do can wear out a valve train as early as 40,000 miles. Every time you pull the valve cover to adjust the valves you can moniter the amount of wear by looking at the position of the adjusting hole in the eccentric adjusting cam. On a new head the hole will almost be pointing straight upward. But as mileage increases, every adjustment moves the hole around until it will finally disappear from sight.

Eventually you won't be able to set the valve to the correct clearance and then valve train noise will really rear its ugly head!

Now, in our opinion, the unforgivable sin of a rebuilder is a new engine with valve train noise and for this reason alone it is worth replacing all the shafts and all the rocker arms. However for those of you that must necessarily economize we suggest replacing the exhaust shaft(s) and rocker arms, reusing the intake shaft(s) (if and only if there is no evidence of scoring where the rocker arms ride) and using the best of the original rocker arms for the intake side. If your rocker arms are clean you can determine which ones are best by sighting along the bottom of the bronze bushing. The ones that are definitely not reusable will look shiny and somewhat rough, whereas the best ones will have a dull and smooth finish all around the inside. After you have picked your 'good' ones slide them onto one of your old shafts (make sure both shaft and rocker arm are clean and dry). Position each one in turn on a part of the shaft that the rocker arm does not normally ride and try to wiggle it sideways or perpendicular to the way it usually rocks. If you feel *any* play at all you will have an abnormal amount of valve noise even if you use new shafts! However if there still seems to be a good fit you might get lucky.

Miscellaneous

Valve springs — if you are well over the 100,000 mile mark, intend to switch to a more radical camshaft and/or anticipate lots of high revving we recommend replacing them.

Teflon valve guide seals — If you have the option request these. To install perfect Teflon Valve Guide Seals you'll need 9010 valve guide seals and cutting tool VST-9010. They offer a better fit with less friction and are more resistant to the gradual brittleness caused by the heat.

General condition — Inspect for stripped threads, broken or missing studs, etc.

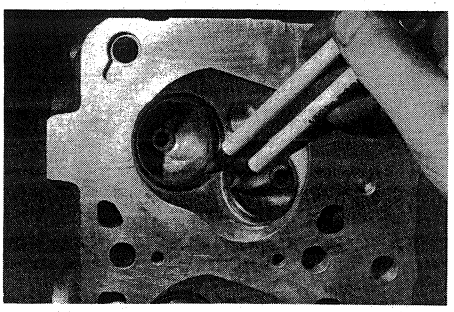
Inventory — While the head is at the machine shop gather all your new and reusable parts so you will not be waiting on ordered parts come reassembly time.

Shade Tree Topics

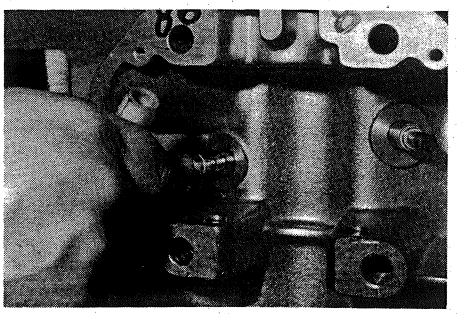
by Jim Rowe and Jim Blanton

ENGINE REBUILDING Part III Assembling The Cylinder Head

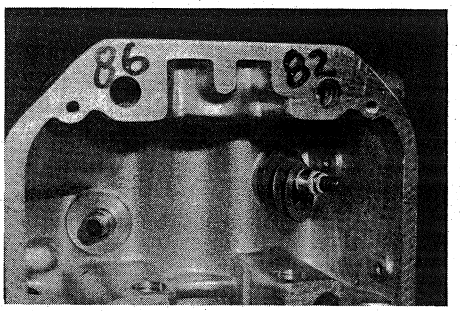
Now we should be ready to assemble this assortment of new, reworked and shiny clean used pieces into one working whole. Gather everything, sort and take a quick inventory to verify that *all* your parts are present so you won't have to be detained. Before we begin, on top of everything else that wil be required of you, you owe it to yourself the *Mechanic's Imperative: **Don't Assume, Verify For Yourself!*** Since your main goal is the best performance and longevity possible, anything that is overlooked that might compromise this end — like improperly ground valve seats, incorrectly installed valve guide seals or misfit rocker arms — is as much your fault as that of the machinist or manufacturer. If in doubt about any of the parts or procedures, check other reliable sources until you're reasonably satisfied. Enough of this, let's get started!



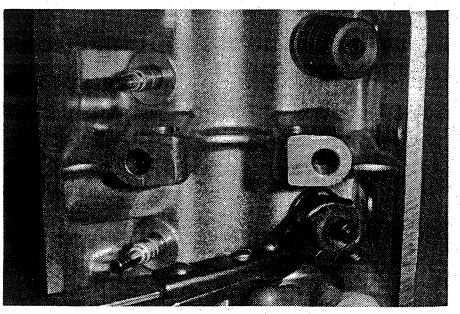
1. Examine 45 degree cut on valve seats Intake width between 1½mm and 2mm exhaust width between 2mm and 3mm. *Note: widths that are too narrow offer insufficient surface area for proper cooling of the valve, and if too wide reduce seat pressure enough to cause carbon spots on the valve face and seat and premature cylinder pressure loss (burnt valves).* ■ Measure 45 degree cut outer diameter. Both intake and exhaust should be about ½mm *smaller* than the diameter of the corresponding valve head. ■ Dip tips of valves into light grease or assembly lube and insert into head (double-check valve guide to stem fit).



2. Install valve guide seals (if larger than hole in valve spring seat, install seat first-older style valve seals). ■ Locate installation tool (12mm-14mm deep socket, ½" plastic tee). ■ Hold valve in position with one hand, use other to press seal over valve tip (using a circular motion) and onto guide (straight down until it seats). ■ Should have snug fit on stem offering some resistance and tight fit on guide (spring band on seal should visibly expand)

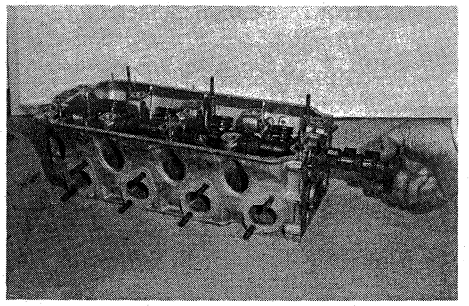


3. Install valve spring seat if not already in position. ■ Fit additional spacers (to effectively stiffen springs) if desired. ■ Position valve spring and spring retainer.

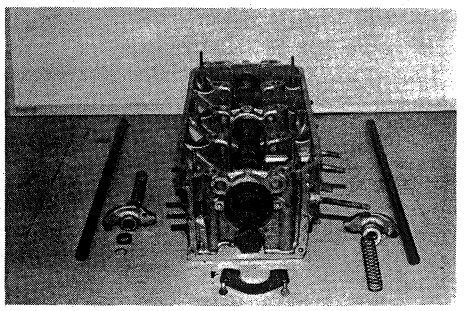


4. Use spring compressor to collapse spring enough to insert both valve keepers. *Note: At this point, install the spark plugs, place the head upside down and fill the combustion chambers with water. Do a 5 minute leak test. Dry ports? — good; a few drops? — OK; puddles on the bench? — not acceptable, recheck assembly and machine work. After testing dump water; dry head, and lightly spray with lubricant to prevent rust formation.*

FOUR CYLINDER HEADS

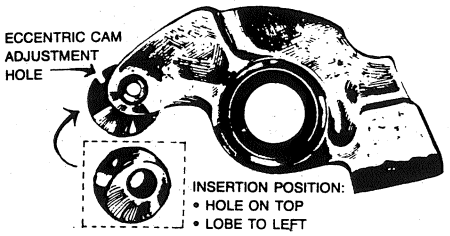


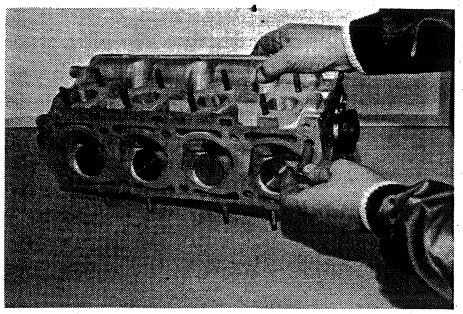
5. Lube cam lobes and journals and install camshaft. ■ Rotate by hand to check for binding.



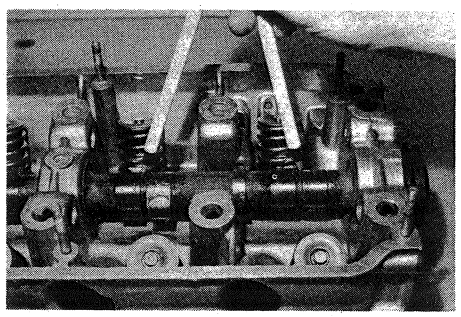
6. Gather rocker arm assembly pieces: ■ Rocker shafts (2). ■ Rocker arms (8) *Note: make sure that valve clearance eccentric cams are correctly bolted to rocker arms, with the adjusting hole straight 'up', the bulk of the eccentric should project beyond the outer edge of the rocker (see drawing).* ■ Shaft springs (8). ■ Washers (8). ■ Retainers (8). ■ 'C' clips (8). ■ Cam retaining plate and mount bolts (2)

Illustration: Mary Rowe

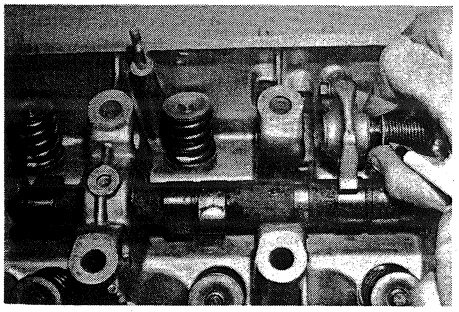




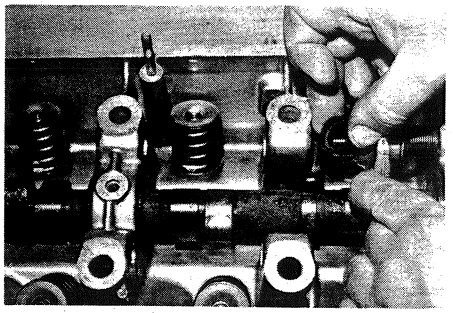
7. Insert ½" x 2' bolts (4) into head bolt holes to protect valve heads during assembly.



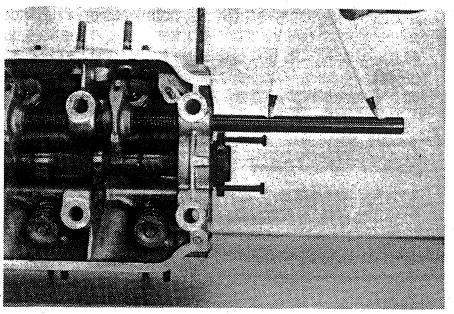
8. Rotate cam until #1 and #2 intake lobes are pointing toward head, i.e., as if intake valves were in closed position.



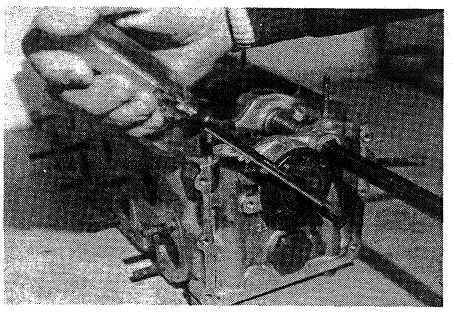
9. Choose the intake rocker arm shaft (11 33 0 634 100) and place it on the head just above its installed position. Verify that (1) the slot for the cam retainer plate is at the front end of the head and in the aligned positon, (2) the slots for the head bolts match the bolt holes and (3) the rocker arm oil holes point directly at the centers of the cam lobe and valve stem. *Note: Before lubing shafts and rocker arms, while still 'dry', slide each rocker in turn onto the shaft and test for the proper fit. There absolutely can be no discernable 'play' perpendicular to the shaft. If there is any movement other than rotational valve train noise is guaranteed.* ■ Insert back end of shaft into front intake hole about halfway to next support hole, use composite (plastic lead filled hammer) or plastic mallet if necessary. ■ Slip spring, washer and rocker arm onto shaft.



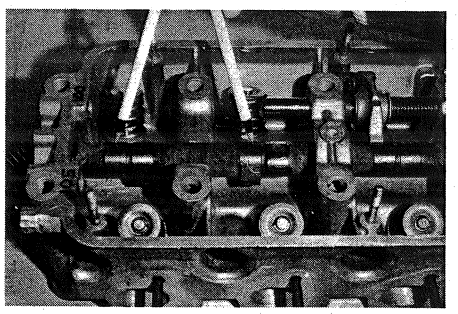
10. Insert shaft further, collapse spring by pressing on rocker arm, then install retainer with flat side toward rocker or grooved side away. ■ Before releasing spring tension, tap shaft through next support, halfway into #2 valve section. ■ Install spring, washer, rocker and retainer and push shaft into #3 section.



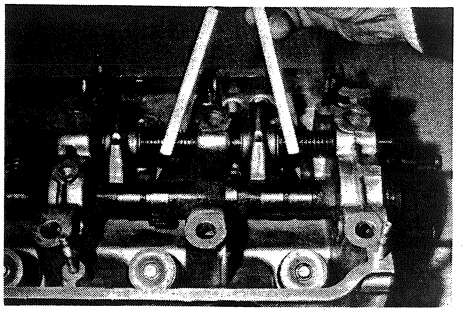
11. Check alignment of head bolt slots, realign if necessary.



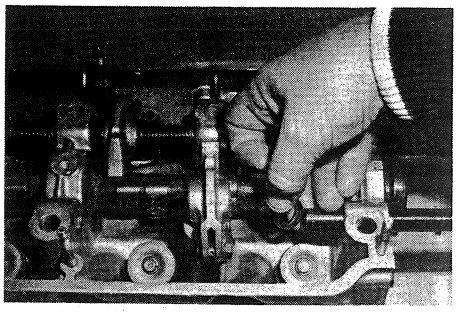
12. Insert two 6mm bolts opposite each other into the cam sprocket drive flange.
■ Use large screwdriver against bolts to rotate cam.



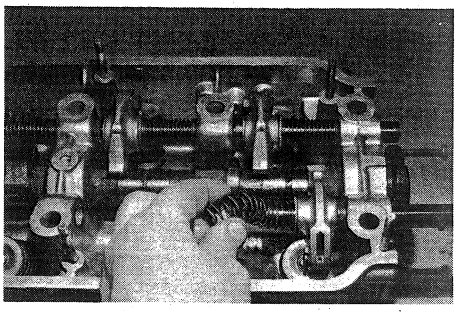
13. Position cam so that #3 and #4 intake lobes are pointing down toward the head (closed valve position).
■ Install #3 and #4 assemblies and tap shaft into but not through the last support.



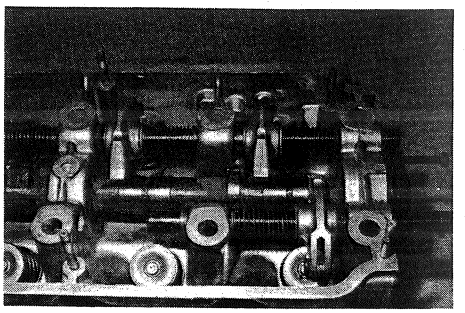
14. Rotate cam to position #1 and #2 exhaust lobes in the downward or valve closed position.



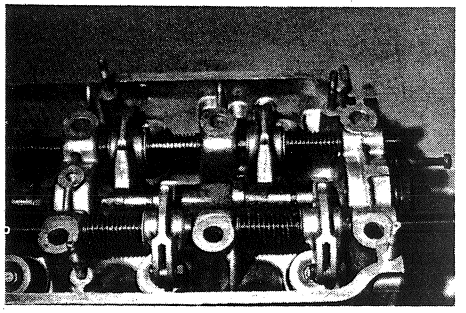
15. Insert remaining shaft, end opposite retainer plate notch, halfway into first support hole.
■ Slide retainer washer (slotted side toward the front) onto shaft.



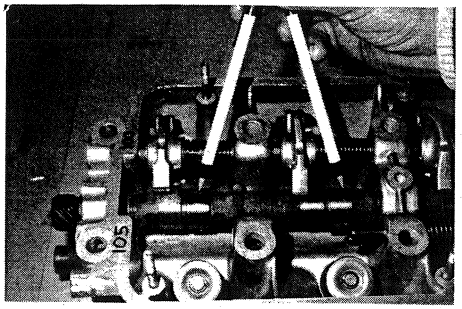
16. Next come the rocker arm, washer and spring.
■ Hold spring collapsed until shaft meets next support.



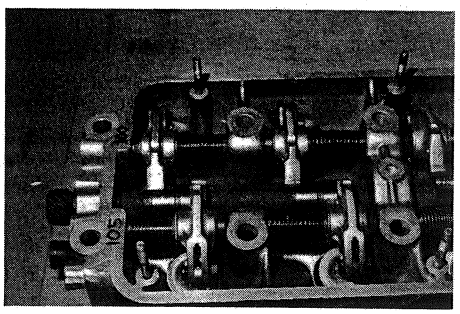
17. Push shaft into next section.
■ Start again with retainer (flat side toward rocker arm).



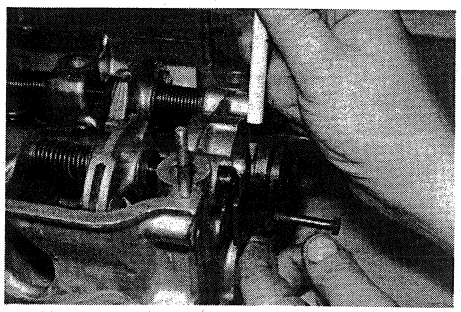
18. Complete section with rocker arm, washer and spring.
■ Tap shaft into next section.



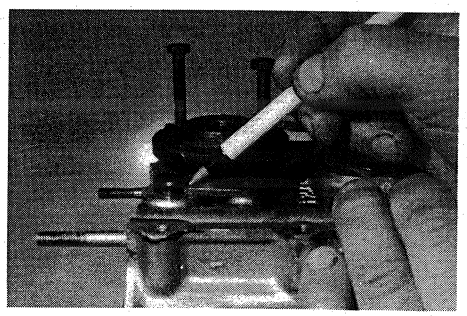
19. Rotate cam to locate #3 and #4 exhaust lobes "down".



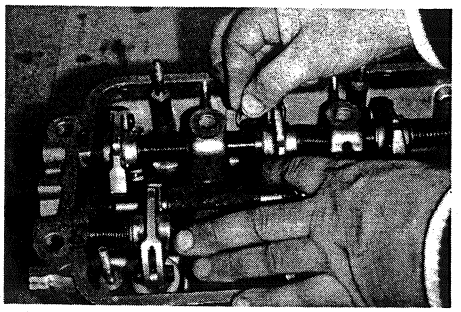
20. Assemble section #3 in the same order.
■ Check alignment of head bolt slots in shaft (picture 11). ■ Assemble last section, but only start shaft into last support.



21. Pull forward on camshaft approximately 10mm from the bottom, slip cam retainer plate into groove behind drive flange.



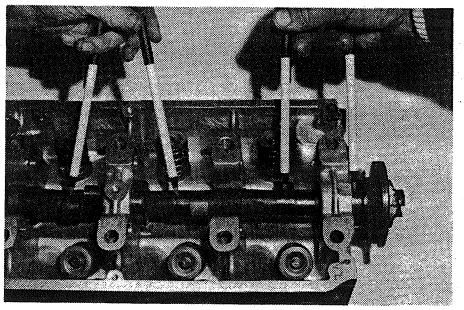
22. Push camshaft back into head until plate meets head
■ Tap on rocker shafts until plate edges slip into anchor slots. ■ Bolt plate to head, when holes are aligned, with 6mm bolts.



23. Pull on rocker arms, that are free to move, to collapse spring
■ Slide retainer to rocker arm. ■ Insert "C" clip. ■ Release spring tension allowing retainer to cover clip. ■ Verify position of rocker arm adjuster as *just off center of* valve stem tip. ■ Rotate cam as necessary to install all "c" clips. ■ Position camshaft on TDC #1, both lobes on #1 cylinder pointing down (line on cam sprocket flange in line with nub on top of head). ■ Bolt distributor housing to head using new gasket and sealant (use special sealing washer on bolt next to oil pressure switch to discourage leakage).

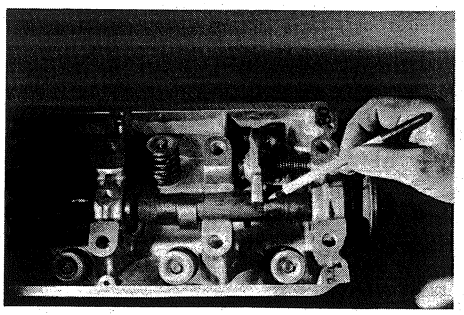
SIX CYLINDER HEADS

(Same procedures as four cylinders with the following exceptions and/or additions)

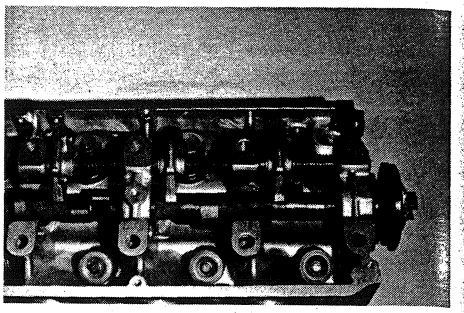


STOCK CAMSHAFT

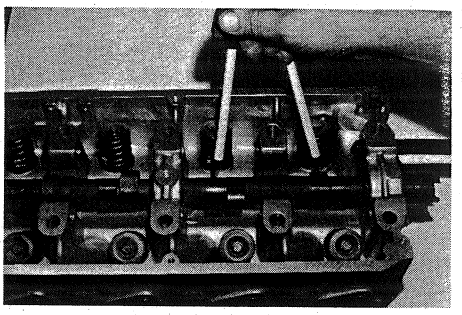
24. Assemble valves and perform water leakage test
■ Insert lubed camshaft leaving slight gap between flange and head, positioning as shown. ■ Choose appropriate shaft. ■ Front intake 11 33 1 250 080. ■ Rear intake 11 33 1 250 082. ■ Front exhaust 11 33 1 250 084. ■ Rear exhaust 11 33 1 250 086. ■ Before inserting, verify that (1) slots for head bolts match holes in head, (2) oil supply holes for rocker arms point directly to centers of cam lobes and valve stems and (3) plugged ends of shafts are to the ends of the head.



25. Rotate cam until slot in flange aligns with shaft hole.
(Use slot with cam lobes least in the way) ■ Insert shaft and slide first assembly in position.

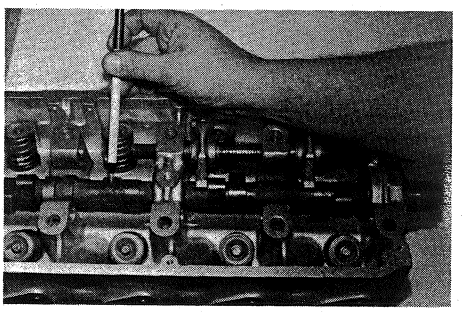


26. Continue assembly of #2 and #3 sections
■ Note that because of the cam position, rockers ride off the lobes easing installation. ■ Continue until all four shafts are installed with head bolt slots and holes perfectly aligned. ■ Rotate cam until slots in drive flange allow bolting of retaining plate with 6mm bolts.

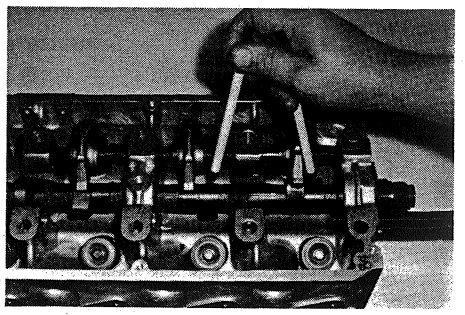


REPLACEMENT CAMSHAFTS

27. With cam sprocket drive removed, position just #1 and #2 lobes as shown.
■ Install the first two sections rocker assemblies.

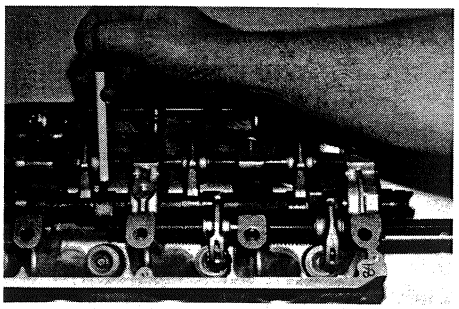


28. With large screwdriver blade in distributor drive slot (front end of camshaft), gently rotate #3 lobe to position shown.
■ Note that #1 and #2 rockers are riding off their lobes.



29. Now rotate cam until #1 and #2 exhaust lobes are as shown.

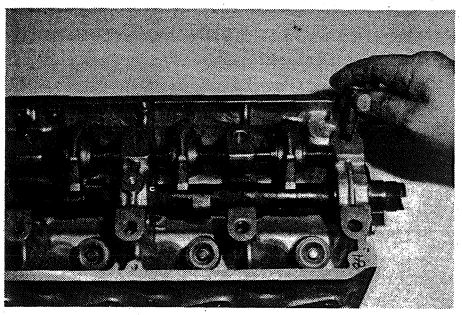
NEXT MONTH: Disassembly of the lower end.



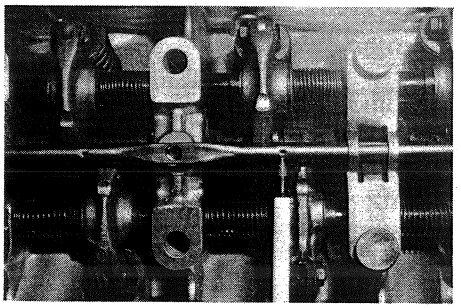
30. Insert proper shaft and install assemblies for sections 1 & 2.
■ Rotate cam until #3 lobe is as shown. ■ Finish assembly of section 3. ■ Assemble both rear shafts and their sections.

ALL CAMSHAFTS

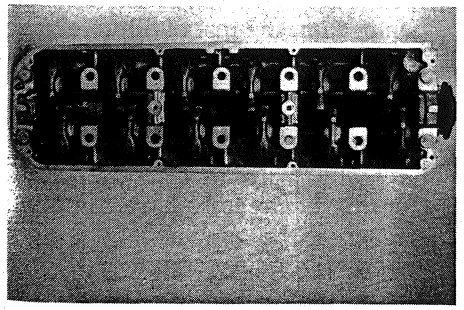
■ Finally, rotate cam to TDC #1, with both lobes 'down'.
■ Remount rear cover plate using new gasket and sealant.



31. When all head bolt slots align with all bolt holes, insert one bolt for each of four shafts to anchor shafts.
■ Bolt cam in position at retaining plate with 6mm bolts. ■ Reinstall sprocket drive flange, lock washer and nut. ■ Then install all "c" clips, rotating camshaft as necessary.



32. Place oil sprayer bar into position, then turn upside down to:
■ Insure that oil holes locate between the intake and exhaust lobes for each cylinder (If the oil sprayer bar is installed incorrectly, only the intake cam lobes will receive oil). ■ Invert bar and bolt to head, noting special "banjo" bolts (with 12mm heads) and sealing washers (aluminum or copper) for above and below the bar.



33. Fully assembled head.

CAUTION: For those of you who are stopping here, important Head to Block assembly info and related procedures will be covered in the JUNE '87 article.

Shade Tree Topics

by Jim Rowe and Jim Blanton

ENGINE BLOCK DISASSEMBLY EVALUATION PREPARATION

Engine Block [Lower End] Disassembly

The strength and endurance of your engine is centered in the lower unit. Accessories and even cylinder heads come and go during 100,000 mile intervals, but the block, if rebuilt and maintained correctly, will persevere.

As you dismantle, its relatively straightforward design might fool you into taking the block's simplicity for granted and thereby overlooking that which is more important than the simple separation of pieces, namely, recognizing the engine's *Assembly Code.* This code is so fundamentally crucial that anything short of strict abidance will result in disaster. It is as follows:

ASSEMBLY CODE

- Main bearing saddles have one and only one correctly fitted bearing cap, each matched pair mating "locks-to-locks" ie. (bearing lock tabs are on the same side).
- Connecting rods likewise have one and only one correctly fitted rod cap, each matched pair mating "locks-away from-locks" ie. (bearing locks tabs are 180° apart.)
- Connecting rods are fitted such that the oil hole in the small end of the rod points toward the front of the block.
- The arrow on the top of the piston points toward the front of the block

Keeping these points in mind, let's begin by positioning the block upside-down. If you are on a flat surface instead of an engine stand, the front of the block will have to hang over the edge to avoid damaging the protruding timing chain guide

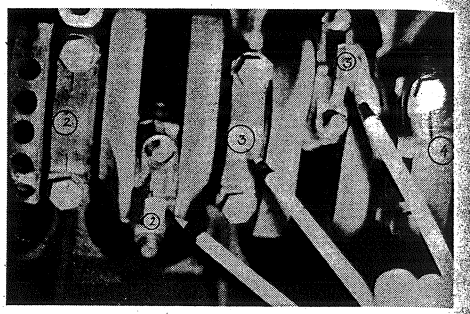
Oil Pan Remove pan bolts. Make sure none are hiding under the usual accumulation of dirt and grease. Note all missing, broken, stripped or otherwise unusable ones.
(6 cyl.) Unbolt power steering pump bracket from crankcase and pan.
(All) Drive something similar to a putty knife through the gasket at each corner of the pan to break what is oftentimes a very firm bond. Some coaxing with the dead blow hammer might be useful.

Rear Seal
Flange Remove both 6mm and 8mm bolts and tap on inside edge to slip it off the two alignment pins. Note relative position of the seal with respect to the flange lip.
Front Pulley Before removing, note any adjusting/mounting bracket(s) that will have to be in place *before* the pulley is reinstalled. Remove nut and warpy washer. This nut may take up to 200 ft. lbs. of torque on a 4 cylinder & up to 300 ft. lbs. on a 6 cylinder to break loose. Then wiggle the pulley back and forth to test for any looseness in the machined fit. It should require the use of a puller or at least some tapping with your composite hammer. Six cylinder engines use a harmonic balancer and need to be removed by using a special puller that uses two 8 mm bolts (approx. 80-100 mm long) that screw into the holes just off center of the harmonic balancer. (A harmonic balancer is an inner and outer pulley bonded together by rubber and is built this way to dampen out engine vibration from the crankshaft.) *Caution: do not use any removal method which might distort the pulley.*

Water Pump
(4 cyl) These bolts are the most likely to be corroded and are therefore the weakest. Work them back and forth and/or apply some heat from the torch while removing gingerly. We suggest replacing the 6mm ones and wire brushing the rest. Keep track of especially long 8mm bolts used to mount wrap-around a/c bracket.
(6 cyl) First remove engine "lift" bracket [6mm bolt is the longest of its size on the engine]. Again, the pump bolts will probably be corroded and should be replaced [except for the two studs].

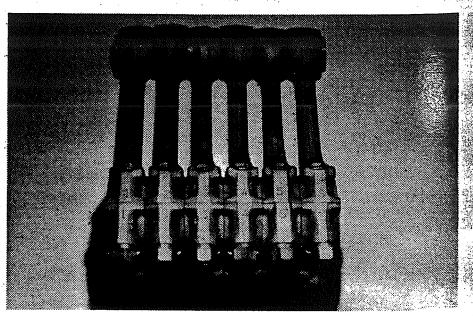
Front Cover Remove all 6mm and 8mm bolts then pry from the back until you've worked it off its alignment pins. Before it comes completely off, notice that the little arm at the top of the chain tensioner guide rail sits in the small oil cavity formed by the front cover casting and the block. Again, note relative position of the pulley seal [either flush with the front lip or against the seal stop on the back side of the cover.]

Timing Chain.
Tensioner & Guide Rails Remove and discard old chain [money well spent). Pry off "E" clips [3 — two of one size, one larger] and save in a safe place. Guide rail can be reused but replace tensioner rail if rubber is cracked, separating or badly grooved [more than .5mm].
Oil Pump Sprocket & Chain Loosen three 6mm bolts and slide sprocket off the shaft. Discard the pump chain as well and inspect crank sprocket for chipped or otherwise misshapen teeth.
Oil Pump
(4 cyl) Remove two 6mm bolts at rear pump support from the main bearing cap and safely store lock tab [pre-'77]. Unbolt front 8mm bolts and pry pump off of alignment pins. Don't misplace "O" ring for external oil return line or any shims underneath the pump.
(6 cyl) Remove two 6mm bolts at rear pump support from the main bearing cap and safely store lock tab [if any]. Unbolt remaining three 8mm bolts and pry pump off of alignment pins. Look for shims underneath the front bolts [long one] and matching shim [short one] under third bolt.



1. Before continuing, look for stamped numbers on the centers of the main bearing caps. Although difficult to read, all but the center [thrust] and "last" [rear] caps are numbered. The rod caps are numbered on one or the other of the sides where the bearing splits [through '74 only]. Later model rods have U distinguishing marks. *CAUTION:* IT IS IMPERATIVE THAT THE MAIN AND ROD CAPS ARE NUMBERED. IF THEY ARE NOT, OR IT IS UNCLEAR, YOU MUST NUMBER THEM WITH A NUMBER PUNCH SET OR CENTERPUNCH, [AS SHOWN].

Piston/Connecting Rod Remove all the nuts on all of the connecting rods. Now position the block on its side and rotate the crankshaft until one pair of pistons is at the bottom of its stroke. Use the dead blow hammer to tap alternately on the ends of one piston's rod bolts. When the rod and cap have separated, slip the cap off the bolts carefully noting on which side of the cap the bearing lock appears. Now look at the rod and locate its bearing lock. THE ROD BEARING LOCKS SHOULD BE 180 DEGREES APART. Before removing the rod and piston, note the relative position of the rod. THE VISIBLE OILING HOLE IN THE SMALL END OF THE ROD POINTS TOWARD THE FRONT OF THE ENGINE. Now tap the rod and piston completely out of the cylinder, pry the bearing shells from both halves and mate the cap back to the rod — LOCKS AWAY FROM LOCKS.



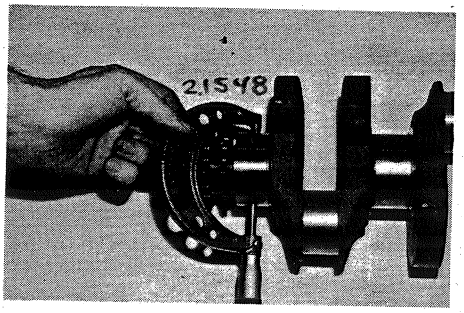
2. Before removing any other pistons, use your number punch to mark one side of the big end of the rod. Stamp both the rod and its cap with the number of the cylinder [numbered from the front of the engine]. Repeat this procedure for all the rods of the engine.

Main Bearing Caps/Crankshaft Now remove all the bolts securing the main bearing caps. Assured that they are legibly numbered, use a large pair of adjustable pliers and wiggle the caps back and forth until they dislodge. *Note that the main bearing locks of the cap and saddle are facing each other [locks to locks].* The final step in disassembly involves simply lifting the crankshaft out of the block.

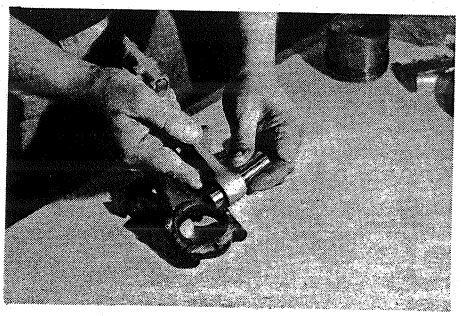
EVALUATION OF PARTS

Next we need to evaluate all these assorted pieces to determine what machining needs to be done. Whether you are going to perform the work yourself or rely on the local machine shop, the end result will depend on your judgement as to which of your "as is" *and* machined parts meet factory specifications. You are going to need the factory specs for your engine [from the BMW or Haynes manuals] and the following tools:

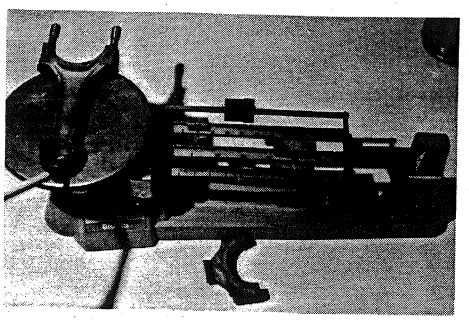
■ Set of micrometers ■ Set of snap gauges ■ Scale-accurate to one tenth of a gram ■ Feeler gauges ■ Precision Hone ■ Ball Hone ■ Die grinder



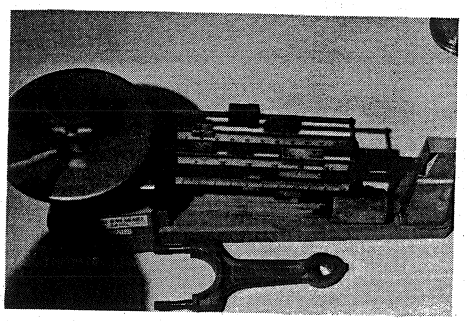
3. Measure the size of one of the main bearing journals, then lock the micrometer on this reading and rotate the micrometer 90 degrees and measure it again. The two readings should be identical (the micrometer should "drag" the same). If they are not you need not measure the remaining ones, for the journal is out of round and will have to be ground. However if they are alike compare the measurement you have obtained with your specs (wear tolerances ar provided). *The example shown is that of a crankshaft ground to .010 undersize.* Repeat this procedure for all the main and rod journals. If any one of the two groups is not within specs, or there are journal surface imperfections the crank had better go into the machine shop pile. If all is well to this point, there is one more measurement to check. Place both halves of the new center main bearing — the one with the thrust surfaces on both sides — around the center main journal. Slide them both to one side of the journal and slip a feeler gauge between the bearing and the other side. Find the blade that will just fit with the slightest amount of drag and compare this measurement with the specs. As a rule if there is more than a .006″ gap, your machinist will have to repair this as well. Everything still within specs? Just for fun, suspend the crank in the air and tap it with a metal hammer. There should be a sustained "ring" with lots of overtones like a triangle. If you hear an abrupt "clank" or "thump", you could have fractures.



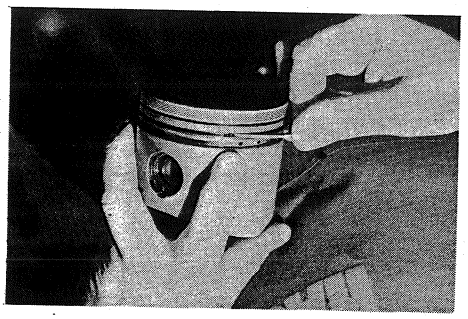
4. If you haven't already, separate the pistons from the connecting rods by removing the circlip on one end of the pin and tapping the wrist pin completely out of the piston. Use some solvent to clean and dry the small end bushing of all the rods and one wrist pin. One by one slip the pin into each rod and wiggle the pin from side to side to feel for any movement at all. A clearance of .0004″ (yes that's ten-thousandths) is easily felt and usually .0003″ can be as well although it is very slight. Ideally the fit should be .0002″, which can't be felt by wiggling, should your wrist pin bushings feel sloppy. BMW will not have these bushings but VW Bug ones are close enough for your machinist.



5. Separate the caps from the rods — if and only if they have been properly numbered — and record the weight of each. Weigh the *lightest* rod again and remove it but leave the scale set to its weight. Now grind on the "nub" of each of the remaining rods [where the pen is pointing] until all weigh within one gram of the lightest. Usually the Factory has them within 5 to 10 grams of the lightest, so it shouldn't require a great deal of grinding.

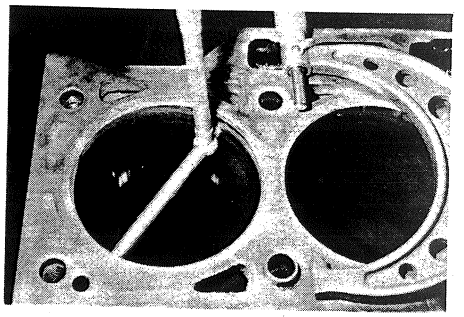


6. Repeat the above procedure for the rod caps and if necessary grind on its bottom "nub".

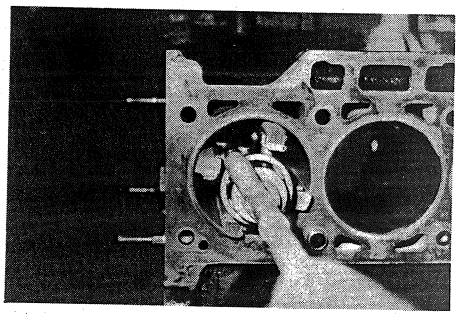


7. Remove the old rings from your pistons and use them to scrape the carbon buildup out of the ring lands. Avoid removing any aluminum in the process. Most of the wear occurs at the top ring land so install a *new* top ring and use your feeler gauges to determine the clearance left between the top of the ring and top of the ring land. If your measurements are greater than the factory tolerances plus .001″, you would be wise to replace the pistons.

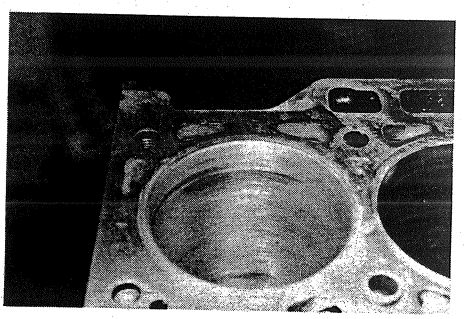
8. If the ring lands are acceptable, weigh each of the pistons to locate the lightest one. Set the scale on this weight and use the die grinder to remove sufficient metal to match the weight of the lightest piston to the nearest tenth of a gram. Grind on the lip along the inside circumference of the piston (where pen is pointing).



9. Clean the oil and carbon from the cylinders and the top edge of the bore for a ridge. As a rule German castings don't wear so much as to leave a ridge, but if your finger nail catches on one you should consider boring to fit oversized pistons (especially if your pistons are borderline or not reusable anyway). With the appropriate size micrometer, measure the diameter of each piston from one side of the skirt to the other at a point about halfway between the bottom of the wrist pin hole and the bottom edge of the skirt. Then, using a snap gauge, measure each of the cylinders at approximately the same point you measured the piston diameter if the piston was at the top of its stroke. The difference in these two measurements represents the piston-to-cylinder clearance and should not exceed .003″. If it does have the block bored for oversized pistons.

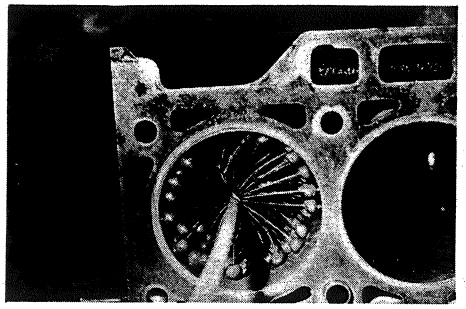


10. The maximum acceptable piston/cylinder clearance is .004″. Admittedly this is precious little to work with since new engine clearance is .0015″ and honing usually removes an additional .001″. However quite frequently high mileage, well maintained engines can fall within these tolerances after they have been rehoned. If yours is one of these, use the precision hone to initially resurface the cylinder walls.



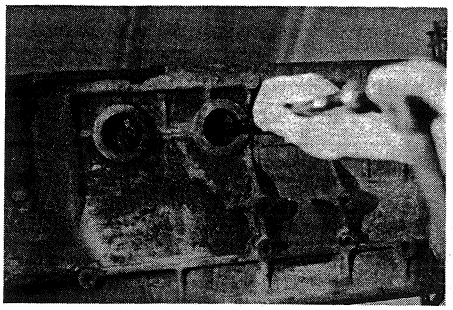
11. The first few passes will dress most of the cylinder wall with exception of the typical low spots at the top and (frequently) the bottom of the piston rings' travel. It is not necessary to completely remove thes low spots, but only to prevent them from totally encircling the cylinder (as shown). Also ideal cross-hatching at between 45 and 60 degrees from horizontal.

Continued

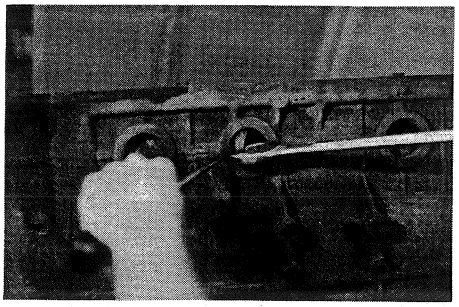


12. Next use the ball hone briefly just to "soften" the rougher texture left by the precision hone. When finished, once again measure the cylinder wall bore and verify that it is no more than .004" larger than the diameter of the piston.

ADDITIONAL PREPARATION

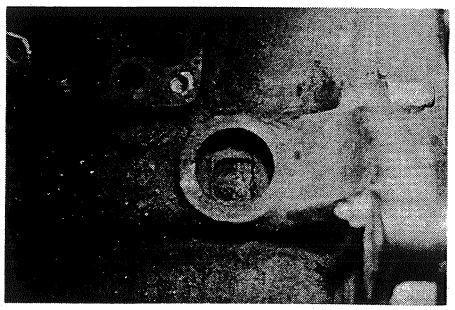


13. Since the following procedures require removal of some of the freeze plugs, it might be a good idea to remove them all. If nothing else it will facilitate the cleaning of the block at the machine shop. Use a large screwdriver or rod and hammer to force the plug *into* the block.

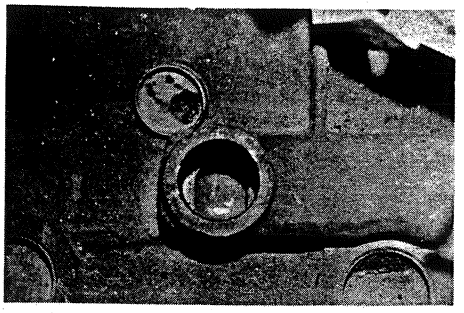


14. Now simultaneously twist the plug with the screwdriver and pry it out with a large open end wrench. Sometimes they are stubborn, be tough.

SIX CYLINDER



15. When all the plugs have been removed, compare the two plug hole that are located in the coolant galley directly behind the water pump mounting flange. Coolant from the pump travels through this gallery and is diverted into these two smaller, more restrictive ports into the cylinder sleeve chamber. As a rule 6 cylinder engines run hottest in the middle of the block, which is evidenced by the frequency of center combustion chamber cracks in 6 cylinder heads. For this reason we suggest you do the following.



16. Enlarge the inner port of the plug hole at the back of the coolant galley with your die grinder. Increase the size of this hole by about 50% to 75% to force more water circulation to the center and back of the engine block.

17. At the front of this same coolant galley where it meets the water pump flange is another restriction caused by some of the residual casting material. Just where the spiraling water passage feeds the galley there is a raised lip and an abruptly sharp bend. Once again, use the die grinder to remove the lip and smooth the bend into a more gradual curve to promote maximum coolant flow.

A final word:

We must emphasize the importance, make that the absolute necessity, of not compromising the bottom end. It is the focal point of any notion of longevity and dependability in an engine. For this reason you, the rebuilder, have the added responsibility of double-checking the machinist as well as yourself. Check the crank journal size, wrist pin bushing and piston/cylinder clearances when the machining is completed. Furthermore, if you're using new oversized pistons, verify that they conform to factory specs, for cylinder wall clearance and balance. Sure, everyone will stand behind their part and/or workmanship, but you will be the one doing the work when it has to be redone. Remember — *assume nothing!* (Next month we'll put the "som-beech" together!

Captain Says

Usually when we think of learning, we think of that stiff/dry text book type education that we used to get in school. Gateway Tech uses a relaxed format for technical exchange. It's a fun way to learn about what makes your BMW tick.

In addition to hearing a great slate of speakers, you'll have a chance to visit with the Area Tech Representatives and National Officers. You'll hear talks on everything from turbos to suspension and from radar to the nuts and bolts of car repair.

I've had an ear on the inside planning of this year's Gateway Tech and I'll just say that Paul Johnson (event Chairman) and the St. Louis Chapter have one hot event planned. So aim yourself in the direction of the Gateway Arch in St. Louis and on March 21 we hope to visit-meet-see you there.

Jim Rowe and Jim Blanton

Shade Tree Topics

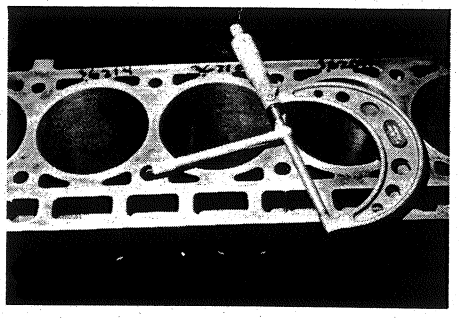
ENGINE REBUILDING
Part V
Engine Assembly

by Jim Rowe and Jim Blanton

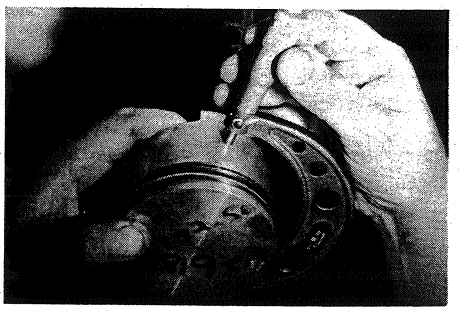
This is it! We are now ready to assemble the lower unit — the foundation of our engine. At this time, more than any other, it is imperative that we check and double-check everything we use and every step we take. A small mistake here could be devastating, so let's get it right the first time.

Note — In the following procedures we use a micrometer and snap gauge set to figure clearances. If you are uncomfortable using either one, we suggest you use Plasti-gauge for measuring bearing clearances and feeler gauges for measuring piston-to-cylinder wall clearance, crankshaft end play and ring gap.

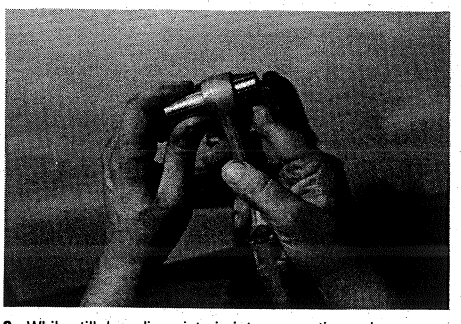
Preassembly Procedures — verifying parts dimensions and proper clearances



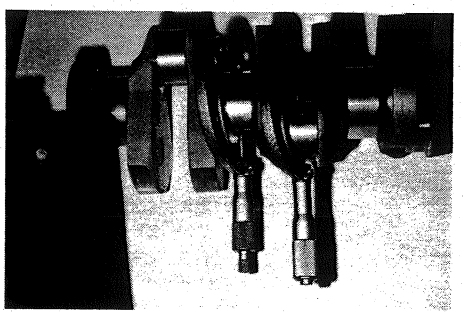
1. Remeasure cylinder bores with snap-gauge and 3″-4″ micrometer.
Write respective measurements next to cylinders.



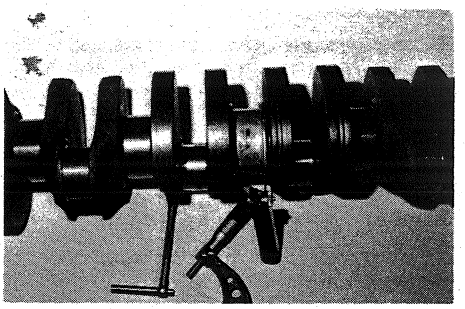
2. Use mic to measure piston diameter (perpendicular to wrist pin).
Match pistons and cylinders to get the tightest fit for all.
Ideal clearance is 0015″-.002″, but not more than .004″.



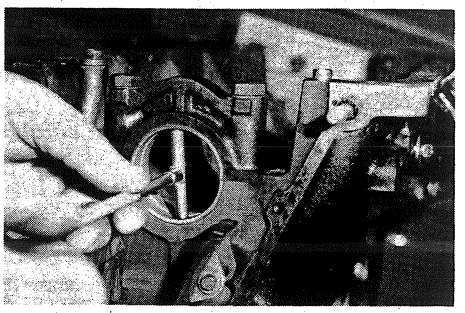
3. While still dry, slip wrist pin into connecting rod.
Try to wiggle the pin 90 degrees to its axis.
If there is *any movement at all*, it will have to be rebushed (even if you are measuring a new bushing, machinists make mistakes too).
Pin clearance needs to be .0002″, any wider and you will feel side-to-side movement.



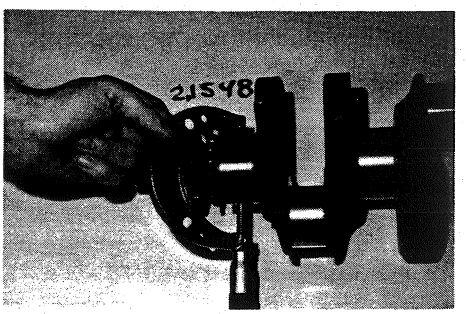
4. Use your 2″-3″ mic to measure all of the main bearing journals, and the 1″-2″ one for measuring the rod journals. Whether standard or ground undersized, compare measurements with factory specs to verify all are within tolerances (some machine shops purposely grind for extra clearance to "cover" themselves).



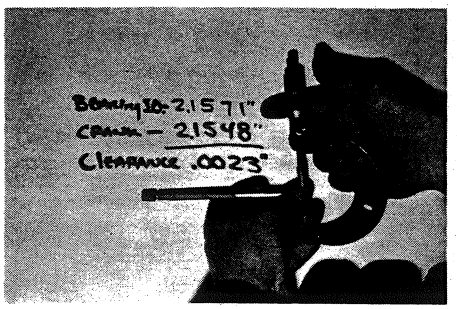
5. Place the middle (thrust) main bearing on the center main journal and use a feeler gauge to measure the distance between the side of the bearing and the crank.
This distance needs to measure between .003″ and .006″.



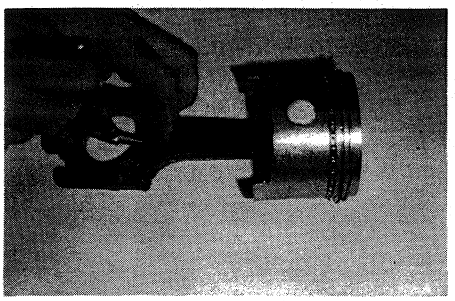
6. Find #1 main bearing cap and install a bearing shell into the cap and #1 saddle (make sure all pieces are clean and dry).
Position cap over saddle with bearing locks-to-locks, start both bolts and washers in by hand, tighten alternately until snug, then torque.
Use snap-gauge to measure opening diameter.



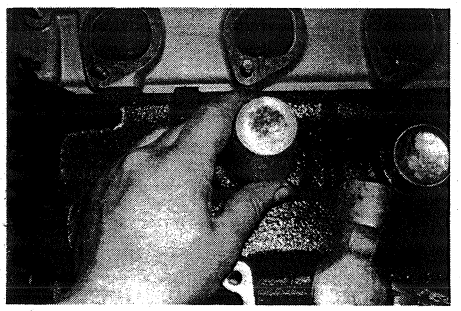
7. Once again, mic #1 main journal (example shown is a .010″ under crank).



8. The difference in the two measurements will represent the bearing clearance and it should meet factory specs (the general rule of thumb is .001″ clearance for every 1″ of journal diameter).

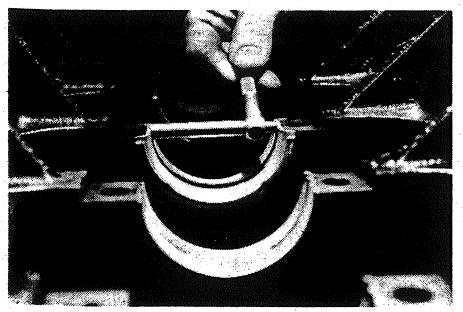


9. Likewise assemble a connecting rod (dry), complete with bearing shells and measure the shell inner diameter, the rod journal size and take their difference to find the clearance. Again, verify that these clearances conform to specs.

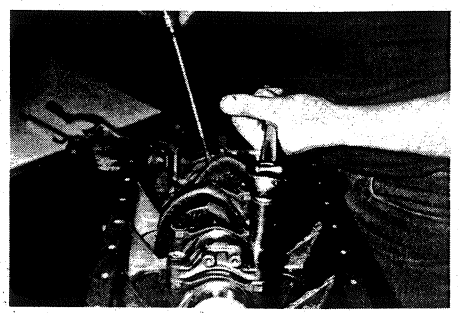


10. If you removed your freeze plugs earlier, now would be a good time to install the new ones.
Find a drift (e.g. large socket, aluminum dowel) that is large enough to align with the outer edge of the plug and with firm blows push it in until the lip edge is flush with the boss.

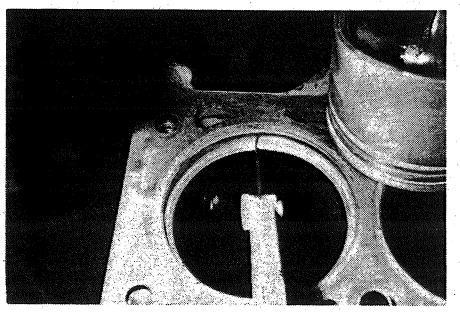
Assembly Procedures



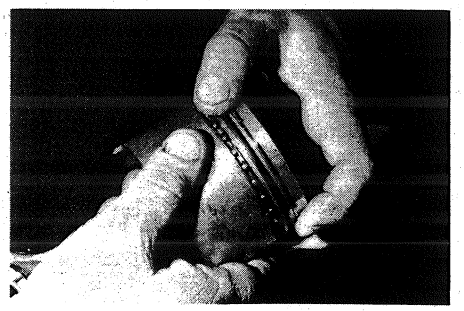
11. With the engine block upside down, install the remaining bearing shells in all the main bearing caps and saddles, making sure everything is clean and dry.
The thrust bearing must go into the center saddle and corresponding cap. Perform one last measurement, from tip to tip, of all shells to insure that all are of the same size (i.e., standard, .010″ under, .020″ under).



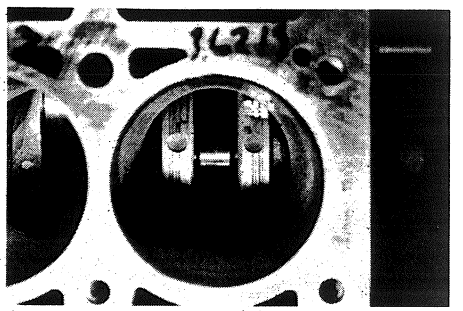
12. Spread a generous amount of white grease, or similar, on the shells in the block and lower the crank into position. Lube the bearings of the caps and place them correctly in position over their respective saddles.
Hand-start the cap bolts and washers (don't forget the additional oil pump support bracket where applicable) and alternately tighten until bolts are *nearly* snug.
Now lever the crankshaft, either forward or backward, to set the two halves of the thrust bearing exactly in line with each other (as shown). Once all bolts are snug, check that the crankshaft rotates freely then torque bolts to spec and once again verify easy rotation.
Install rear seal into rear seal flange, align with pins and bolt to the block.



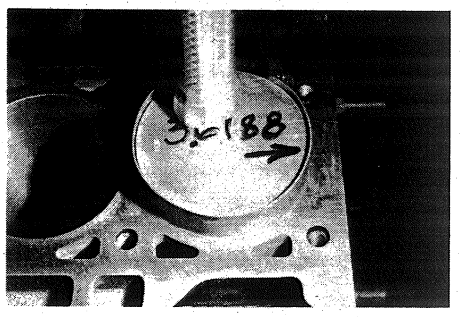
13. Rotate block to upright position, place the top piston ring into the largest of the cylinders and measure the ring gap with a feeler gauge.
To be correct the gap should be about .014″ (this measurement is not that critical). The general formula is .003″ per 1″ of cylinder bore.



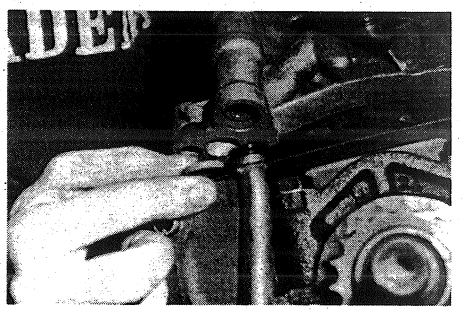
14. Install piston rings.
Locate the gaps of the four rings — two thin oil rings, two compression rings-over the wrist pin holes alternately 180 degrees apart.
If you haven't already, apply some grease to the wrist pins and rod bushings and assemble so that small oil hole in small end of rod and arrow on top of piston are on same side (don't forget both pin circlips).



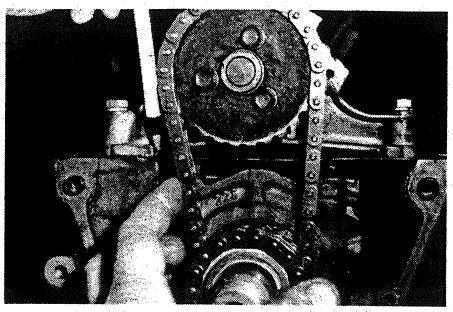
15. In preparation for installing pistons, rotate crank so that two rod journals are at bottom of their strokes.
Apply a generous amount of oil to the cylinder wall, piston rings and skirt as well as light grease to the rod bearings.



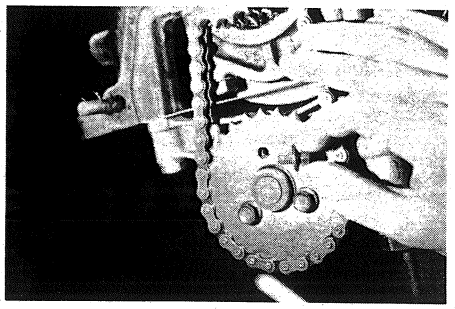
16. Using the appropriate sized ring compressor, tap the piston/rod into the cylinder taking care to point the arrow on the top of the piston towards the front of the engine.
Once the top of the piston is totally into the cylinder, reach around to the big end of the rod and guide it onto the rod journal while you continue tapping on the piston.
When the rod is seated, install the rod cap and nuts tightening alternately a little at a time until the nuts are snug.
Repeat for the other cylinder with its rod journal in position and then rotate the crank to both check that the crank moves freely and position another pair of rod journals at bottom-dead-center.
Continue until all piston/rods are installed and rod nuts snug. Finally, torque each pair of rod nuts to spec and after each one also move the crank to check freedom of movement.



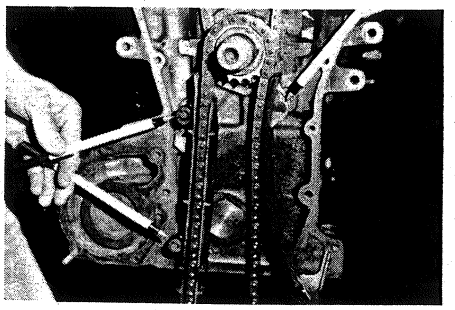
17. When the oil pump is placed in position, there should be a slight gap where the pump shims are, due to the "o" ring on the oil supply tube. You should feel the "o" ring compress slightly when you push the pump down against the block. This engine required an additional "o" ring for a proper seal.



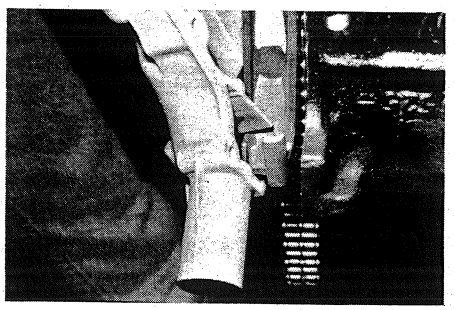
18. Mount the oil pump to the block making sure that the thin shims that were removed are back in place.
Next place your *new* oil pump chain on the crank sprocket, slip the pump sprocket into the chain and onto the pump shaft.
Attach the pump sprocket to the flange with the three 6mm bolts and measure the deflection in the oil pump chain. There should be a slight amount of chain movement without being taut or too sloppy (add or remove shims as necessary).



19. Once the right shims are chosen, remove the pump sprocket bolts and apply "Loctite" or something similar to retain the bolts.



20. Replace the timing chain guide and tension rails as shown.
Note that the largest of the "e" clips retains the tension rail and the two smaller clips are for the guide rail.
Next position the *new* timing chain on the crank sprocket as shown.



21. Install the front cover.
Note that (1) the cover must locate on the alignment pins and (2) the tab on the top of the tension rail must go inside the oil reservoir formed by the cover's casting.

OIL PAN Apply a thin coat of gasket sealant to block and oil pan. Position the gasket on the block and then the pan. Attach and tighten (choke-up on your ratchet) all pan bolts as evenly as possible.

CYLINDER HEAD Reposition the block upright, disregarding the timing chain for now. Check that the block surface is clean and dry, that the two head alignment pins are in place and that the head bolt holes are clean. Rotate the crank until the first and last pistons are at TDC, while making sure that the timing chain does not catch.
Apply some gasket sealant to the top edge of the front cover only and position the head gasket on the alignment pins.

IMPORTANT — DOUBLE CHECK THE POSITION OF THE CAM.

It must be on TDC #1 cylinder, where both valves are closed and the cam lobes are pointing down toward the cylinder head.

- **4 CYL The cam alignment groove on the edge of the sprocket flange aligns with a 'boss' on the head, just under the sprayer bar.**
- **6 CYL One of the bolt holes aligns with a 'boss' on the head.**

Carefully place the cylinder head onto the block so as not to dislodge or damage the head gasket. When properly located on the pins, it will sit squarely and evenly without rocking. Slip the head bolts into the head and snug them all evenly. Now follow the torquing sequence and tighten to specs.

CAM SPROCKET Slip the sprocket into the chain and pull it up to align it with the flange. The sprocket can only attach one way due to an alignment pin pressed into it.
Once mated to the flange, use the special lock tabs and bolts to fasten it.
When the bolts are tight, bend a corner of each tab up against its respective bolt head.

CAM SPROCKET COVER Apply gasket sealant to the exposed head gasket and the front edges of the cylinder head.
6 CYL. ONLY Insert distributor drive with "o" ring into the front of the cam.
Position the cover and bolt it to the front cover and head.

TIMING CHAIN TENSIONER Move engine so that it is approximately in its normal tilted position with the bottom of the oil pan horizontal.
Insert *new* tensioner piston into hole so that the tab on the tension rail sits in the slot on the end of the tensioner.
Next insert the spring, washer and threaded plug, then tighten.
Pour oil down the inside edge of the cam sprocket cover to fill the tensioner oil reservoir.
Now with a long screwdriver pry on the tensioner rail against the force of the tensioner spring, then release the rail. Repeat until the air is nearly bled from the tensioner and the rail quits moving.
Then push the tensioner rail the opposite direction, against the chain, until the tensioner will hold it tight against the timing chain (it might be necessary to refill the oil reservoir to completely bleed the tensioner).

SET VALVE CLEARANCE Since the engine is still at TDC, adjust the valves of #1 cylinder.
Now rotate the engine clockwise until the next set of cam lobes are pointing directly down and adjust these valves. Continue until all valves are adjusted.
Now you have felt the engine turn over one final time to insure there is no binding and you are back to TDC #1 for setting the distributor timing.