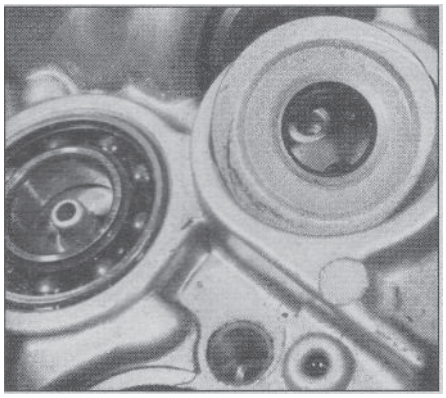
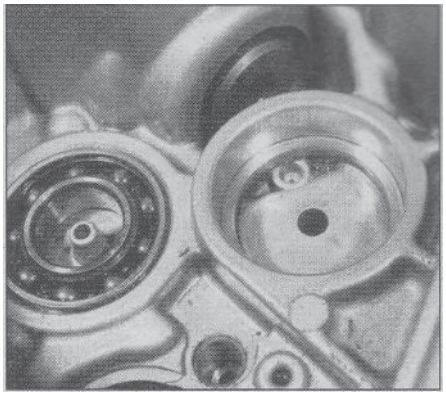
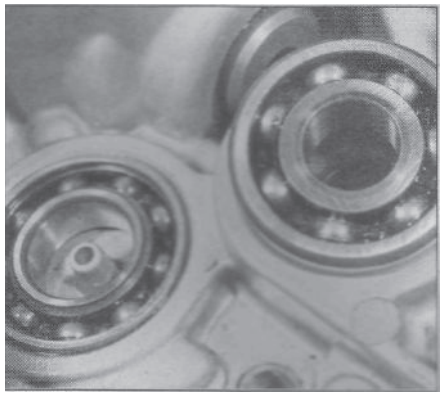


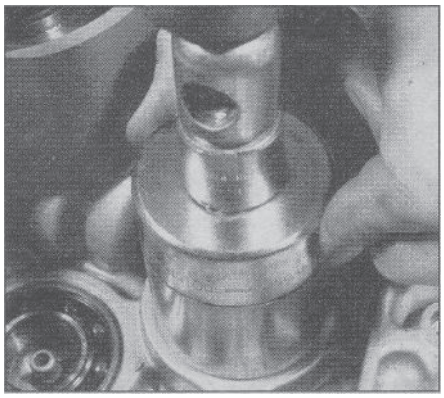
21.5a Pry the oil seal out of the bearing bore . . .



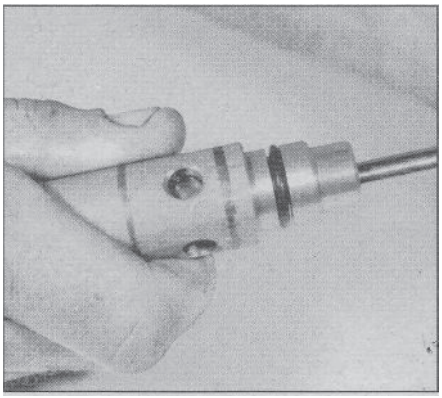
21.5b . . . make sure the oil passage is clear and tap in a new seal



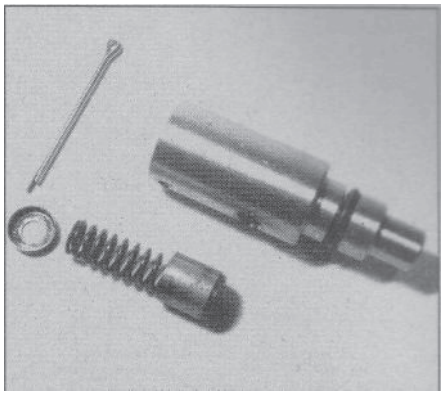
21.6a Push the bearing sU<wyhl into its housing . . .



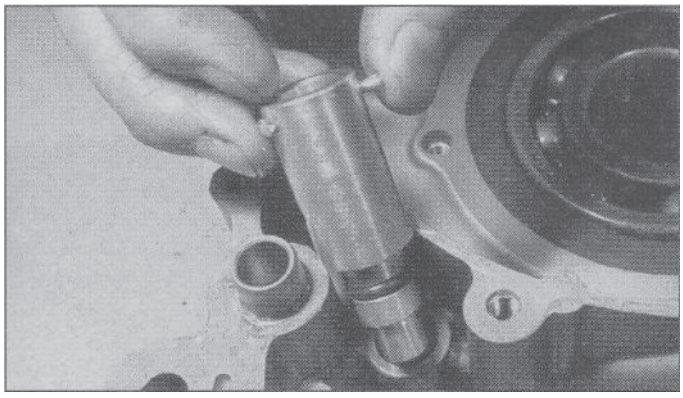
21.6b . . . then drive it all the way in with a bearing driver or socket that bears against the outer race of the bearing



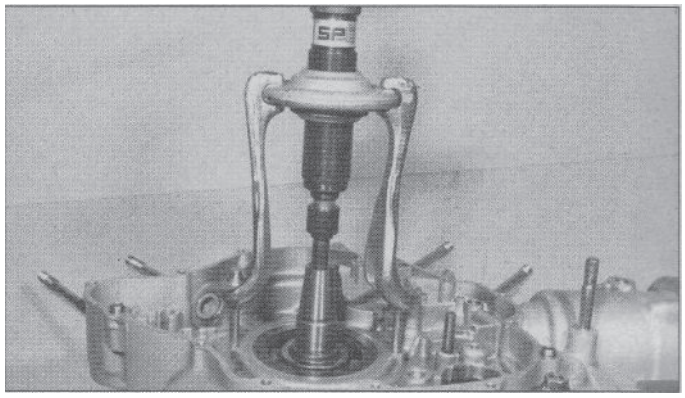
22.3 Push in on the relief valve plunger to make sure it moves freely



22.4 Check the relief valve parts for wear or damage



22.6 Coat the new O-ring with engine oil and work the relief valve back into its bore



23.3a Use a puller like this one to push the crankshaft out of the bearing

replace it. **Caution:** *If you reuse the relief valve, install a new cotter pin before installing the relief valve in the engine.*

6 Install a new O-ring on the valve **(see illustration).** Coat the O-ring with engine oil and work the valve back into its bore in the crankcase.

23 Crankshaft and main bearings - removal, inspection, main bearing replacement and installation

Note: *The crankshaft is a tight interference fit in its ball bearing in the left crankcase half. Special tools are required for removal and installation. Substitutes for the Yamaha factory tools are described and illustrated in this Section, but even these may be difficult to obtain. If you don't have the proper tools or substitutes, don't try to drive the crankshaft out or back in. Take the left crankcase half to a Yamaha dealer or other qualified shop for crankshaft removal and installation.*

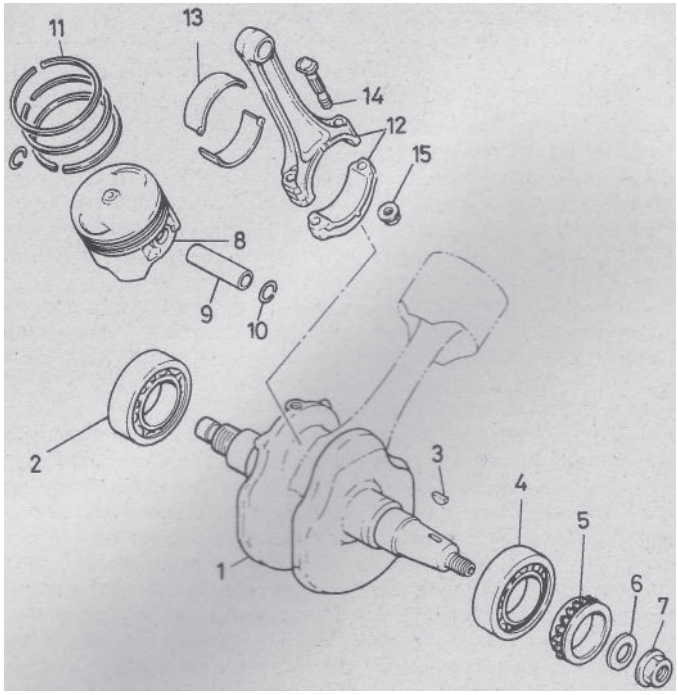
Crankshaft removal

Refer to illustrations 23.3a and 23,3b

1 Separate the crankcase halves (see Section 20).

2 Remove the oil pump drive sprocket from the crankshaft (see Section 15).

3 Attach a puller to the crankshaft and push it out of the main bearing **(see illustrations). Caution:** *Support the crankshaft as it's removed so it doesn't fall.*



23.3b Crankshaft details

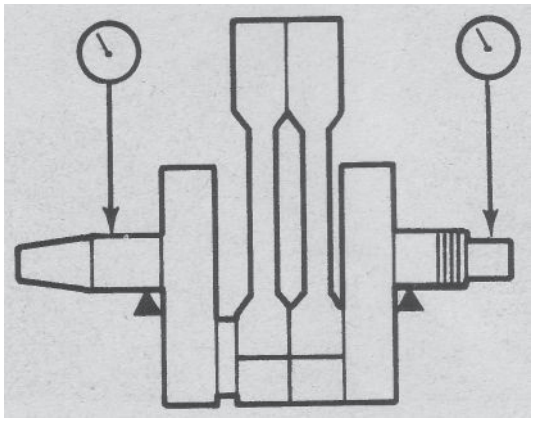
1	*Crankshaft*	9	*Piston pin*
2	*Right main bearing*	10	*Circlip*
3	*Woodruff key*	11	*Piston rings*
4	*Left main bearing*	12	*Connecting rod*
5	*Oil pump drive sprocket*	13	*Connecting rod bearings*
6	*Washer*	14	*Connecting rod studs*
7	*Nut*	15	*Connecting rod nuts*
8	*Piston*		

Inspection

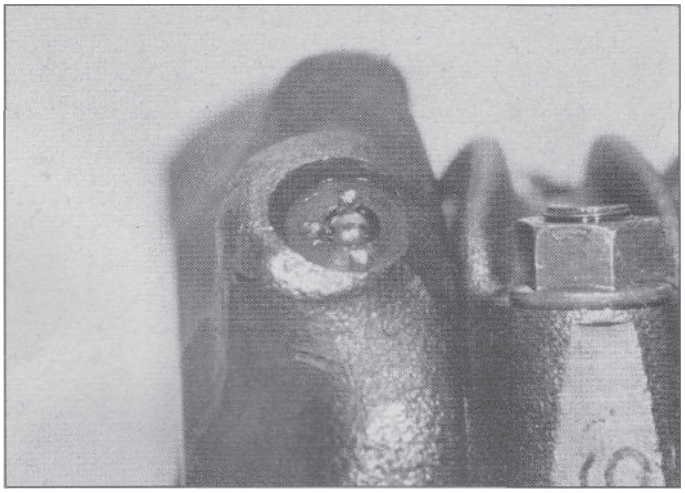
Refer to illustrations 23.5 and 23.7

4 If you haven't already done so, mark and remove the connecting rods from the crankshaft (see Section 25).

5 Clean the crankshaft with solvent, using a rifle-cleaning brush to scrub out the oil passages. Make sure the oil passage plugs are tight **(see illustration).** Check the crankshaft for cracks and other damage.



23.7 Check crankshaft runout with a pair of dial indicators



23.5 Make sure the oil passage plugs are tight

It should be magnafluxed to reveal hidden cracks - a dealer service department or motorcycle machine shop will handle the procedure.

6 If available, blow the crank dry with compressed air. Check the main and connecting rod journals for uneven wear, scoring and pits. Rub a copper coin across the journal several times - if a journal picks up copper from the coin, it's too rough. Replace the crankshaft.

7 Set the crankshaft on V-blocks and check the runout with a dial indicator touching the alternator and primary drive gear mounting surfaces **(see illustration).** Compare your findings with this Chapter's Specifications. If the runout exceeds the limit, replace the crankshaft.

Mainbearinginspectionandreplacement

Refer to illustration 23.8

8 The crankshaft rides in ball bearings which are pressed into steel sleeves in the aluminum case halves **(see illustration).**

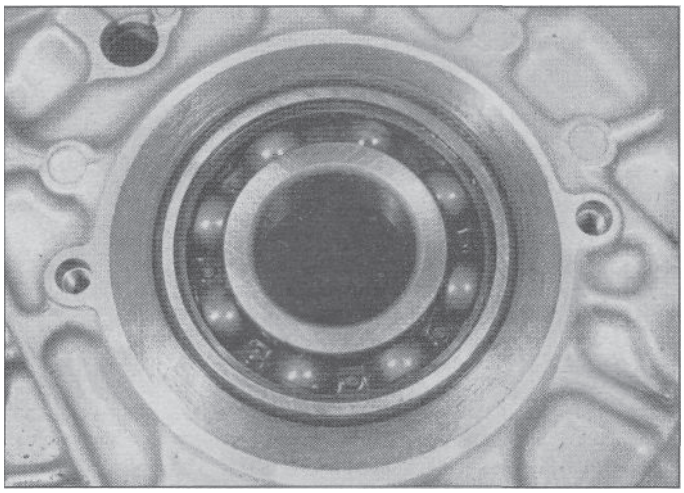
9 Spin the bearings with fingers and check for looseness, roughness or excessive noise. If the condition of the bearings is doubtful or definitely bad, have them pressed out and new ones pressed in by a Yamaha dealer or other qualified repair shop.

Installation

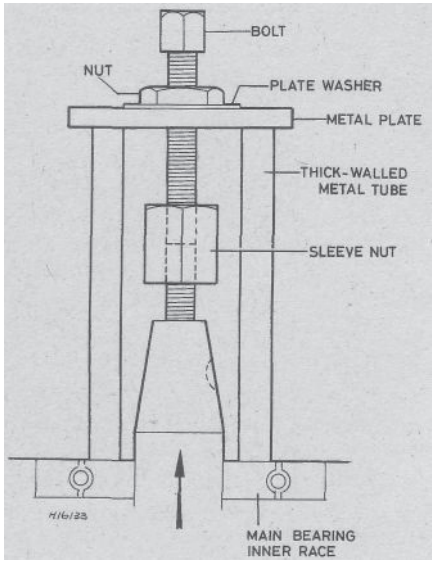
Refer to illustrations 23.11, 23.12, 23.13 and 23.14

10 Install the connecting rods on the crankshaft at this point if they were removed (see Section 25).

11 To pull the crankshaft into the ball bearing in the left crankcase half, you'll need a puller that can be attached to the threaded end of



23.8 The crankshaft bearings are mounted in steel sleeves



23.11 Set up a puller like this one to pull the crankshaft into the left main bearing

the crankshaft with a sleeve nut. This can be fabricated **(see illustration),** but the puller must apply force to the inner race of the ball bearing. A puller that's braced against the outer race of the ball bearing will transfer the installation force to the balls and retainers, damaging the bearing. The same thing will happen if the crankshaft is driven into the bearing with a hammer.

12 Carefully lower the crankshaft into the bearing until it stops **(see illustration).** Make sure the crankshaft isn't cocked sideways in the bearing.

13 Thread a sleeve nut onto the end of the crankshaft **(see illustration).** Install a thick-walled metal tube over the end of the crankshaft to act as a spacer. The tube must be large enough to fit over the crankshaft, but small enough that it rests on the inner race of the ball bearing.

14 Attach a puller to the sleeve nut with its plate resting on the metal tube **(see illustration).**

15 Tighten the puller bolt to pull the crankshaft into its bearing.

16 Remove the puller and align the connecting rods with the cylinders.

17 Assemble the case halves (see Section 20) and check to make sure the crankshaft and the transmission shafts turn freely.

24 Connecting rod bearings - general note

1 Even though connecting rod bearings are generally replaced with new ones during the engine overhaul, the old bearings should be retained for close examination as they may reveal valuable information about the condition of the engine.

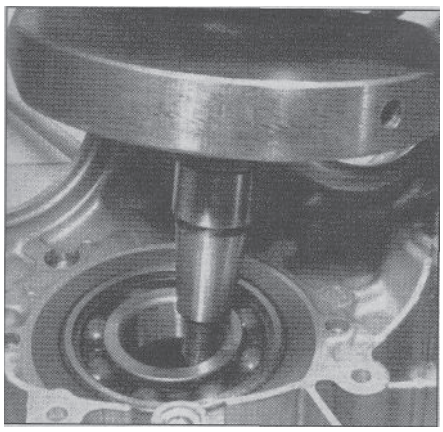
2 Bearing failure occurs mainly because of lack of lubrication, the presence of dirt or other foreign particles, overloading the engine and/or corrosion. Regardless of the cause of bearing failure, it must be corrected before the engine is reassembled to prevent it from happening again.

3 When examining the bearings, remove the rod bearings from the connecting rods and caps and lay them out on a clean surface in the same general position as their location on the crankshaft journals. This will enable you to match any noted bearing problems with the corresponding side of the crankshaft journal.

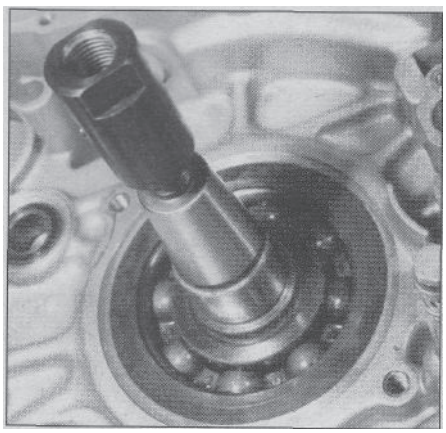
4 Dirt and other foreign particles get into the engine in a variety of ways. It may be left in the engine during assembly or it may pass through filters or breathers. It may get into the oil and from there into the bearings. Metal chips from machining operations and normal engine wear are often present. Abrasives are sometimes left in engine components after reconditioning operations such as cylinder honing, especially when parts are not thoroughly cleaned using the proper cleaning methods. Whatever the source, these foreign objects often end up imbedded in the soft bearing material and are easily recognized. Large particles will not imbed in the bearing and will score or gouge the bearing and journal. The best prevention for this cause of bearing failure is to clean all parts thoroughly and keep everything spotlessly clean during engine reassembly. Frequent and regular oil and filter changes are also recommended.

5 Lack of lubrication or lubrication breakdown has a number of interrelated causes. Excessive heat (which thins the oil), overloading (which squeezes the oil from the bearing face) and oil leakage or throw off (from excessive bearing clearances, worn oil pump or high engine speeds) all contribute to lubrication breakdown. Blocked oil passages will also starve a bearing and destroy it. When lack of lubrication is the cause of bearing failure, the bearing material is wiped or extruded from the steel backing of the bearing. Temperatures may increase to the point where the steel backing and the journal turn blue from overheating.

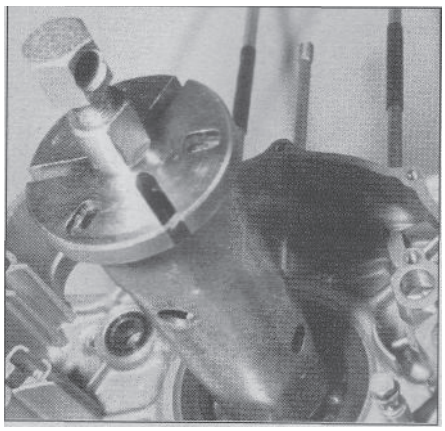
6 Riding habits can have a definite effect on bearing life. Full throttle low speed operation, or lugging (laboring) the engine, puts very high loads on bearings, which tend to squeeze out the oil film. These loads cause the bearings to flex, which produces fine cracks in the bearing face (fatigue failure). Eventually the bearing material will loosen in pieces and tear away from the steel backing. Short trip driving leads to corrosion of bearings, as insufficient engine heat is produced to drive



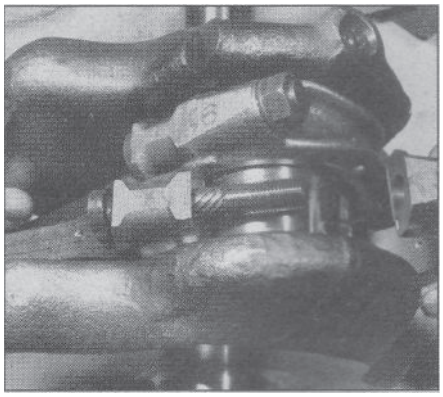
23.12 Push the crankshaft into the bearing as far as it will go (don't let it tilt sideways and jam)



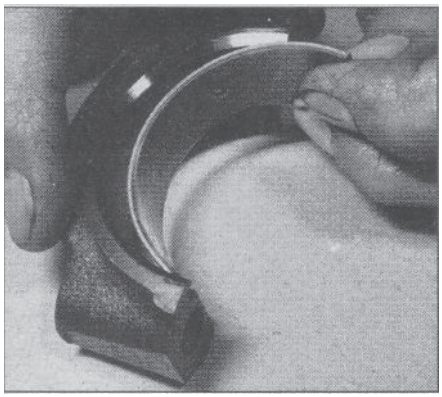
23.13 Thread a sleeve nut onto the end of the crankshaft



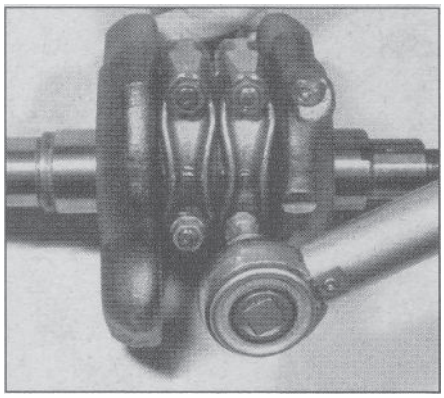
23.14 Place a thick metal tube over the crankshaft, then position the puller plate on top of it and thread the puller bolt into the sleeve nut



25.3 Remove the nuts and separate the cap from the connecting rod



25.10 Make sure the tab aligns with the notch; when installing the bearing upper half, make sure the oil holes in the bearing and connecting rod are aligned



25.12 Tighten the cap nuts to the specified torque in one continuous motion

off the condensed water and corrosive gases produced. These products collect in the engine oil, forming acid and sludge. As the oil is carried to the engine bearings, the acid attacks and corrodes the bearing material.

7 Incorrect bearing installation during engine assembly will lead to bearing failure as well. Tight fitting bearings which leave insufficient bearing oil clearances result in oil starvation. Dirt or foreign particles trapped behind a bearing insert result in high spots on the bearing which lead to failure.

8 To avoid bearing problems, clean all parts thoroughly before reassembly, double check all bearing clearance measurements and lubricate the new bearings with engine assembly lube or moly-based grease during installation.

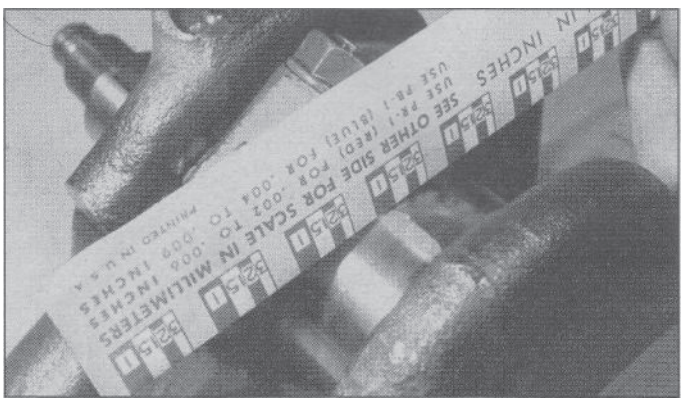
25 Connecting rods and bearings - removal, inspection, bearing selection and installation

Removal

Refer to illustration 25.3

1 Before removing the connecting rods from the crankshaft, insert a feeler gauge between the crankshaft and the big end of each connecting rod and between the two connecting rods and measure the side clearance **(see illustration 26.1 in Part A of this Chapter).** If the clearance on any rod is greater than that listed in this Chapter's Specifications, that rod will have to be replaced with a new one.

2 Using a center punch or felt pen, mark the position of each rod and cap, relative to its position on the crankshaft (left or right) **(see illustration 26.2 in Part A of this Chapter). Note:** *The rear cylinder connecting rod may have one or two oil holes in the upper side of the big end (the front cylinder connecting rod on all models has one oil hole). Look at the rear cylinder connecting rod before removing the rods and determine whether it has one or two oil holes.*



25.13 Place the Plastigage scale next to the flattened Plastigage to measure the bearing clearance

3 Unscrew the bearing cap nuts, separate the cap from the rod, then detach the rod from the crankshaft **(see illustration 23.3b and the accompanying illustration).** If the cap is stuck, tap on the ends of the rod bolts with a soft-faced hammer to free them.

4 Roll the bearing inserts sideways to separate them from the rods and caps. Keep them in order so they can be reinstalled in their original locations. Wash the parts in solvent and dry them with compressed air, if available.

Inspection

5 Check the connecting rods for cracks and other obvious damage. Lubricate the piston pin for each rod, install it in the proper rod and check for play **(see illustration 26.5 in Part A of this Chapter).** If it wobbles, replace the connecting rod and/or the pin.

6 Examine the connecting rod bearing inserts. If they are scored, badly scuffed or appear to have been seized, new bearings must be installed. Always replace the bearings in the connecting rods as a set. If they are badly damaged, check the corresponding crankshaft journal. Evidence of extreme heat, such as discoloration, indicates that lubrication failure has occurred. Be sure to thoroughly check the oil pump and pressure relief valves as well as all oil holes and passages before reassembling the engine.

7 Have the rods checked for twist and bending at a dealer service department or other motorcycle repair shop.

Connectingrodbearingselection

Refer to illustrations 25.10, 25.12, 25.13 and 25.18a through 25.18d

8 If the bearings and journals appear to be in good condition, check the oil clearances as follows:

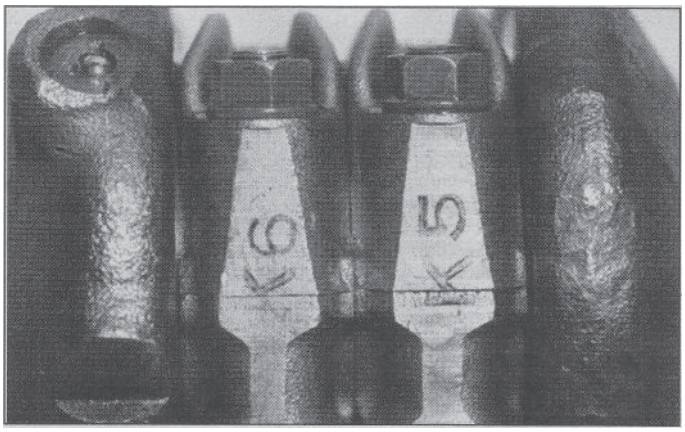
9 Start with the rod for one cylinder. Wipe the bearing inserts and the connecting rod and cap clean, using a lint-free cloth.

10 Install the bearing inserts in the connecting rod and cap **(see illustration).** Make sure the tab on the bearing engages with the notch in the rod or cap.

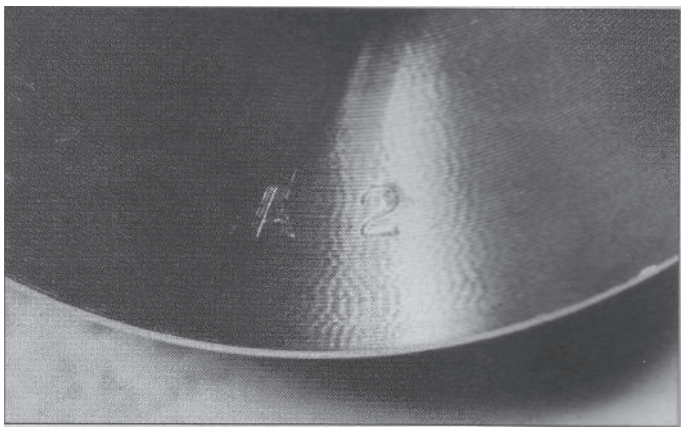
11 Wipe off the connecting rod journal with a lint-free cloth. Lay a strip of Plastigage (type HPG-1) across the top of the journal, parallel with the journal axis **(see illustration 26.11 in Part A of this Chapter).**

12 Position the connecting rod on the journal, then install the rod cap and nuts. Tighten the nuts to the torque listed in this Chapter's Specifications **(see illustration),** but don't allow the connecting rod to rotate at all.

13 Unscrew the nuts and remove the connecting rod and cap from the journal, being very careful not to disturb the Plastigage. Compare the width of the crushed Plastigage to the scale printed in the Plastigage envelope to determine the bearing oil clearance **(see illustration).**



25.18a The number on each connecting rod is used for bearing selection; the letter is used to align the rod and cap



25.18b The letter on the crankshaft is used together with the **connecting rod number to select bearings**

14 If the clearance is within the range listed in this Chapter's Specifications and the bearings are in perfect condition, they can be reused. If the clearance is greater than the wear limit, replace the bearing inserts with new inserts that have the same color code, then check the clearance once again. Always replace all of the inserts at the same time.

15 The clearance should now be within the range listed in this Chapter's Specifications.

16 If the clearance is greater than the maximum clearance listed in this Chapter's Specifications, measure the diameter of the connecting rod journal with a micrometer. Yamaha doesn't provide diameter or wear limit specifications, but by measuring the diameter at a number of points around the journal's circumference, you'll be able to determine whether or not the journal is out-of-round. Take the measurement at each end of the journal to determine if the journal is tapered.

17 If any journal is tapered or out-of-round or bearing clearance is beyond the maximum listed in this Chapter's Specifications (with new bearings), replace the crankshaft.

18 Each connecting rod has a number stamped on it in ink **(see illustration).** Subtract this number from the connecting rod journal number on the crankshaft to get a bearing number **(see illustration).** For example, the number on the right connecting rod shown in the accompanying illustration is 5. The corresponding number for that connecting rod's journal, stamped into the crankshaft, is 2. Subtracting 2 from 5 produces 3, which is the bearing number for that journal. According to the accompanying chart, bearing no. 2 is color-coded black **(see illustration).** The color codes are painted on the edges of the bearings **(see illustration).**

19 Repeat the bearing selection procedure for the remaining connecting rods.

BEARING COLOR CODE	
No. 1	Blue
No. 2	Black
No. 3	Brown
No. 4	Green
No. 5	Yellow

25.18c Calculate the bearing number by subtracting the crankshaft number from the connecting rod number, then use the bearing number to select a color code

Installation

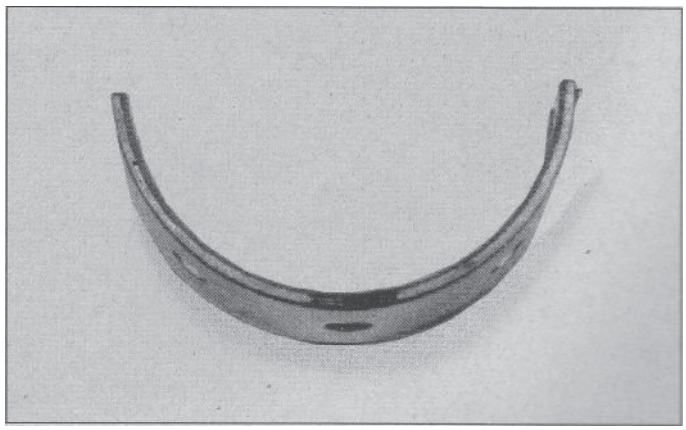
20 Wipe off the bearing inserts, connecting rods and caps. Install the inserts into the rods and caps, using your hands only, making sure the tabs on the inserts engage with the notches in the rods and caps (see **illustration 25.10).** When all the inserts are installed, lubricate them with engine assembly lube or moly-based grease. Don't get any lubricant on the mating surfaces of the rod or cap.

21 Assemble each connecting rod to its proper journal, referring to the previously applied cylinder numbers. Make sure the Y mark on each rod is toward the tapered end of the crankshaft. The letter present at the rod/cap seam on one side Of the connecting rod should fit together perfectly when the rod and cap are assembled **(see illustration 25.18a).** If it doesn't, the wrong cap is on the rod. Fix this problem before assembling the engine any further.

22 When you're sure the rods are positioned correctly, lubricate the threads of the rod bolts and the surfaces of the nuts with molybdenum disulfide grease and tighten the nuts to the torque listed in this Chapter's Specifications **(see illustration 25.12). Note:** Snug *both nuts evenly, then tighten them to the specified torque in a continuous motion. If you must stop tightening between 32 and 36 Nm (22 and 25 ft-lbs), loosen the nuts to a torque less than 32 Nm (22 ft-lbs), then retighten them to the specified torque in one continuous motion.*

23 Turn the rods on the crankshaft. If either of them feels tight, tap on the bottom of the connecting rod caps with a hammer - this should relieve stress and free them up. If it doesn't, recheck the bearing clearance.

24 As a final step, recheck the connecting rod side clearances (see , Step 1). If the clearances aren't correct, find out why before proceeding with engine assembly.



25.18d The color codes, painted on the sides of the bearings, **identify bearing thickness**