

Chapter 2 Part C: Four-stroke engines (Sfera 125, Liberty 125, ET4 125)

Refer to the beginning of Chapter 1 for model identification details

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Degrees of difficulty

Easy, suitable for novice with little experience



Fairly easy, suitable for beginner with some experience



Fairly difficult, suitable for competent DIY mechanic



Difficult, suitable for experienced DIY mechanic



Very difficult, suitable for expert DIY or professional



Specifications

General

Type	Single cylinder four-stroke
Capacity	124 cc
Bore	57.0 mm
Stroke	48.6 mm
Compression ratio	10.6 to 1

Valves, guides and springs

Valve clearances	See Chapter 1
Intake valve	
Stem diameter	
Standard	4.987 to 4.972 mm
Service limit (min)	4.96 mm
Guide bore diameter	
Standard	5.000 to 5.012 mm
Service limit (max)	5.022 mm
Seat width	1.8 mm
Exhaust valve	
Stem diameter	
Standard	4.975 to 4.960 mm
Service limit (min)	4.96 mm
Guide bore diameter	
Standard	5.000 to 5.012 mm
Service limit (max)	5.022 mm
Seat width	1.8 mm
Valve springs free length (intake and exhaust)	
Standard	29.9 mm
Service limit (min)	29.5 mm

Cylinder head

Warpage (max) 0.05 mm

Cylinder bore

Standard

Size-code A	56.990 to 56.995 mm
Size-code B	56.995 to 57.000 mm
Size-code C	57.000 to 57.005 mm
Size-code D	57.005 to 57.010 mm
Size-code E	57.010 to 57.015 mm
1st oversize	56.190 to 57.215 mm
2nd oversize	57.390 to 57.415 mm
3rd oversize	57.590 to 57.615 mm
Service limit (all sizes)	0.030 mm more than nominal diameter

Piston

Piston diameter (measured 25 mm down from piston oil ring groove, at 90° to piston pin axis)

Standard

Size-code A	56.935 to 56.939 mm
Size-code B	56.940 to 56.944 mm
Size-code C	56.945 to 56.949 mm
Size-code D	56.950 to 56.954 mm
Size-code E	56.955 to 56.959 mm
1st oversize	57.135 to 57.159 mm
2nd oversize	57.335 to 57.359 mm
3rd oversize	57.535 to 57.559 mm
Piston-to-bore clearance (when new)	0.0505 to 0.0606 mm
Piston pin diameter	
Size A	14.000 to 14.002 mm
Size B	13.998 to 14.000 mm
Service limit (min)	13.995 mm
Piston pin bore diameter in piston (max)	14.015 mm
Piston pin-to-piston clearance (max)	0.02 mm

Piston rings

Ring end gap (installed)

Top ring	
Standard	0.15 to 0.30 mm
Service limit (max)	0.50 mm
2nd ring	
Standard	0.10 to 0.25 mm
Service limit (max)	0.40 mm
Oil control ring	
Standard	0.15 to 0.30 mm
Service limit (max)	0.50 mm
Ring-to-groove clearance (max)	0.08 mm

Lubrication system

Oil pump

Inner rotor tip-to-outer rotor clearance (max)	0.12 mm
Outer rotor-to-body clearance (max)	0.20 mm
Rotor endfloat (max)	0.09 mm
Relief valve spring free length (min)	14.0 mm

Connecting rod

Small-end internal diameter

Size I	14.0085 to 14.0120 mm
Size II	14.0050 to 14.0085 mm
Service limit (max)	14.020 mm
Big-end side clearance	
Standard	0.14 to 0.41 mm
Service limit (max)	0.50 mm
Big-end radial freeplay	
Standard	0.015 to 0.025 mm
Service limit (max)	0.35 mm

Crankshaft and bearings

Runout (max) 0.06 mm

Torque settings

Valve cover bolts	12 Nm
Camshaft holder/cylinder head nuts	29 Nm
Cylinder head-to-block bolt	13 Nm
Oil cooler mounting bolts	8 Nm
Oil cooler pipe banjo bolts	13 Nm
Cam chain tensioner spring cap bolt	10 Nm
Cam chain tensioner blade bolt	9 Nm
Camshaft sprocket bolt	13 Nm
Rocker shaft stopper bolt	6 Nm
Oil pump mounting screws	5.5 Nm
Oil pump driven sprocket bolt	13 Nm
Sump cover bolts	12 Nm
Alternator rotor nut	40 to 44 Nm
Crankcase bolts	11 to 13 Nm

1 General information

The engine unit is a single cylinder, overhead-camshaft four-stroke, with fan-assisted air cooling. The fan is mounted on the alternator rotor, which is on the right-hand end of the crankshaft. The camshaft is chain-driven off the left-hand end of the crankshaft, and operates two valves via rocker arms.

The crankshaft assembly is pressed together, incorporating the connecting rod. The crankcase divides vertically.

2 Operations possible with the engine in the frame

All components and assemblies, with the exception of the crankshaft assembly and its bearings, can be worked on without having to remove the engine/transmission unit from the frame. If, however, a number of areas require attention at the same time, removal of the engine is recommended, as it is easy to do so.

3 Operations requiring engine removal

To access the crankshaft and connecting rod assembly and its bearings, the engine must be removed from the frame and the crankcase halves must be separated.

4 Major engine repair – general note

1 It is not always easy to determine when or if an engine should be completely overhauled, as a number of factors must be considered.

2 High mileage is not necessarily an indication that an overhaul is needed, while low mileage, on the other hand, does not preclude the need for an overhaul. Frequency of servicing is probably the single most important

consideration. An engine that has regular and frequent oil and filter changes, as well as other required maintenance, will most likely give many miles of reliable service. Conversely, a neglected engine, or one which has not been run-in properly, may require an overhaul very early in its life.

3 Exhaust smoke and excessive oil consumption are both indications that piston rings and/or valve guide oil seals are in need of attention, although make sure that the fault is not due to oil leakage.

4 If the engine is making obvious knocking or rumbling noises, the connecting rod and/or main bearings are probably at fault.

5 Loss of power, rough running, excessive valve train noise and high fuel consumption rates may also point to the need for an overhaul, especially if they are all present at the same time. If a complete service does not remedy the situation, major mechanical work is the only solution.

6 An engine overhaul generally involves restoring the internal parts to the specifications of a new engine. The piston and piston rings are renewed and the cylinder is rebored. The valve seats are reground and new valve springs are fitted. The main bearings in the crankcase are renewed and, if the connecting rod bearings are worn, a new crankshaft assembly is fitted. The end result should be a like-new engine that will give as many trouble-free miles as the original.

7 Before beginning the engine overhaul, read through the related procedures to familiarise yourself with the scope and requirements of the job. Overhauling an engine is not all that difficult, but it is time-consuming. Plan on the scooter being tied up for a minimum of two weeks. Check on the availability of parts and make sure that any necessary special tools, equipment and supplies are obtained in advance.

8 Most work can be done with typical workshop hand tools, although a number of precision measuring tools are required for inspecting parts to determine if they must be renewed. Often a dealer will handle the inspection of parts and offer advice concerning reconditioning and renewal. As a general rule, time is the primary cost of an overhaul, so it does not pay to install worn or substandard parts.

9 As a final note, to ensure maximum life and

minimum trouble from a rebuilt engine, everything must be assembled with care in a spotlessly-clean environment.

5 Engine/transmission unit – removal and installation

Caution: *The engine is not heavy, although engine removal and installation should be carried out with the aid of an assistant; personal injury or damage could occur if the engine falls or is dropped.*

Removal

1 The procedure for removing the engine is the same as for air-cooled two-stroke models. If required, drain the engine oil (see Chapter 1).

Note: *There is no external oil feed or external oil pump on the four-stroke engine.*

2 Refer to Chapter 2A, Section 5, for the rest of the procedure.

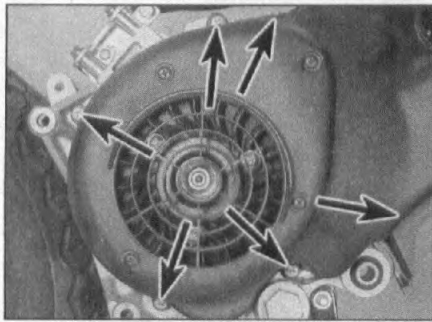
Installation

3 Installation is the reverse of the procedure in Chapter 2A. Note that if the engine oil was drained, or if any oil has been lost during overhaul, the engine must be filled with the specified quantity of oil (see Chapter 1 Specifications) and the oil level checked as described in *Daily (pre-ride) checks*.

6 Disassembly and reassembly – general information

Disassembly

1 Before disassembling the engine, the external surfaces of the unit should be thoroughly cleaned and degreased. This will prevent contamination of the engine internals, and will also make working a lot easier and cleaner. A high flash-point solvent, such as paraffin can be used, or better still, a proprietary engine degreaser such as Gunk. Use old paintbrushes and toothbrushes to work the solvent into the various recesses of the engine casings. Take care to exclude solvent or water from the electrical components and intake and exhaust ports.



7.2 Remove the screws (arrowed) securing the alternator cover . . .



Warning: The use of petrol (gasoline) as a cleaning agent should be avoided because of the risk of fire.

2 When clean and dry, arrange the unit on the workbench, leaving a suitable clear area for working. Gather a selection of small containers and plastic bags so that parts can be grouped together in an easily identifiable manner. Some paper and a pen should be on hand to permit notes to be made and labels attached where necessary. A supply of clean rag is also required.

3 Before commencing work, read through the appropriate section so that some idea of the necessary procedure can be gained. When removing components it should be noted that great force is seldom required, unless specified. In many cases, a component's reluctance to be removed is indicative of an incorrect approach or removal method – if in any doubt, recheck with the text.

4 When disassembling the engine, keep 'mated' parts that have been in contact with each other during engine operation together. These 'mated' parts must be re-used or renewed as an assembly.

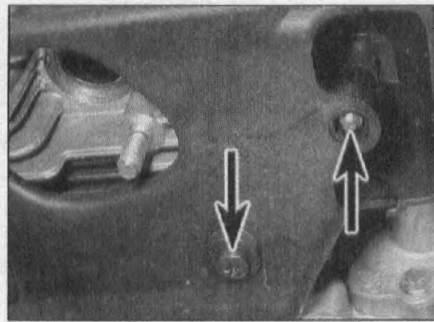
5 Complete engine disassembly should be done in the following general order with reference to the appropriate Sections. Refer to Chapter 2G for details of transmission components disassembly.

Remove the valve cover.

Remove the camshaft and rockers.

Remove the cylinder head.

Remove the cylinder.



7.3 . . . and the engine lower cover (arrows)

Remove the piston.

Remove the alternator.

Remove the variator (see Chapter 2G).

Remove the starter motor (see Chapter 9).

Remove the sump cover.

Remove the oil pump.

Separate the crankcase halves.

Remove the crankshaft.

Reassembly

6 Reassembly is accomplished by reversing the general disassembly sequence.

7 Valve cover – removal and installation

Note: The valve cover can be removed with the engine in the frame. If the engine has been removed, ignore the steps which do not apply.

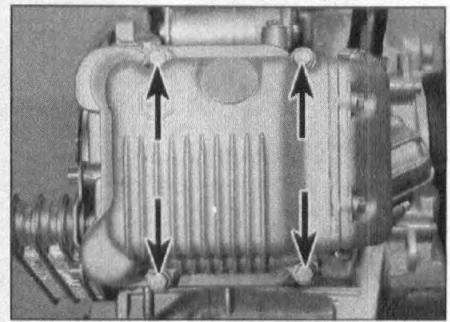
Removal

1 Remove the bodywork as required by your model to access the engine (see Chapter 7).

2 Pull the cap off the spark plug, then remove the screws securing the alternator cover and remove the cover (see illustration).

3 Remove the screws securing the lower engine cover and remove the cover (see illustration).

4 Unscrew the four bolts securing the valve cover, then lift the cover off the cylinder head (see illustration). If it is stuck, do not try to lever it off with a screwdriver. Tap it gently around the sides with a rubber hammer or block of wood to



7.4 The valve cover is secured by four bolts (arrowed)

dislodge it. Remove the gasket and discard it, as a new one must be used.

Installation

5 Clean the mating surfaces of the cylinder head and the valve cover with lacquer thinner, acetone or brake system cleaner.

6 Lay the new gasket onto the valve cover, making sure it fits correctly into the groove (see illustration).

7 Position the valve cover on the cylinder head, making sure the gasket stays in place (see illustration). Install the cover bolts with their washers. Tighten the bolts evenly and in a criss-cross sequence to the torque setting specified at the beginning of the Chapter.

8 Install the remaining components in the reverse order of removal.

8 Oil cooler and pipes – removal and installation

Note: The oil cooler can be removed with the engine in the frame. If the engine has been removed, ignore the steps which do not apply.

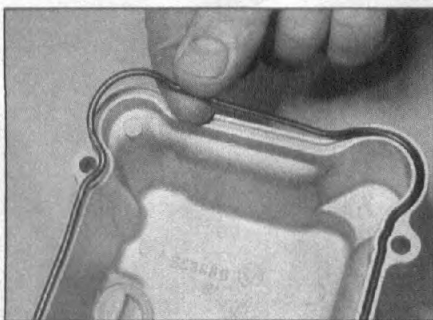
Removal

1 Remove the bodywork as required by your model to access the engine (see Chapter 7).

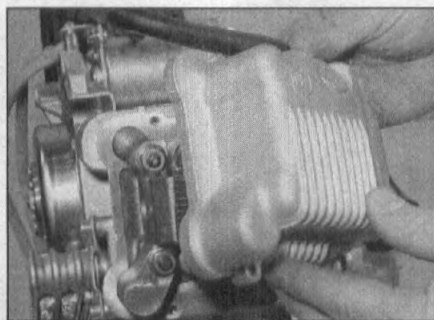
2 Drain the engine oil (see Chapter 1).

3 Remove the screws securing the alternator cover and remove the cover (see illustration 7.2).

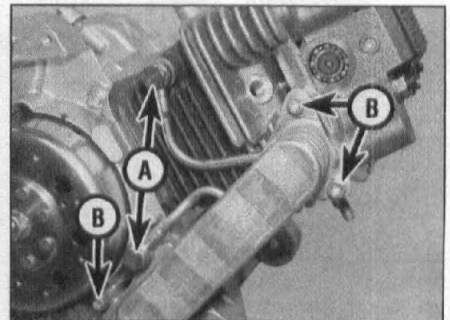
4 Unscrew the banjo bolt securing each pipe union to the crankcase (see illustration). Now



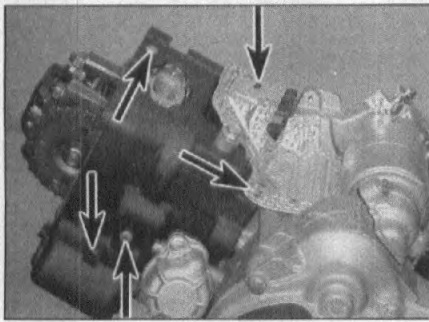
7.6 Fit a new gasket into the groove . . .



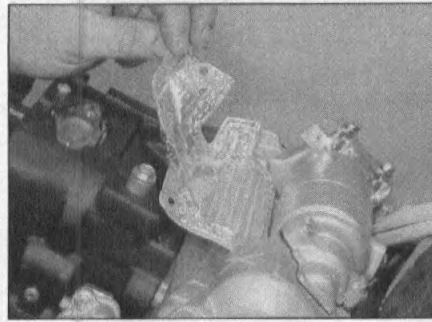
7.7 . . . then install the cover



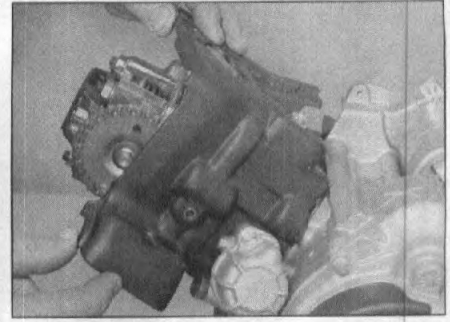
8.4 Oil pipe banjo bolts (A) and cooler mounting bolts (B)



9.3a Remove the screws (arrowed) . . .



9.3b . . . lift off the heat shield . . .



9.3c . . . and remove the cover

unscrew the three cooler mounting bolts, noting the fitting of the washers, and remove the cooler and pipes. If required, unscrew the banjo bolt securing each pipe to the cooler and detach the pipes. Discard the pipe sealing washers, as new ones must be used.

Installation

5 Installation is the reverse of removal, noting the following:

- a) Check the condition of the cooler mounting washers and renew them if they are damaged or deteriorated.
- b) Always use new sealing washers on the pipe unions.
- c) Tighten the cooler bolts and the banjo bolts to the torque settings specified at the beginning of the Chapter.
- d) Fill the engine with oil (see Chapter 1) and check the oil level (see Daily (pre-ride) checks).

9 Cam chain tensioner – removal, inspection and installation

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Note: The cam chain tensioner can be removed with the engine in the frame.

Removal

- 1 Remove the bodywork as required by your model to access the engine (see Chapter 7).
- 2 Remove the carburettor and the intake manifold (see Chapter 4).
- 3 Remove the screws securing the engine lower cover to the upper engine cover (see illustration 7.3), followed by the screws

securing the engine upper cover to the engine and alternator cover, then lift off the heat shield and remove the upper cover (see illustrations).

4 Unscrew the two tensioner mounting bolts and withdraw the tensioner from the cylinder (see illustration).

5 Remove the gasket from the base of the tensioner or from the cylinder and discard it, as a new one must be used.

Inspection

6 Unscrew the tensioner spring cap bolt and withdraw the spring from the tensioner body (see illustration 9.4).

7 Examine the tensioner components for signs of wear or damage.

8 Release the ratchet mechanism from the tensioner plunger and check that the plunger moves freely in and out of the tensioner body (see illustration 9.11).

9 If the tensioner or any of its components are worn or damaged, or if the plunger is seized in

the body, they must be renewed. Individual components are available.

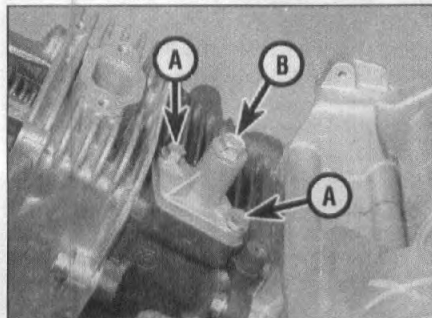
Installation

10 Remove the cooling fan (see Section 18). Turn the engine in a clockwise direction using the alternator rotor nut. This removes all the slack between the crankshaft and the camshaft in the front run of the chain and transfers it to the back run where it will be taken up by the tensioner.

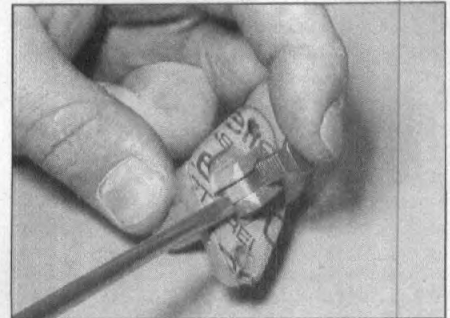
11 Release the ratchet mechanism and press the tensioner plunger all the way into the tensioner body (see illustration).

12 Place a new gasket on the tensioner body, then install it in the engine and tighten the bolts (see illustration).

13 Install a new sealing washer on the spring cap bolt. Install the spring and cap bolt and tighten the bolt to the torque setting specified at the beginning of the Chapter (see illustrations).



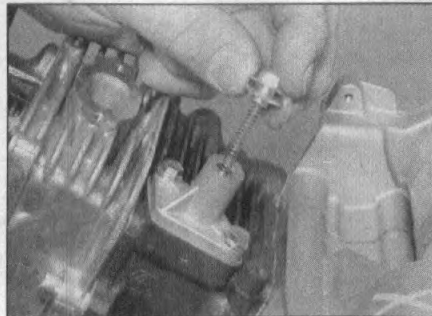
9.4 Tensioner mounting bolts (A) and spring cap bolt (B)



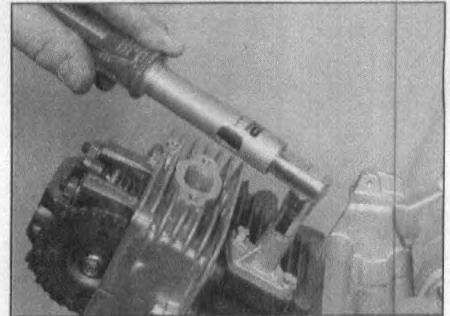
9.11 Release the ratchet and press the plunger fully in



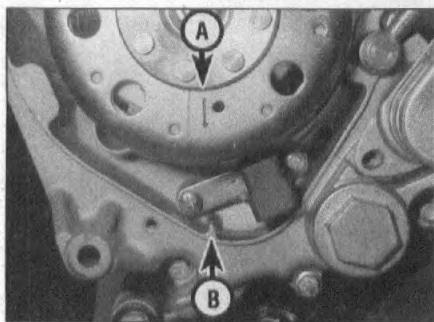
9.12 Install the tensioner . . .



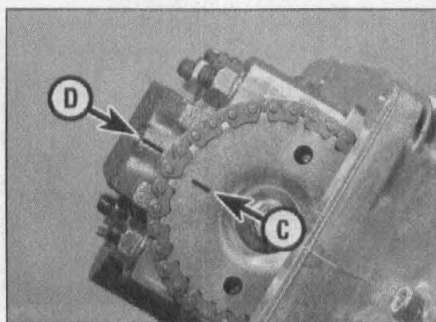
9.13a . . . then fit the spring and cap bolt . . .



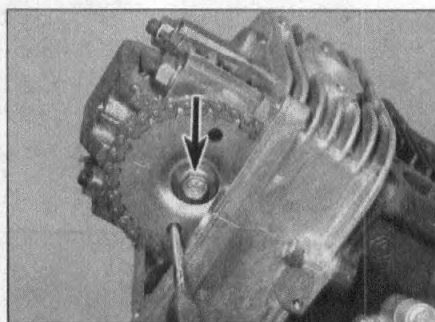
9.13b . . . and tighten the bolt to the specified torque



10.3a Turn the engine until the arrow (A) aligns with the index mark (B) . . .



10.3b . . . and the mark on the sprocket (C) aligns with that on the camshaft holder (D)



10.5a Unscrew the bolt (arrowed), using a tool to hold the sprocket . . .

14 It is advisable to remove the valve cover (see Section 7) and check that the cam chain is tensioned. If it is slack, the tensioner plunger did not release when the bolt was tightened.

15 Install the cooling fan (see Section 18), the engine covers, and the carburettor and intake manifold (see Chapter 4).

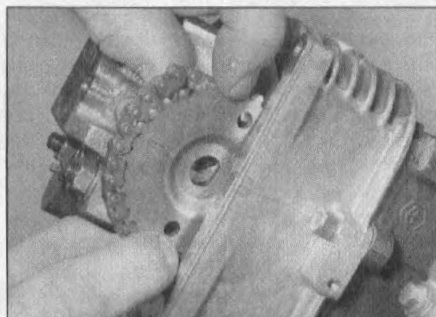
10 Cam chain, blades and sprockets – removal, inspection and installation



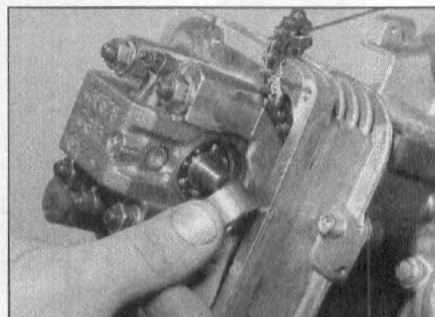
Note: The cam chain and sprockets can be removed with the engine in the frame.

Removal

1 Remove the valve cover (see Section 7).



10.5b . . . and slip the sprocket off the shaft and out of the chain



10.5c Remove the spacer for safekeeping if required

2 If the cam chain or tensioner blade is being removed, remove the oil pump driven sprocket, drive chain and drive sprocket (see Section 21).

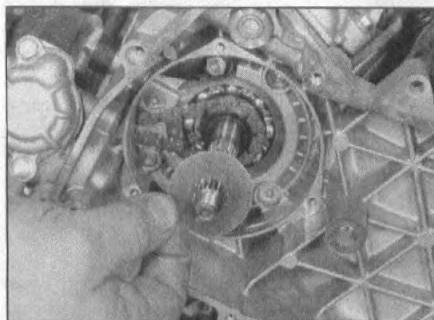
3 Remove the cooling fan (see Section 18). Turn the engine in a clockwise direction using the alternator rotor nut, until the timing mark on the rotor aligns with the index mark on the crankcase, and the timing mark on the sprocket aligns with the index mark on the camshaft holder (see illustrations). At this point the engine is at TDC (top dead centre) on the compression stroke (both valves closed).

4 Remove the cam chain tensioner (see Section 9).

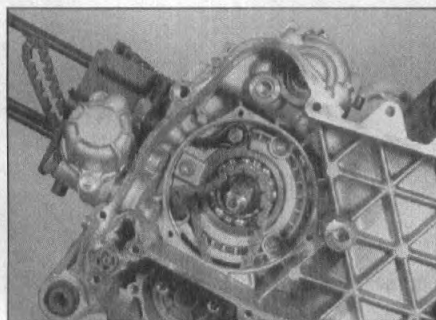
5 Unscrew the bolt securing the sprocket to the camshaft (see illustration). To prevent the sprocket from turning, use the Piaggio service tool (Part No. 020565Y) or a suitable holding tool fitted into the hole(s) in the sprocket. Discard the bolt and its washer, as new ones must be used. Draw the sprocket off the end of the camshaft and disengage it from the camchain (see illustration). Remove the sprocket spacer for safekeeping if required (see illustration).

6 Remove the thrustwasher from the end of the crankshaft, then lower the cam chain down its tunnel and slip it off the sprocket on the crankshaft, and draw the chain out of the engine (see illustrations). If required, remove the sprocket from the crankshaft, noting how it locates over the pin (see illustration).

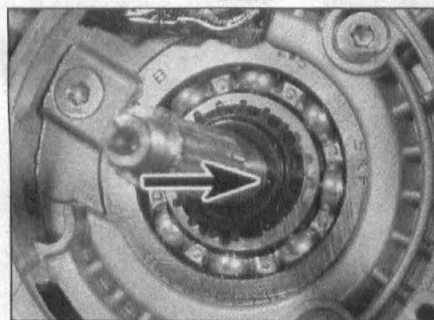
7 If required, remove the bolt securing the cam chain tensioner blade to the crankcase and withdraw the blade, noting which way round it fits (see illustration). Also remove the



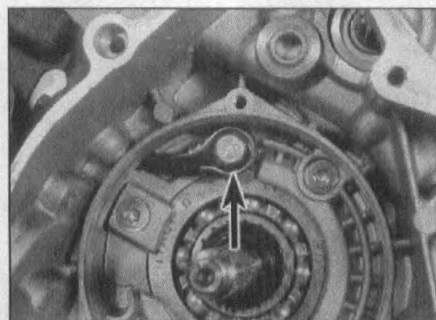
10.6a Remove the thrustwasher . . .



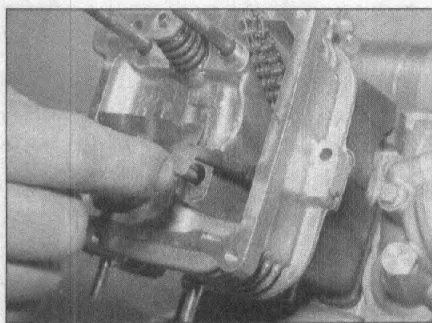
10.6b . . . then lower the chain and draw it out of the engine



10.6c Note how the sprocket locates over the pin (arrowed)



10.7a The tensioner blade is secured by a pivot bolt (arrowed)



10.7b Lift the guide blade out

guide blade, noting how it fits (**see illustration**).

Inspection

8 Check the sprockets for wear, cracks and other damage, renewing them if necessary. If the sprocket teeth are worn, the chain is also worn. If wear this severe is apparent, the entire engine should be disassembled for inspection.

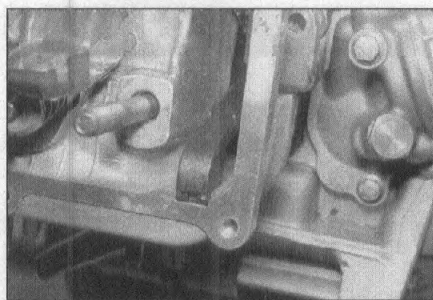
9 Check the chain tensioner blade and guide blade for wear or damage and renew them if necessary. If they are worn or damaged, the chain may be worn out or improperly tensioned. Check the operation of the cam chain tensioner (see Section 9).

Installation

10 If removed, install the tensioner blade and guide blade, making sure they are the correct way round (**see illustration**). Tighten the tensioner blade bolt to the torque setting specified at the beginning of the Chapter.

11 If removed, install the sprocket onto the crankshaft, aligning the cutout in the sprocket with the pin on the crankshaft (**see illustration 10.6c**). Also fit the camshaft sprocket spacer, if removed (**see illustration 10.5c**).

12 Slip the cam chain down through the tunnel and engage it with the crankshaft sprocket (**see illustration 10.6b**). Slip the camshaft sprocket into the top of the chain, then fit the sprocket onto the camshaft, aligning the squared edges between the sprocket and the shaft end, and making sure any slack in the chain is at the back of the engine so that it is later taken up by the tensioner, and that all the timing marks align as described in Step 3 (**see illustration 10.5b**). Secure the sprocket with a new bolt and washer, then, using the method employed on removal to



10.10 Make sure the guide blade is properly fitted

prevent the sprocket turning, tighten the bolt to the torque setting specified at the beginning of the Chapter (**see illustrations**). Fit the thrustwasher onto the end of the crankshaft (**see illustration 10.6a**), then install the oil pump drive sprocket, chain and driven sprocket (see Section 21).

Caution: *If the marks are not aligned exactly as described, the valve timing will be incorrect and the valves may strike the piston, causing extensive damage to the engine.*

13 Install the cam chain tensioner (see Section 9). After installation, rotate the engine and check again that all the timing marks align as described in Step 3. If not, remove the sprocket and align the marks correctly.

14 Install the remaining components in the reverse order of removal.

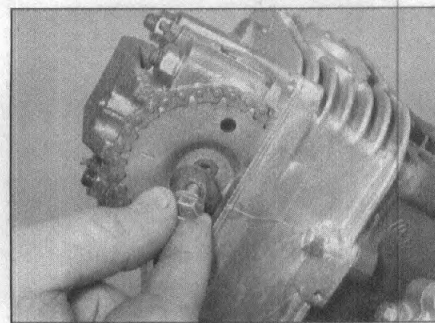
11 Camshaft holder, camshaft and rockers – removal, inspection and installation

Note: *The camshaft and rockers can be removed with the engine in the frame. Place rags over the cam chain tunnel to prevent any component from dropping into the engine.*

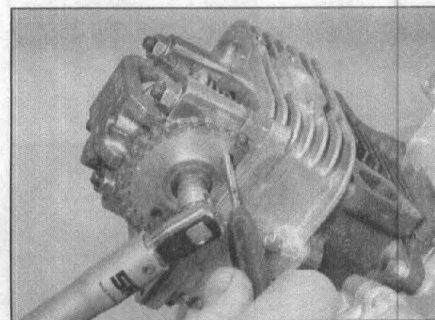
Removal

1 Remove the valve cover (see Section 7). Remove the rubber insulating pad from the top of the camshaft holder for safekeeping, noting how it fits (**see illustration**).

2 Remove the cooling fan (see Section 18). Turn the engine in a clockwise direction using the alternator rotor nut, until the timing mark on the rotor aligns with the index mark on the crankcase, and the timing mark on the sprocket



10.12a Use a new bolt and washer ...



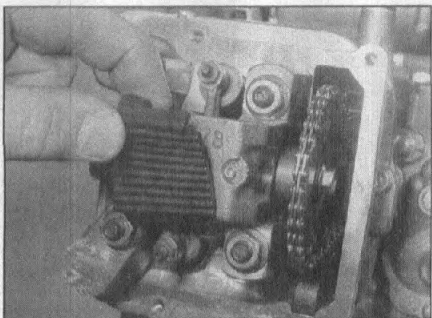
10.12b ... and tighten the bolt to the specified torque

aligns with the index mark on the camshaft holder (**see illustration 10.3a and 10.3b**). At this point the engine is at TDC (top dead centre) on the compression stroke (both valves closed).

3 Remove the cam chain tensioner (see Section 9).

4 Unscrew the bolt securing the sprocket to the camshaft (**see illustration 10.5a**). To prevent the sprocket from turning, use the Piaggio service tool (Part No. 020565Y) or a suitable holding tool fitted into the hole in the sprocket. Discard the bolt and its washer, as new ones must be used. Draw the sprocket off the end of the shaft and disengage the camchain (**see illustration 10.5b**). Secure the top of the chain to the cylinder head using a tie to prevent it dropping into the engine.

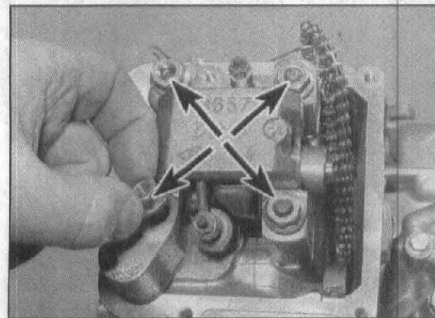
5 Slacken the bolt securing the cylinder head to the cylinder (**see illustration**). Now unscrew the camshaft holder nuts, which also secure the cylinder head, evenly and a little at a time in a criss-cross pattern, until they are all loose (**see illustration**). Remove the nuts



11.1 Remove the rubber pad



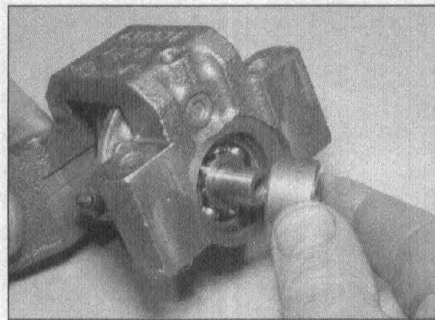
11.5a Slacken the bolt (arrowed) ...



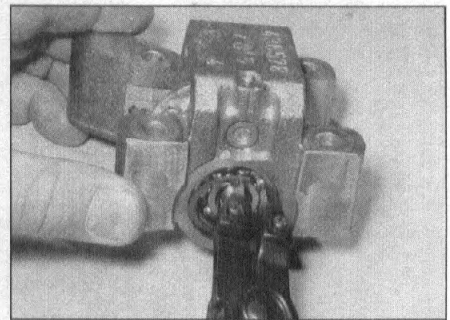
11.5b ... then unscrew the nuts (arrowed) ...



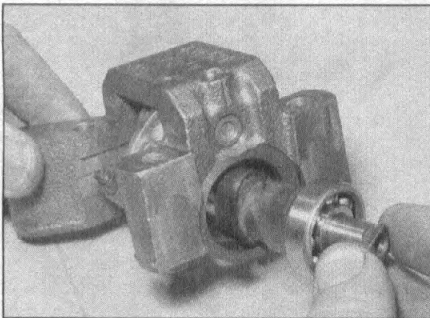
11.5c ... and remove the holder



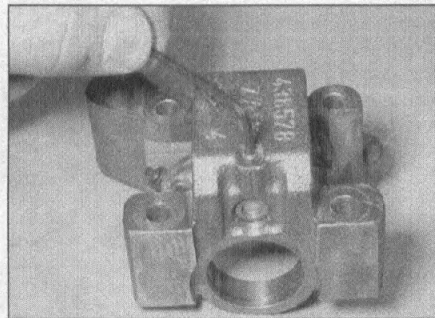
11.6a Remove the spacer ...



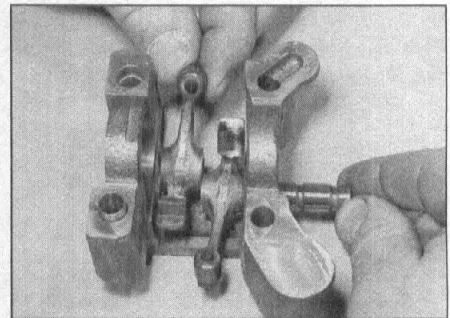
11.6b ... and the circlip ...



11.6c ... and draw out the camshaft



11.7a Unscrew the stopper bolt ...



11.7b ... and remove the rocker shaft and arms

then lift off the camshaft holder (**see illustration**).

6 To separate the camshaft from the holder, remove the camshaft sprocket spacer, then remove the circlip securing the bearing in the holder (**see illustrations**). Grasp the end of the camshaft and draw it out of the holder along with the bearing (**see illustration**). The bearing on the right-hand end of the shaft will stay in the holder.

7 To remove the rocker arms and shaft, remove the shaft stopper bolt from the camshaft holder (**see illustration**). Draw the shaft out of the holder and remove the rockers and the washer that fits between them, noting carefully which fits where, as they must be installed in their original positions (**see illustration**).

Inspection

8 Clean all of the components with solvent and dry them off. Check the camshaft lobes for heat discoloration (blue appearance), score

marks, chipped areas, flat spots and spalling (**see illustration**). If damage is noted or wear is excessive, the camshaft must be renewed.

9 Check the condition of the camshaft bearings. If they are in any way worn, damaged, run noisily or roughly, or have excessive play, they must be renewed. Draw the bearing off the camshaft using a suitable puller, and drive the bearing out of the holder using a suitable piece of tubing or a socket that bears on the outer race only. Take care not to damage the holder. When installing the bearing into the holder, use a drift that bears on the inner race only. When installing the bearing onto the camshaft, heat the bearing to aid installation and use a drift which bears on the inner race only. When installing the bearing into the holder, use a drift that bears on the outer race only; apply heat to the holder to aid bearing installation.

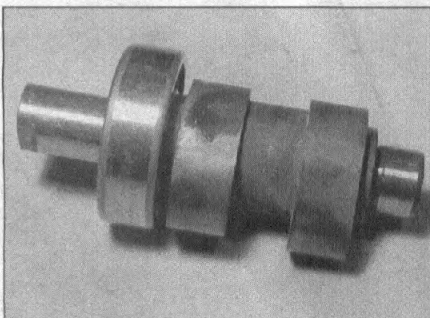


Warning: When heating components, take great care not to burn your hands.

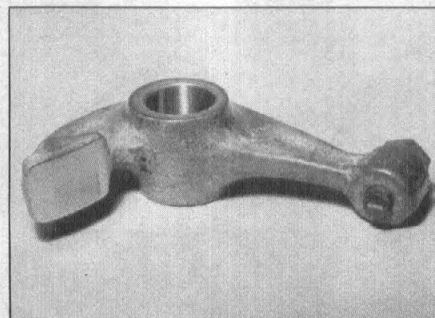
10 Blow through the oil passages in the rocker arms with compressed air, if available. Inspect the rocker arm faces for pits, spalling, score marks and rough spots (**see illustration**). If the faces of the rocker arms are damaged, the rocker arms and the camshafts should be renewed as a set. Check the rocker arm-to-shaft contact areas. Look for cracks in each rocker arm. Check the contact areas between the adjusting screws and the valve stems. If they are worn, rounded or damaged in any other way, they should be renewed as a set.

Installation

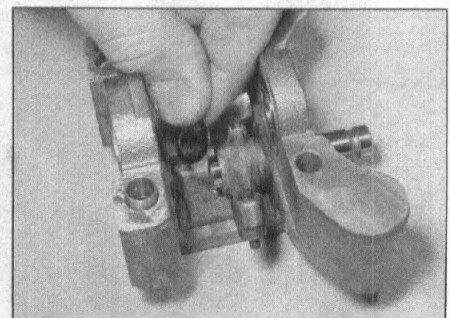
11 Lubricate the rocker shaft with engine oil. Slide the shaft into the holder, making sure the groove for the stopper bolt is correctly positioned, and fit each rocker arm and the washer that fits between them (**see illustration**). Make sure each rocker is installed in its original position (**see**



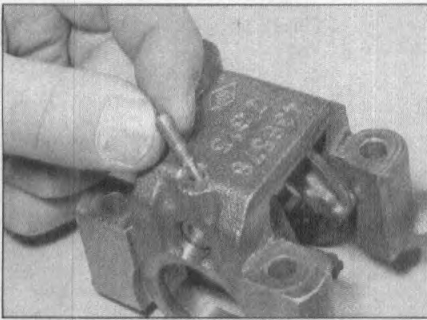
11.8 Check the camshaft for wear and damage



11.10 Check the rocker arms for wear and damage



11.11a Do not forget the washer between the rocker arms



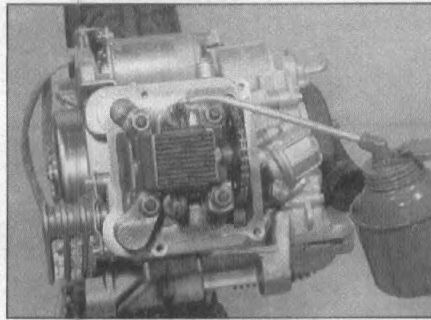
11.11b Fit the stopper bolt and tighten it to the specified torque

illustration 11.7b). Fit the stopper bolt and tighten it to the torque setting specified at the beginning of the Chapter (**see illustration**).

12 Slide the camshaft into the holder, making sure the bearing enters its housing squarely and is pressed fully home (**see illustration 11.6c**). Fit the bearing circlip, making sure it locates correctly into its groove, then fit the sprocket spacer (**see illustrations 11.6b and 11.6a**).

13 Locate the camshaft holder onto the cylinder head, with the sprocket end on the left-hand side of the engine (**see illustration 11.5c**). Fit the holder nuts and tighten them evenly and a little at a time in a criss-cross sequence to the torque setting specified at the beginning of the Chapter (**see illustration 11.5b**). Now tighten the bolt securing the cylinder head to the cylinder to the specified torque (**see illustration 11.5a**). Lubricate all the camshaft holder components with clean engine oil (**see illustration**).

14 Slip the camshaft sprocket into the top of the chain (**see illustration 10.5b**), then fit the sprocket onto the camshaft, aligning the squared edges between the sprocket and the shaft end. Ensure any slack in the chain is at the back of the engine so that it is later taken up by the tensioner, and that all the timing marks align as described in Step 2 (**see illustration 10.3b**). Secure the sprocket with a new bolt and washer, then, using the method employed on removal to prevent the sprocket turning, tighten the bolt to the torque setting



11.13 Lubricate all components with clean engine oil

specified at the beginning of the Chapter (**see illustration 10.12a and 10.12b**).

Caution: If the marks are not aligned exactly as described, the valve timing will be incorrect and the valves may strike the piston, causing extensive damage to the engine.

15 Install the cam chain tensioner (see Section 9). After installation, rotate the engine and check again that all the timing marks align as described in Step 2. If not, remove the sprocket and align the marks correctly.

16 Check the valve clearances and adjust them if necessary (see Chapter 1).

17 Install the remaining components in the reverse order of removal.

12 Cylinder head – removal and installation

Note: The cylinder head can be removed with the engine in the frame. If the engine has been removed, ignore the steps which don't apply.

Caution: The engine must be completely cool before beginning this procedure or the cylinder head may become warped.

Removal

- 1 Remove the oil cooler (see Section 8).
- 2 Remove the exhaust system (see Chapter 4).
- 3 Remove the camshaft holder (see Section 11).

4 Remove the previously-slackened bolt securing the cylinder head to the cylinder (**see illustration 11.5a**), then pull the cylinder head up off the cylinder (**see illustration**). If it is stuck, tap around the joint faces of the cylinder head with a soft-faced mallet to free the head. Do not attempt to free the head by inserting a screwdriver between the head and cylinder – you'll damage the sealing surfaces. Remove the old cylinder head gasket and discard it, as a new one must be used (**see illustration**).

5 Check the cylinder head gasket and the mating surfaces on the cylinder head and cylinder for signs of leakage, which could indicate warpage. Refer to Section 14 and check the flatness of the cylinder head.

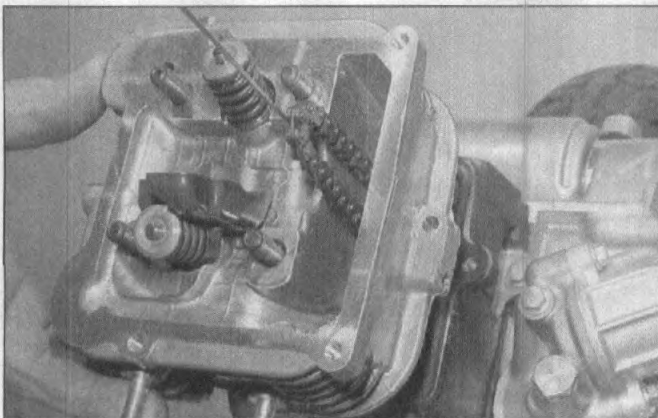
6 Clean all traces of old gasket material from the cylinder head and cylinder. If a scraper is used, take care not to scratch or gouge the soft aluminium. Be careful not to let any of the gasket material fall into the crankcase, the cylinder bore or the oil passages.

Installation

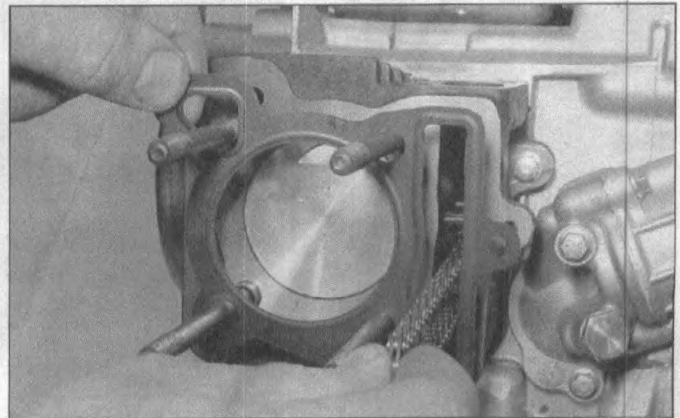
- 7 Lubricate the cylinder bore with engine oil.
- 8 Ensure both cylinder head and block mating surfaces are clean, then lay the new head gasket in place on the cylinder block, making sure all the holes are correctly aligned (**see illustration 12.4b**). Never re-use the old gasket.
- 9 Carefully fit the cylinder head onto the block (**see illustration 12.4a**).
- 10 Install the camshaft holder (see Section 11).
- 11 Install the remaining components in a reverse of their removal sequence, referring to the relevant Sections or Chapters.

13 Valves/valve seats/valve guides – overhaul

1 If a valve spring compressor is available, the home mechanic can remove the valves from the cylinder head, grind in the valves and renew the valve stem seal. If the necessary measuring tools are available, you can assess the amount of wear on the valves and guides and measure the valve-to-seat contact areas.



12.4a Lift the head off the cylinder ...



12.4b ... and remove the gasket

2 If the valve guides or the valve seats in the cylinder head are worn beyond their service limits a new head will have to be fitted.

3 After any servicing or repair work, be sure to clean the head very thoroughly before installation on the engine to remove any metal particles or abrasive grit that may still be present. Use compressed air, if available, to blow out all the holes and passages.

14 Cylinder head and valves – disassembly, inspection and reassembly



1 Disassembly, cleaning and inspection of the valves and related components can be done by the home mechanic if the necessary special tools are available. If there is any doubt about the condition of any components, have them checked by a Piaggio dealer.

2 To disassemble the valve components without the risk of damaging them, a valve spring compressor suitable for motorcycle engines is absolutely necessary.

Disassembly

3 Before proceeding, arrange to label and store the valves and their related components so that they can be returned to their original location without getting mixed up (see illustration).

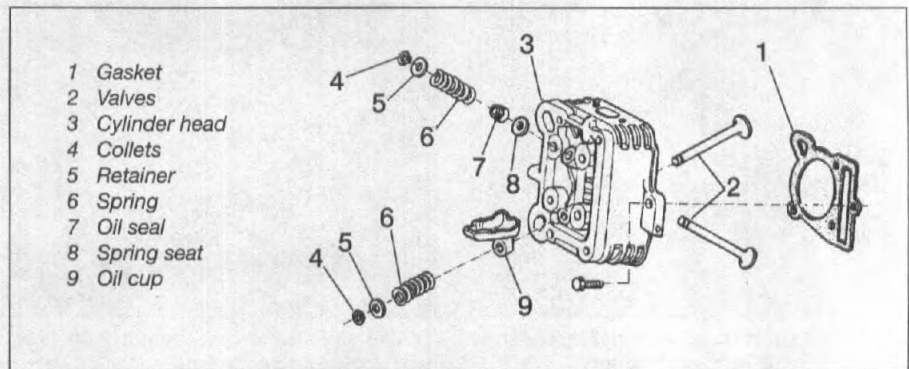
4 If not already done, clean all traces of old gasket material from the cylinder head. If a scraper is used, take care not to scratch or gouge the soft aluminium.

5 Compress the valve spring on the intake valve with a spring compressor, making sure it is correctly located onto each end of the valve assembly. Do not compress the spring any more than is absolutely necessary. Remove the collets, using either needle-nose pliers, tweezers, a magnet or a screwdriver with a dab of grease on it (see illustration). Carefully release the valve spring compressor and remove the spring retainer, noting which way up it fits, the spring, the spring seat, and the valve from the head. If the valve binds in the guide (won't pull through), push it back into the head and deburr the area around the collet groove with a very fine file or whetstone (see illustration). Once the valve has been removed, pull the valve stem oil seal off the top of the valve guide with pliers and discard it (the old seal should never be re-used).

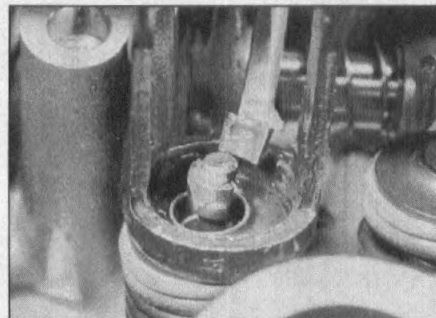
6 Repeat the procedure for the exhaust valve, noting that it has an oil cup in place of the spring seat and stem oil seal. Remember to keep the parts for each valve together and in order so they can be reinstalled in the same location.

7 Next, clean the cylinder head with solvent and dry it thoroughly. Compressed air will speed the drying process and ensure that all holes and recessed areas are clean.

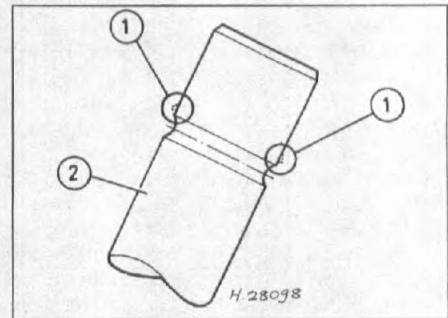
8 Clean the valve springs, collets, retainers, spring seat or oil cup with solvent and dry



14.3 Cylinder head components



14.5a Remove the collets with needle-nose pliers, tweezers, a magnet or a screwdriver with a dab of grease on it



14.5b If the valve stem (2) won't pull through the guide, deburr the area (1) above the collet groove

them thoroughly. Work on the parts from one valve at a time so as not to mix them up.

9 Scrape off any deposits that may have formed on the valve, then use a motorised wire brush to remove deposits from the valve heads and stems. Again, make sure the valves do not get mixed up.

Inspection

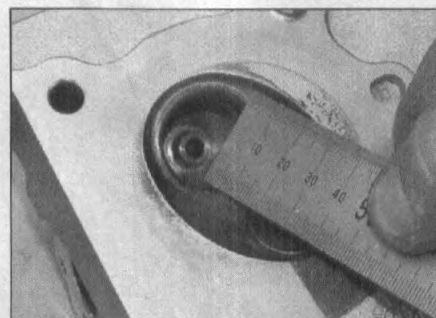
10 Inspect the head very carefully for cracks and other damage. If cracks are found, a new head will be required.

11 Using a precision straight-edge and a feeler gauge set to the warpage limit listed in the specifications at the beginning of the Chapter, check the head gasket mating surface for warpage. Lay the straight-edge lengthways, across the head and diagonally, intersecting the stud holes, and try to slip the

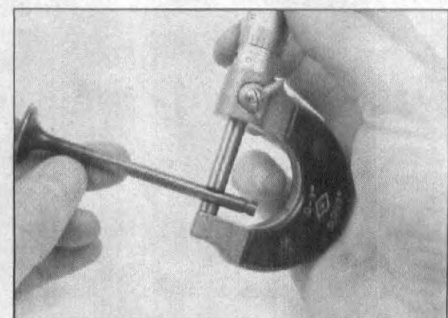
feeler gauge under it on either side of the combustion chamber. If the feeler gauge can be inserted between the straight-edge and the cylinder head, the head is warped and must be either machined or, if warpage is excessive, renewed.

12 Examine the valve seats in the combustion chamber. If they are deeply pitted, cracked or burned, it may be possible to have them repaired by a specialist engineer, otherwise a new head will be required. Measure the valve seat width and compare it to this Chapter's Specifications (see illustration).

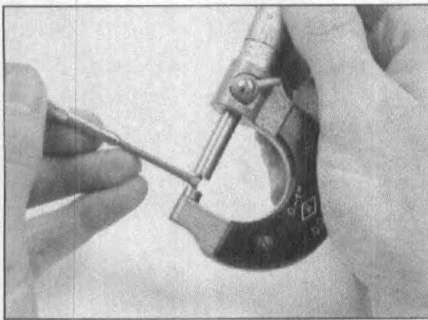
13 Measure the valve stem diameter (see illustration). If the valve is worn beyond its service limit a new one must be fitted. Clean the valve guides to remove any carbon build-up, then measure the inside diameter of each guide with a small hole gauge. Insert the



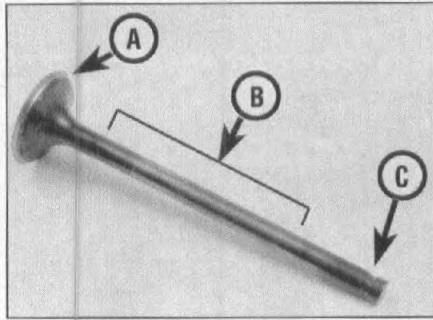
14.12 Measuring the valve seat width (for greater precision use a vernier caliper)



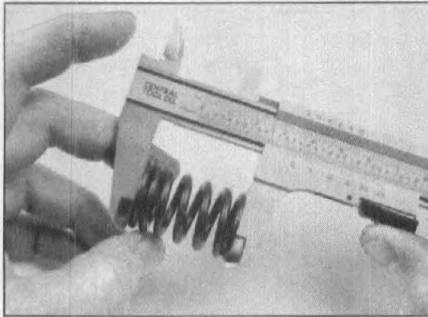
14.13a Measure the valve stem diameter with a micrometer



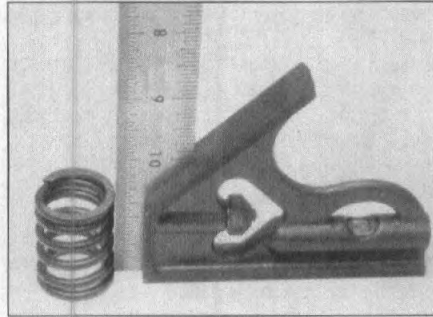
14.13b Measure the small hole gauge with a micrometer



14.14 Check the valve face (A), stem (B) and collet groove (C) for signs of wear and damage



14.15a Measure the free length of the valve springs



14.15b Check the valve springs for squareness

gauge into the guide and expand it so there's a slight drag when it's pulled out. Measure the gauge with a micrometer (see illustration). Take measurements at both ends and at the centre of the guide to determine if it is worn unevenly. Piaggio do not list new valve guides, so if the guide is worn beyond its limit, have the head checked by a specialist engineer who may be able to bore out the guide and fit a sleeve in it. Otherwise a new cylinder head will have to be fitted.

14 Carefully inspect each valve face for cracks, pits and burned spots. Check the valve stem and the collet groove for cracks (see illustration). Rotate the valve and check for any obvious indication that it is bent. Check the end of the stem for pitting and excessive wear. The presence of any of the above conditions indicates the need for valve

overhaul. If the stem end is pitted or worn, also check the contact area of the valve clearance adjuster in the rocker arm.

15 Check the end of each valve spring for wear and pitting. Measure the spring free length and compare it to that listed in the specifications (see illustration). If either spring is shorter than specified it has sagged and must be renewed. Also place the spring upright on a flat surface and check it for bend by placing a square against it (see illustration). If the bend in the spring is excessive, it must be renewed.

16 Check the spring retainers and collets for obvious wear and cracks. Any questionable parts should not be re-used, as extensive damage will occur in the event of failure during engine operation.

17 If the inspection indicates that no overhaul

work is required, the valve components can be reinstalled in the head.

Reassembly

18 Unless a valve overhaul has been performed, before installing the valves in the head they should be ground in (lapped) to ensure a positive seal between the valves and seats. This procedure requires coarse and fine valve grinding compound and a valve grinding tool. If a grinding tool is not available, a piece of rubber or plastic hose can be slipped over the valve stem (after the valve has been installed in the guide) and used to turn the valve.

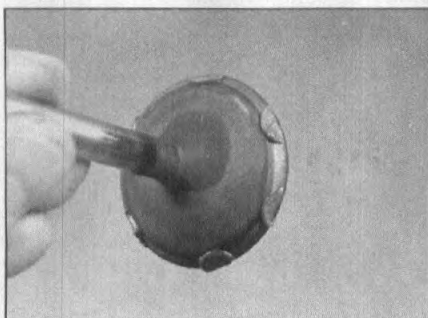
19 Apply a small amount of coarse grinding compound to the valve face, then slip the valve into the guide (see illustration). Note: Make sure each valve is installed in its correct guide and be careful not to get any grinding compound on the valve stem.

20 Attach the grinding tool (or hose) to the valve and rotate the tool between the palms of your hands. Use a back-and-forth motion (as though rubbing your hands together) rather than a circular motion (ie, so that the valve rotates alternately clockwise and anti-clockwise rather than in one direction only) (see illustration). Lift the valve off the seat and turn it at regular intervals to distribute the grinding compound properly. Continue the grinding procedure until the valve face and seat contact area is of uniform width and unbroken around the entire circumference of the valve face and seat (see illustration).

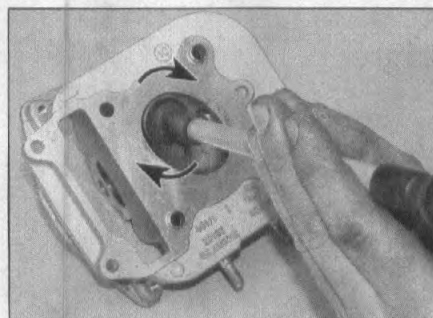
21 Carefully remove the valve from the guide and wipe off all traces of grinding compound. Use solvent to clean the valve and wipe the seat area thoroughly with a solvent-soaked cloth.

22 Repeat the procedure with fine valve grinding compound, then repeat the entire procedure for the other valve.

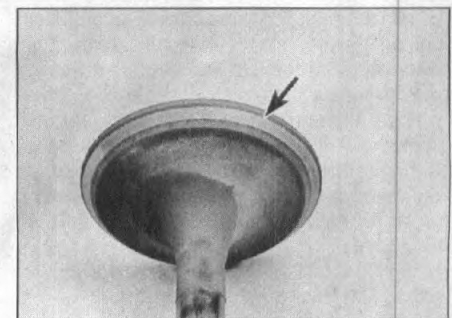
23 Lay the spring seat for the intake valve in place in the cylinder head, then install a new valve stem seal onto the guide. Use an appropriate size deep socket to push the seal over the end of the valve guide until it is felt to clip into place. Don't twist or cock it, or it will not seal properly against the valve stem. Also, don't remove it again or it will be damaged.



14.19 Apply the grinding compound very sparingly, in small dabs, to the valve face only



14.20a Rotate the tool back-and-forth between the palms of your hands



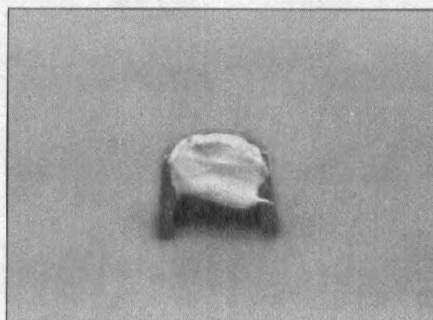
14.20b Valve contact area should show a uniform unbroken ring

24 Lubricate the intake valve stem with molybdenum disulphide grease, then install it into its guide, rotating it slowly to avoid damaging the seal. Check that the valve moves up and down freely in the guide. Next, install the spring, with its closer-wound coils facing down into the cylinder head, followed by the spring retainer, with its shouldered side facing down so that it fits into the top of the spring.

25 Apply a small amount of grease to the collets to help hold them in place as the pressure is released from the spring (see illustration). Compress the spring with the valve spring compressor and install the collets (see illustration 14.5a). When compressing the spring, depress it only as far as is absolutely necessary to slip the collets into place. Make certain that the collets are securely locked in their retaining grooves.

26 Fit the oil cup for the exhaust valve onto the guide, then repeat the procedure in Steps 24 and 25 for that valve (see illustration).

27 Support the cylinder head on blocks so the valves can't contact the workbench top, then very gently tap each of the valve stems with a soft-faced hammer. This will help seat the collets in their grooves.



14.25 A small dab of grease will help to keep the collets in place on the valve while the spring is released



14.26 Make sure the oil cup is correctly installed



Check for proper sealing of the valves by pouring a small amount of solvent into each of the valve ports. If the solvent leaks past any valve into the combustion chamber area the valve grinding operation on that valve should be repeated.

15 Cylinder – removal, inspection and installation



Note: The cylinder can be removed with the engine in the frame.

Removal

1 Remove the cylinder head (see Section 12).
2 Undo the bolt securing the cylinder to the crankcase (see illustration).

3 Lift the cylinder up off the studs, supporting the piston as it becomes accessible to prevent it hitting the crankcase. If the cylinder is stuck, tap around its joint faces with a soft-faced mallet to free it from the crankcase. Don't attempt to free the cylinder by inserting a screwdriver between it and the crankcase – you'll damage the sealing surfaces. When the cylinder is removed, stuff a clean rag around the piston to prevent anything falling into the crankcase.

4 Remove the gasket and discard it; a new one should be used on reassembly.

Inspection

5 Inspect the cylinder bore carefully for scratches and score marks. A rebore will be

necessary to remove any deep scores (see Step 7).

6 Using telescoping gauges and a micrometer, check the dimensions of the cylinder to assess the amount of wear, taper and ovality. Measure near the top (but below the level of the top piston ring at TDC), centre and bottom (but above the level of the bottom ring at BDC) of the bore both parallel to and across the crankshaft axis (see illustration). Calculate any differences between the measurements to determine any taper or ovality in the bore. Compare the results to the cylinder bore specifications at the beginning of this Chapter. **Note:** *Cylinders and pistons are size-coded during manufacture and it is important that they are of the same size-code. Piaggio list five size-codes (A to E) for this engine. The size-code is stamped in the gasket surface at the top or base of the cylinder, and in the piston crown. When purchasing a new cylinder or piston, always supply the size-code letter.*

7 Calculate the piston-to-bore clearance by subtracting the piston diameter (see Section 16) from the bore diameter. If the cylinder is in good condition and the piston-to-bore clearance is within specifications, the cylinder can be re-used.

8 If the cylinder is tapered, oval, or worn beyond the service limit, badly scratched, scuffed or scored, have it rebored by a Piaggio dealer or motorcycle engineer. If the cylinder is rebored, it will require an oversize piston and rings. If the cylinder has already been rebored to the maximum oversize and is

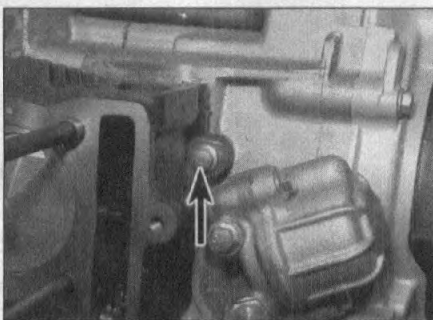
worn or damaged, the cylinder must be renewed.

9 Check that all the cylinder head studs are tight in the crankcase halves. If any are loose, remove them and clean their threads. Apply a suitable permanent thread locking compound and tighten them securely.

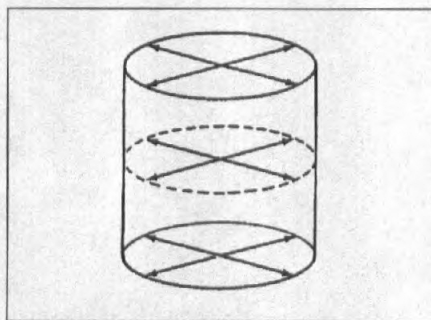
Installation

10 Check that the mating surfaces of the cylinder and crankcase are clean. Three different thicknesses of cylinder base gasket are available from Piaggio. To establish which size is required, the cylinder must be assembled on the crankcase and piston without a base gasket, and a dial gauge mounted against the crown of the piston. Set the dial gauge in the mounting plate, and with the mounting plate feet and gauge tip resting against the cylinder sealing face, zero the gauge dial (see illustration 8.18 in Chapter 2A). Rotate the engine so that the piston is part way down the bore, then clamp the mounting plate diagonally across two of the cylinder studs and tighten the stud nuts to 28 to 30 Nm to ensure that the cylinder is held firmly against the crankcase.

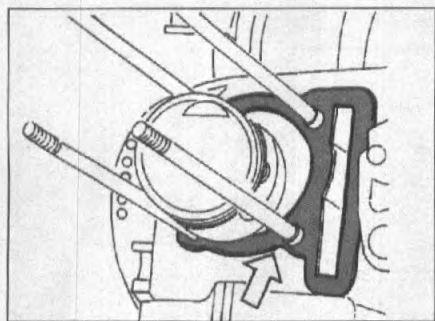
11 Rotate the crankshaft via the alternator rotor nut so the piston rises to the top of its stroke (TDC). At this point read off the dial gauge (see illustration 8.21 in Chapter 2A). If the reading is between -0.1 and $+0.2$ mm a 0.7 mm gasket is required, between $+0.1$ and $+0.3$ mm a 0.6 mm gasket is required, and between $+0.3$ and $+0.5$ mm a 0.4 mm gasket is required – refer to your Piaggio dealer for



15.2 Remove the bolt (arrowed) securing the cylinder to the crankcase



15.6 Measure the cylinder bore in the directions shown



15.11 Lay a new base gasket on the crankcase

details. Having established the correct gasket thickness, fit it to the crankcase (**see illustration**). Never re-use the old gasket.

12 If required, install a piston ring clamp onto the piston to ease its entry into the bore as the cylinder is lowered. This is not essential as the cylinder has a good lead-in enabling the piston rings to be hand-fed into the bore. If possible, have an assistant to support the cylinder while this is done. Check that the piston ring end gaps are positioned as described in Section 17.

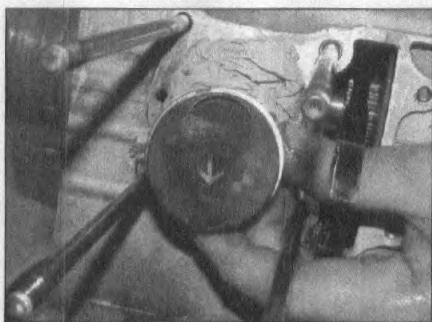
13 Lubricate the cylinder bore, piston and piston rings, and the connecting rod big- and small-ends, with the clean engine oil, then fit the cylinder down over the studs until the piston crown fits into the bore.

14 Gently push down on the cylinder, making sure the piston enters the bore squarely and does not get cocked sideways. If a piston ring clamp is not being used, carefully compress and feed each ring into the bore as the cylinder is lowered. If necessary, use a soft mallet to gently tap the cylinder down, but do not use force if it appears to be stuck as the piston and/or rings will be damaged. If a clamp is used, remove it once the piston is in the bore.

15 When the piston is correctly installed in the cylinder, press the cylinder down onto the base gasket.

16 Install the cylinder bolt and tighten it finger-tight only at this stage (**see illustration 15.2**).

17 Install the cylinder head (see Section 12), then tighten the cylinder block bolt.



16.1 Mark the piston before removing it

16 Piston – removal, inspection and installation



Note: The piston can be removed with the engine in the frame.

Removal

1 Remove the cylinder (see Section 15). Before removing the piston from the connecting rod, stuff a clean rag into the hole around the rod to prevent the circlips or anything else from falling into the crankcase. The piston should have an arrow marked on its crown which should face towards the exhaust valve. If this is not visible, mark the piston accordingly so that it can be installed the correct way round (**see illustration**). Note that the arrow may not be visible until the carbon deposits have been scraped off and the piston cleaned.

2 Carefully prise out the circlip on one side of the piston using a pointed instrument or a small flat-bladed screwdriver inserted into the notch (**see illustration**). Push the piston pin out from the other side to free the piston from the connecting rod. Remove the other circlip and discard them both, as new ones must be used. Use a socket extension to push the piston pin out if required.



To prevent the circlip from flying away or from dropping into the crankcase, pass a rod or screwdriver with a greater diameter than the gap between the circlip ends through the piston pin. This will trap the circlip if it springs out.



If a piston pin is a tight fit in the piston bosses, heat the piston gently with a hot air gun – this will expand the alloy piston sufficiently to release its grip on the pin.

Inspection

3 Before the inspection process can be carried out, the piston rings must be removed

and the piston must be cleaned. Note that if the cylinder is being rebored, piston inspection can be overlooked as a new one will be fitted. All three piston rings can be removed by hand; a ring removal and installation tool can be used on the two compression rings, but do not use it on the oil control ring (**see illustration**). Carefully note which way up each ring fits and in which groove, as they must be installed in their original positions if being re-used. The upper surface of each ring should be marked at one end. Do not nick or gouge the piston in the process.

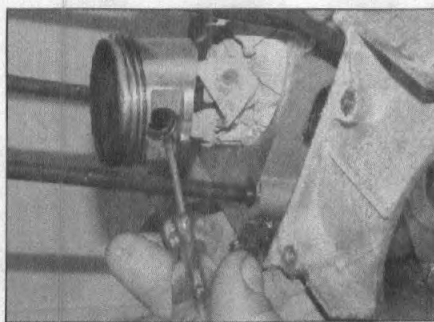
4 Scrape all traces of carbon from the top of the piston. A hand-held wire brush or a piece of fine emery cloth can be used once most of the deposits have been scraped away. Do not, under any circumstances, use a wire brush mounted in a drill motor to remove deposits from the piston; the piston material is soft and will be eroded away by the wire brush.

5 Use a piston ring groove cleaning tool to remove any carbon deposits from the ring grooves. If a tool is not available, a piece broken off an old ring will do the job. Be very careful to remove only the carbon deposits. Do not remove any metal and do not nick or gouge the sides of the ring grooves. Once the deposits have been removed, clean the piston with solvent and dry it thoroughly.

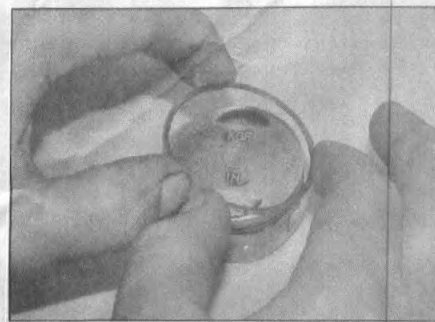
6 Inspect the piston for cracks around the skirt, at the pin bosses and at the ring lands. Normal piston wear appears as even, vertical wear on the thrust surfaces of the piston and slight looseness of the top ring in its groove. If the skirt is scored or scuffed, the engine may have been suffering from overheating and/or abnormal combustion, which caused excessively high operating temperatures. Also check that the circlip grooves are not damaged.

7 A hole in the piston crown is an extreme example that abnormal combustion (pre-ignition) was occurring. Burned areas at the edge of the piston crown are usually evidence of spark knock (detonation). If any of the above problems exist, the causes must be corrected or the damage will occur again.

8 Check the piston-to-bore clearance by measuring the bore (see Section 15) and the



16.2 Prise the circlip out carefully



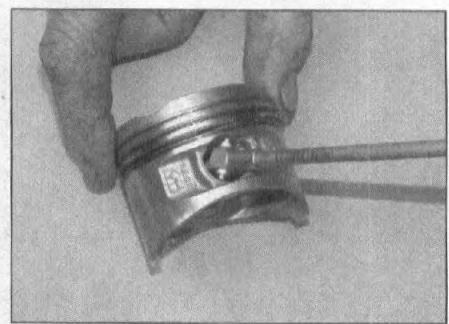
16.3 Removing the piston rings



16.8 Measuring the piston diameter



16.9a Measure the piston pin diameter at each end . . .



16.9b . . . and the boss diameter on each side of the piston

piston diameter. Measure the piston 25 mm down from the bottom of the lower piston ring groove and at 90° to the piston pin axis (see illustration). Subtract the piston diameter from the bore diameter to obtain the clearance. If it is greater than the specified figure, the piston must be renewed (assuming the bore itself is within limits, otherwise a rebore is necessary).

9 Use a micrometer and a small hole gauge to determine whether there is wear between the piston pin and piston. Measure the piston pin diameter at the ends and the diameter of each pin boss in the piston and compare the results with the Specifications (see illustrations).

10 To check for wear between the piston pin and connecting rod small-end, measure the

piston pin diameter at its centre and the internal diameter of the rod small-end (see illustrations). There are two size groups for the piston pin (A or B) and connecting rod small-end (I or II). Look for identification marks on the components and supply these to the dealer when ordering new parts.

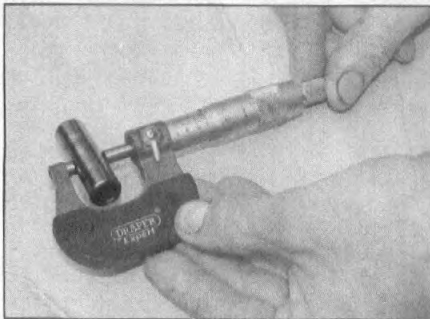
11 Piston ring-to-groove clearance can be measured to determine whether the ring grooves in the piston are worn. Install the rings on the piston (see Section 17), then use a feeler gauge to measure the clearance between the ring and groove and compare the result with the specifications (see illustration). If the clearance is greater than the limit, repeat the check using new rings, if the clearance is still too great, the piston should be renewed.

Installation

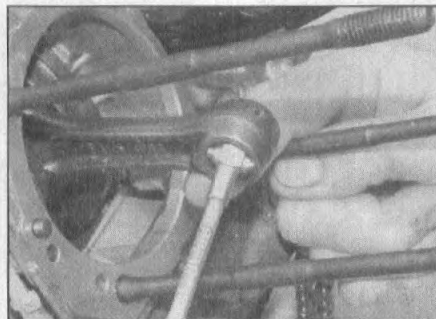
12 Inspect and install the piston rings (see Section 17).

13 Lubricate the piston pin, the piston pin bore and the connecting rod small-end bore with clean engine oil. Install a new circlip in one side of the piston (do not re-use old circlips). Line up the piston on the connecting rod, making sure the arrow on the piston crown faces towards the exhaust, and insert the piston pin (see illustration). Secure the piston pin with the other new circlip (see illustration). When installing the circlips, compress them only just enough to fit them in the piston, and make sure they are properly seated in their grooves with the open end away from the removal notch (see illustration).

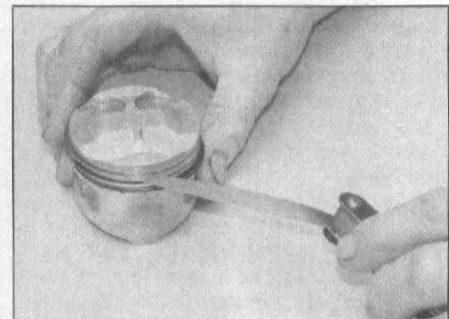
14 Install the cylinder (see Section 15).



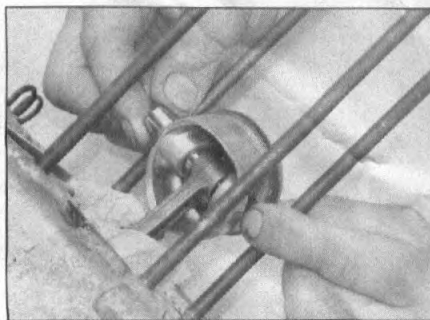
16.10a Measure the piston pin diameter in the middle . . .



16.10b . . . and the rod small-end diameter



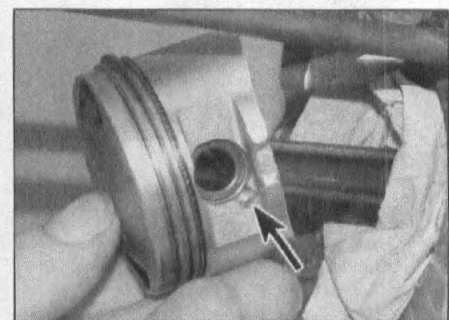
16.11 Measuring piston ring-to-groove clearance



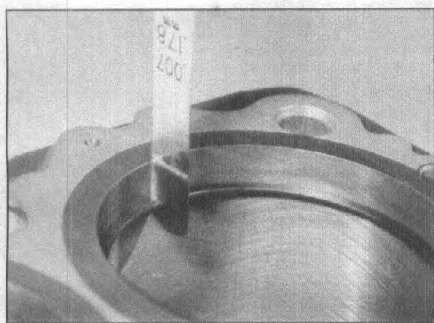
16.13a Insert the piston pin . . .



16.13b . . . and secure it with a new circlip



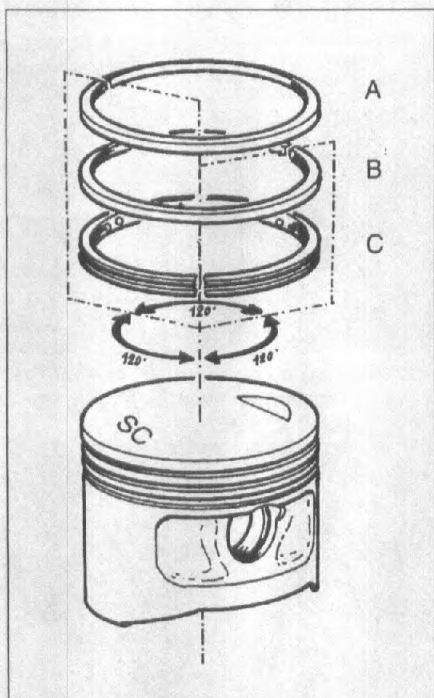
16.13c Ensure the ends of the circlip are clear of the notch (arrowed)



17.2 Measuring piston ring installed end gap

17 Piston rings – inspection and installation

- 1 New piston rings should be fitted whenever an engine is being overhauled. Before installing the new piston rings, the ring end gaps must be checked with the rings installed in the bore.
- 2 To measure the installed ring end gap, insert the top ring into the bottom of the bore and square it up with the bore walls by pushing it in with the top of the piston. The ring should be about 20 mm from the bottom edge of the bore. To measure the end gap, slip a feeler gauge between the ends of the ring and compare the measurement to the



17.8 Ensure that the ring end gaps are positioned at 120° intervals

- A First (top) compression ring
- B Second (middle) compression ring
- C Oil control ring

specifications at the beginning of the Chapter (see illustration).

3 If the gap is larger or smaller than specified, double check to make sure that you have the correct rings before proceeding. If the gap is too small the ends may come in contact with each other during engine operation, which can cause serious damage. Check the piston and bore diameters with the specifications to confirm whether they are standard or oversize.

4 Excess end gap is not critical unless it exceeds the service limit. Again, double-check to make sure you have the correct rings for your engine and check that the bore is not worn.

5 Repeat the procedure for the other two rings.

6 Once the ring end gaps have been checked, the rings can be installed on the piston.

7 The oil control ring (lowest on the piston) is installed first. Always install this ring by hand and do not expand the ring any more than is necessary to slide it into place. Next install the 2nd compression ring, noting that there is usually a marking or letter near the gap to denote the upper surface of the ring. Finally install the top ring into its groove. A ring installation tool can be used on the two compression rings if desired.

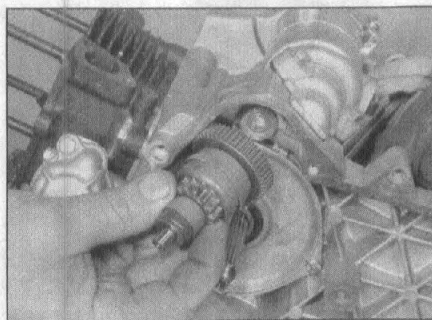
8 Once the rings are correctly installed, check they move freely without snagging and stagger their end gaps as shown (see illustration).

18 Cooling fan – removal and installation

Note: The cooling fan can be removed with the engine in the frame.

Removal

- 1 Remove the bodywork as required by your model to access the alternator cover on the right-hand side of the engine (see Chapter 7).
- 2 Remove the screws securing the alternator cover and remove the cover (see illustration 7.2).
- 3 Remove the three screws securing the



20.1 Removing the starter pinion assembly

cooling fan to the alternator rotor and remove the fan (see illustration 11.4 in Chapter 2A).

Installation

4 Installation is the reverse of removal.

19 Alternator rotor and stator – removal and installation

Note: The alternator can be removed with the engine in the frame

- 1 Remove the cooling fan (see Section 18).
- 2 The remainder of the procedure for removal, inspection and installation of the alternator rotor and stator is the same as for two-stroke models. Refer to Chapter 2A, Section 12, for the procedure.

20 Starter pinion assembly – removal, inspection and installation

Note: The starter pinion assembly can be removed with the engine in the frame.

- 1 The procedure for removal, inspection and installation of the starter pinion assembly is the same as for two-stroke models, except that it is located in the top of the transmission housing rather than the bottom (see illustration). Refer to Chapter 2A, Section 13, for the procedure.

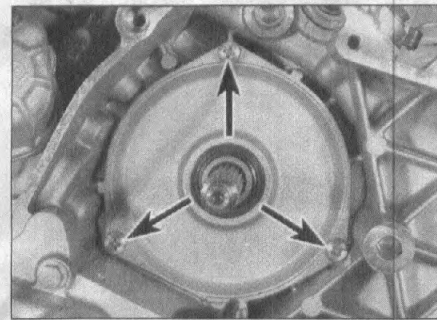
21 Oil pump and relief valve – removal, inspection and installation

Note: The oil pump and pressure relief valve can be removed with the engine in the frame.

Oil pump

Removal

- 1 Remove the air filter housing (see Chapter 4).
- 2 Remove the drive pulley and variator (see Chapter 2G).
- 3 Remove the screws securing the pump drive chain cover and remove the cover (see illustration). Discard the cover O-ring as a new one should be used.



21.3 The cover is secured by three screws (arrowed)

4 Remove the bolts securing the sump cover and remove the cover (see illustration).

5 Remove the screws securing the driven sprocket plate and remove the plate, noting how it fits (see illustration).

6 Insert a pin punch or screwdriver through one of the holes in the driven sprocket and locate it against part of the casing to prevent the sprocket turning, then unscrew the sprocket bolt (see illustration).

7 Draw the sprocket off the pump and slip it out of the chain (see illustration). If required, draw the chain up into the transmission housing and remove it from the drive sprocket (see illustration). Slide the drive sprocket off the end of the crankshaft (see illustration).

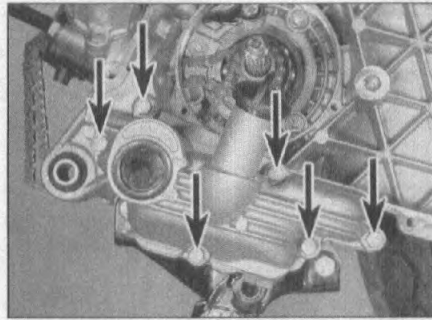
8 Remove the two screws securing the oil pump and remove the pump (see illustration). Also remove the gasket from behind the pump and discard it as a new one must be used.

Inspection

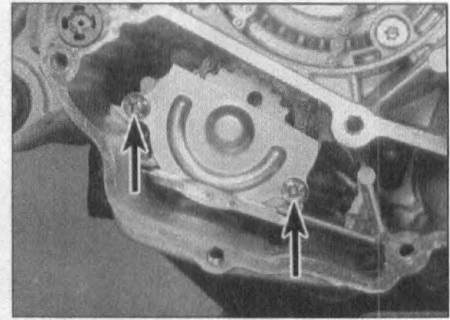
9 Remove the two screws securing the cover to the pump body, then remove cover (see illustrations).

10 Clean the pump in solvent. Inspect the pump body and rotors for scoring and wear. If any damage, scoring or uneven or excessive wear is evident, renew the pump (individual components are not available). Dry the pump with compressed air.

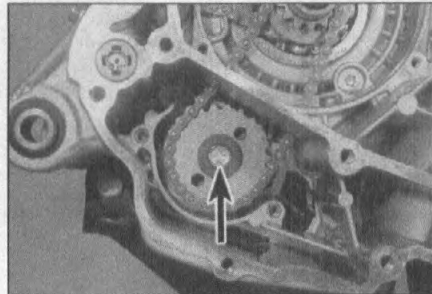
11 Measure the clearance between the inner rotor tip and the tip of one of the crescents on the outer rotor with a feeler gauge and compare it to the maximum clearance listed in



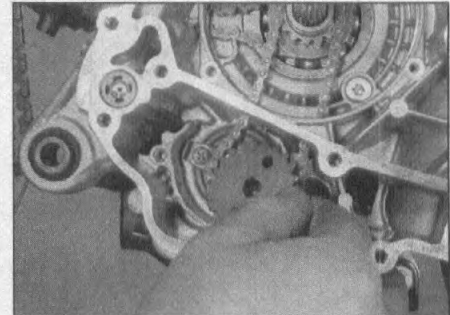
21.4 The sump cover is secured by six bolts (arrowed)



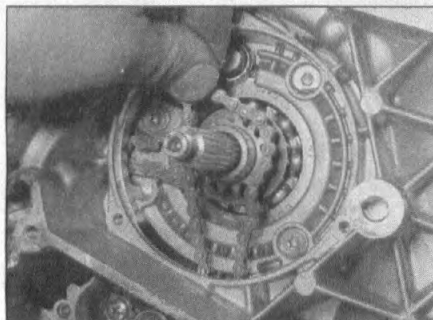
21.5 The driven sprocket plate is secured by two screws (arrowed)



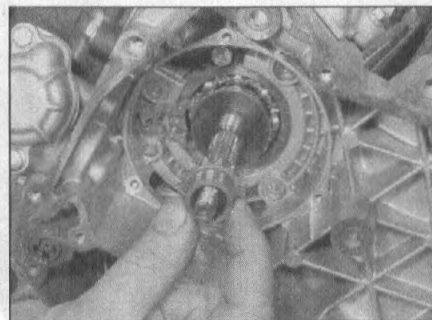
21.6 Unscrew the sprocket bolt (arrowed) using a tool in one of the holes to prevent it turning



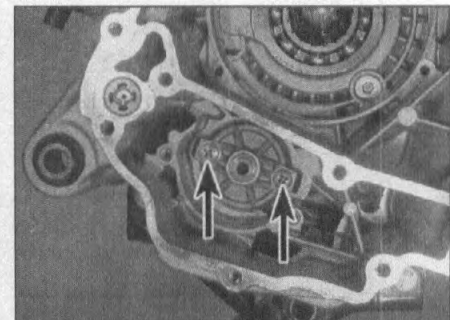
21.7a Remove the driven sprocket . . .



21.7b . . . the chain . . .



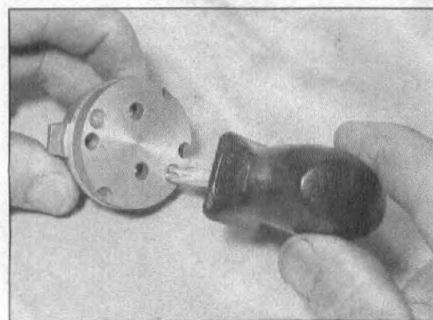
21.7c . . . and the drive sprocket



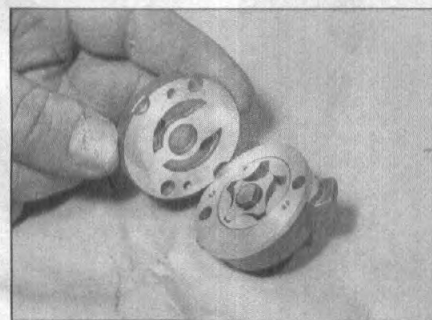
21.8 The pump is secured by two screws (arrowed)

the specifications at the beginning of the Chapter (see illustration). If the clearance measured is greater than the maximum listed, renew the pump.

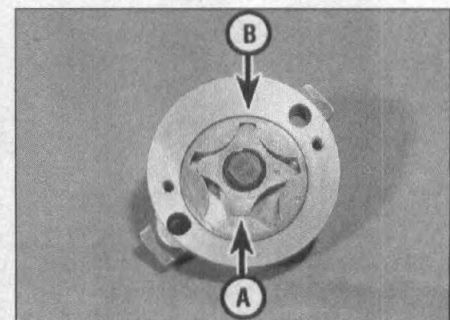
12 Measure the clearance between the outer rotor and the pump body with a feeler gauge and compare it to the maximum clearance listed in the specifications at the beginning of



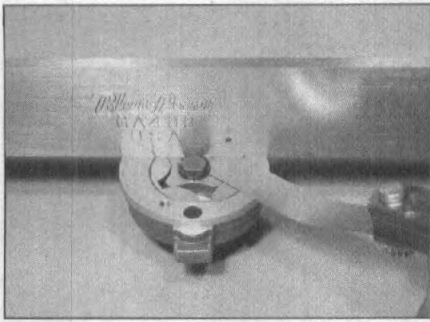
21.9a Remove the screws . . .



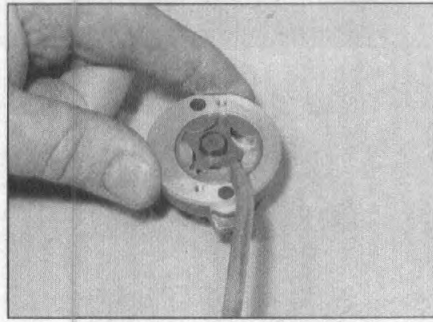
21.9b . . . and lift off the pump cover



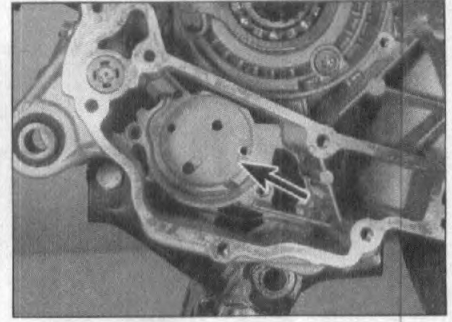
21.11 Measure inner-to-outer rotor clearance (A) and outer rotor-to-body clearance (B)



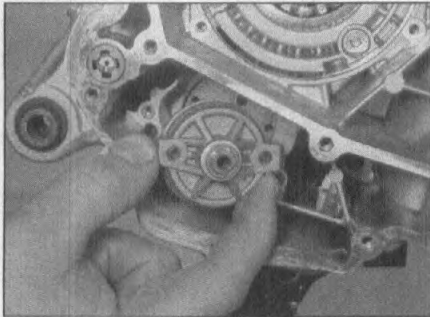
21.13 Measuring rotor endfloat



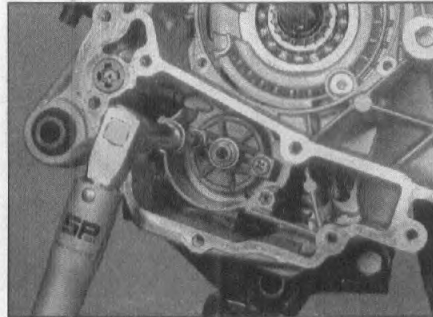
21.15 Lubricate the pump with clean oil



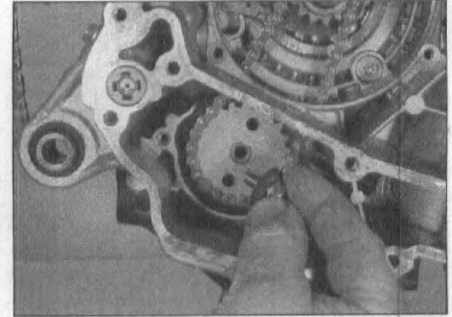
21.18 Fit a new gasket (arrowed)



21.19a Install the pump ...



21.19b ... and tighten its screws to the specified torque



21.21a Fit the sprocket then install the bolt ...

the Chapter (see illustration 21.11). If the clearance measured is greater than the maximum listed, renew the pump.

13 Lay a straight-edge across the rotors and the pump body and, using a feeler gauge, measure the rotor endfloat (the gap between the rotors and the straight-edge) (see illustration). If the clearance measured is greater than the maximum listed, renew the pump.

14 Check the pump drive chain and sprockets for wear or damage, and renew them as a set if necessary.

15 If the pump is good, make sure all the components are clean, then lubricate them with new engine oil (see illustration).

16 Fit the cover, noting that it can only be fitted one way, and tighten the screws securely (see illustrations 21.9b and 21.9a).

17 Rotate the pump shaft by hand and check that the rotors turn smoothly and freely.

Installation

18 Lay a new pump gasket onto the crankcase, making sure the holes in the gasket align correctly with the oil holes (see illustration).

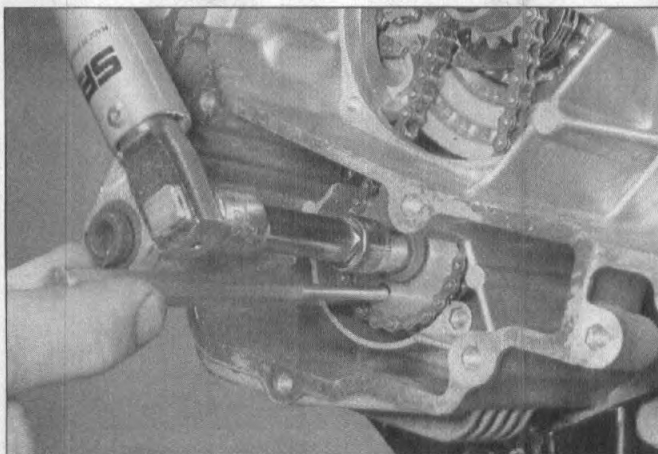
19 Install the pump, noting that it can only be fitted one way, and tighten the screws to the torque setting specified at the beginning of the Chapter (see illustrations). Piaggio specify that this torque setting is crucial.

Slide the drive sprocket, with its shouldered end facing out, onto the crankshaft (see illustration 21.7c). Fit the drive chain around the sprocket and slip it down into the sump (see illustration 21.7b).

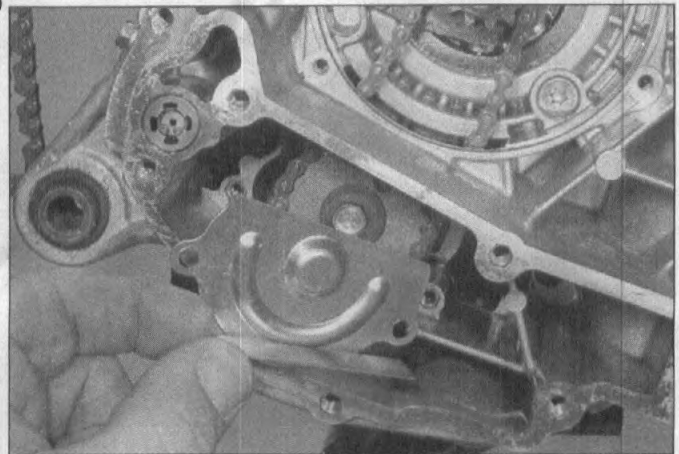
21 Fit the driven sprocket into the chain (see illustration 21.7a), then fit the sprocket onto the pump, aligning the flat with that on the pump shaft (see illustration). Install the bolt, and using the method employed on removal to prevent the sprocket turning, tighten the sprocket bolt to the specified torque (see illustration).

22 Install the driven sprocket plate and tighten its screws securely (see illustration).

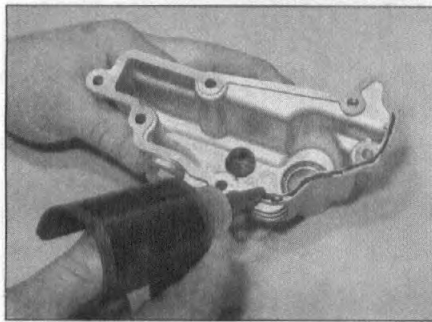
23 Remove any traces of old sealant from the



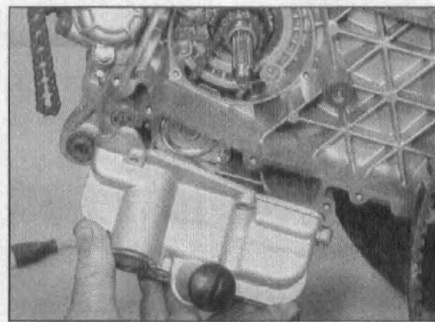
21.21b ... and tighten it to the specified torque



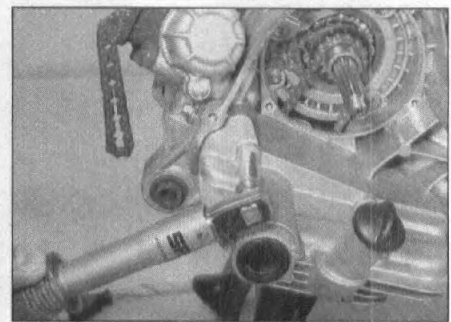
21.22 Install the sprocket plate



21.24a Apply a sealant ...



21.24b ... then install the cover ...



21.24c ... and tighten the bolts to the specified torque

sump cover and crankcase mating surfaces and make sure they are clean. If a scraper is used, take care not to scratch or gouge the soft aluminium.

24 Apply a suitable sealant (such as Loctite 501) to the sump cover, then fit the cover and tighten the bolts to the specified torque (see illustrations).

25 Check the condition of the oil seal and the chain guide in the drive chain cover and renew them if there are any signs of oil leakage on the cover or crankshaft or wear on the guide (see illustration). Fit a new O-ring onto the cover, then install the cover with its flat edge at the bottom, making sure the chain fits correctly around the guide shoe, and tighten its screws securely (see illustration).

26 Install the drive pulley and variator (see Chapter 2G).

27 Install the air filter housing (see Chapter 4).

28 Fill the engine with the correct type and quantity of oil as described in Chapter 1. Start the engine and check that there are no leaks around the sump.

Oil pressure relief valve

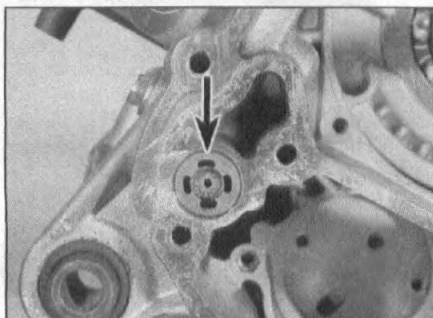
Removal

29 Remove the air filter housing (see Chapter 4).

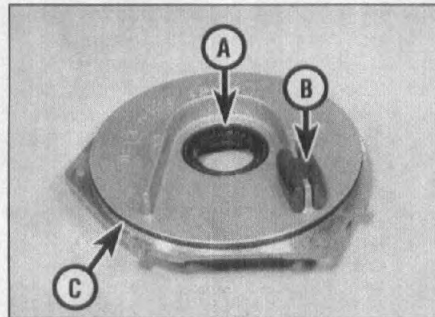
30 Remove the transmission cover (see Chapter 2G).

31 Remove the bolts securing the sump cover and remove the cover (see illustration 21.4).

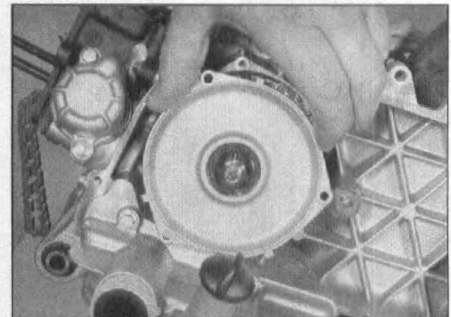
32 The valve is a push-fit in the crankcase (see illustration). Draw it out and discard the O-ring, as a new one must be used.



21.32 Oil pressure relief valve (arrowed)



21.25a Renew the oil seal (A) and chain guide (B) if necessary, and fit a new O-ring (C)



21.25b Install the cover with its flat edge at the bottom

Inspection

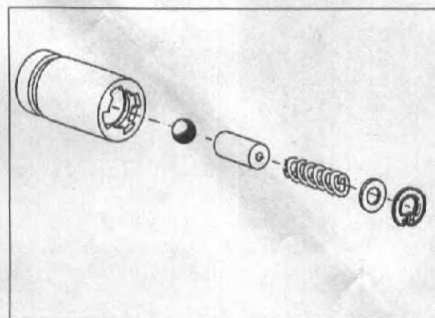
33 Push the valve ball and plunger on the inner end of the valve into the valve body and check that it moves smoothly and freely against the spring pressure. If not, renew the relief valve – individual components are not available.

34 Carefully remove the circlip from the outer end of the valve, noting that it is under spring pressure, and withdraw the washer, spring, plunger and ball from the valve (see illustration). Inspect all components for wear or damage and renew the valve if any is found.

35 Measure the free length of the spring. If it is less than the minimum specified at the beginning of the Chapter, renew the valve.

Installation

36 Fit the ball, plunger, spring and washer into the valve body and secure them with the circlip.



21.34 Oil pressure relief valve components

37 Smear the new valve body O-ring with clean engine oil, then fit it onto the body. Press the valve into its bore in the crankcase (see illustration 21.32).

38 Apply a suitable sealant (such as Loctite 501) to the sump cover, then fit the cover and tighten the bolts to the specified torque (see illustrations 21.24a, 21.24b and 21.24c).

39 Fit the transmission cover (see Chapter 2G), then install the air filter housing (see Chapter 4).

22 Crankcase halves, crankshaft and connecting rod



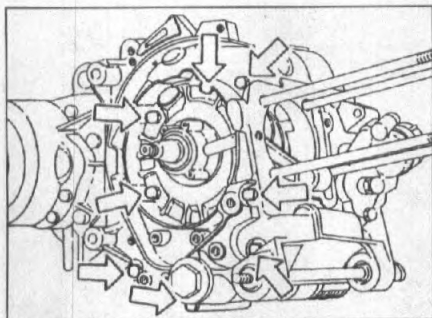
Note: To separate the crankcase halves, the engine must be removed from the frame.

Separation

1 To access the crankshaft and its bearings, the crankcase must be split into two parts.

2 To enable the crankcases to be separated, the engine must be removed from the frame (see Section 5). Before the crankcases can be separated the following components must be removed:

- a) Camchain, blades and sprockets (see Section 10).
- b) Cylinder head (see Section 12).
- c) Cylinder (see Section 15).
- d) Alternator rotor and stator (see Section 19).
- e) Variator (see Chapter 2G).
- f) Starter motor (see Chapter 9).
- g) Oil pump (see Section 21).



22.3 Crankcase bolt locations (arrowed)

3 Unscrew the eight crankcase bolts evenly, a little at a time and in a criss-cross sequence until they are all finger-tight, then remove them (see illustration). Carefully lift the right-hand crankcase half off the left-hand half. Lift the crankshaft out of the left-hand (transmission side) crankcase.

4 Remove the oil seals from each crankcase half, having taken careful note of their fitted positions.

Inspection

5 Check the condition of the crankshaft main bearings. The crankshaft right-hand bearing will remain on the crankshaft and the left-hand bearing will be held in the left-hand crankcase half. The bearings should spin freely and smoothly without any rough spots or excessive noise. Renew them if there is any doubt about their condition. The right-hand bearing should be removed from the crankshaft using an external bearing puller – make sure that the puller clamp or legs fit securely behind the bearing and are in no danger of slipping out. Before removing the left-hand bearing, remove the three screws which secure the bearing retaining plate to the crankcase (see illustration). Use a suitable diameter tube to drive the bearing out of the crankcase; if necessary heat the bearing housing using a hot air gun to aid bearing removal.

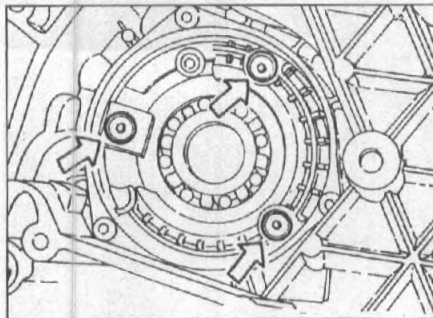
6 Refer to Chapter 2A, Section 15, for inspection procedures, referring also to the Specifications section of this Chapter.

7 Check the connecting rod big-end side clearance using feeler gauges (see illustration).

Reassembly

8 Install new crankshaft oil seals in the crankcase halves in the same position as noted on removal. Use a bearing driver or a suitably-sized socket which contacts only the outer face of the seal to drive it into position.

9 To fit the right-hand main bearing onto the crankshaft, the manufacturer advises that the bearing is first heated in an oil bath to around 120°C, then driven onto the crankshaft using a tubular drift which contacts the inner race of the bearing only – not the balls or outer race (see illustration 15.16 in Chapter 2A). To aid



22.5 Left-hand main bearing retaining plate screws (arrowed)

the fitting of the left-hand bearing in the left-hand crankcase half it is recommended that the bearing housing in the crankcase is first heated using a hot air gun. Use a tubular drift which contacts only the outer race of the bearing to drive it into its housing. Fit the bearing retaining plate (it can only be fitted one way due to its offset screw holes), apply thread locking compound to the threads of the three retaining plate bolts and tighten them securely.

10 If not already done, remove all traces of old gasket sealant from both crankcase halves. Use a rag moistened with high flash-point solvent to degrease the mating surfaces.

11 Lubricate the crankshaft big-end and main bearings with engine oil and insert the crankshaft into the left-hand half, positioning the connecting rod in line with the crankcase mouth. Apply a suitable gasket sealant to the crankcase mating surfaces. Guide the crankcase right-hand half over the crankshaft end, pressing it over the right-hand main bearing. Use a soft-faced mallet to help the casing seat, but don't apply too much pressure. **Note:** If the crankcases do not meet, remove the right-hand half and investigate the problem – do not be tempted to pull the crankcases together using the bolts.

12 Clean the threads of the crankcase bolts and install them finger-tight. Tighten the bolts evenly, in a criss-cross sequence, to the torque setting specified at the beginning of this Chapter. Rotate the crankshaft to check that it moves freely.

13 Install all other components in a reverse of the order given in Step 2.

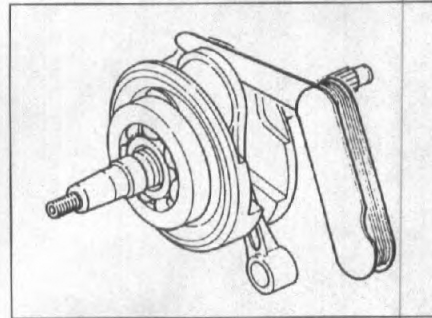
23 Initial start-up after overhaul

1 Make sure the engine oil level is correct (see Daily (pre-ride) checks).

2 Make sure there is fuel in the tank.

3 With the ignition OFF, operate the kickstart a couple of times to check that the engine turns over easily.

4 Turn the ignition ON, start the engine and allow it to run at a slow idle until it reaches



22.7 Checking the connecting rod big-end bearing side clearance

operating temperature. Do not be alarmed if there is a little smoke from the exhaust – this will be due to the oil used to lubricate the piston and bore during assembly and should subside after a while.

5 If the engine proves reluctant to start, remove the spark plug and check that it has not become wet and oily. If it has, clean it and try again. If the engine refuses to start, go through the fault finding charts at the end of this manual to identify the problem.

6 Check carefully for oil leaks and make sure the transmission and controls, especially the brakes, function properly before road testing the machine. Refer to Section 24 for the recommended running-in procedure.

7 Upon completion of the road test, and after the engine has cooled down completely, recheck the valve clearances (see Chapter 1) and check the engine oil level (see Daily (pre-ride) checks).

24 Recommended running-in procedure

1 Treat the machine gently for the first few miles to make sure oil has circulated throughout the engine and any new parts installed have started to seat.

2 Even greater care is necessary if the engine has been rebored or a new crankshaft has been installed. In the case of a rebore, the bike will have to be run-in as when new. This means a restraining hand on the throttle until at least 600 miles (1000 km) have been covered. There's no point in keeping to any set speed limit – the main idea is to keep from labouring the engine and to gradually increase performance up to the 600 mile (1000 km) mark. Make sure that the throttle position is varied to vary engine speed, and use full throttle for only short bursts, but do not allow the machine to attain more than 80% full speed, or to maintain any one speed for too long. Experience is the best guide, since it's easy to tell when an engine is running freely.

3 If a lubrication failure is suspected, stop the engine immediately and try to find the cause. If an engine is run without oil, even for a short period of time, severe damage will occur.

