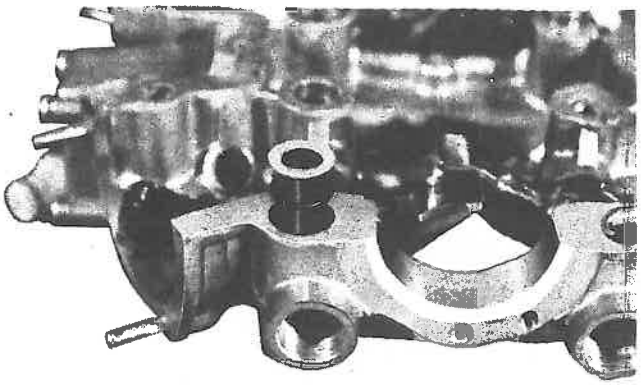
3-6. CYLINDER HEAD

A. Removal of Parts

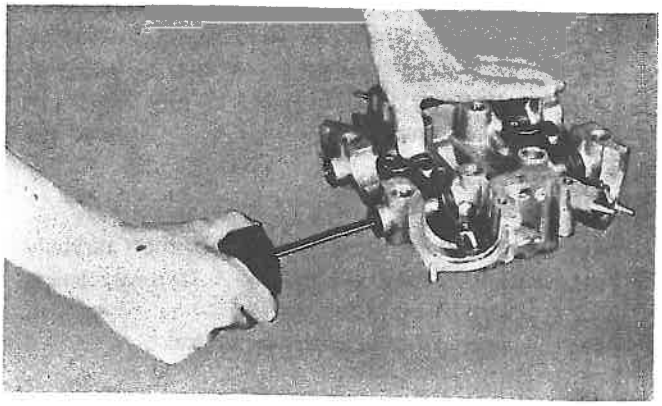


Rocker Arm and Rocker Shaft Removal

1. First, remove all four rocker shaft covers. Then remove the shouldered sleeves and O-rings (see picture). Insert a 6 mm. screw into the tapped shaft, and withdraw the rocker shaft. It should slide out easily. Lift the rocker arm out of the head cover. Repeat this procedure for each rocker assembly.

Note:

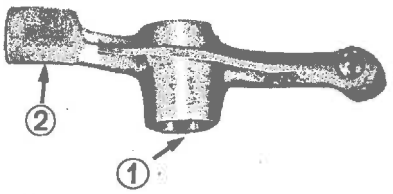
Keep each mating rocker arm and shaft assembly separated. Reinstall them as a unit.



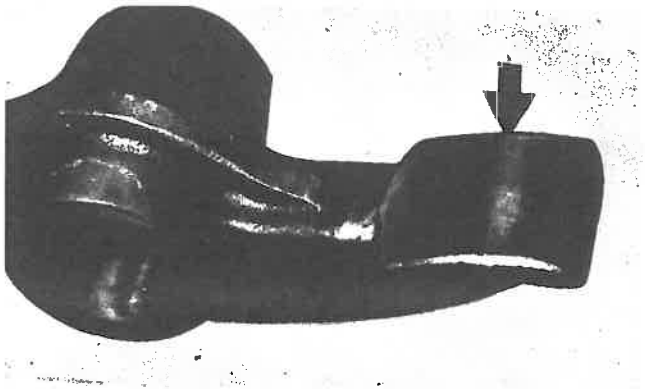
2. Reinstall the shafts using the 6 mm. screw. That way, the threaded hole will be properly positioned for future disassembly; without the hole and screw it is very difficult to remove the shaft.

3. Rocker Arm and Rocker Shaft Wear

   a) The rocker arm usually wears at two spots: ① at the rocker shaft hole where it rubs against the rocker shaft, and ② at the cam lobe contacting surface.

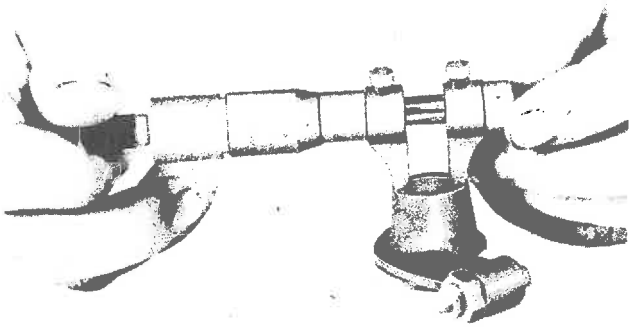


   b) Check the cam lobe contacting surface of the rocker arm for grooves in the surface, for deep and obvious scratches, flaking of the hardened surface, or a blue discoloration of the metal (obvious evidence of too much heat). Check the mating cam lobes in the same manner.



c) If any grooves are readily apparent, replace the rocker arm. Do not try to repair the surface by cleaning with an oil stone or emery cloth as this will change the curvature of the follower and thereby the rate of valve opening.

d) Measure the rocker shaft hole in the rocker arm. Standard size is 0.59 in. (15.01 mm.)

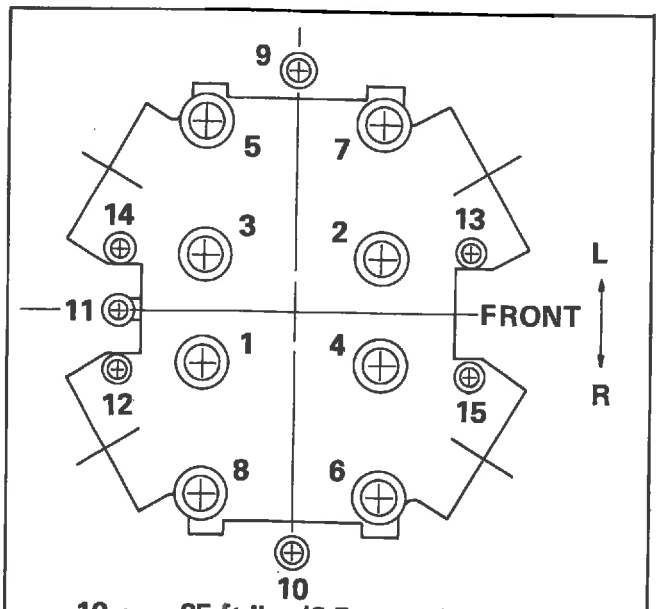


e) Rocker shaft diameter measures 0.59 in. (14.98 mm.) when new. The shaft has been hardened and it should not wear excessively. If a groove has developed in its surface that can be felt, or if it shows a blue discoloration, then the shaft should be replaced and the lubrication system (pump and passages) checked.

f) Standard clearance between the rocker shaft and hole should be 0.002 in. (0.05 mm.). If measurement shows more than 0.004 in. (0.10 mm.) clearance, replace either or both parts as necessary.

B. Cylinder Head

1. Assembling the Cylinder Head Cover
   a) All head cover components can be installed in the head cover in reverse order of removal, beginning with rocker arms and rocker shafts. Be sure to coat all surfaces with oil as the parts are reassembled.
   b) All rocker arms are idential and all rocker shafts are identical, which make them interchangeable. However, try to keep the arms and shafts together as four individual sets (one arm and one shaft to a set) and to reinstall them in the head cover in their original location. Also, when installing the rocker shafts, see that the drilled and tapped end points outward to facilitate future disassembly. Complete this phase of assembly by installing the shaft hole covers.
2. Installing the Cylinder Head Cover and Attached Parts
   a) Coat the head and cover mating surfaces with a non-hardening sealant (Yamaha Bond #4) and slip the head cover into position on the head. Install all head cover retaining nuts and retaining bolts and thread them down until lightly seated. USE A TORQUE WRENCH to tighten these nuts and bolts to the proper torque setting, and in proper torque sequence. Tightening torque for 10 mm. studs is 25 ft-lbs. (3.5 m-kgs.), for 8 mm. it is 14 ft-lbs. (2.0 m-kgs.), and for 6 mm. it is 7 ft-lbs. (1.0 m-kg.).

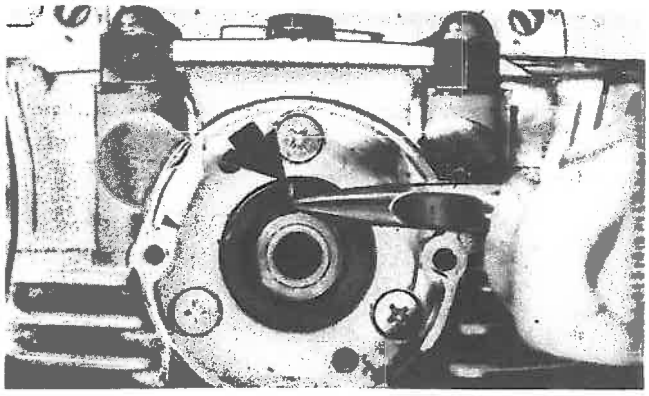


Caution:

If the stud threads are not lubricated prior to cylinder head cover assembly, it is possible to shear a stud when tightening cover nuts. Therefore, apply a liberal coating of 30 weight oil to all threads first, and then torque the head cover down.

b) Install the ignition points housing and the centrifugal advance housing. These housings are identical and can only fit on the machine one way.

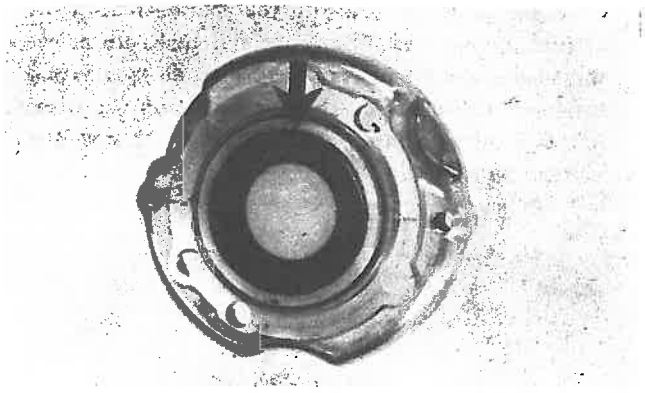
c) Install the centrifugal advance unit locating pin.



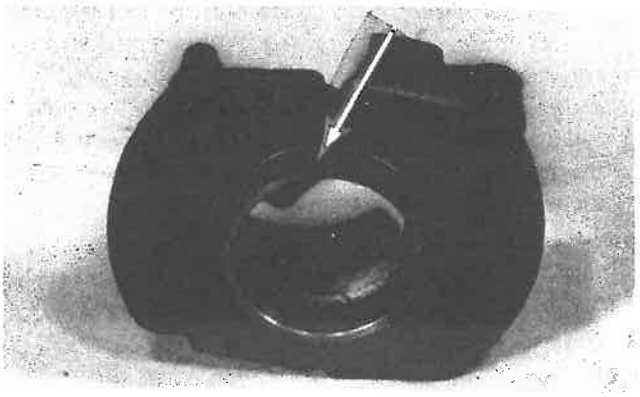
d) If necessary, insert a new gasket between the housing and head covers. Also, if any oil residue is found on the ignition points, then the rubber seal may be leaking. Check the seal for grooves, creases, or any deformity that would permit oil to leak past. If found, replace the seal.

Note:

Grease the seal lip before installing the housing.



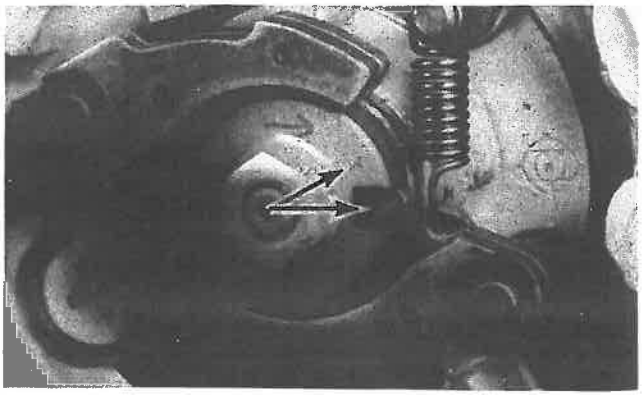
e) Mount the governor (centrifugal advance) unit in its housing. It can only fit one way as there is a notch in the back of the unit that must line up with the locating pin. Next, screw the ring nut onto the camshaft end until tight and then use a punch and hammer to completely tighten the ring nut.



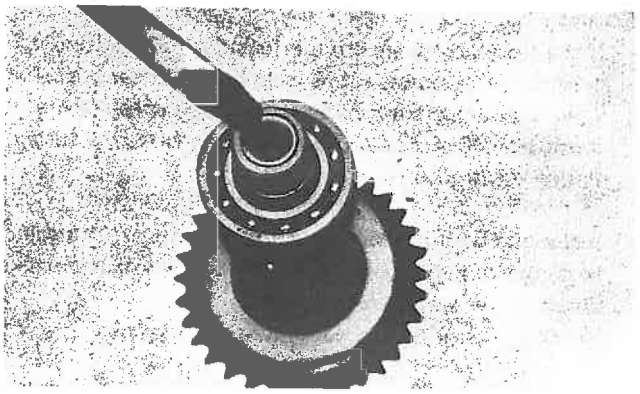
f) Place the disk into position and engage the centrifugal weight arms into the proper disk slots.

Caution:

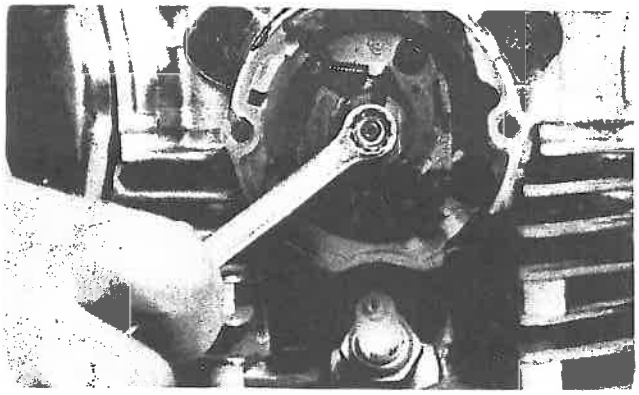
Make sure the disk face with the arrow showing direction of rotation faces outward. Also, there is a color mark on it. This arm must fit into the disk slot identified by a color mark right next to it. If either of these steps is performed incorrectly, operation of the advance unit will be impaired.



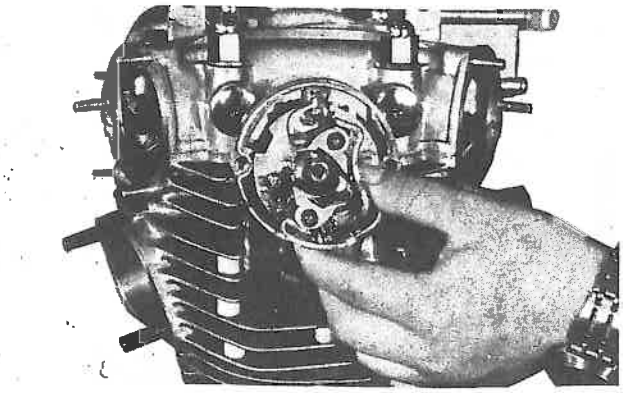
g) Before inserting the governor rod, both supportive needle bearings (located inside each end of the camshaft) should be lubricated with a light-weight grease. These bearings support the point cam rod and every time this unit is taken apart these bearings should be greased.



h) Slide the governor rod into the camshaft from the ignition points side. A locating pin sticks up at the threaded end of the governor rod. Install the rod and rotate it until this locating pin slips into the inner notch in the governor unit disk. Next install and tighten the lock nut.



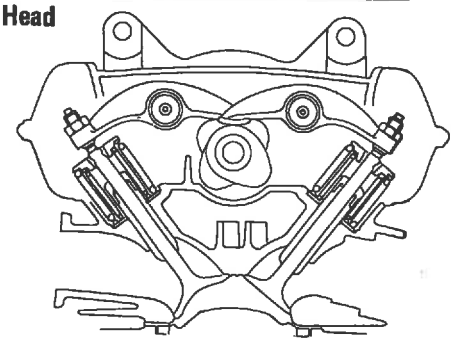
i) Install the ignition point assembly. Do this by expanding the two sets of points and slipping the assembly over the point cam. The point assembly is designed to fit only one way. Position the right cylinder points (stamped "R" on the plate just below the points) at the top of the housing. Install and tighten both securing screws.



j) Make sure the point wire rubber grommet is in good shape and installed correctly, then secure the point housing cover in place.

k) Install the oil delivery line. (After the engine has run sufficiently to warm up to operating temperature, check for oil leaks at this point if necessary.)

Cylinder Head

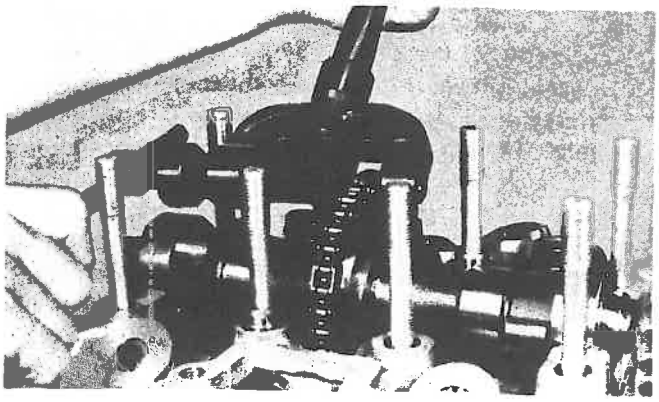


Cutaway View of Cylinder Head

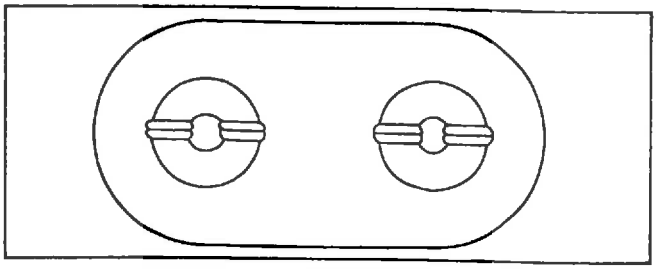
3. Cam Chain Removal

a) The single row cam drive chain connects the camshaft to the crankshaft. The chain is "endless" in that there is no master link to disassemble it, other than the link riveted at the factory when the chain was first installed.

b) A chain breaker (in Special Tool kit) must be used to remove a selected link. Place a rag around the sprocket to prevent metal chips from falling into the engine.

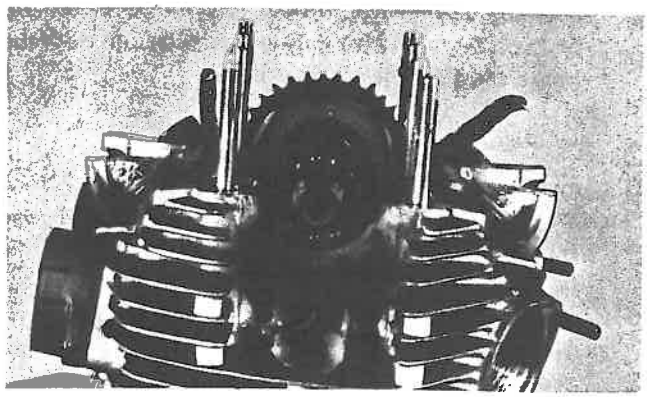


c) Separate the chain link that was originally riveted at the factory. The rivet heads on this link have punch marks and slots across the heads.



Caution:

d) Attach a wire to a chain link on each side of the link to be separated. Do this before separating the chain to prevent the chain from dropping into the crankcase. After separating the chain anchor both retaining wires to prevent the chain from dropping down.



(1) Remove the chain, clean it in solvent, then examine for wear.

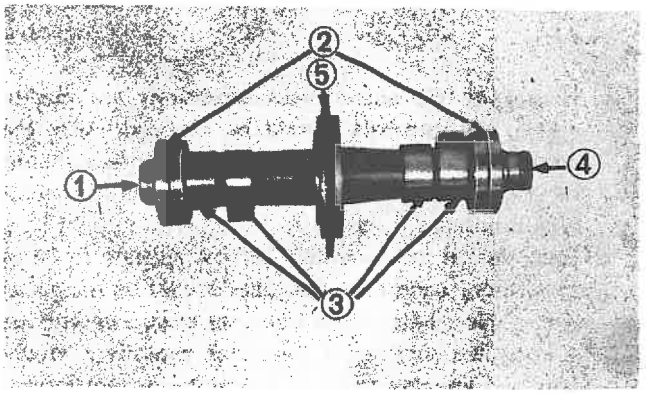
(2) If the engine is not to be disassembled, pull a length of wire through with the chain during removal in order to provide a means of reinstalling the chain after cleaning and checking.
It is also a good idea to have a mechanic's mechanical claw on hand to help feed the chain around the guide bars on the lower drive sprocket during reassembly.

Note:

Checking Cam Chain Wear:
Check the cam chain using the same methods as when the secondary drive chain is checked.

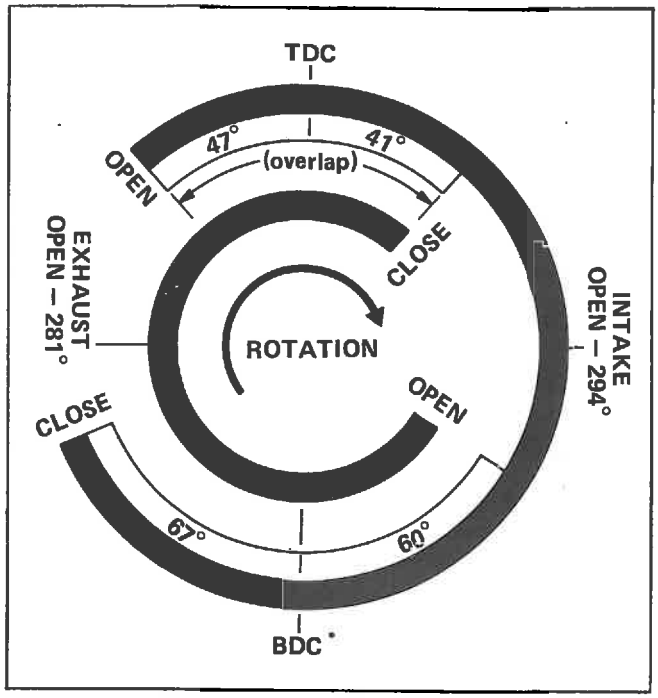
4. Camshaft

a) The XS650B engine uses a single overhead camshaft. All four cam lobes (2 intake and 2 exhaust) are located on one shaft. The cam lobes have been specially tempered to resist wear. The camshaft is connected to the crankshaft by a single row endless chain. Sprocket ratio is 2.1, which turns the camshaft at half crankshaft rpm. The camshaft is supported on top of the cylinder head by four single row ball bearings at each end.

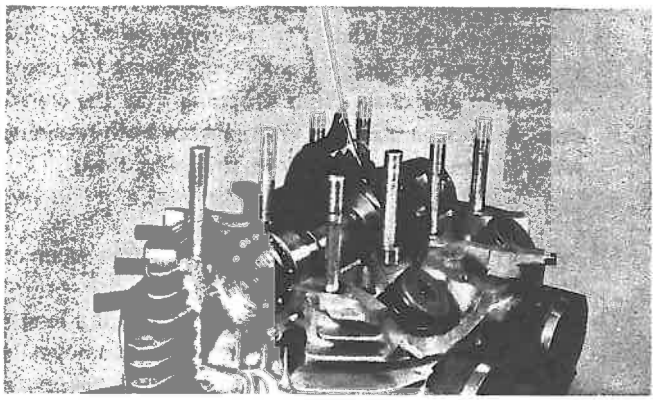


1. Needle bearing
2. Single row ball bearings (4)
3. Cam lobes
4. Governor mounting threads
5. Camshaft sprocket (34 teeth)

b) The ignition points fit against, but do not mount directly to, the left end of the camshaft. The camshaft right end is threaded and the ignition governor (centrifugal advance) unit mounts directly to this end. The shaft is hollow and the governor rod slips through this passage to link the governor unit with the ignition points unit. Each end of this drilled passage is fitted with a needle bearing to support the rod and a small labyrinth seal to prevent governor rod lubricating oil from leaking into both units; especially the ignition points unit.



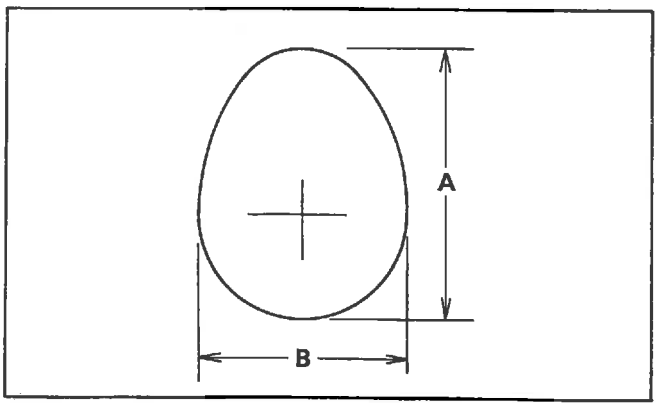
c) The intake valve open 47° before top dead center and closes 67° after bottom dead center, which means the intake valve is held open 294°. The exhaust valve opens 60° before bottom dead center and closes 41° after top dead center. It remains open for a duration of 281°. At one point during cam rotation, both the intake and the exhaust valve closes.



5. Camshaft Removal
   a) With the camshaft drive chain removed (or held away by safety wire), the camshaft can be lifted out of the head.
6. Camshaft Wear
   a) The cam lobe metal surface may have a blue discoloration due to excessive friction. The metal surface could also start to flake off or become pitted. This is due to poor lubrication, incorrect clearances (from poor adjustment or valve bounce), or due to normal wear.

	Cam Lift (A)		Base Circle Diameter (B)	
	Standard Value	Wear Limit	Standard Value	Wear Limit
Intake	39.99 ± 0.05	39.88	32.24 ± 0.05	32.02
Exhaust	40.03 ± 0.05	39.88	32.30 ± 0.05	32.15

b) If any of the above wear conditions are readily visible, the camshaft should be replaced. Also, the corresponding rocker arm contacting surface should be checked for similar wear and replaced if obvious wear is noted.
c) Even though the cam lobe surface appears to be in satisfactory condition, the lobes should be measured with a micrometer. Cam lobe wear can occur without scarring the surface. If this wear exceeds a predetermined amount, valve timing and lift are affected. Replace the camshaft if wear exceeds the limits listed.



d) All camshaft bearings should be removed, cleaned, dried, and the races visually checked for pits, rust spots or chatter marks where the balls have dragged. If any of these conditions exists the bearing(s) should be replaced.

Note:

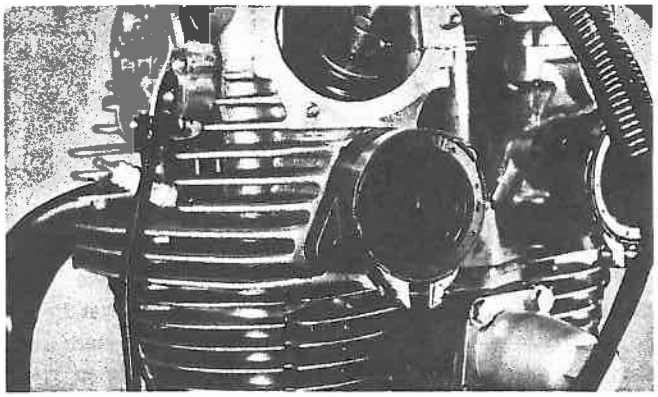
Lubricate the bearings immediately after examining them to prevent rust formation.

7. Carburetor Manifold Removal

The rubber manifolds are secured to the head by two Allen-head screws each. Remove the screws and the manifolds.

8. Cylinder Head Removal

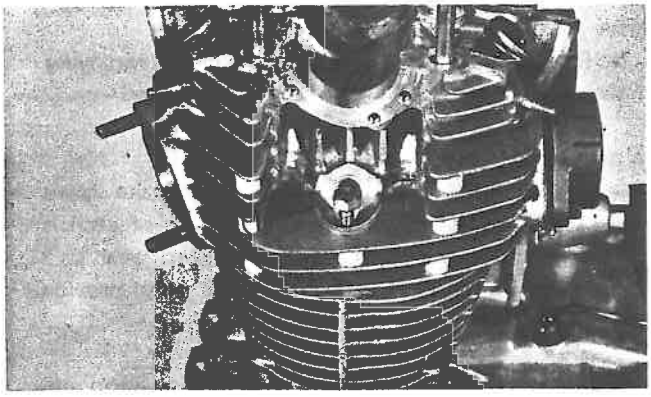
a) The head is now held in place by two hex-head screws (#1) beneath each spark plug hole and one 6 mm. screw (#2) which is located between the intake manifolds. Remove the bolts and slide the cylinder head up over the studs. While performing this operation, hold the safety wires to the cam chain so it does not fall into the crankcase.

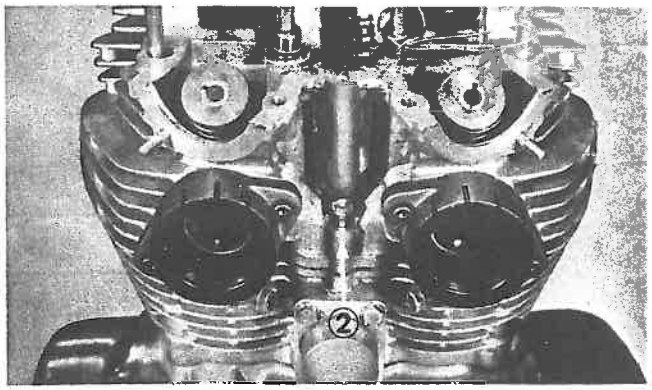


9. Cylinder Head Wear

a) There must be no head warpage. Clean the head thoroughly with solvent, dry it, and lay it on a machined surface plate. If warpage is extreme, the head will rock back and forth. Check for lesser warpage by running a 0.001" – 0.002" feeler gauge under the head mating surface. If the gauge slips in between the head and the surface plate anywhere around the perimeter, then the head must be re-surfaced.

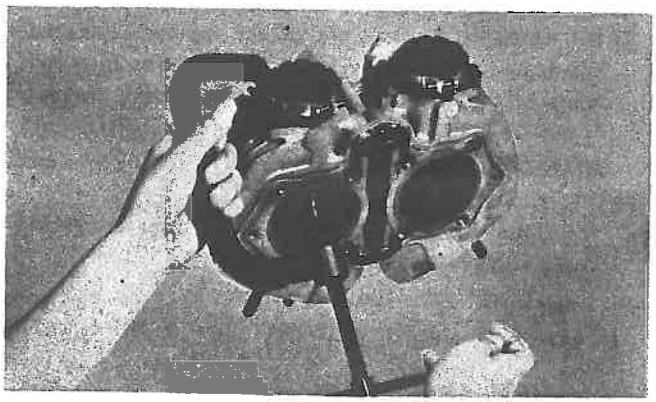
b) Place a sheet of #400 grit emery paper on the surface plate and slide the head mating surface across this paper in a figure 8 pattern to remove any measureable warpage. If more than 0.0025" needs to be removed, the head should be taken to a machine shop for milling.





10. Valve Removal

a) A valve spring compressor is available in the Special Tool kit. Compress the valve spring and then remove both keepers. Remove the compressor and lift off the collar and springs.



Note:

The keepers might be partially stuck in the collar. Use a rubber hammer to tap the edge of the collar a few times to loosen the keepers.

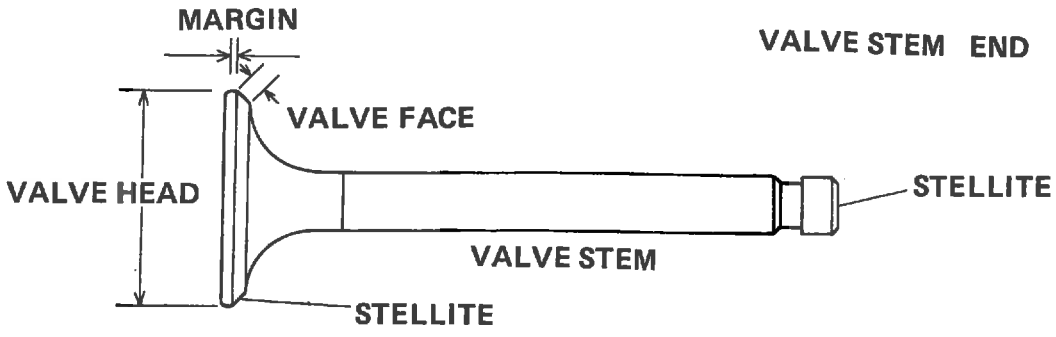
b) Pull the valve out. If the stem tip or keeper groove edges are slightly expanded, causing difficult removal, do not force the valve out as the valve guide inner diameter might be damaged. First, use a fine file to remove any lip that exists on the stem and then remove the valve.

Note:

Be sure to remove the valve stem seal before removing the valve. Otherwise the seal could be damaged.

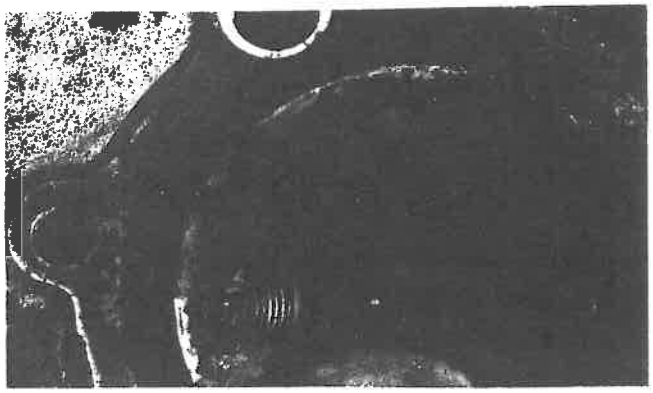
11. Valve Description

The head is equipped with four valves; two intake valves and two exhaust. The stem tip and valve face of each is plated with Stellite (hardened metal) to keep wear at a minimum. The intake valve diameters are larger to provide less restriction for the incoming fuel/air charge.



12. Decarbonization of the Head and Components

Carbon deposits build up in the combustion chambers, on the valves, and in the exhaust ports. Thoroughly clean all parts with a blunt scraper, then wash in solvent and dry with compressed air. The parts can then be examined and measured for wear.



Combustion chamber carbon deposits

13. Valve Wear

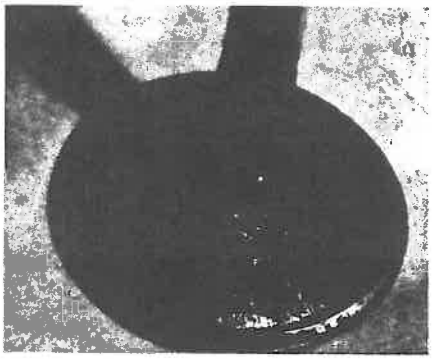
a) Check the valve stem tip for an indentation caused by the adjustor constantly striking the tip. If this indentation is 0.015 in. – 0.020 in. (0.4 – 0.5 mm.) deep, or more, then regrind the tip surface flat. Remove only the material necessary, no more. Use a commercial valve grinder with the appropriate adaptor mounted on it to grind the tip.

b) Valve stem wear must be measured and then combined with valve guide measurements to arrive at a stem-to-guide clearance. This clearance must be within the tolerances shown below. If it exceeds the maximum limit then replace either or both parts as required.

c) The valve should also be checked for a bent stem. Roll the stem along the edge of a surface plate and visually check for stem warpage. Replace the valve if any warpage exists.

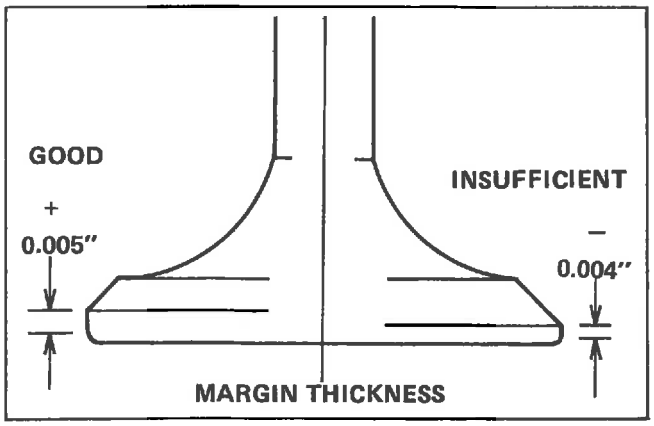
Note:

When checking the stem for warpage, be sure all carbon has been cleaned off.
Otherwise, an accurate check cannot be made.



Valve carbon deposits

d) Check the valve for pits, carbon deposits, warpage (including the entire head), and actual chips broken off the margin. If warpage exists or if the surface is chipped, replace the valve. If it is just pitted and/or carboned up, lap it to the valve seat. If it does not clean up by lapping then use a mechanical grinder to resurface the valve face. After grinding, check valve margin thickness. If it has been reduced to a sharp edge because of grinding, the valve should be replaced as this thin edged margin can readily heat up and cause pre-ignition.

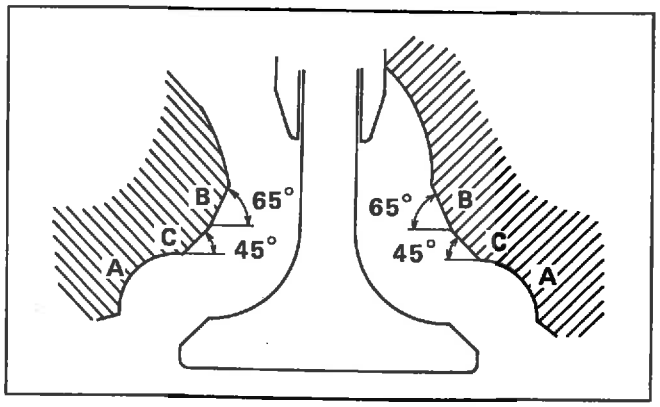


e) Check the stem for scratches. These occur when carbon collects in the valve guide and then hardens. As the stem continually rubs against this hard carbon, scratches are worn in the stem. Replace the valve if deep scratches are found.

	Original Clearance	Replacement Clearance
Intake	0.020 – 0.044 mm.	0.100 mm.
Exhaust	0.035 – 0.059 mm.	0.120 mm.

14. Grinding the Valve Seat

a) The valve seat is subject to severe wear similar to the valve face. Whenever the valve face is resurfaced, the valve seat should also be resurfaced at a 45° angle. In addition, if a new valve guide has been installed (without any valve repair), the valve seat should be checked to guarantee complete sealing between the valve face and seat.



Caution:

If the valve seat is obviously pitted or worn, it should be cleaned with a valve seat cutter. Use the 45° cutter, and when twisting the cutter, keep an an even downward pressure to prevent chatter marks.

If cutting section 'A' of the intake valve seat, use cutter 8R (radius cutter). If cutting section 'A' of the exhaust valve seat, use cutter 8R (also radiused).

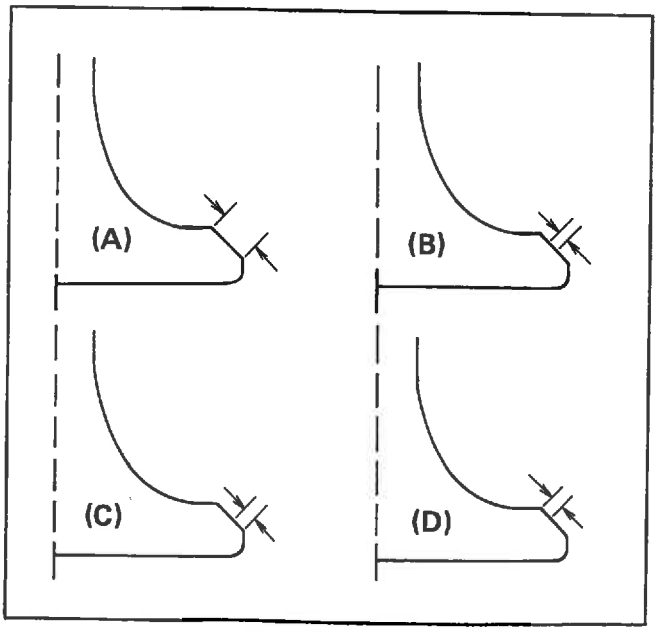
If cutting section 'B', use the 65° cutter.

If cutting section 'C', use the 45° cutter.

b) Measure valve seat width. Apply mechanic's bluing dye (such as Dykem) to the valve face, apply a very small amount of fine grinding compound around the surface of the valve seat, insert the valve into position, and spin the valve quickly back and forth. Lift the valve, clean off all grinding compound, and check valve seat width. The valve seat will have removed the blueing wherever it contacted the valve face.
Measure the seat width with vernier calipers. It should measure approximately 0.05 in. (1.3 mm.). Also, the seat should be uniform in contact area. If valve seat width varies, or if pits still exist, then continue to cut with the 45° cutter. Remove just enough material to achieve a satisfactory seat.

	Standard Width	Wear Limit
Seat Width	0.051 in. (1.3 mm.)	0.078 in. (2.0 mm.)

c) If the valve seat is uniform around the perimeter of the valve face, but is too wide or not centered on the valve face, it must be altered. Use either the "R" (radius), 45°, or 65° cutters to correct the improper seat location in the manner described below:



(A) If the valve face shows that the valve seat is centered on the valve face, but too wide, then lightly use both the "R" and the 65° cutters to reduce the seat width to 0.05 in. (1.3 mm.).

(B) If the seat shows to be in the middle of the valve face, but too narrow, use the 45° cutter until the width equals 0.05 in. (1.3 mm.).

(C) If the seat is too narrow, and right up near the valve margin, then first use the "R" cutter and then the 45° cutter to get the correct seat width.

(D) If the seat is too narrow and down near to bottom edge of the valve face, then first use the 65° cutter and then the 45° cutter.

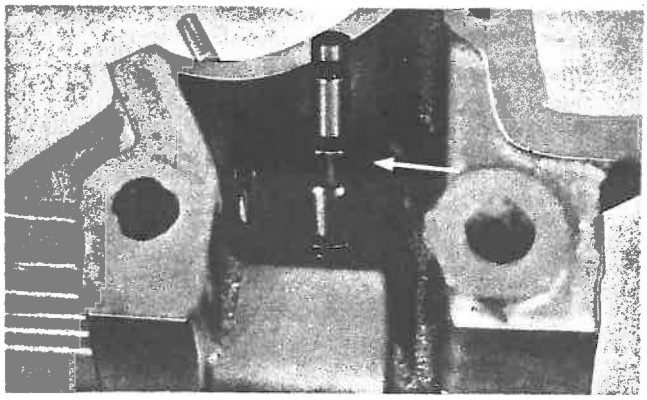
15. Lapping the Valve/Valve Seat Assembly
   a) The valve-valve seat assembly should be lapped if, (1) neither the seat nor the valve face are severely worn, or: (2) if the valve face and valve seat have been resurfaced and now require a final light grinding operation for perfect sealing.
   b) Apply a small amount of coarse lapping compound to the valve face. Insert the valve into the head. Rotate the valve until there is a burnished spot all the way around the valve face. Clean off the coarse compound, then follow the same procedure with fine compound. Continue lapping until the valve face shows a complete and smooth surface all the way around. Clean off all compound material. Apply bluing dye to the valve face and rotate the valve face for full seat contact which is indicated by a shiny surface all around the valve face where the bluing has been rubbed away.

   Note:

   The valve can most easily be rotated if a section of flexible rubber hose of 5/16" ID is slipped over the valve stem and spun.

16. Valve Leakage Check
   a) After all work has been performed on the valve and valve seat, and all head parts have been assembled, check for proper valve seat sealing by pouring solvent into each of the intake ports, then the exhaust ports. There should be no leakage by the seat. If this fluid leaks, disassemble the valve assembly and continue to lap with fine compound. Clean all parts thoroughly, reassemble and check again with solvent. Repeat this procedure as often as necessary to obtain a satisfactory seal.

17. Valve Stem Seal
   a) This seal slips down over the valve stem to prevent excessive amounts of oil from passing down the stem and into the combustion chamber. If this seal is cracked, split, or hardened, replace it.

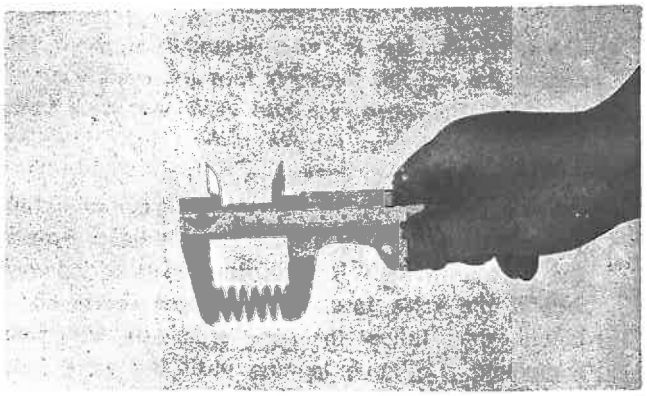


18. Valve Spring
   a) The 650 series engine use two springs of different size to prevent valve float or surging.
   The chart below shows the basic value characteristics.

	OUTER	INNER
Diameter of Wire	4.5 mm.	2.9 mm.
Direction of Winding	Right Hand	Left Hand
Total Windings	6.0	7.25
Free Length	41.8 mm.	41.0 mm.
Installed Length (Valve Closed)	37 mm.	35 mm.
Installed Pressure	20.1 kgs. (44 lbs.)	9.7 kgs. (20 lbs.)
* Compressed Length (Valve Open)	27.8 mm.	25.8 mm.
Compressed Pressure	60.0 kgs. (132 lbs.)	25 kgs. (55 lbs.)

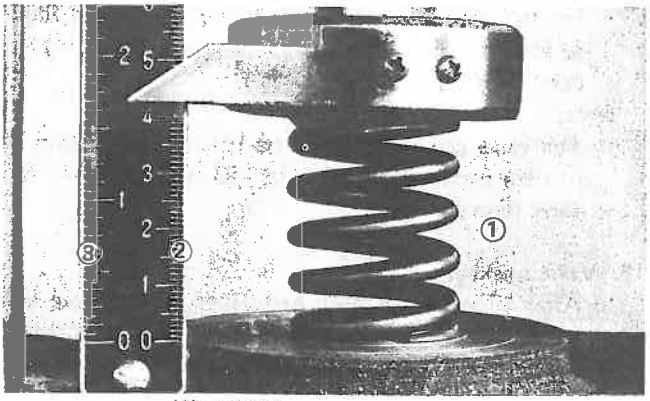
* Measured without collar
All measurements ± three percent.

b) Even though the spring is constructed of durable spring steel, it gradually loses some of its tension. This is evidenced one way by a gradual shortening free length. Use a vernier caliper to measure spring free length. If the free length of any spring has reduced more than 0.080 in. (2 mm.) from its specification, replace it.



c) Another symptom of a fatigued spring is insufficient spring pressure when compressed. This can be checked using a valve spring compression rate gauge.

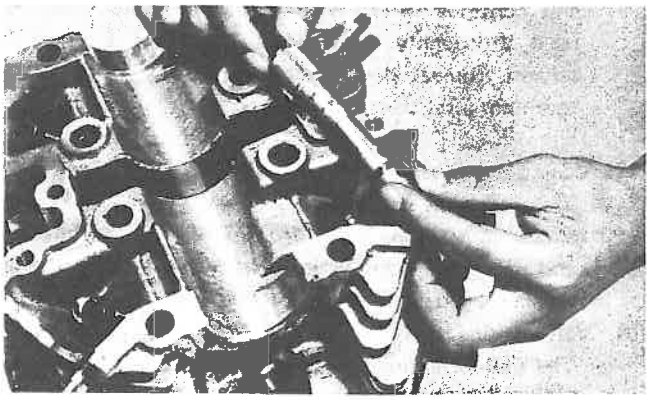
Test each spring individually. Place it in the gauge and compress the spring first to the specified compressed length with the valve closed (all spring specifications can be found in previous section, Valve Spring) then to the length with the valve open. Note the poundage indicated on the scale at each setting. This procedure must be performed on the outer springs, then the inner springs.



(1) Individual spring
(2) Length measuring scale
(3) Pounds pressure scale

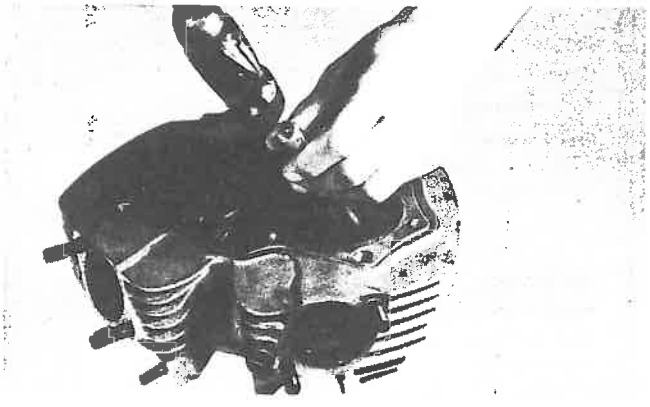
19. Valve Guide

a) The inside diameter must be measured with a ball gauge. Measure at each end and in the center of the drilled passage. Compare this measurement, using the largest measurement of these spots, with factory specifications listed in Valve Description. If this measurement exceeds the maximum tolerance, replace the guide.



b) The valve guide is replaceable. It is held in the head by an interference fit of approximately 0.0015" (0.04mm). To ease guide removal and reinstallation, and to maintain the correct interference fit, heat the head to 200 ~ 400° Farenheit. If possible, use an oven to avoid any possibility of head warpage due to uneven heating.

c) Use the appropriate shouldered drift (Special Tools Kit) to drive the old guide out and the new guide in.



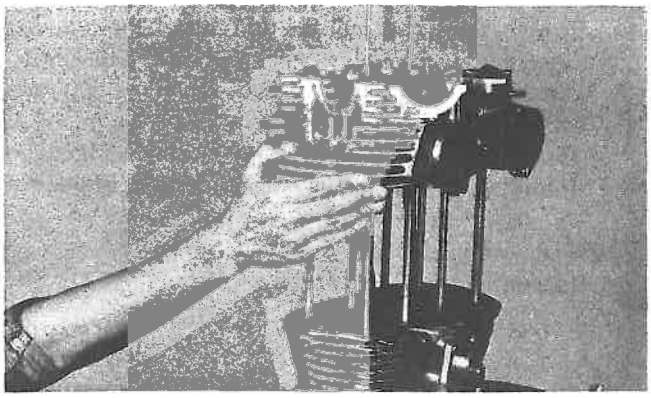
CAUTION:
The valve guides which are sold as spare parts are oversizes, and therefore, when replacing a valve guide, the valve guide hole in the cylinder head must be bored by a reamer.

After fitting the valve guide into the cylinder head, be sure to grind the valve seat, and perform valve lapping.
The valve must be replaced by a new one.

	Reamer outside diameter	Bushing outside diameter
1st oversize	15.1 $^{+0.015}_{+0.007}$ mm.	15.1 $^{+0.063}_{+0.045}$ mm.
	0.5952 $^{+0.00059}_{+0.00027}$ in.	0.5952 $^{+0.00247}_{+0.00177}$ in.
2nd oversize	15.2 $^{+0.015}_{+0.007}$ mm.	15.2 $^{+0.063}_{+0.045}$ mm.
	0.5992 $^{+0.00059}_{+0.00027}$ in.	0.5992 $^{+0.00247}_{+0.00177}$ in.

20. Installing the Head
    a) A new head gasket must be installed. The gasket can correctly fit only one way. Slip the cylinder head over the studs and onto the cylinder.
    b) While performing this step, push the cam chain safety wires up through the slot in the head and pull the cam chain up. Install and tighten both retaining bolts and the one 6 mm. screw.

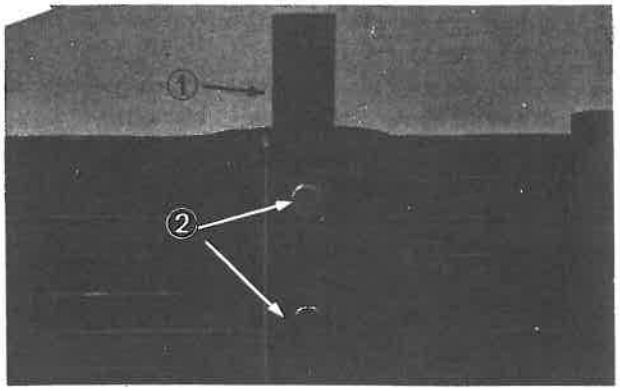
    Note:
    After completing this phase, plug the spark plug holes to prevent anything from dropping into the cylinder.



Cam Chain Vibration Dampener (Opposite the tensioner)

a) This rubber dampener (1) prevents the cam chain from bowing out because of chain weight and engine rpm. It is located in the hollow cavity between the cylinders and to the front, opposite the tensioner. It receives little abuse from the chain and should last indefinitely. However if the cam chain loosens sufficiently to rub hard against the rubber dampener, it could wear out. It is held in place by two bolts (2) at the front of the cylinder. Remove these two bolts and lift the dampener out.

b) After completing the cam chain adjustment, recheck the rotor timing mark and cam sprocket timing groove positions to guarantee that they did not rotate out of position during chain installation.

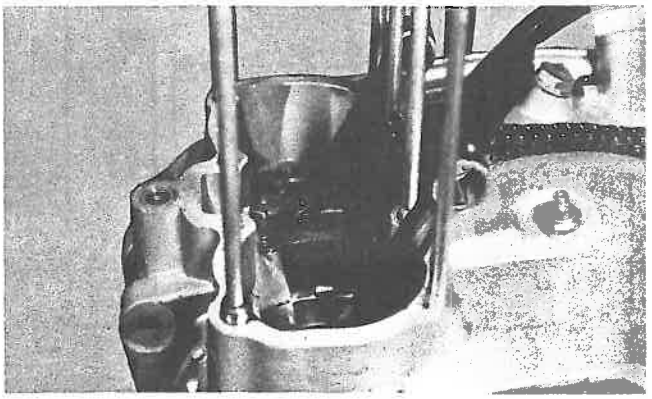


(1) Dampener
(2) Set screw

Cam Chain Vibration Dampener (in engine case)

a) The rubber faced dampener supports the cam chain, helping to keep it running straight between the camshaft sprocket and crankshaft sprocket.

b) The entire unit mounts in the top engine case half; in the center cavity between the two pistons. Remove the four securing screws and (after the cylinders are removed) the unit can be removed.
Check for tearing or excessive wear.
c) Note the position of the two slotted screws, these have a tapered shoulder for proper location in the cases, during reassembly replace as shown.



21. Chain Tensioner

a) The chain tensioner consists of a steel based rubber that is held against the cam chain by a spring and a locked in-place push rod. This slider takes up any free play in the chain. In addition, a rubber dampener solidly mounted to the tensioner arm, just below the steel wheel, helps to guide the cam chain. Because of gradual chain wear, an adjustment is required periodically.

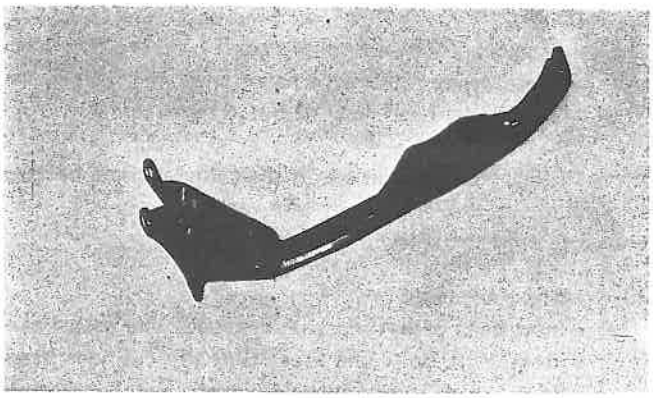
b) Four 6 mm. bolts hold the tensioner housing in place. Remove these and pull the unit out of the cylinder.

c) Reverse this procedure to install the unit. During installation, install a new gasket coated on both sides with Yamaha Bond #4.

d) Rotate crankshaft in a counterclockwise direction (from the left side of the engine) to place all slack in the area of the chain tensioner.

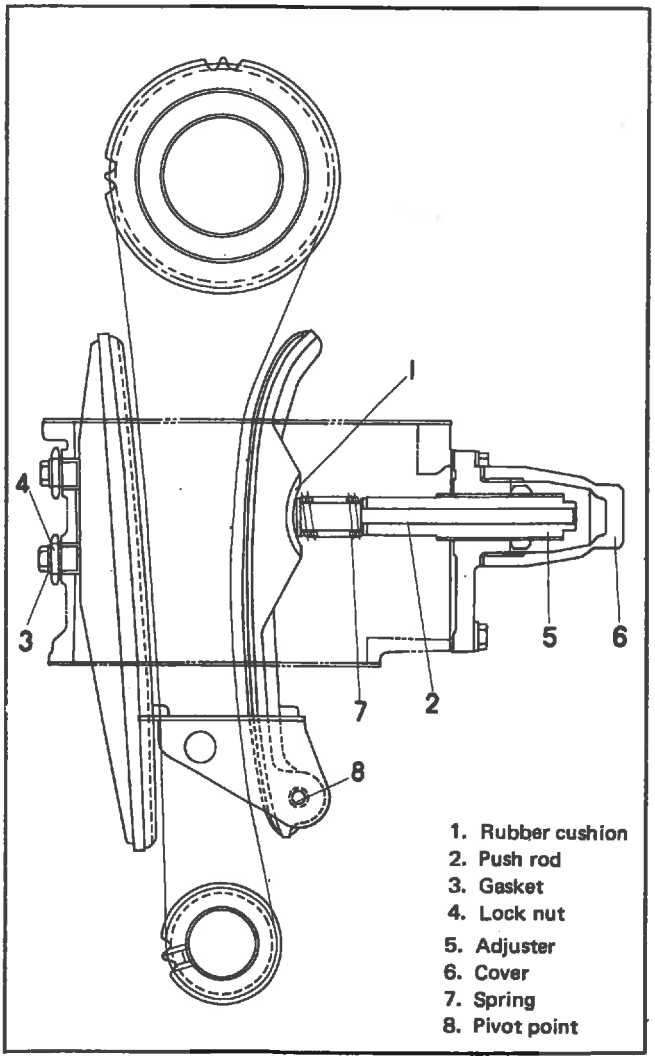
e) Remove the cast metal protective cover.

f) Loosen the tensioner lock nut.



g) Use a 22 mm. wrench to turn the adjuster in until the push rod (inside adjuster) is flush with the end of the adjuster.

h) Tighten the rock nut and install the cover. Check this adjustment every 2,000 miles. (3,000 kms.)

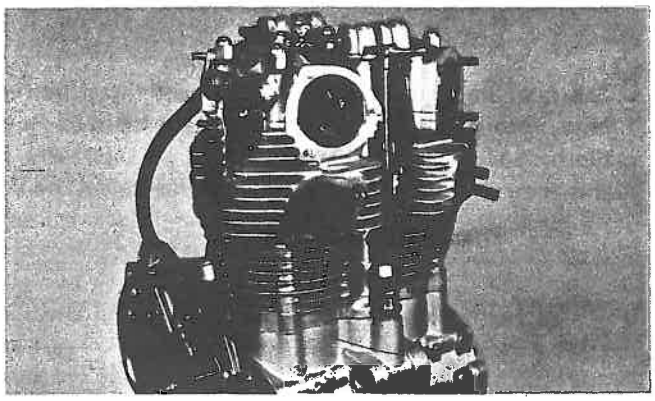


3-7. CYLINDER & PISTON ASSEMBLY

The cylinder is constructed of aluminum with cast iron sleeves. It has a cavity down the center of the cylinder that serves two purposes. First, it provides a channel for the cam chain to run in between the camshaft and the crankshaft. Secondly, it provides a space for air circulation that aids in cooling both cylinders.

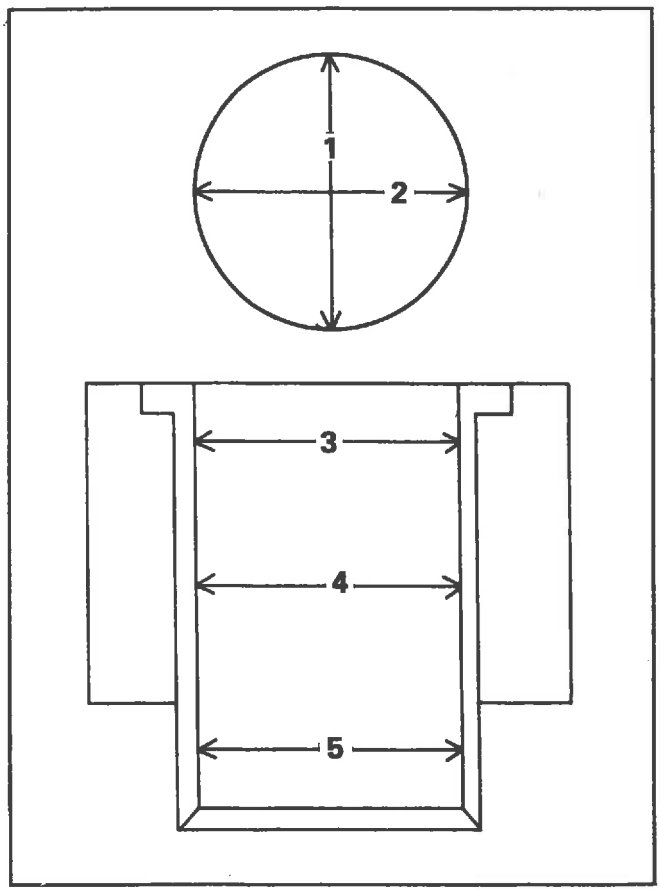
A. Removing the Oil Line Fitting

With the head cover and cylinder head removed, remove the oil line fitting at the front base of the cylinder. The cylinder is now free to be lifted off. The cylinder might have to be tapped a few times with a rubber hammer to break the base gasket adhesion. As the cylinder is lifted for removal, place shop rags in the crankcase opening beneath both pistons to keep any contamination or parts (such as circlips) from dropping into the crankcase.

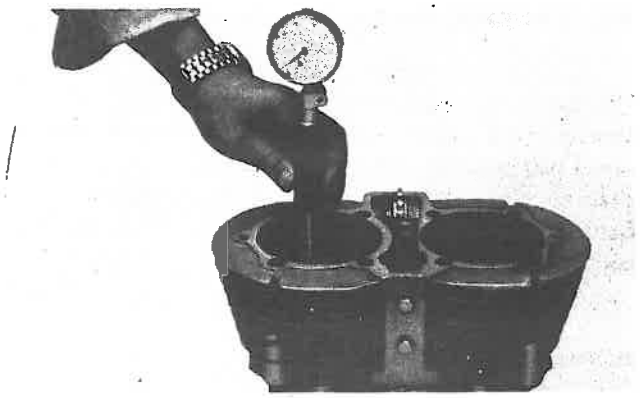


B. Cylinder Wear and Repair Procedures

1. Constant friction between the bore and piston, plus microscopic particles of contamination that enter through the intake, cause a gradual wear of the bore. This wear can be detected by measuring various points in the bore and comparing these measurements against standard specifications.
2. This drawing shows the places to take bore measurements with a cylinder measuring gauge (tool available through Yamaha International).



3. Subtract the bottom bore measurement from the top bore measurement. The difference between these two dimensions is called the "cylinder taper". Check to see if the amount of taper is still within specified limits.



	Standard	Wear Limit
Cylinder Bore (mm.)	75.0	75.1
Cylinder Tape (mm.)	0.005	0.05

4. The bore might be lightly damaged with scratches or nicks. Run a hone through the bore a few times to see if the bore cleans up. If these scratches are too severe, a hone cannot remove them, and a cylinder rebore would be necessary. (Pistons are available in four oversizes: 0.25 mm., 0.50 mm., 0.75 mm. and 1.0 mm.)

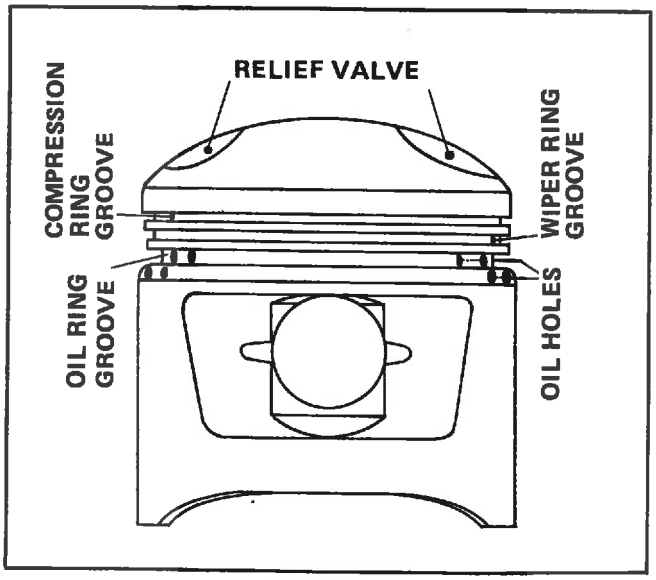
Note:

The hone should be used in a low rpm. drill and the hone should be moved through the entire bore at an even speed. This should result in a "crosshatch" pattern which aids ring seating.

C. Piston

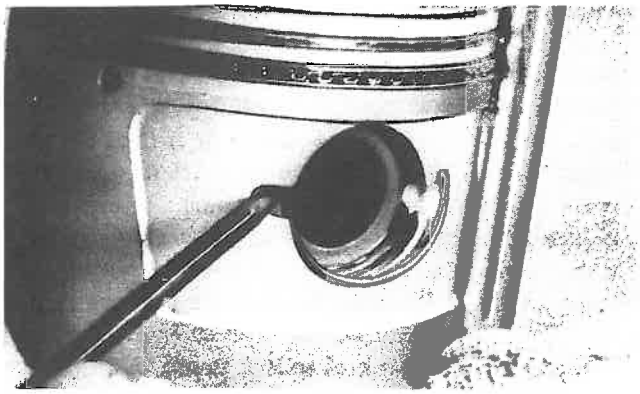
The piston crown is domed. It also has two relief areas for valve head clearance during engine operation. The relief areas are unequal in size since the intake valve is larger than the exhaust valve. An arrow is stamped on the crown to indicate piston position for installation. The piston should be installed with the arrow pointing forward.

Oil drain holes have been drilled in the oil scraper ring groove and in the piston wall just beneath the bottom groove. This provides an escape path for oil scraped off the cylinder wall. It also provides a path for lubrication of the piston pin and bearing.



D. Piston Removal

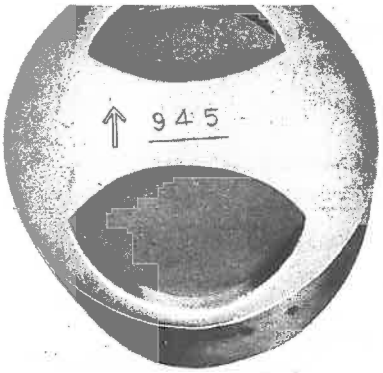
1. Remove the outer circlip from each piston. Support the piston by hand and push out the piston pin using a soft drift (do not use a hammer). Lift the piston off and set it to one side with the piston pin and needle bearing.



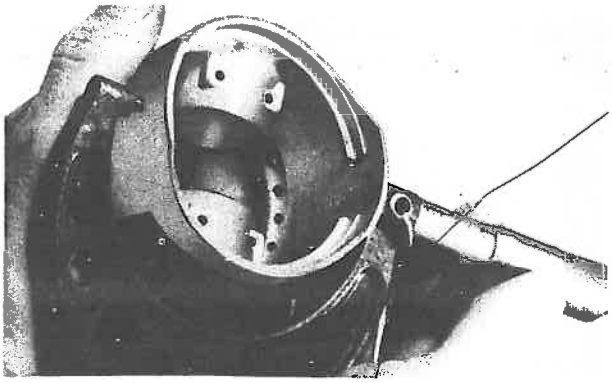
2. Each piston must be marked as to which cylinder it came from to ensure identical match-up during re-installation. Lightly scribe an "L" inside the left piston skirt and an "R" inside the right piston skirt.

E. Piston Wear

1. First, check the piston for cracked or broken sections, including the crown, ring lands, and skirt. Also check the piston crown for possible metal disintegration due to excessive heat in the combustion chamber.
2. If severe score marks are found on the skirt, this can be attributed to insufficient lubrication sometime during engine operation or improper clearance. If these marks can be removed with fine emery cloth the piston can be used again.
3. All of the above wear conditions may require piston replacement (except as noted). If a defective piston is reinstalled, the engine will not perform satisfactorily and premature engine failure may occur.
4. Check for additional wear by measuring piston diameter 0.75 in. (20 mm.) from the bottom of the skirt and at right angles to the piston pin holes. Piston standard size is 2.95 ins. (75 mm.).
5. Standard piston wear usually does not exceed 0.2 mm. This measurement is important when determining piston-to-cylinder clearance.



Piston size mark



Measuring maximum piston diameter

F. Piston Clearance

1. Piston-to-bore clearance is the difference between minimum cylinder bore measurement and maximum piston diameter. Standard clearance is 0.0020 in. – 0.0022 in. (0.050 – 0.055 mm.). If measurements prove that the clearance equals 0.10 mm. or more, it is excessive, and one of two corrective measures must be taken to bring the clearance back within tolerances.
2. If cylinder taper is within tolerances, and if the cylinder can be cleaned up by honing, then obtain a larger size standard piston that is large enough to obtain the correct clearance.
3. Bore and hone out the cylinder to the size of a first oversize piston, plus the correct clearance.
4. How to Calculate Standard Size Piston-to-Cylinder Clearance from Stamped Numbers
   Nominal piston standard size is 75 mm. The number stamped on the piston crown is the actual size. (The 74 is dropped.)

Example:

0.956 on crown really means 74.954 mm. piston diameter, or 0.046 mm. undersize.
Cylinder standard bore size is marked in large numbers on the very bottom of the cylinder. It equals 75 mm. plus the amount marked.

Example:

0.007 marked on cylinder really means 75.007 mm. cylinder bore, or 0.007 mm oversize.
If the above piston is used with this cylinder, total clearance would be 0.0021 in. (0.053 mm.).

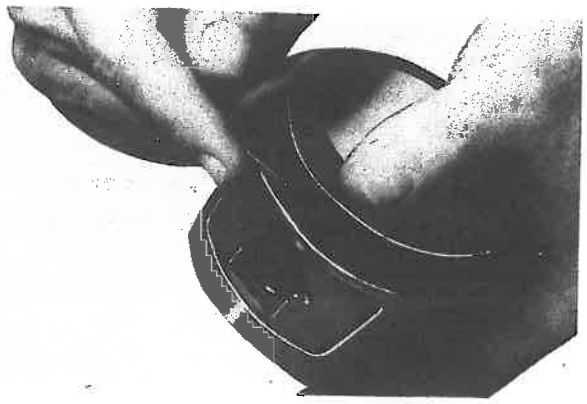
Example:

75.007 mm. (Cylinder)
–74.954 mm. (Piston)

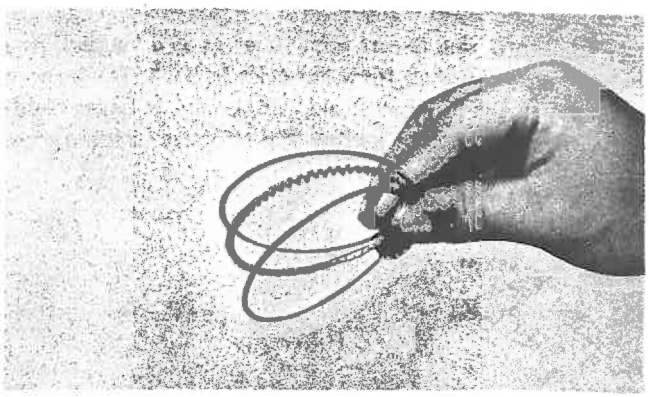
0.053 mm. (Clearance)

G. Cleaning Piston Ring Grooves

1. Carbon and varnish gradually build up in the ring grooves. Remove the rings and use the blunt end of a discarded ring to clean all carbon from the grooves. The oil ring (bottom) should not require this procedure. Check to make sure the oil relief holes are not blocked.



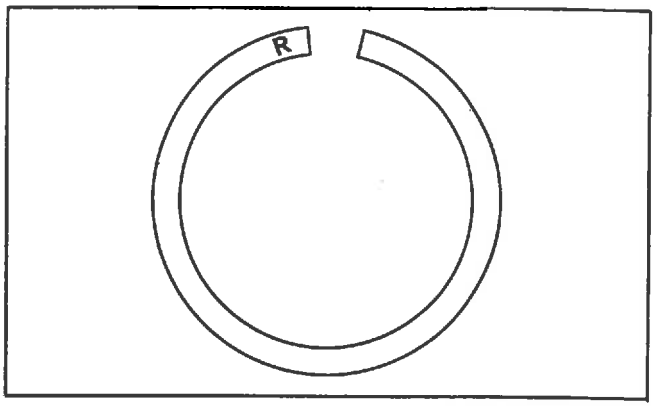
H. Piston Ring Removal and Installation



The piston is equipped with three rings. Remove them in sequence, starting with the top ring. Installation of these rings is basically a reversal of the above process, except for the bottom (oil control) ring.

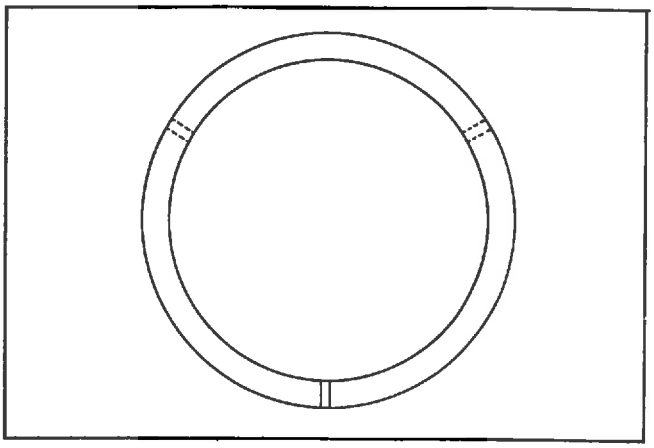
1. Oil control Ring Installation (Installed first):
   The oil control ring consists of three separate parts, two identical rails and one expanding spacer. First, slip the spacer over the piston, and into the bottom groove. Neither rail has a particular top side. So install one rail into the bottom part of the groove and then position the last rail, either side up, into the top part of the groove. Finally, position the three end gaps approximately 120° from each other.

2. Middle and Top Ring Installation:
   Install the middle ring and top ring. Each ring is stamped with an "R" on one side that must face up toward the piston crown when installed.

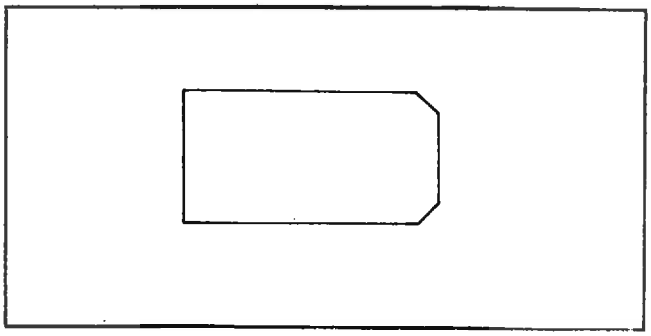


3. Spacing of All Ring End Gaps:
   All ring end gaps must be off-set from one another to prevent the leakage of compression and oil.
   Stagger their positions evenly around the perimeter of the piston.

Note:
The oil control ring has three gaps. Use the top rail's gap to judge where the compression and wiper ring gaps should be aligned.

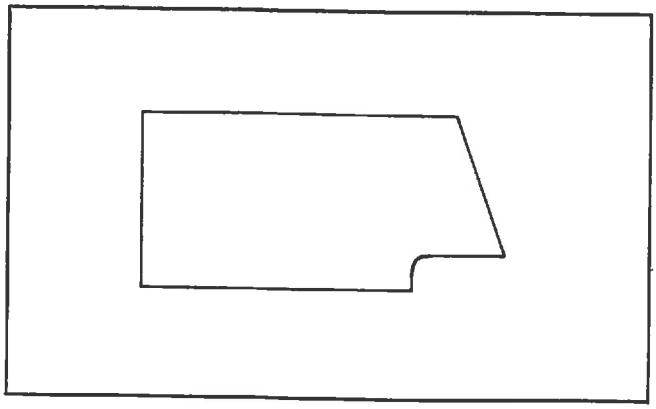


I. Piston Ring Description

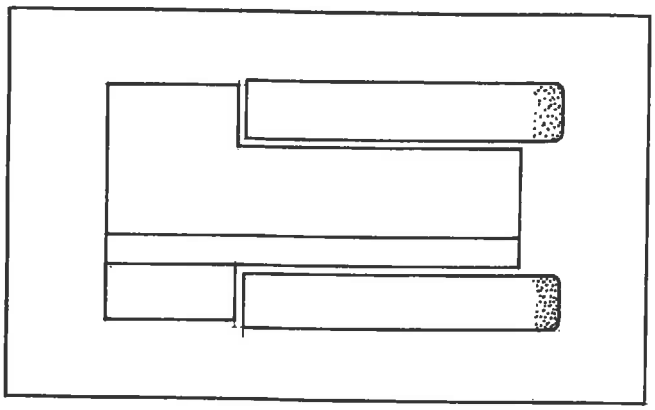


1. Top ring:
   This is the compression ring. It must provide efficient sealing and must be able to withstand the greatest amount of heat. The outer edge is chrome-plated for wear and heat resistance. Both outer edges of this ring are beveled (see the drawing of ring cross-sectional view) to provide a good compression sealing edge.

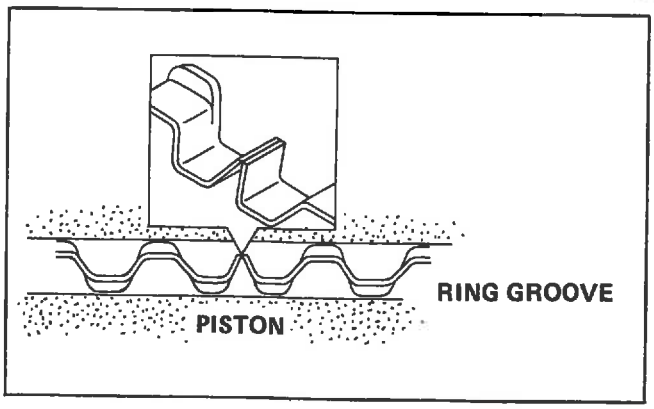
2. Middle ring:
This second ring is cast iron. It serves as a "wiper" ring to scrape excess oil from the cylinder wall. The bottom of the ring is notched to aid this process. It flexes slightly, which provides a narrow and effective scraping edge.



3. Bottom ring:
This ring's purpose is to trap and remove oil from the cylinder wall. The ring consists of three separate components: top and bottom spring steel rails, and a stainless steel wave type expanding spacer. Oil is trapped between the two rails and is forced out the holes drilled in the piston ring groove. The rail outer edge is chrome-plated to resist wear.



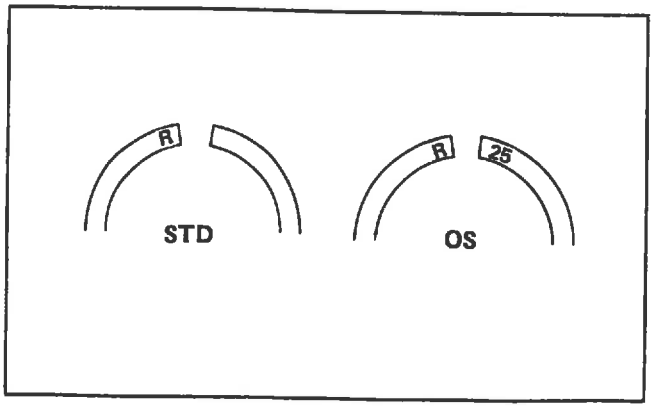
4. The expander spacer, because of its design, pushes both rails against the ring groove sides. In addition, the spacer is equipped with a projecting inner lip that pushes both rails out, creating an excellent oil trapping action.



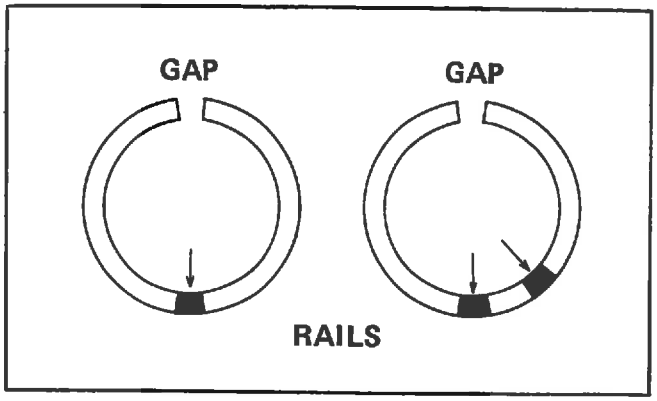
J Piston Ring (standard and oversize) Identification Code

1. The oversize top and middle ring sizes are stamped on top of the ring.

SIZE (mm.)		MARK
Standard		None
Oversize	1st	25
	2nd	50
	3rd	75
	4th	100



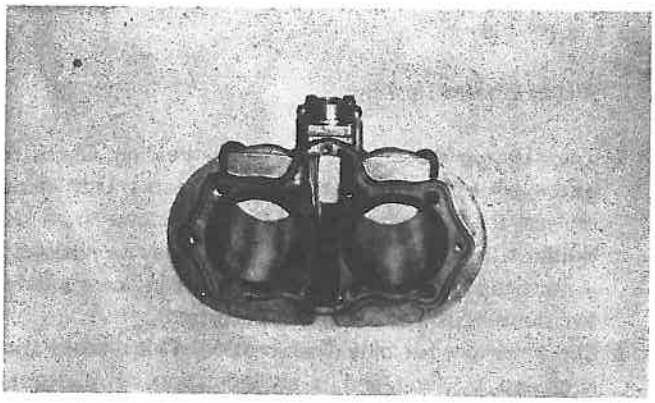
2. All three pieces of the bottom ring (oil control) are color-coded to identify sizes. The color marks are painted on the ring, 180° opposite the end gap (see below).



SIZE		COLOR	
Standard		Blue	(1 mark)
Oversize 1st	25 (0.25 mm.)	Blue	(2 marks)
2nd	50 (0.50 mm.)	Red	(1 mark)
3rd	75 (0.75 mm.)	Red	(2 marks)
4th	100 (1.0 mm.)	Yellow	(1 mark)

K. Piston Ring Wear

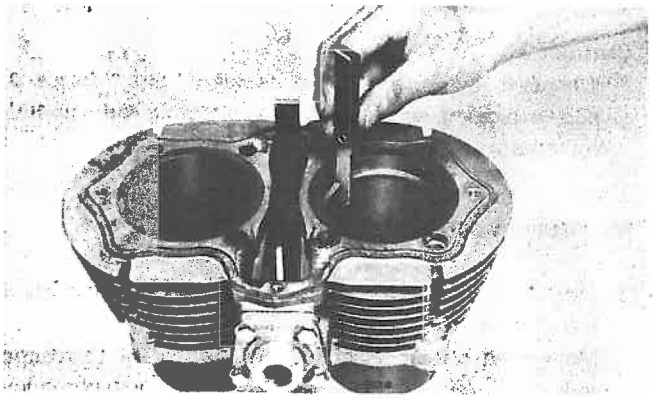
1. All three rings experience the same type of wear. Any check applied to one ring can be used to also test the others.
2. Before checking for wear, clean all carbon from the ring surface. This insures an accurate wear check.
3. Check for gaps between the ring contacting edge and the cylinder wall. Push the ring into the bore (with an inverted piston to make sure it is not cocked). Slip a piece of white paper beneath the cylinder bore (for visual contrast) and check the outer perimeter for visible gaps between the ring and the cylinder wall.



4. With the ring still positioned in the bore, check and gap clearance with a feeler gauge. Standard specifications and maximum wear limits are listed below.

Note:

The end gap on the expander spacer of the oil control ring is unmeasurable. If the oil control ring rail(s) show excessive gap all three components should be replaced.



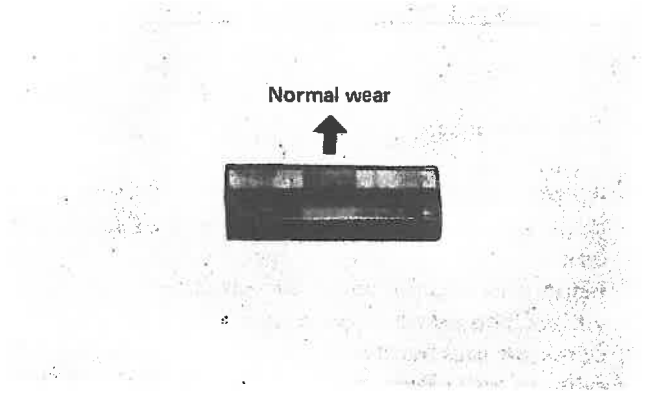
	Standard Gap (mm.)	Wear Limit
Compression Ring	0.2 – 0.4	0.8
Wiper Ring	0.2 – 0.4	0.8
Oil Control (Rails)	0.3 – 0.6	1.0

5. Piston ring/ring groove fit must have correct clearance. If the piston and ring have already been used in the engine, the ring must be removed, the ring groove cleaned of carbon, and then the ring should be reinstalled. Use a feeler gauge to measure the gap between the ring and the land. The standard tolerance is 0.0016 in. (0.04 mm.) to 0.0032 in. (0.08 mm.). The wear limit is 0.006 in. (0.15 mm.).

6. **Note:** There must be no side gap clearance at all on the oil control ring. If any clearance exists, the expander spacer has become fatigued. Replace the ring.
7. If any of the previous three wear checks prove any of the rings to be worn beyond acceptable tolerances, replace the entire set.

Caution:

Whether the rings are new or used, they must always be checked for correct ring end gap clearances. This applies to all three piston rings.



L. Piston Pin and Bearing

1. The piston pin oscillates in a needle bearing. Check the piston pin surface for needle bearing marks. If any exist, replace the pin and needle bearing. However, a dull finish at the center section of the pin may be noticed. It is normal operating wear and does not indicate a defective pin (unless this dull surface is pitted).
2. Check the pin for blue discoloration. This discoloration is caused by heat and is an indication of inadequate lubrication. The pin should be replaced and the lubrication system checked.

Caution:

Whenever the piston pin is replaced, also replace the needle bearing and check the connecting rod small end for wear which might require rod replacement.

M. Piston Installation

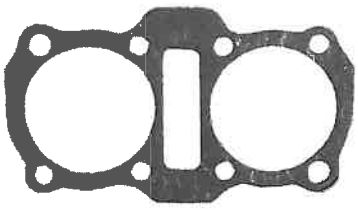
1. Lubricate the needle bearings with oil prior to piston installation.
2. Mount the piston (rings installed) onto the connecting rods. Be sure the arrow stamped on the piston crown points forward. Also make sure that the left piston (already marked during removal) is fitted to the left-hand connecting rod. This guarantees that all previous clearances remain unchanged unless new parts are installed or cylinder work is done.

Note:

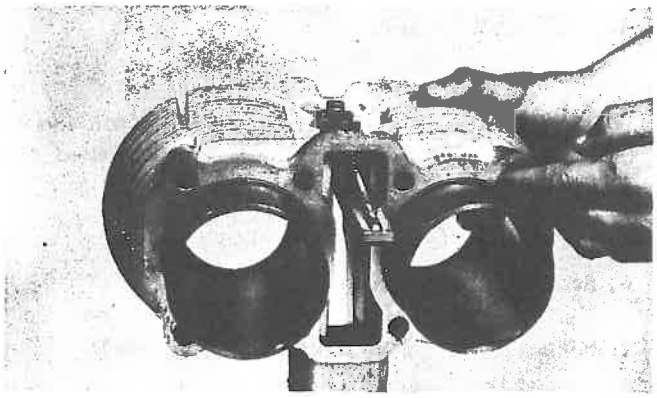
The piston pin should be a thumb-press fit into the piston. After the pin has been installed, lock it in place with two new circlips. Never use old circlips.

N. Cylinder Installation

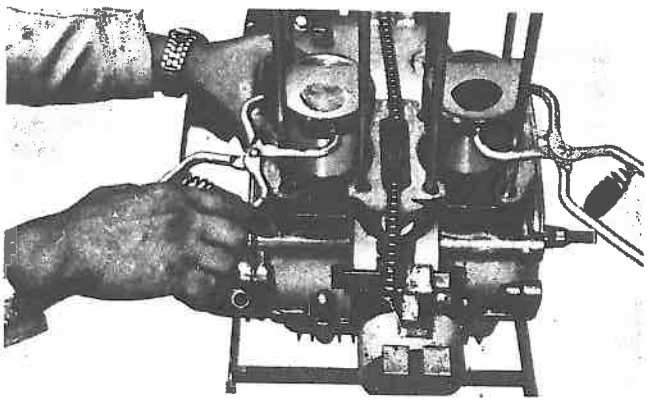
1. Make sure the crankcase and cylinder bottom matching surface are clean, then install a new base gasket.



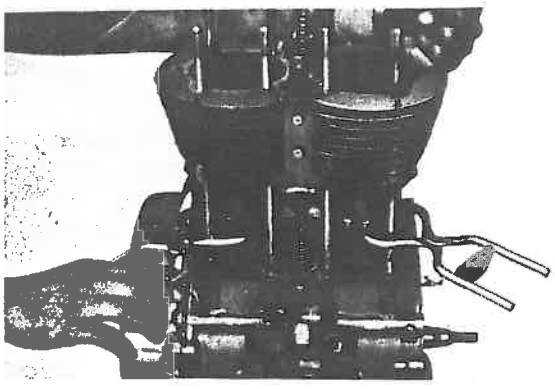
2. Check to see that the cylinder base O-rings are in place. Replace as necessary to avoid oil leakage.



3. Slip a piston support plate (found in Special Tool Kit) under each piston skirt. This prevents the pistons from being pushed down during cylinder installation. Place a rag under each base special tool to protect the new gasket.



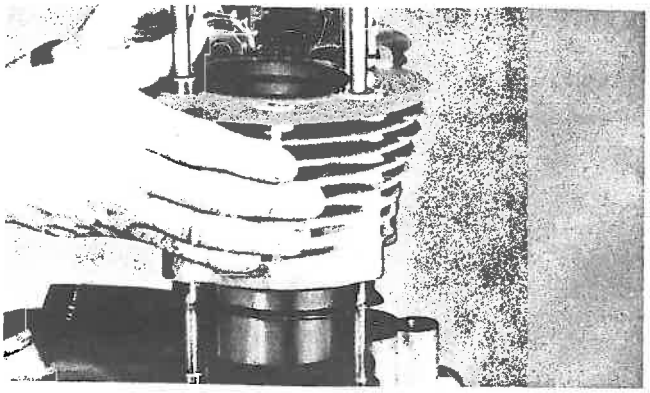
4. Lubricate the piston wrist pin bearing, and rings. Position and tighten the ring compressors (found in Special Tool Kit) so the rings can slip up into the cylinder without catching on the bottom of the cylinder. Lubricate both bores. Slip the cylinder down over the studs until it slips over the pistons and rests on the ring compressors.



5. Rotate the crankshaft so that the pistons slide up into the bores. Remove the ring compressors and piston bases, then push the cylinder down until it butts against the crankcase.

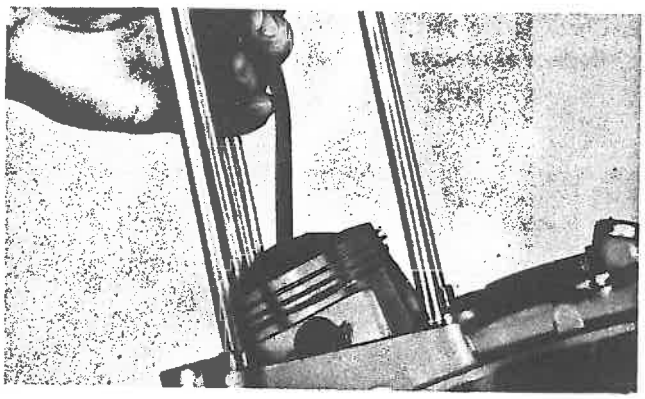
Note:

All parts should be well lubricated during assembly. When a newly rebuilt engine is started for the first time the oil supply passages will be empty and there will be a short period when no oil is delivered to various parts. It is a good idea to kick the engine over several times prior to starting to fill these passages.



3-8. CRANKCASES

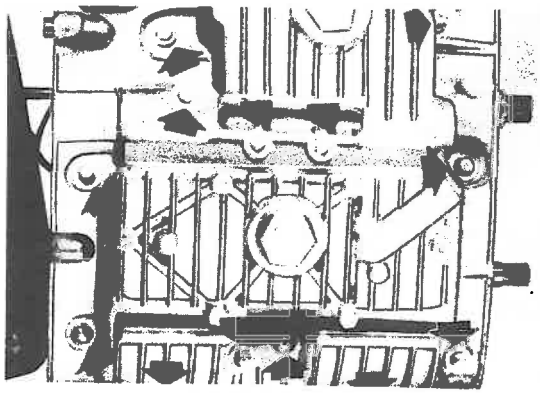
The 650 series unit construction crankcase contains the transmission, crankshaft, oil sump, and associated parts such as oil strainer (in crankcase sump), etc.



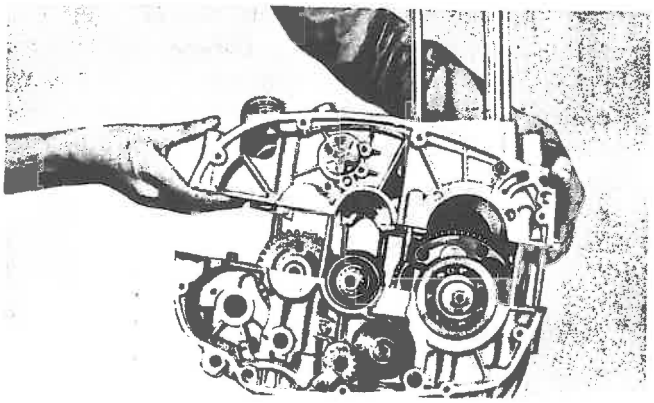
A. Separating Crankcases

1. Pull out the cam chain (if not already removed).

2. Loosen and remove all case securing bolts located on the bottom of the case plus the case bolts around the dip stick on top. Start with #18 and loosen each bolt to #1. Loosen each bolt ¼ turn at a time to avoid case warpage. Start with #18 and loosen each bolt to #1. (Numbers are stamped on the case next to each nut.

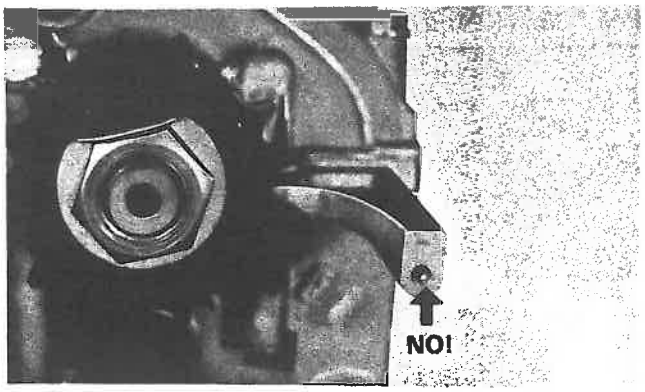


3. Separate the cases by lifting the top case. It might be necessary to tap the top case loose with a rubber hammer.

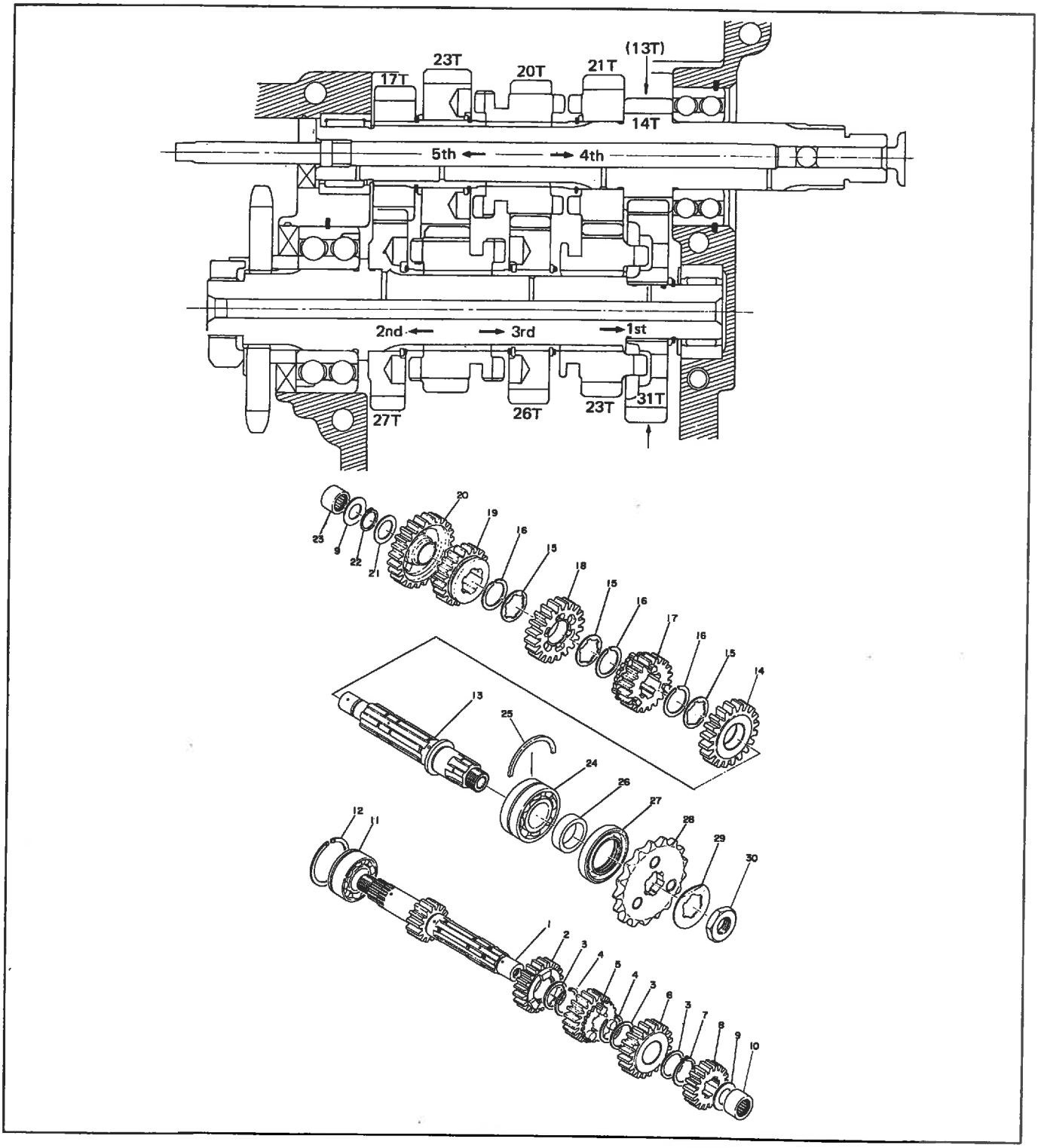


Caution:

Do not hammer on the case cover mounting flange; it could easily break off.



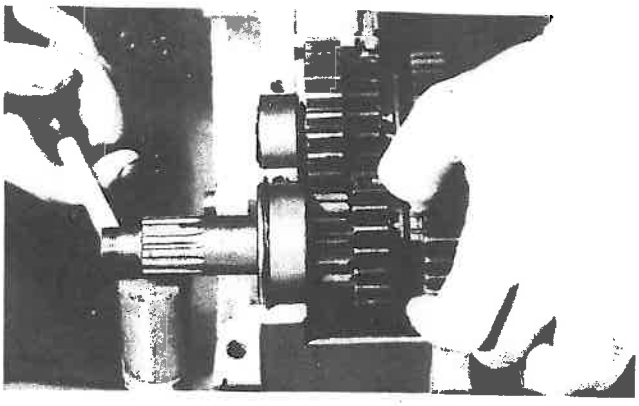
3-9. TRANSMISSION



1. Main axle
2. 4th pinion gear
3. Gear hold washer 5
4. Circlip
5. 3rd pinion gear
6. 5th pinion gear
7. Circlip
8. 2nd pinion gear
9. Drive axle shim
10. Bearing
11. Bearing
12. Circlip
13. Drive axle
14. 2nd wheel gear
15. Gear hold washer 3
16. Circlip
17. 5th wheel gear
18. 3rd wheel gear
19. 4th wheel gear
20. 1st wheel gear
21. Gear hold washer
22. Circlip
23. Bearing
24. Bearing
25. Circlip
26. Distance collar
27. Oil seal
28. Drive sprocket
29. Lock washer
30. Lock nut

A. Transmission Removal

1. Tap lightly with a rubber hammer to loosen the transmission, then lift it out.

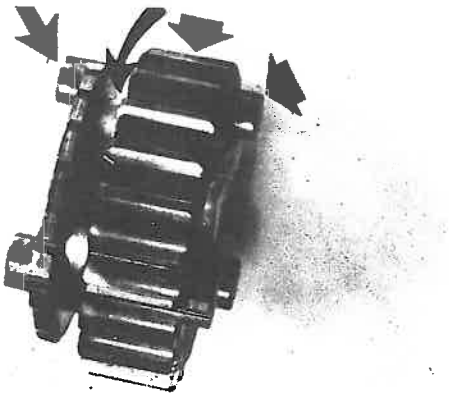


2. Check the gears for chipped teeth.
   Check engagement dogs and slots for rounded edges. Check the sliding gear fork grooves for a blue discoloration. If any of the above mentioned conditions are obviously noticeable, replace the gear(s).

Note:

Especially in the case of damaged engagement dogs, check the mating gear for damage or excessive wear. It is sometimes necessary to replace the parts as a set.

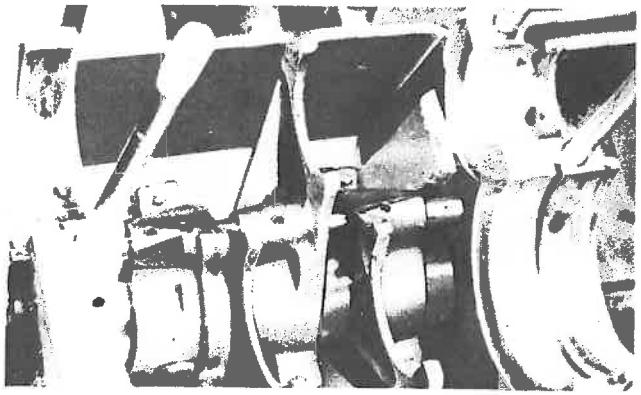
If any circlip has been removed several times, it should be replaced by a new one.



Gear wear points

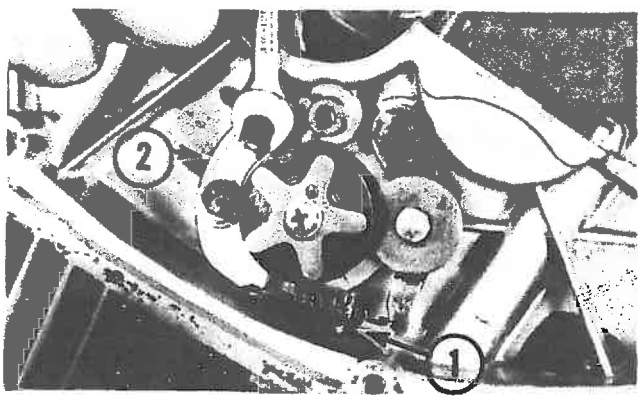
B. Shift Drum Assembly

1. By turning the shift cam with the shift fork, check to see whether the shift fork moves smoothly or not.
   If not, check the guide bar for bends, or check the shift cam groove for scratches.



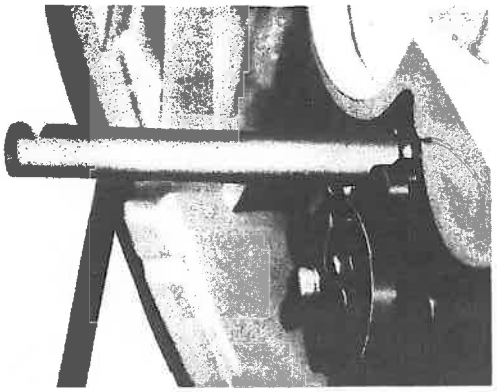
Shift forks and drum in position

On the exterior section of the right-hand case is the shift drum stopper. Release the stopper spring (#1) and remove the stopper unit. Bend the lock tabs down on the locating plate bolts and remove the plate (#2).

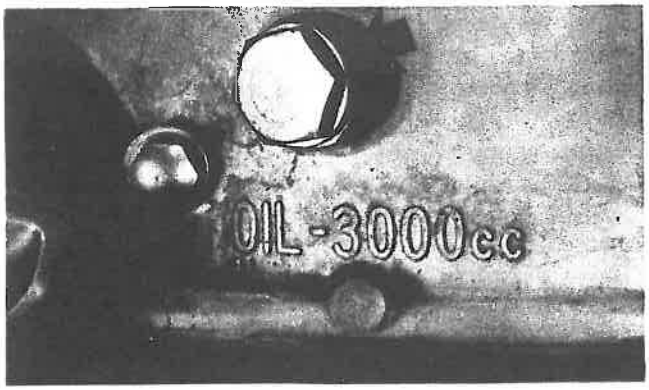


a) Fork Guide Bar Removal and Installation
The fork guide bar is held in place by the shift drum stopper plate. With the plate removed, the bar can be pulled out.

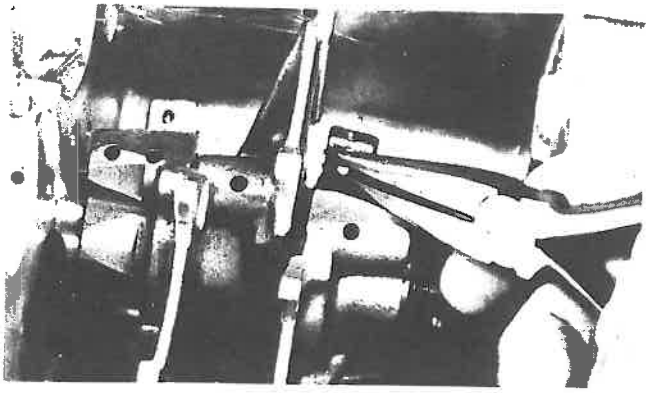
Caution:
Note that the stopper plate has a locking tab to secure the two bolts holding the plate in place. During reassembly, always make sure the locking tabs are bent up firmly around the securing bolt heads.

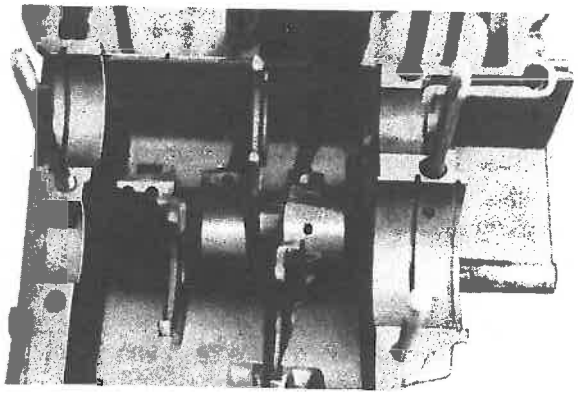


2. Check the guide bar for alignment. Roll it over a surface plate and check for bends. If it is bent, replace it.
3. Shift Drum Removal
Remove the neutral detent unit.

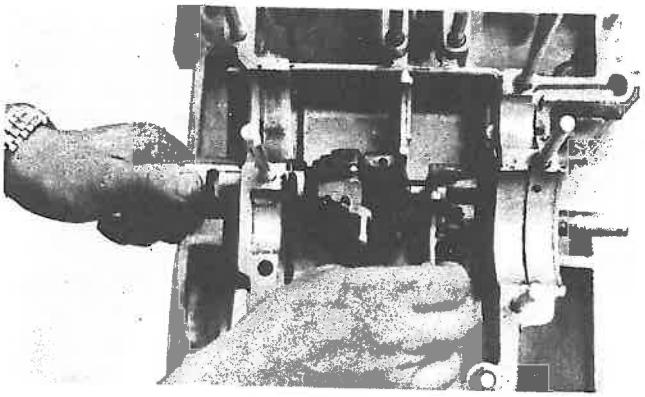


4. A cam follower pin mounted in each fork is held in place by cotter pin and cam follower roller.

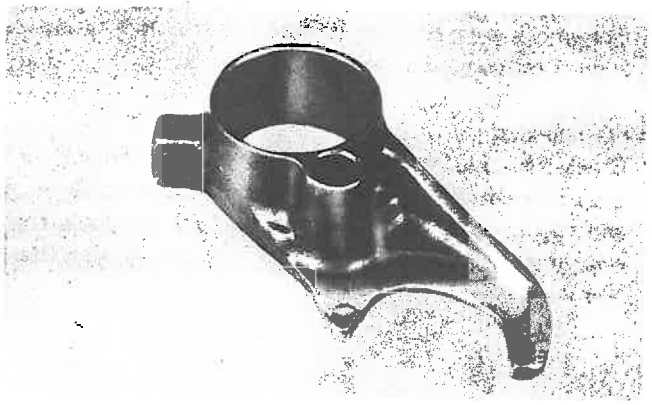




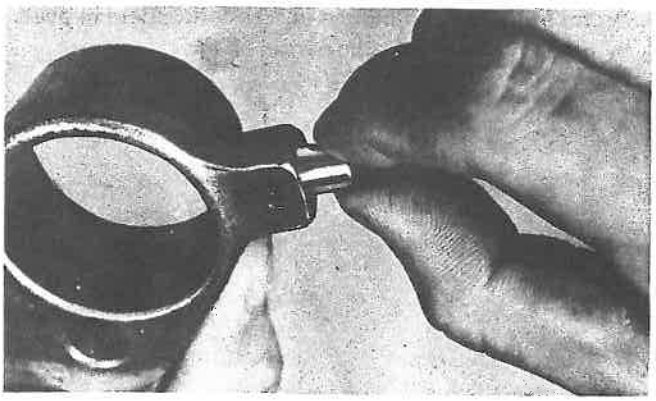
5. Pull out the shift drum and remove all three shift forks from the case. Take care, when removing the shift drum to catch all three cam follower rollers that rest in the grooves in the drum.



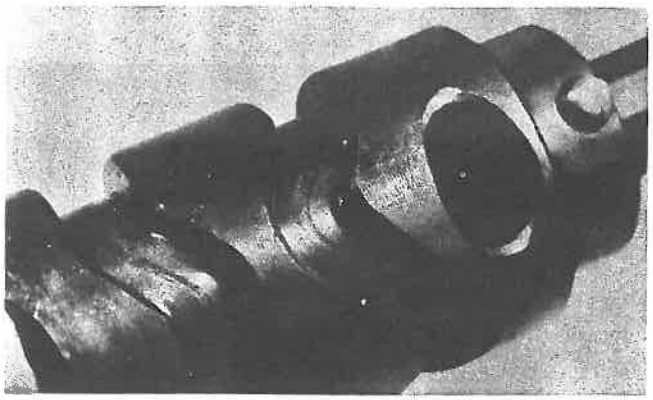
6. Checking the shift fork
   a) Check the ends of fork for seizure (due to friction), scratches and twists. If faulty, replace the fork.



b) Insert the cam follower pin into the hole in shift fork, and check the wear of hole by moving the pin.
If the gap between the pin and hole measures more than 0.039 in. (1 mm.), replace both pin and fork.

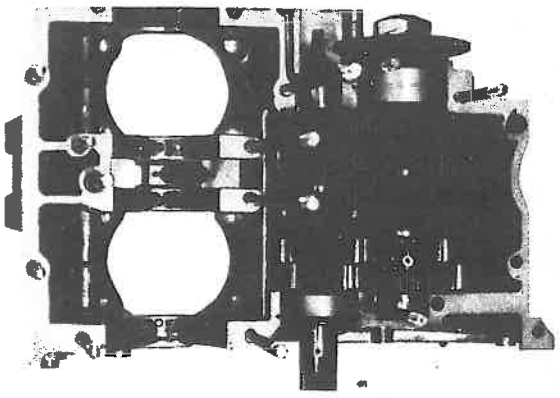


7. Checking the shift cam
If the shift cam groove is worn excessively or scratched, the cam follower pin does not move smoothly, thus impairing gear shifting. If the pin does not move due to scratches in the shift cam groove, replace the shift cam.
8. Shift Drum and Shift Fork Installation:
Installation of this unit is a reversal of the previous steps. Be sure to lubricate the shift drum and forks before installation. When installing the cam follower pin, always use new cotter pins. After bending the cotter pins, make sure the bent pin ends do not drag. Check for smooth fork movement on the shift drum after assembly.
9. When installing the cam follower pins, the one located in the center should be installed first.

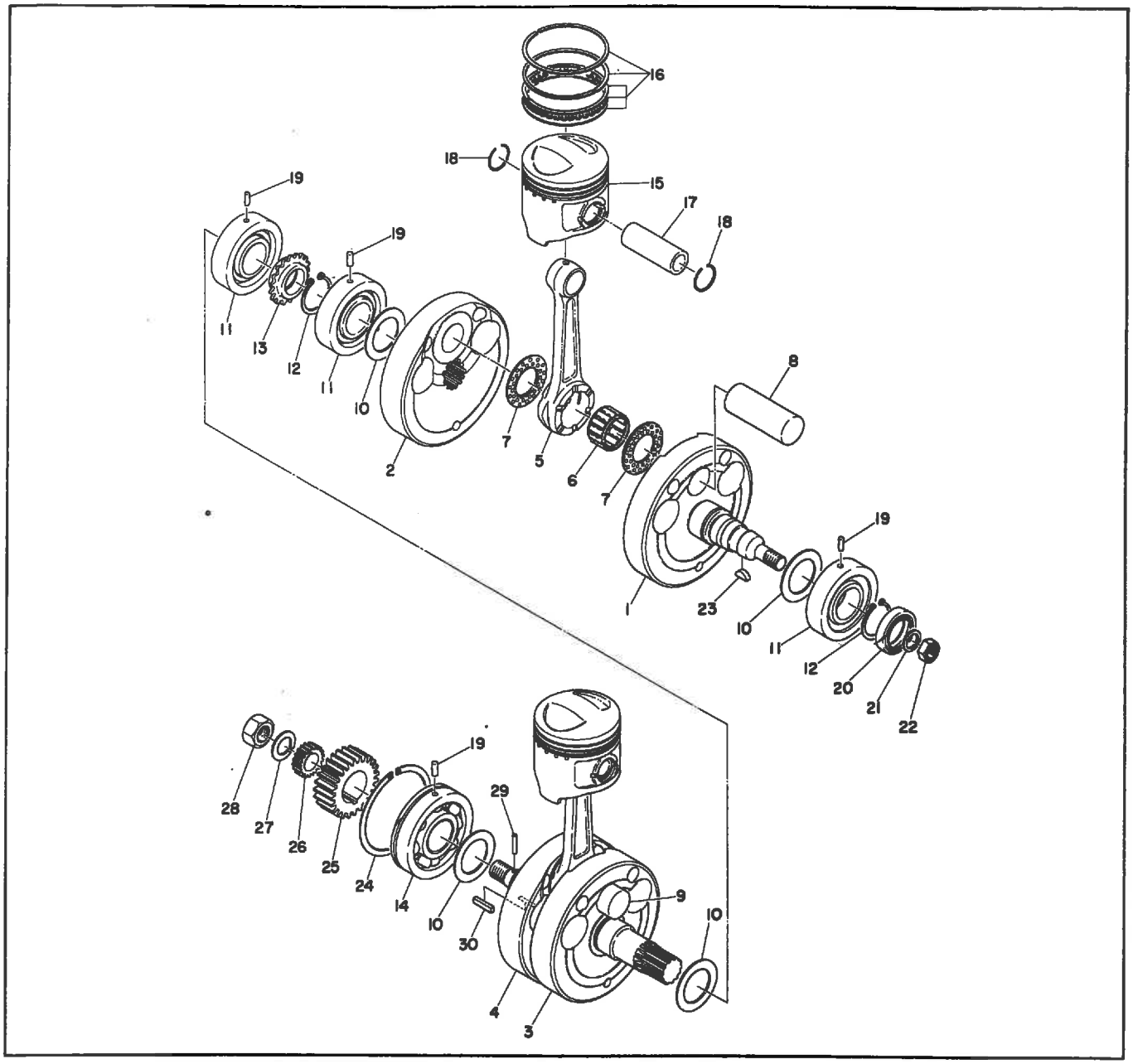


10. Pay particular attention to the direction and order of fork installation. Fifth gear wheel shift fork has a clearance notch machined into one side to allow clearance for the neutral light button. Fourth gear wheel shift fork is also notched on one side to provide clearance for the neutral position stopper. If these shift forks are incorrectly installed, the neutral stopper and neutral light button will not fit into position.
11. Installation
With both shafts assembled, including all bearings and seals, fit the transmission into the TOP CASE. This permits the shift forks to slip over the sliding gears easily. Be sure both transmission shaft circlips are fitted to the bearings and the circlips have been positioned in the circlip grooves.

Note:
Transmission installation is easier if the shift drum is rotated to the neutral position.



Very Important
Check for smooth and complete shifting through all gears after installing the shift drum, shift fork, guide bar, and transmission. At the same time check for complete engagement of all engaging dogs into the appropriate gear slots.



1. Crank 1 (left)
2. Crank 1 (right)
3. Crank 2 (left)
4. Crank 2 (right)
5. Connecting rod
6. Con-rod big end bearing
7. Crank pin washer
8. Crank pin
9. Crank pin
10. Crank shim
11. Bearing
12. Circlip
13. Cam chain sprocket
14. Bearing
15. Piston
16. Piston ring set
17. Piston pin
18. Piston pin clip
19. Dowel pin
20. Oil seal
21. Spring washer
22. Crank shaft nut 2
23. Woodruff key
24. Circlip
25. Primary drive gear
26. Drive gear
27. Spring washer
28. Crank shaft nut 1
29. Dowel pin
30. Woodruff key

Note:

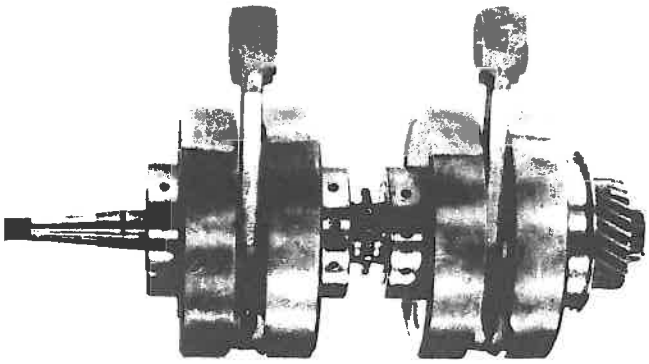
Unless the roller main bearings are to be replaced, do not remove them from the crankshaft as the aluminum roller cage can be damaged. The crankshaft can be disassembled with bearings in place; just remove the outer race to provide pressing clearance.

If removing the bearings, use a guillotine type bearing puller.

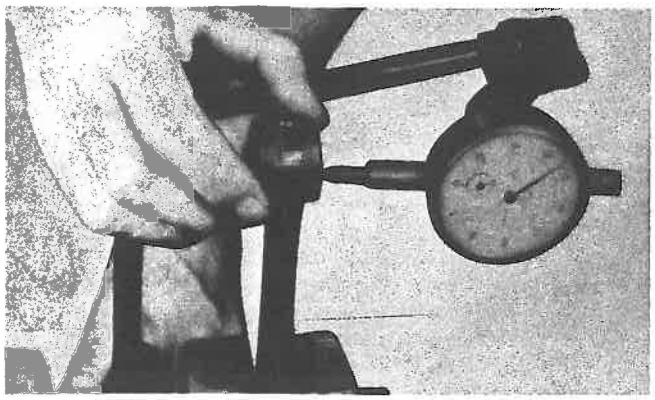
C. Crankshaft

The crankshaft is built up of pressed together parts. It has four full circle crank wheels. The entire unit runs in four main bearings, three rollers and one ball bearing (the ball bearing is the outer right-hand bearing). The rods run parallel (360° crank) on needle bearings over hollow center crank pins. The left and right crank halves are pressed together with the cam chain drive sprocket between the halves.

1. Crankshaft removal:
   Tap the crankshaft with a rubber hammer to loosen it, then lift it out.
2. Crankshaft main bearing wear
   Though the crankshaft main bearings are heavy duty and will withstand much abuse, they should still be checked for wear.
3. Clean the bearing in solvent and dry it with air. Visually inspect all friction surfaces for obvious pits, scratches, chatter marks, or rust. Any of these bearing conditions that are bad enough to be readily seen should be sufficient cause for bearing replacement.
4. Measure connecting rod axial looseness at the small end to determine the amount of wear in the big end (crank pin and big end bearing). Hold the big end stable to prevent it from sliding, then rock the small end.
   Maximum Allowable Tolerance: 2 mm. Small End Play

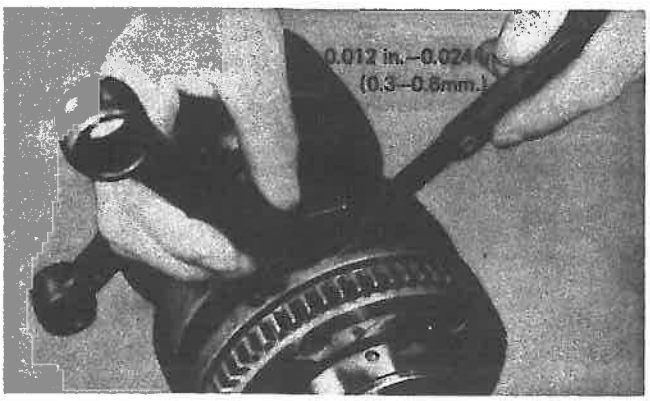


Completely assembled crankshaft



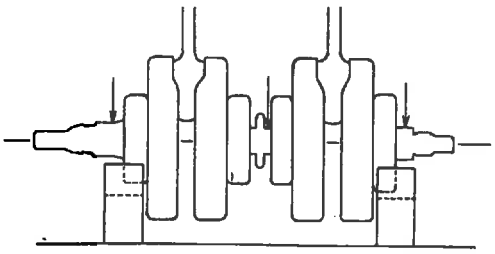
Checking for big end wear

5. If small end side play exceeds 2 mm., disassemble the crankshaft and check the connecting rod, crank pin, and needle bearing for wear. Replace worn parts and recheck small end play. It should measure no more than 1.0 mm. with new parts.
6. Check for correct connecting rod big end side play. Slide the big end to one side and insert a feeler gauge between the crankwheel and rod big end. It should measure between 0.012 in. (0.3 mm.) and 0.024 in. (0.6 mm.). If it exceeds 0.26 in. (0.65 mm.), the connecting rod big end should be closely checked for excessive wear. In addition, total crankshaft width should be measured.



Measuring big end side clearance

7. Check the crankshaft unit for excessive run out. Mount the crankshaft in V-blocks and check for run out using a dial indicator. Run out at all measurement points should not exceed 0.0012 in. (0.03 mm.)



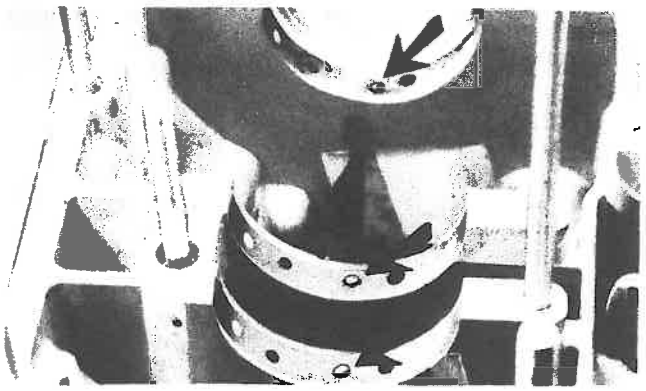
0.0012 in. (0.03 mm.).

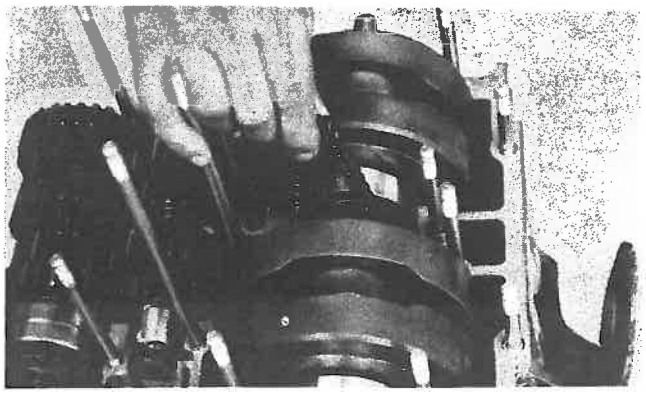
D. Crankshaft Installation (including cam chain)

Note:

Prior to crankshaft installation, make sure the left-hand crank seal is mounted on the crankshaft, teflon lip facing out.

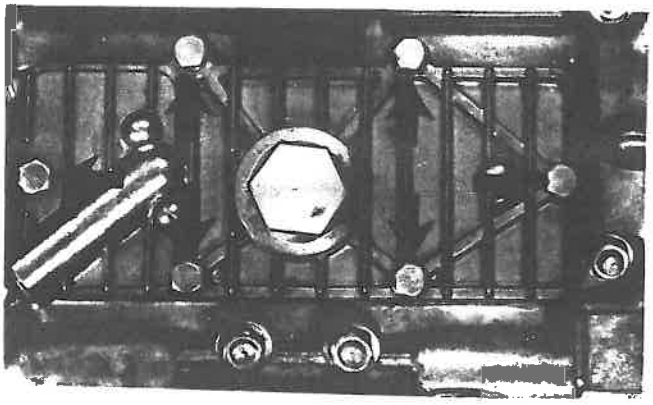
1. Lubricate all crank bearings, then install the crankshaft into the top case. Make sure that each main bearing outer race fits in place over its locating pin in the case. DO NOT STRIKE THE CRANKSHAFT OR MAIN BEARINGS WITH A HAMMER TO SEAT THE CRANKSHAFT but rather fit each bearing over each locating pin and push the crankshaft into position by hand. Each bearing outer race has a punch mark, and lining this mark up with the crankcase mating surface helps the bearing race to fit in the locating pin.
2. Fit the chain over the crankshaft cam sprocket so that it drops into the center slot. Attach safety wire to each end of the cam chain and tie it off to prevent the chain from dropping back into the cases during further engine assembly.





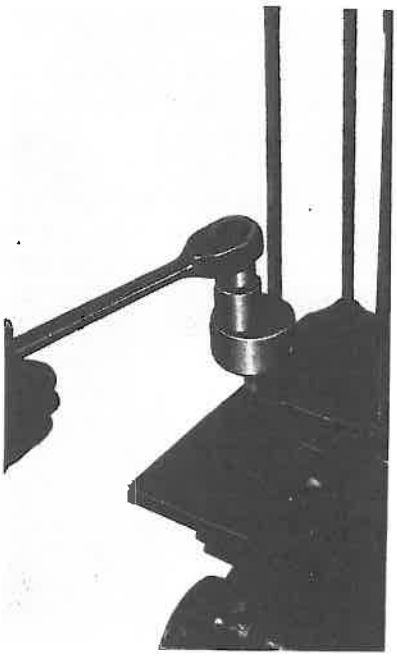
E. Oil Strainer in Bottom Case

1. A wire mesh oil strainer mounts on a removable plate at the bottom of the lower engine case. The strainer can be removed for cleaning. The oil strainer mounting plate is held to the case by six bolts. When the plate is removed the gasket surfaces must be thoroughly cleaned. A new gasket must be used when the plate is installed back on the lower case. Apply Yamaha bond #5 to both gasket surfaces prior to reassembly.

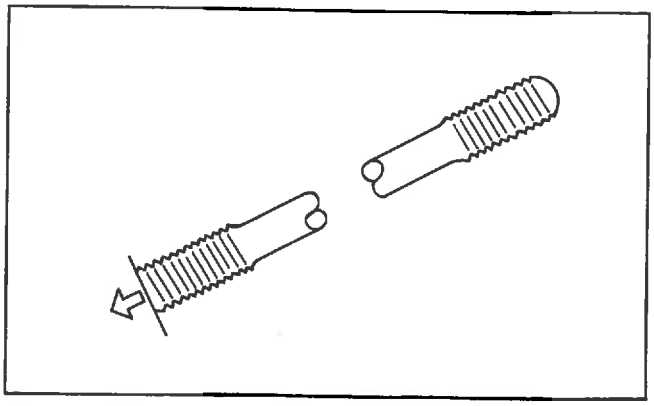


F. Replacing Cylinder Mounting Studs

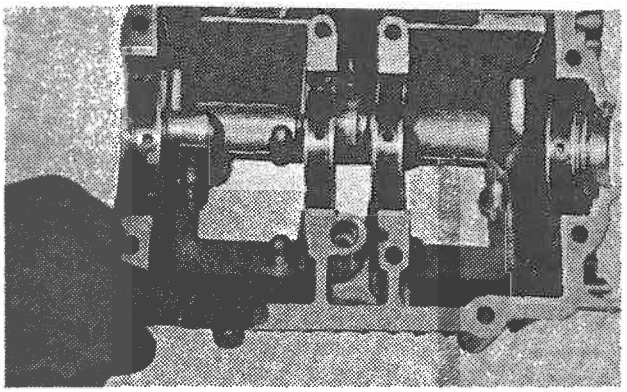
1. The studs are replaceable. They can be removed with a standard stud puller.



2. If a cylinder stud must be replaced, be sure the flat stud is screwed into the case.



Assembling top and bottom cases:
The shifting mechanism, transmission, and crankshaft have already been installed in the top case. Make sure both case gasket surfaces are clean, then apply Yamaha Bond #4 (non-drying, rubber base sealer) to the gasket surfaces. Slide the cases together.



3. Complete the crankcase assembly by installing and tightening all crankcase securing nuts and bolts to 14 ft/lbs. (2 kg/m.), following the tightening sequence numbers stamped on the case next to each nut. (1 through 18 tighten in 3 gradual stages.)