Chapter 2
Engine, clutch and transmission

Contents

Alternator ..... see Chapter 9
Balancer shaft and bearings 29
Camshafts and followers 9
Cam chains, tensioner blades and guide blades 10
Cam chain tensioners 8
Clutch check ..... see Chapter 1
Clutch 14
Clutch master cylinder 15
Clutch release cylinder 16
Clutch – bleeding and fluid change 17
Connecting rods and bearings 21
Crankcase halves and cylinder bores 26
Crankcase separation and reassembly 25
Crankshaft and main bearings 28
Cylinder heads 11
Cylinder head and valve inspection 12
Cylinder compression check ..... see Chapter 1
Engine removal and installation 5
Engine disassembly and reassembly general information 6
Gearchange mechanism 18
General information 1
Idle speed check and adjustment ..... see Chapter 1
Initial start-up after overhaul 33
Main and connecting rod bearings general note 27
Major engine repair general note 4
Middle gear assembly 24
Neutral switch ..... see Chapter 9
Oil and filter change ..... see Chapter 1
Oil level check ..... see Daily (pre-ride) checks
Oil pressure check ..... see Chapter 1
Oil level sensor ..... see Chapter 9
Oil pump removal and installation 19
Oil pump disassembly, inspection and reassembly 20
Operations possible with the engine in the frame 2
Operations requiring engine removal 3
Pistons 22
Piston rings 23
Pulse generator coil(s) ..... see Chapter 5
Recommended running-in procedure 34
Selector drum and forks 32
Spark plug check ..... see Chapter 1
Starter clutch 13
Starter motor ..... see Chapter 9
Transmission shaft removal and installation 30
Transmission shaft disassembly and reassembly 31
Valve clearance check and adjustment ..... see Chapter 1
Valve covers 7

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

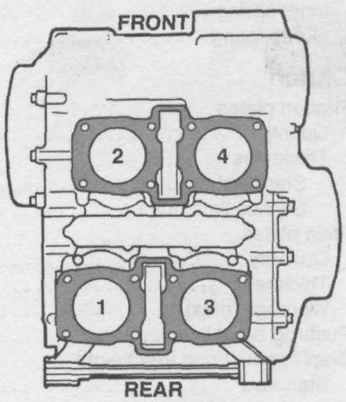
Difficult, suitable for experienced DIY mechanic

Very difficult, suitable for expert DIY or professional

Specifications

General

Type	Four-stroke V-four, liquid cooled
Capacity	1198 cc
Bore	76.0 mm
Stroke	66.0 mm
Compression ratio	10.5 to 1
Cylinder numbering	Rear left – 1, front left – 2, rear right – 3, front right – 4
Clutch	Wet multi-plate
Transmission	Five-speed constant mesh
Final drive	Shaft



Cylinder identification

Camshafts

Lobe height	
Standard	36.25 to 36.35 mm
Service limit (min)	36.15 mm
Journal diameter	24.967 to 24.980 mm
Holder/head bore diameter	25.000 to 25.021 mm
Journal oil clearance	0.020 to 0.054 mm
Runout (max)	0.03 mm

Cam chain

Type	DID219FTS

Cylinder head

Warpage (max)	0.03 mm

Valves, guides and springs

Valve clearances	see Chapter 1
Stem diameter	
Intake valve	
Standard	5.475 to 5.490 mm
Service limit (min)	5.445 mm
Exhaust valve	
Standard	5.460 to 5.475 mm
Service limit (min)	5.420 mm
Guide bore diameter – intake and exhaust valves	
Standard	5.500 to 5.512 mm
Service limit (max)	5.550 mm
Stem-to-guide clearance	
Intake valve	
Standard	0.010 to 0.037 mm
Service limit (max)	0.08 mm
Exhaust valve	
Standard	0.025 to 0.052 mm
Service limit (max)	0.1 mm
Valve stem end – intake and exhaust valves	
Min length above collet groove	4.0 mm
Seat width – intake and exhaust valves	
Standard	0.9 to 1.1 mm
Service limit (max)	1.4 mm
Head diameter	
Intake valve	30.4 to 30.6 mm
Exhaust valve	24.9 to 25.1 mm
Face width	
Intake valve	1.6 to 3.1 mm
Exhaust valve	1.3 to 2.4 mm
Margin thickness – intake and exhaust valves	
Standard	1.1 to 1.5 mm
Service limit (min)	0.7 mm
Valve stem runout (max)	0.01 mm
Valve springs free length	
Inner spring – intake and exhaust valves	
Standard	39.65 mm
Minimum	37.45 mm
Outer spring – intake and exhaust valves	
Standard	41.10 mm
Minimum	38.90 mm
Valve spring bend (max) – intake and exhaust	
Inner spring	1.7 mm
Outer spring	1.8 mm

Clutch

Friction plates	
Quantity	8
Thickness	
Standard	2.9 to 3.1 mm
Service limit (min)	2.8 mm
Plain plates	
Quantity	7
Thickness	2.2 to 2.4 mm
Warpage (max)	0.2 mm
Pushrod bend limit	0.5 mm
Diaphragm spring free height	
Standard	7.0 mm
Service limit (min)	6.5 mm
Diaphragm spring warp limit	0.1 mm

Clutch release mechanism

Clutch fluid type	DOT 4
Master cylinder bore ID	15.87 mm
Release cylinder bore ID	38.1 mm

Lubrication system

Oil pressure	see Chapter 1
Relief valve opening pressure	63 to 80 psi (4.35 to 5.52 Bar)
By-pass valve setting pressure	24 to 34 psi (1.65 to 2.35 Bar)
Oil pump	
Inner rotor tip-to-outer rotor clearance	
Standard	0.0 to 0.12 mm
Service limit (max)	*0.17 mm*
Outer rotor-to-body clearance	
Standard	0.03 to 0.08 mm
Service limit (max)	0.08 mm

Connecting rods

Big-end side clearance	0.320 to 0.924 mm
Big-end oil clearance	0.021 to 0.043 mm

Pistons

Piston diameter	
Measuring point	6.2 mm up from skirt base, at 90° to piston pin axis
Standard	75.905 to 75.955 mm
1st oversize	+0.25 mm
2nd oversize	+0.50 mm
Piston-to-bore clearance	
Standard	0.055 to 0.075 mm
Service limit (max)	*0.15 mm*
Piston pin diameter	18.991 to 19.000 mm
Piston pin bore diameter in piston	19.004 to 19.015 mm
Piston pin-to-pin bore clearance	0.004 to 0.024 mm

Piston rings

Top ring	
Type	Barrel
Ring width	3.1 mm
Ring thickness	1.0 mm
Ring end gap (installed)	
Standard	0.35 to 0.50 mm
Maximum	0.75 mm
Piston ring-to-groove clearance	
Standard	0.03 to 0.07 mm
Maximum	0.12 mm
2nd ring	
Type	Taper
Ring width	3.1 mm
Ring thickness	1.2 mm
Ring end gap (installed)	
Standard	*0.35 to 0.50 mm*
Maximum	0.75 mm
Piston ring-to-groove clearance	
Standard	0.02 to 0.06 mm
Maximum	0.12 mm
Oil ring	
Ring width	3.1 mm
Ring thickness	*2.5 mm*
Side-rail end gap (installed)	0.2 to 0.8 mm

Middle gear assembly

Middle gear backlash	0.05 to 0.12 mm

Cylinder bores

Bore	
Standard	75.967 to 76.02 mm
Service limit (max)	76.1 mm
Ovality (out-of-round) (max)	0.05 mm
Taper (max)	0.05 mm
Cylinder compression	see Chapter 1

Crankshaft and bearings

Main bearing oil clearance	
Standard	0.020 to 0.044 mm
Service limit (max)	0.09 mm
Runout (max)	0.03 mm

Balancer shaft and bearings

Bearing oil clearance	
Standard	0.020 to 0.048 mm
Service limit (max)	0.09 mm

Transmission

Gear ratios (no. of teeth)	
Primary reduction	1.776 to 1 (87/49T)
Final reduction (overall)	
US origin models	2.851 to 1 (21/27T x 33/9T)
UK origin models	2.567 to 1 (21/27T x 33/10T)
1st gear	2.529 to 1 (43/17T)
2nd gear	1.773 to 1 (39/22T)
3rd gear	1.348 to 1 (31/23T)
4th gear	1.077 to 1 (28/26T)
5th gear	0.929 to 1 (26/28T)
Shaft runout (max)	0.08 mm
Output shaft length (see Text)	253.81 to 254.37 mm

Selector drum and forks

Selector fork shaft runout (max)	0.025 mm

Torque wrench settings

Cam chain guide (top) bolts	10 Nm
Cam chain tensioner mounting bolts	12 Nm
Cam chain tensioner cap bolt	20 Nm
Cam chain tensioner blade seat bolt	24 Nm
Camshaft holder bolts	10 Nm
Camshaft sprocket bolts	24 Nm
Clutch cover bolts	10 Nm
Clutch diaphragm spring bolts	8 Nm
Clutch hose banjo bolt – master cylinder union	
1985 to 1995 models	25 Nm
1996 to 2003 models	30 Nm
Clutch master cylinder clamp bolts	9 Nm
Clutch nut	70 Nm
Clutch pipe banjo bolt – release cylinder union	25 Nm
Clutch release cylinder bolts	12 Nm
Clutch release cylinder bleed valve	6 Nm
Clutch release cylinder banjo bolt joint piece	25 Nm
Connecting rod cap nuts (see Text)	
Initial setting	20 Nm
Final setting	36 Nm
Crankcase bolts	
Lower crankcase bolt nos. 1 to 8	40 Nm
Lower crankcase bolt nos. 9 to 22	
8 mm bolts	24 Nm
6 mm bolts	12 Nm
Upper crankcase bolt nos. 23 to 36	
8 mm bolts	24 Nm
6 mm bolts	12 Nm
Crankcase breather housing bolts (all)	10 Nm
Cylinder head nuts	43 Nm
Engine mounting bolts	
Cradle section-to frame bolts and nuts	45 Nm
Upper front mounting bracket-to left-hand frame downtube bolts and nuts	16 Nm
Rear engine mounting bolts	70 Nm
Lower front engine mounting-to-frame cross piece bolts	
1985 to 2000 models	40 Nm
2001 to 2003 models	42 Nm

Torque wrench settings (continued)

Engine mounting bolts (continued)	
Frame cross piece-to frame nuts and bolts	
1985 to 2000 models	15 Nm
2001 to 2003 models	16 Nm
Upper front mounting bar nuts	
1985 to 2000 models	40 Nm
2001 to 2003 models	42 Nm
External oil pipe banjo bolts	
10 mm bolt	20 Nm
8 mm bolts	18 Nm
Gearchange stopper arm bolt	
1985 to 2000 models	8 Nm
2001 to 2003 models	10 Nm
Internal oil pipe assembly bolts	
6 mm bolts	12 Nm
8 mm crankcase bolt	24 Nm
Internal oil pipe banjo bolt	18 Nm
Middle drive gear bearing retainer plate screws	25 Nm
Middle drive gear bearing nut	110 Nm
Middle driven gear shaft nut	90 Nm
Middle driven gear assembly mounting bolts	30 Nm
Oil baffle plate screws	12 Nm
Oil pump mounting bolts	10 Nm
Oil sump bolts	10 Nm
Starter clutch housing bolts	24 Nm
Transmission input shaft bearing retainer plate screws	7 Nm
Valve cover bolts	10 Nm

1 General information

The engine/transmission unit is a liquid-cooled V-four cylinder. The engine/transmission is a unit assembly constructed from aluminium alloy. The crankcase divides horizontally.

The sixteen valves are operated by double overhead camshafts which are chain driven off the middle of the crankshaft. A balancer shaft, located in the front of the crankcase and driven directly off the crankshaft, irons out vibrations for smooth running.

The crankcase incorporates a wet sump, pressure-fed lubrication system which uses a dual-rotor trochoidal oil pump with integral pressure relief valve that is gear-driven off the back of the clutch. The system also has an oil filter with integral by-pass valve (in case of blockage), and an oil level sensor and warning light.

The alternator is on the left-hand end of the crankshaft and has the starter clutch mounted behind it. The water pump is on the right-hand side of the engine, and is gear driven off the crankshaft. The pulse generator coil(s) run off triggers incorporated in the alternator rotor.

Power from the crankshaft is routed to the transmission via the clutch. The clutch is of the wet, multi-plate type and is gear-driven off the crankshaft. The clutch is hydraulically operated. The transmission is a five-speed constant-mesh unit. The drive is then turned through 90° by a middle gear assembly, and is transmitted to the final drive housing on the rear wheel by a driveshaft running inside the swingarm.

2 Operations possible with the engine in the frame

The components and assemblies listed below can be removed without having to remove the engine from the frame. If however, a number of areas require attention at the same time, removal of the engine is recommended.

Valve covers
Cam chain tensioners and blades
Camshafts
Pulse generator coil(s)
Clutch
Gearchange mechanism
Alternator rotor and stator
Oil filter and oil cooler
Oil sump, oil strainer, oil pump (including pressure relief valve)
Starter motor
Starter clutch
Water pump
Middle driven gear

3 Operations requiring engine removal

It is necessary to remove the engine/transmission assembly from the frame to gain access to the following components.

Cylinder heads
Connecting rods and bearings
Pistons, piston rings and cylinder bores

It is necessary to remove the engine/transmission assembly from the frame and separate the crankcase halves to gain access to the following components.

Crankshaft and bearings
Cam chains
Balancer shaft
Transmission shafts/middle drive gear
Selector drum and forks

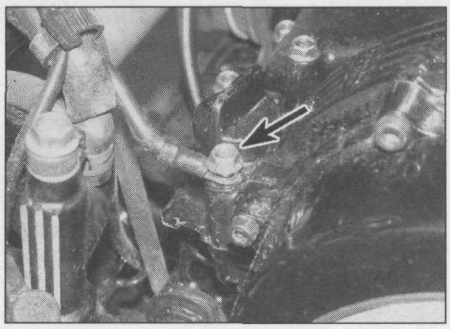
4 Major engine repair – general note

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 guides 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



5.5 Unscrew the bolt (arrowed) and detach the earth lead

rumbling noises, the connecting rods and/or main bearings are probably at fault.

5 Loss of power, rough running, excessive valve train noise and high fuel consumption may also point to the need for an overhaul, especially if they are all present at the same time. If a complete tune-up 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 rings and main and connecting rod bearings are usually replaced and the cylinder walls honed or, if necessary, re-bored (oversize pistons are available), during a major overhaul. Generally the valve seats are re-ground, since they are usually in less than perfect condition at this point. 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 motorcycle 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.

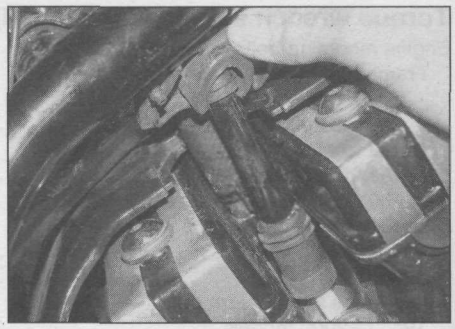
5 Engine – removal and installation

Caution: The engine is VERY heavy. Engine removal and installation should be carried out with the aid of at least one strong assistant, though two are preferable; personal injury or damage could occur if the engine falls or is dropped.

HAYNES HiNT ***Where options are given for removal of components not essential for engine removal, for example the starter motor and thermostat housing, bear in mind that although these do not weigh much in themselves, they add to the weight of the engine, and anything that can be removed to reduce the overall weight is a bonus. With that in mind you may wish to consider removing the alternator, water pump and clutch assemblies before removing the engine, especially if you will be removing them anyway as part of an engine strip. The exposed shaft ends that removing the alternator and clutch reveal can make useful handles for manoeuvring the engine, but make sure they are thoroughly degreased first.***

Removal

1 Support the bike on its centrestand, making sure it is on level ground. Work can be made easier by raising the machine to a suitable working height on an hydraulic ramp or a suitable platform. Make sure the motorcycle is secure and will not topple over (also see *Tools and Workshop Tips* in the Reference section).



5.6 Pull the caps off the spark plugs, on the rear cylinders noting how the covers locate

2 Remove the rider's seat, top cover, side covers and side panels (see Chapter 8).

3 If the engine is dirty, particularly around its mountings, wash it thoroughly. This will make work much easier and rule out the possibility of caked on lumps of dirt falling into some vital component.

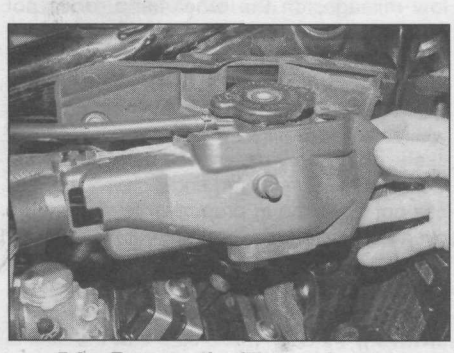
4 Drain the engine oil and the cooling system (see Chapter 1). Remove the oil filter (see Chapter 1).

5 Unscrew the rear crankcase bolt on the right-hand side and detach the earth (–ve) lead **(see illustration)**. Re-install the bolt and tighten it finger-tight.

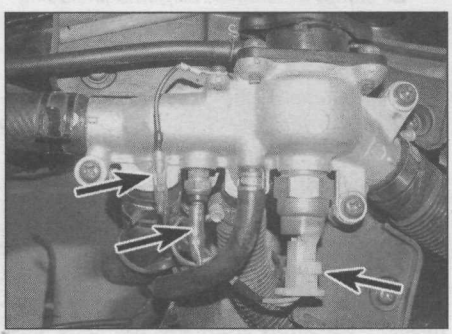
6 Pull the caps off the spark plugs, on the rear cylinders noting how the covers locate in the heat shield **(see illustration)**.

7 Remove the radiator (see Chapter 3). If required, remove the thermostat housing (see Chapter 3).

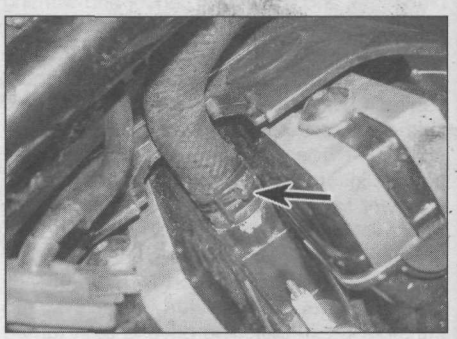
8 Remove the filler neck cover **(see illustration)**. Disconnect the wiring connectors from the temperature gauge sensor and fan switch in the radiator filler neck, and disconnect the earth wire connector **(see illustration)**. Trace the large bore hoses from the filler neck and detach them from their unions on the cylinder heads and the drain valve pipe on the front of the engine **(see illustration)**. Also detach the small bore hose from the bottom of the filler neck, and the overflow hose from the top of it **(see illustration)**. Free the front cylinder heat shield tabs from the filler neck mounting board **(see illustration)**. Undo the screws securing the



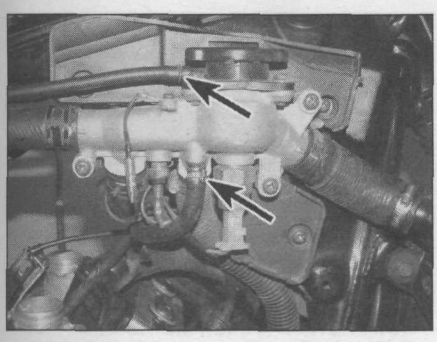
5.8a Remove the filler neck cover



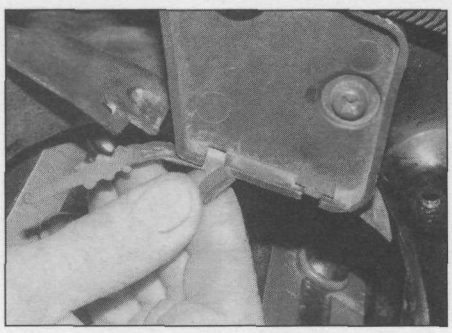
5.8b Disconnect the wiring connectors (arrowed)



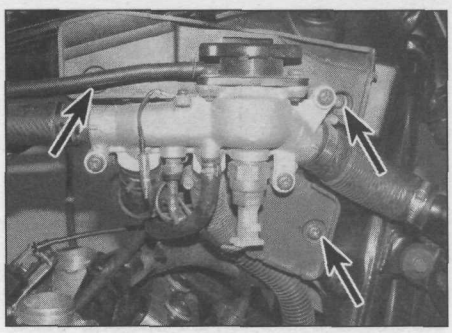
5.8c Release the clamp (arrowed) and pull the hose off each cylinder head



5.8d Detach the small bore hoses (arrowed) from their unions



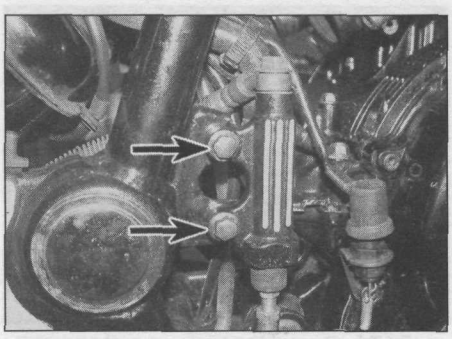
5.8e Release the tabs . . .



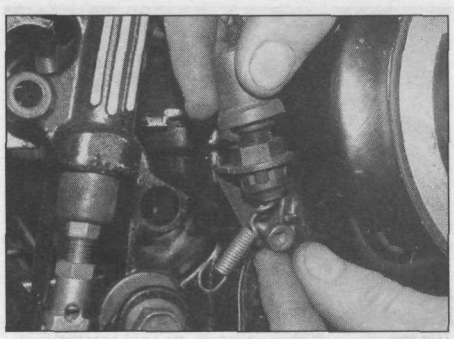
5.8f . . . then undo the screws (arrowed) and remove the filler neck assembly



5.12 Pull back the terminal cover on the black (starter motor) lead, then unscrew the nut (arrowed) and detach the lead



5.13a Unscrew the master cylinder bolts (arrowed)



5.13b Unscrew the brake light switch bolt and unhook the spring

mounting board and remove it along with the filler neck and its hoses **(see illustration)**.

9 Remove the exhaust system (see Chapter 4).

10 Remove the air filter housing and the carburettors (see Chapter 4). When accessing the throttle cable splitter behind the electrical component board on the left-hand side, instead of just displacing the board, it is better to disconnect the wiring connectors as required and to remove it. On restricted power models, if required remove the intake duct assembly (see Chapter 4). Plug the intakes with clean rag.

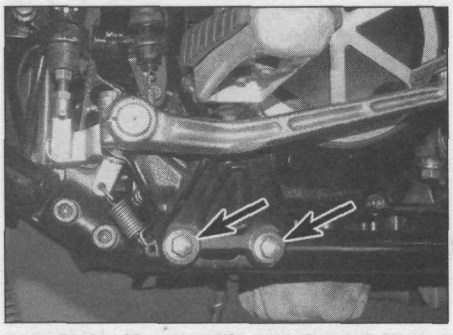
11 On V-Boost models, remove the servo motor, and if required the V-Boost duct assembly (see Chapter 4). Plug the intakes with clean rag.

12 If required, remove the starter motor (see Chapter 9). If you want to leave the starter motor in situ, pull back the rubber cover on the starter motor lead terminal on the starter relay, then unscrew the nut and disconnect the lead **(see illustration)**. Feed the lead down to the engine.

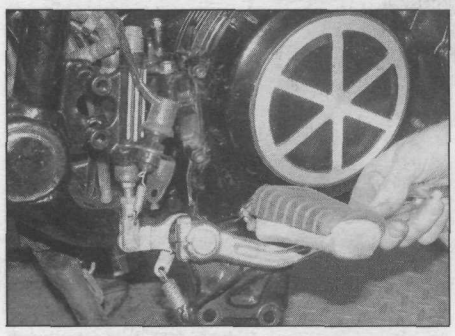
13 Unscrew the rear brake master cylinder mounting bolts and displace the master cylinder **(see illustration)**. Unscrew the clutch cover bolt that secures the brake light switch bracket and displace the switch, then unhook its spring from the pedal pivot **(see illustration)**. Re-install the bolt and tighten it finger-tight. Unscrew the two bolts securing the right-hand footrest bracket/brake pedal assembly **(see illustration)**. Manoeuvre the rear brake master cylinder/pedal/footrest assembly rearwards and secure it over the passenger footrest, using a rag between them to prevent scratches **(see illustration)**. Secure the brake light switch clear of the engine.

14 Unscrew the two bolts securing the rider's left-hand footrest bracket and remove the footrest assembly **(see illustration)**.

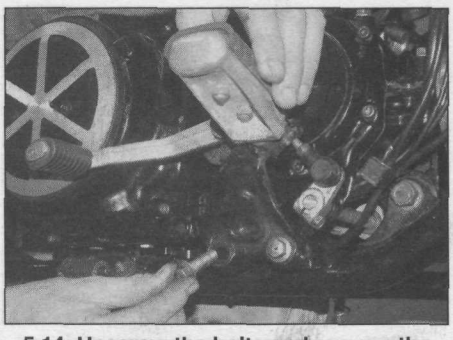
15 Unscrew the gearchange linkage arm pinch bolt and slide the arm off the shaft, noting how the slot in the arm aligns with the punch mark on the shaft **(see illustration)**. Unscrew the two bolts securing the



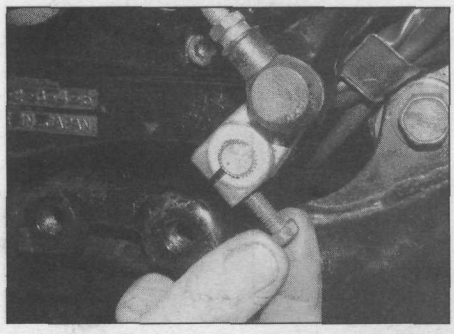
5.13c Unscrew the bracket bolts (arrowed) . . .



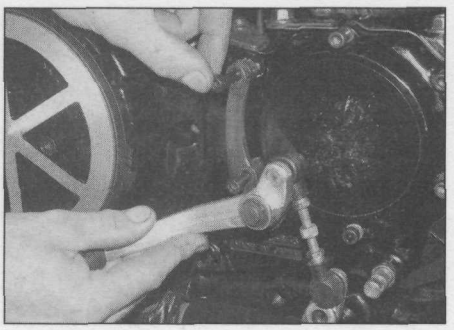
5.13d . . . then displace the whole assembly and secure it clear



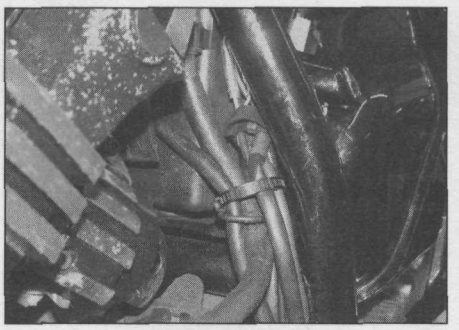
5.14 Unscrew the bolts and remove the left-hand footrest assembly



5.15a Unscrew the pinch bolt and slide the arm off the shaft



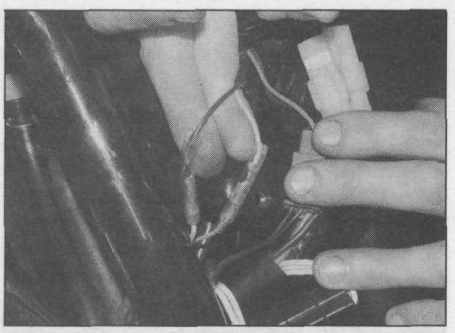
5.15b Unscrew the bracket bolts and remove the gearchange lever assembly



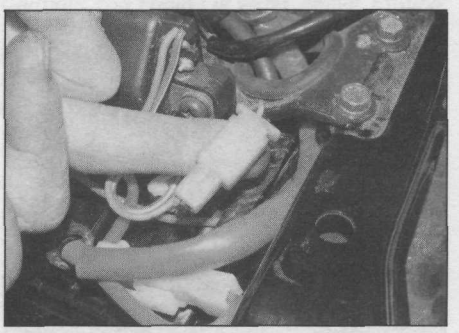
5.17a Release the cable ties . . .



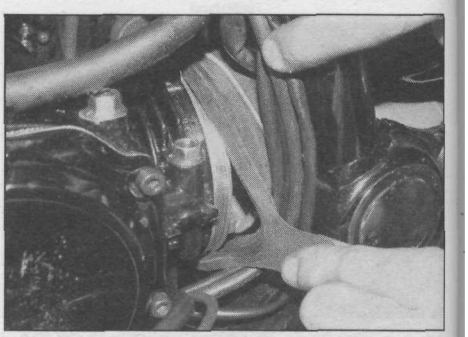
5.17b . . . then disconnect the alternator wiring connector . . .



5.17c . . . the neutral switch and oil level sensor wiring connectors . . .



5.17d . . . and the pick-up coil wiring connector (single coil type shown)



5.18 Draw the boot back off the flange

gearchange lever pivot bracket and remove the lever assembly **(see illustration)**.

16 Refer to Section 16 and either remove the clutch release cylinder, or if you want to leave it attached, detach the hydraulic pipe.

17 Release the cable ties holding the engine wiring together and to the frame on the left-hand side **(see illustration)**. Disconnect the alternator, neutral switch, oil level sensor and pick-up coil wiring connectors **(see illustrations)**. Feed the wiring down to the engine, noting its routing, and coil it on the crankcase so it does not get in the way.

18 Unhook or move back the spring securing the driveshaft UJ rubber boot, then pull the boot back off the flange **(see illustration)**.

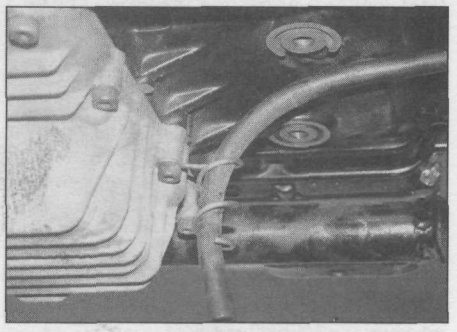
19 Pull the fuel tank breather hose up out of its guide on the bottom of the engine and secure it clear, noting its routing **(see illustration)**.

20 Disconnect the horn wiring connectors **(see illustration)**.

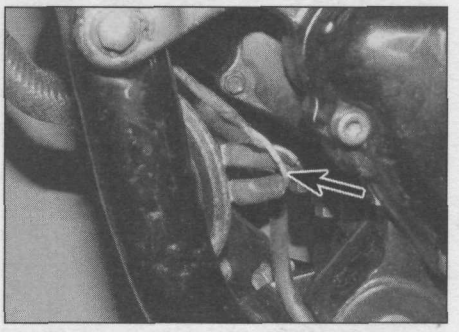
21 Remove the rear cylinder valve cover (see Section 7) – while this is not essential, it provides extra clearance at the back which makes a difference when manoeuvring the engine out of the frame.

22 At this point, position an hydraulic or mechanical jack under the engine with a block of wood between the jack head and sump. Make sure the jack is positioned under the flat section so the engine will not topple in any direction when the last mounting bolt is removed. Raise the jack to take the weight of the engine, but make sure it is not lifting the bike and taking the weight of that as well. The idea is to support the engine so that there is no pressure on any of the mounting bolts once they have been slackened, so they can be easily withdrawn. Note that it may be necessary to alter the position of the jack as some of the bolts are removed to relieve the stress transferred to the other bolts.

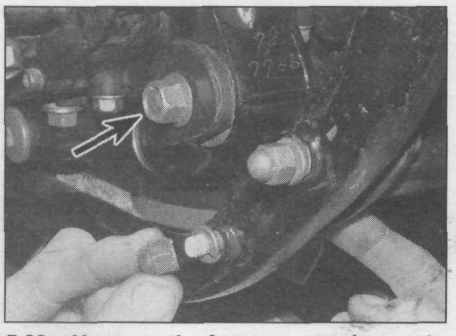
23 Unscrew the nuts and withdraw the bolts securing the frame cross-piece at the front of the engine, then unscrew and remove the lower front engine mounting bolt on each side and remove the cross-piece, noting how it fits **(see illustrations)**.



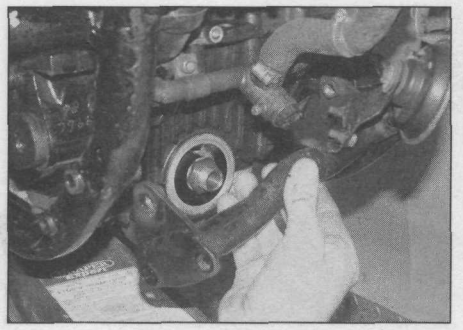
5.19 Draw the breather hose up out of its guide



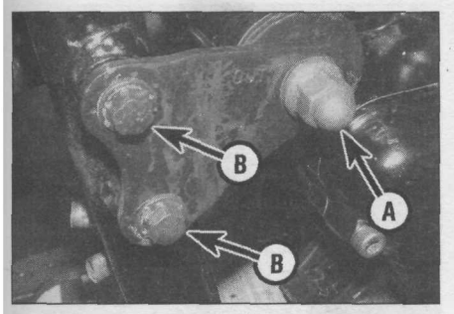
5.20 Disconnect the wiring connectors (arrowed) from the horn



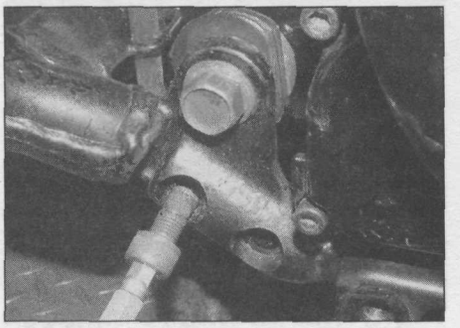
5.23a Unscrew the frame cross-piece nuts and bolts, followed by the mounting bolt (arrowed), on each side . . .



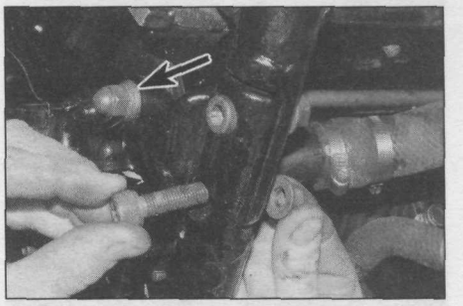
5.23b . . . and remove the cross-piece



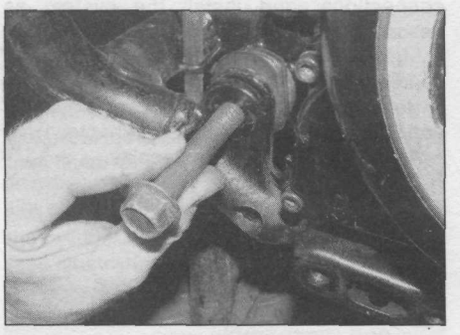
5.24 Unscrew the nut (A), then unscrew the nuts and withdraw the bolts (B) and remove the bracket



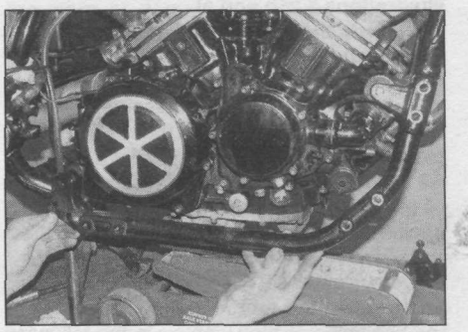
5.25a Unscrew and remove the rear cradle bolts



5.25b Unscrew the nuts and withdraw the front cradle bolts, then unscrew the domed nut (arrowed) on the end of the bar



5.25c Unscrew the rear mounting bolt on the right-hand side . . .



5.25d . . . and remove the cradle

24 Unscrew the nut on the left-hand end of the upper front mounting bar, using the hex on the centre section of the bar to counter-hold it and prevent it turning **(see illustration)**. Unscrew the nuts, withdraw the bolts and remove the upper front mounting bracket on the left-hand frame downtube. Note the OUT marking on the bracket.

25 Check that the engine is properly supported by the jack. Unscrew the bolts securing the rear of the removable cradle section of the frame **(see illustration)**. Unscrew the nuts and withdraw the bolts securing the front of the removable cradle section of the frame **(see illustration)**. Unscrew the domed nut on the right-hand end of the front mounting bar. Unscrew the rear mounting bolt on the right-hand side and remove the cradle section of the frame **(see illustrations)**.

26 Check again that the engine is properly supported by the jack. If at this point you do not have an assistant to help you, get one, and preferably two (not only is the engine extremely heavy, but it is useful to have another person solely to raise and lower the jack as required while manoeuvring the engine out). To prevent scratching any paint, place rags or tape over any exposed areas of frame that might come into contact with the engine while it is being manoeuvred.

27 Unscrew and remove the rear mounting bolt on the left-hand side. The engine can now be removed from the frame (see ***Caution*** above). Check that all wiring, cables and hoses are well clear, then carefully manoeuvre the engine up and forwards while twisting the front to the right, raising and lowering the jack as required to clear the rear mounting lugs and making sure the universal joint at the back disengages from the driveshaft, and remove it from the right-hand side **(see illustration)**.

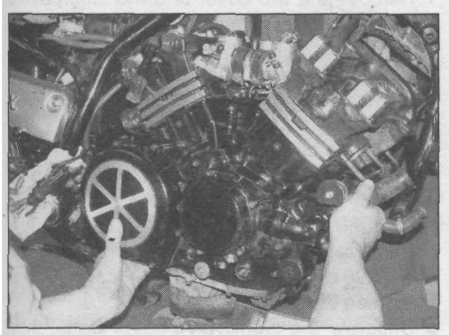
28 Remove the engine mounting bushes (six in all) and the front mounting bar **(see illustrations)**. Check the bushes for damage, deformation and deterioration. Fit them back into their bores (the ones with the larger bolt holes go at the back of the engine) and check for any freeplay. If they slide in and out easily (they should be a fairly tight fit) and if there is any freeplay between them and their bores, replace them with new ones. Note that many owners prefer to replace the original rubber bushes with aftermarket solid ones – it is supposed to improve handling, and it shouldn't induce any vibration as the engine is inherently smooth – contact a V-Max specialist for further details.

Installation

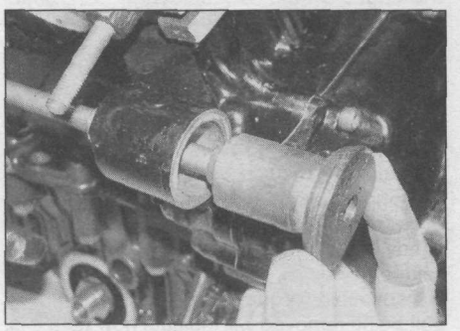
29 Before installing the engine it is worth removing the rear wheel (see Chapter 7) and the final drive housing and driveshaft (see Chapter 6) – it is quick and easy to do, and prevents having to engage the universal joint with the driveshaft at the same time as manoeuvring the engine into the frame. It is much easier to slide the driveshaft into the UJ once the engine is in place than it is to manipulate the UJ onto the driveshaft, especially as you can't really see what you are doing and there is very little room in which to use any tools.

30 Install the front mounting bar and the engine mounting bushes (see Step 28) **(see illustrations 5.28b and a)**.

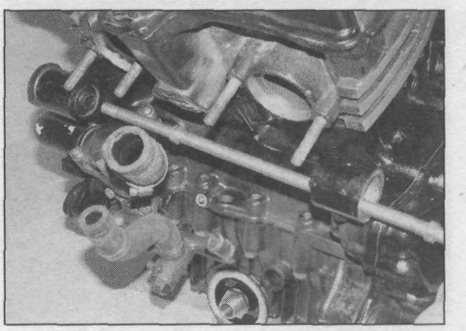
31 Manoeuvre the engine into position in the



5.27 Carefully remove the engine as described



5.28a Withdraw the mounting bushes . . .



5.28b . . . and the bar

frame and onto the jack **(see illustration 5.27)**. Raise and lower the jack as required to align all the mounting bolt holes. Note that it may be necessary to adjust the jack as some of the bolts are installed to realign the other bolt holes.

32 Install the rear mounting bolt on the left-hand side and tighten it finger-tight.

33 Install the cradle section of the frame on the right-hand side, locating it on the end of the front mounting bar, then Install the rear mounting bolt on the right-hand side and tighten it finger-tight **(see illustrations 5.25d and c)**. Install the front and rear cradle bolts and nuts and tighten them finger-tight **(see illustrations 5.25b and a)**.

34 Locate the upper front mounting bracket on the left-hand frame downtube and upper front mounting bar, making sure the OUT mark is on the outside, and secure it with its nuts and bolts, tightening them finger-tight **(see illustration 5.24)**.

35 Locate the frame cross-piece at the front of the engine and secure it to the frame and engine with its nuts and bolts, tightening them finger-tight **(see illustrations 5.23b and a)**.

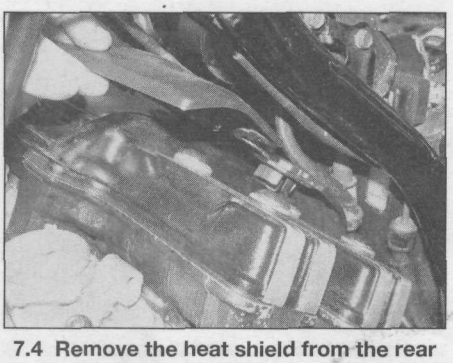
36 Now tighten all the engine and frame nuts and bolts to the torque settings specified at the beginning of the Chapter, in the following order:

- Cradle section top front bolt.
- Cradle section rear bolts.
- Cradle section bottom front bolt.
- Upper front mounting bracket-to-left-hand frame downtube bolts and nuts.
- Rear mounting bolt on each side.
- Lower front mounting bolt on each side.
- Frame cross piece nuts and bolts on each side.
- Upper front mounting bar nut on each side.

37 Install the driveshaft and final drive housing (see Chapter 6).

38 The remainder of the installation procedure is the reverse of removal, noting the following points:

- Use new sealing washers on each side of the clutch pipe union and tighten the banjo bolt to the specified torque setting.
- Do not forget to fit the rubber fillet, locating it around the clutch pipe and over the bleed valve.
- Use a new gasket on the middle gear assembly cover, and do not forget the cover locating dowels. Install the bottom bolt using a new sealing washer.
- When fitting the gearchange linkage arm onto the gearchange shaft, align the slit in the arm with punch mark on the shaft **(see illustration 5.15a)**.
- Do not forget to secure the earth lead to the engine using the crankcase bolt, and tighten the bolt to the specified torque setting – it is a 6 mm bolt.
- Make sure all wires, cables and hoses are correctly routed and securely connected, and retained by any clips or ties.
- Use new gaskets on the exhaust pipe connections, and install the system as described in Chapter 4.
- Make sure all coolant hoses are in good condition and secured by their clamps.
- Refill the engine with the specified quantity and type of oil and coolant (see Chapter 1).
- Adjust the throttle cable freeplay.
- Start the engine and check that there are no oil, coolant or exhaust leaks. Adjust the idle speed (see Chapter 1).



7.4 Remove the heat shield from the rear cylinders, noting how it locates

6 Engine disassembly and reassembly – general information

Disassembly

1 Before disassembling the engine, thoroughly clean and degrease its external surfaces. 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 (kerosene) 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 casings. Take care to exclude solvent or water from the electrical components and intake and exhaust ports.

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

2 When clean and dry, position the engine on the workbench, leaving suitable clear area for working. Gather a selection of small containers, plastic bags and some labels so that parts can be grouped together in an easily identifiable manner. Also get some paper and a pen so that notes can be taken. You will also need a supply of clean rag, which should be as absorbent as possible.

3 Before commencing work, read through the appropriate section so that some idea of the necessary procedure can be gained. When removing components note that great force is seldom required, unless specified (checking the specified torque setting of the particular bolt being removed will indicate how tight it is, and therefore how much force should be needed). In many cases, a component's reluctance to be removed is indicative of an incorrect approach or removal method – if in any doubt, re-check with the text.

4 When disassembling the engine, keep 'mated' parts together (including gears, cylinder bores, pistons, connecting rods, valves, etc. that have been in contact with each other during engine operation). These 'mated' parts must be reused or replaced as an assembly. It is worth obtaining a large sheet of card and marking it according to the layout of the engine so that parts can be placed on it and stored in relation to their position in the engine as they are removed.

5 A complete engine/transmission disassembly should be done in the following general order with reference to the appropriate Sections.

Remove the valve covers
Remove the camshafts
Remove the cylinder heads
Remove the clutch
Remove the gearchange mechanism
Remove the water pump (see Chapter 3)
Remove the starter motor (see Chapter 9)
Remove the alternator/starter clutch (see Chapter 9)
Remove the clutch release cylinder
Remove the oil sump
Remove the oil pump
Remove the connecting rods and pistons
Separate the crankcase halves
Remove the middle driven gear
Remove the crankshaft
Remove the balancer shaft
Remove the transmission shafts
Remove the selector drum and forks

Reassembly

6 Reassembly is accomplished by reversing the general disassembly sequence.

7 Valve covers – removal and installation

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

Removal

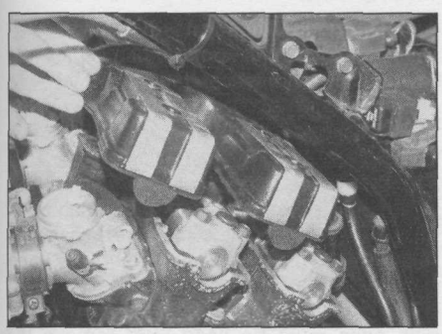
1 Remove the top cover and the side covers (see Chapter 8). Remove the carburettors (see Chapter 4).

2 Pull the caps off the spark plugs, on the rear cylinders noting how the covers locate in the heat shield **(see illustration 5.6)**.

3 Drain the coolant (see Chapter 1). Release the clamp securing each coolant hose to its union on the cylinder head and detach them **(see illustration 5.8c)**.

4 Remove the heat shield from the top of the rear valve cover, noting how it locates on the bolts **(see illustration)**.

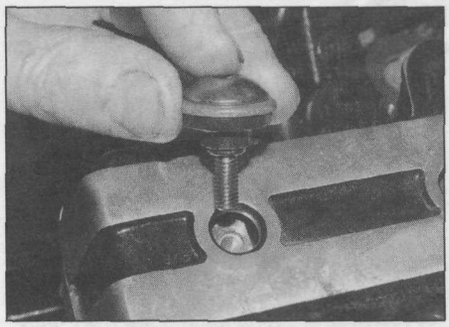
5 Unscrew the eight valve cover bolts, then lift the cover off the cylinder head and remove it **(see illustration)**. Take care not to dislodge



7.5 Unscrew the bolts and manoeuvre the cover out to one side



7.6 Make sure the gasket locates in the groove and stays there



7.7 Install the bolts with their seals and washers

any of the rubber bungs in the camshaft holders. If the cover 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 dislodge it. Note the washers and rubber seals for the bolts and remove them if they are loose. The rubber gasket is normally glued into the groove in the cover, and is best left there if it is reusable. If the gasket is in any way damaged, deformed or deteriorated, remove it.

Installation

6 Examine the valve cover gasket for signs of damage or deterioration and fit a new one if necessary. If a new one is used, clean all traces of the old glue from the groove in the cover and clean it and the cylinder head mating surface with solvent. Fit the new gasket into the groove, using a suitable glue, sealant or grease to hold it in place **(see illustration)**. Also apply a suitable sealant to the cut-outs in the cylinder head.

7 Make sure the rubber bung in each camshaft holder is seated correctly. Position the valve cover on the cylinder head **(see illustration 7.5)**, making sure the gasket stays in place, and noting that the arrow on the inside of the cover must point to the exhaust side of the cylinder head. If removed, fit the washers and rubber seals onto the bolts, using new ones if required **(see illustration)**. Install the cover bolts and tighten them to the torque setting specified at the beginning of the Chapter.

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

8 Cam chain tensioners – removal and installation

Note: *The cam chain tensioners can be removed with the engine in the frame. If the engine has been removed, ignore the steps which do not apply.*

Removal

1 To access the front cylinder tensioner, remove the carburettors, and for best access the V-Boost duct assembly (full power models) or one or both intake duct assemblies (restricted power models) (see Chapter 4).

2 To access the rear cylinder tensioner, remove the exhaust system (see Chapter 4).

3 Unscrew the tensioner cap bolt and withdraw the spring from the tensioner body **(see illustration)**.

4 Unscrew the two tensioner mounting bolts and withdraw the tensioner from the back of the cylinder head, noting which way up it fits **(see illustration)**.

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

Inspection

6 Examine the tensioner components for signs of wear and damage.

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

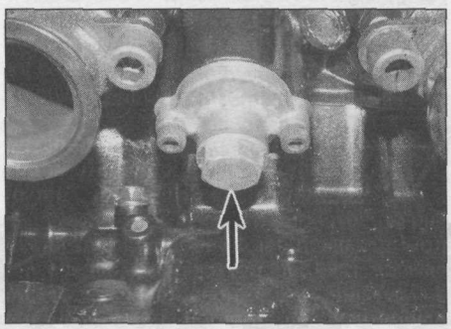
8 If the tensioner or any of its components are worn or damaged, or if the plunger is seized in the body, the tensioner must be replaced with a new one. Individual internal components are not available.

Installation

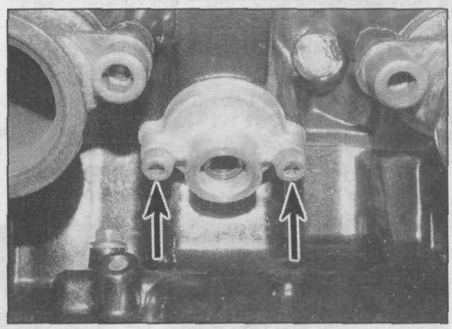
9 Release the ratchet mechanism and press the tensioner plunger all the way into the tensioner body **(see illustration 8.7)**.

10 Fit a new gasket onto the tensioner body, then fit the tensioner into the engine, making sure the ratchet release lever is on the top **(see illustration)**. Tighten the bolts to the torque setting specified at the beginning of the Chapter.

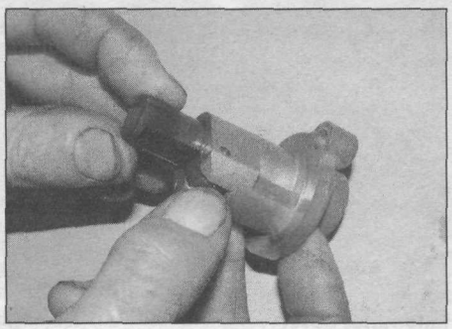
11 Check the condition of the sealing washer on the cap bolt and replace it with a new one if it is worn or damaged – Yamaha do not supply one separately from the complete tensioner assembly, but any good dealer, accessory or hardware shop should keep a



8.3 Unscrew the cap bolt (arrowed) and withdraw the spring



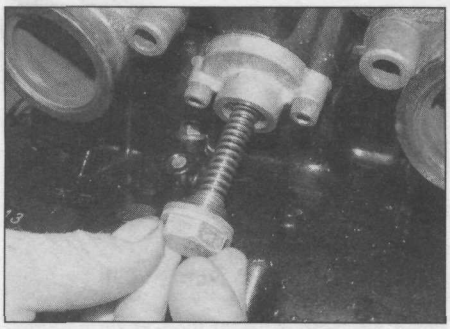
8.4 Tensioner mounting bolts (arrowed)



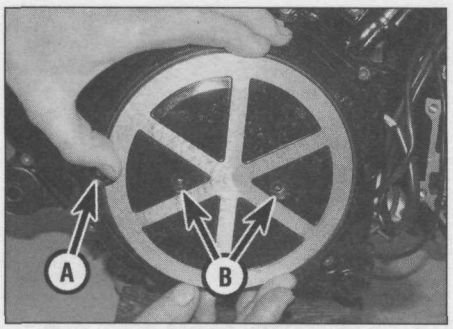
8.7 Release the ratchet and check the action of the plunger



8.10 Fit a new gasket and install the tensioner with the ratchet at the top



8.11 Install the spring and cap bolt



9.2 Unscrew the timing plug (A), then undo the screws (B) and remove the cap

selection of copper washers from which a match can be made. Install the spring and cap bolt and tighten the bolt to the specified torque setting **(see illustration)**. While you are installing the spring and tightening the bolt you should hear the plunger being forced out and clicking over the ratchet mechanism.

12 Undo the screws securing the crankshaft end cap to the alternator cover on the left-hand side of the engine and remove it **(see illustration 9.2)**. Discard the rubber gasket and O-ring as new ones must be used, and remove the collared washer from the centre of the cover. Turn the crankshaft anti-clockwise through two full turns using an offset 32 mm ring spanner or socket on the hex on the alternator rotor boss (do not turn the engine using the rotor bolt itself). This will allow the tensioner to set itself properly. Install the crankshaft end cap collared washer, with the collared section facing in, and the cap, using a new gasket and O-ring – the rubber gasket has three holes which locate over the small pins on the alternator cover **(see illustrations 9.38a, b and c)**. Smear the O-ring with oil and push the cover on until the O-ring is felt to locate.

13 It is advisable to remove the valve covers (see Section 7) and check that the cam chains are tensioned and all the timing marks are in alignment (see Section 9). If a chain is slack, the tensioner plunger did not release when the spring and cap bolt were installed. Remove the tensioner again and re-check it. Again check the timing marks (see Section 9), then install the valve cover (see Section 7).

14 Install the V-Boost or intake duct assembly and carburettors, and the exhaust system (see Chapter 4).

9 Camshafts and followers – removal, inspection and installation

Note 1: *The camshafts can be removed with the engine in the frame. Place clean rags over the spark plug holes and the cam chain tunnel to prevent any component from dropping into the engine.*

Note 2: *The front and rear cylinder heads and all their components are interchangeable. It is therefore very important not to get any of them mixed up as they must be returned to their original locations. Take great care to store all front and rear components separately and in order.*

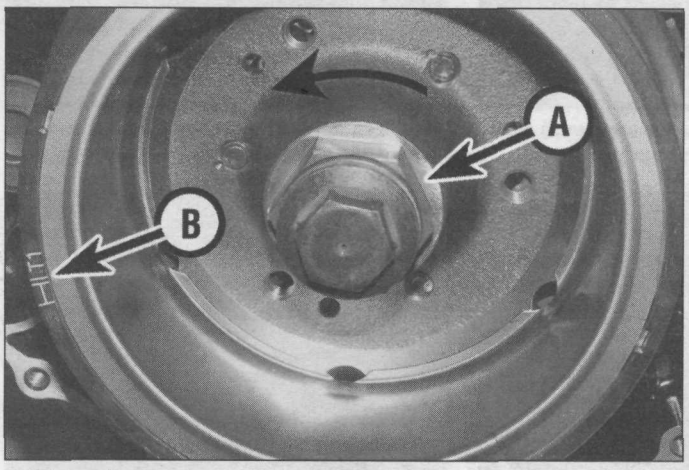
Removal

1 Remove the valve cover(s) (see Section 7) and the spark plugs (see Chapter 1). Each cylinder is referred to by a number – the rear left is number 1, the front left is number 2, the rear right is number 3, the front right is number 4.

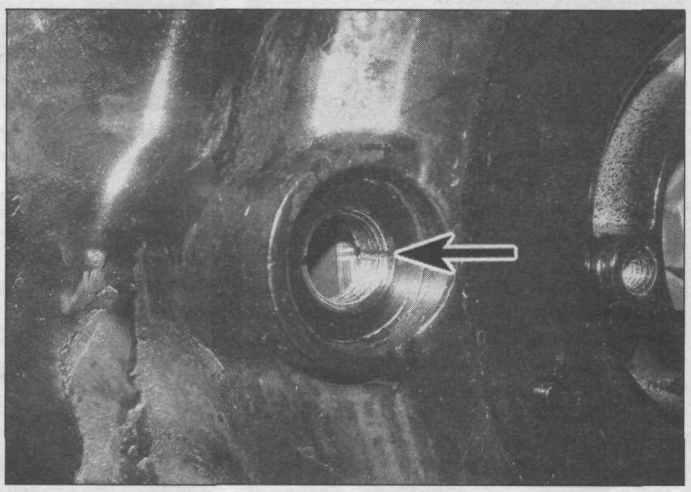
2 Unscrew the timing mark inspection plug from the alternator cover on the left-hand side of the engine, then undo the screws securing the crankshaft end cap and remove it **(see illustration)**. Discard the inspection plug O-ring and the end cap rubber gasket and O-ring as new ones must be used, and remove the collared washer from the centre of the cover.

3 When removing the rear cylinder camshafts, the engine must be turned so that the No. 1 piston is at TDC (top dead centre) on its compression stroke. When removing the front cylinder camshafts, the engine must be turned so that the No. 2 piston is at TDC (top dead centre) on its compression stroke. Turn the engine using an offset 32 mm ring spanner or socket on the hex on the alternator rotor boss (do not turn the engine using the rotor bolt itself), turning it in an anti-clockwise direction only **(see illustration)**. Note that the timing marks are difficult to see – you will need a torch, and you have to look in at an angle from the front as the marks are not directly visible from the side. This makes the triangular pointer (static timing mark) redundant, and so you must use the notch in the rear side of the inspection hole as the static mark.

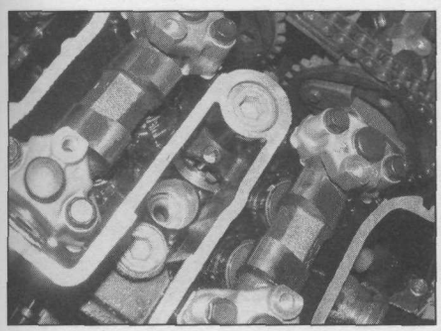
4 To remove the rear cylinder head camshafts, turn the engine anti-clockwise until the line nearest to the 'T1' mark on the alternator rotor aligns with the static timing mark (the notch in the inspection hole), and the camshaft lobes for the No. 1 (rear left) cylinder face up and slightly towards each other, and the **small** punch mark on the right-hand end of each rear cylinder camshaft points up and aligns with the index line on the adjacent camshaft holder **(see illustrations)**.



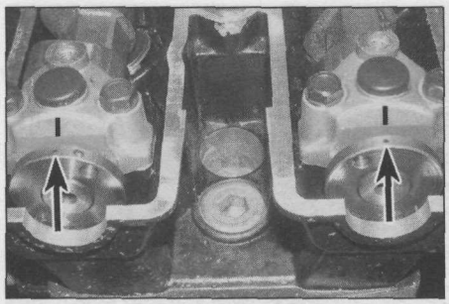
9.3 Turn the engine anti-clockwise using a spanner or socket on the large hex (A), not the bolt in the centre (alternator cover removed for clarity. Note the line nearest to the T1 mark (B) on the rotor rim – this is the TDC mark for the No. 1 cylinder



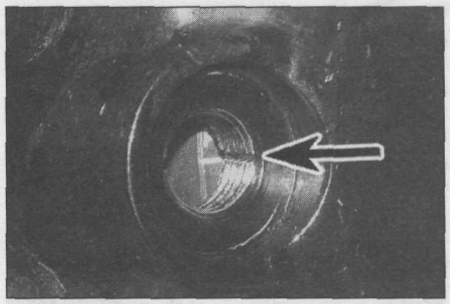
9.4a Turn the engine until the line next to the T1 mark (the top line) aligns with the notch (arrowed) . . .



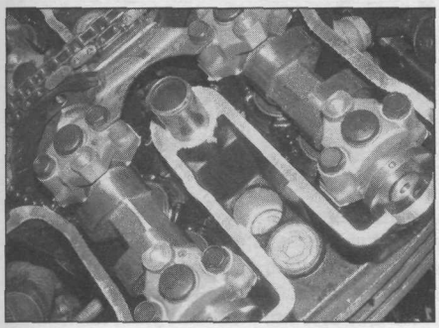
9.4b . . . the No. 1 cylinder cam lobes face up and slightly towards each other . . .



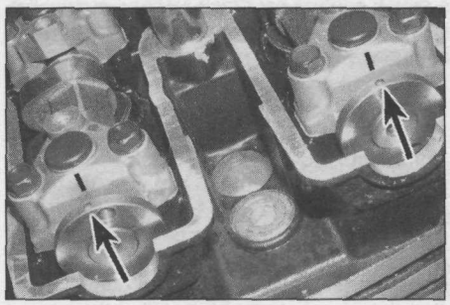
9.4c . . . and the small punch marks (arrowed) are at the top and aligning with the index lines (highlighted)



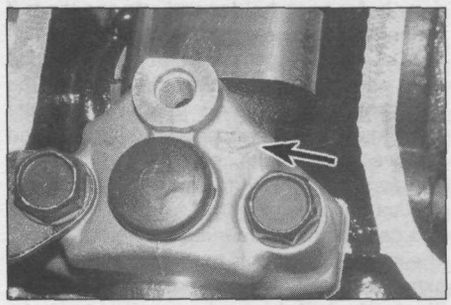
9.5a Turn the engine until the line next to the T2 mark aligns with the notch (arrowed) . . .



9.5b . . . the No. 2 cylinder cam lobes face away from each other . . .



9.5c . . . and the large punch marks (arrowed) are at the top and aligning with the index lines (highlighted)



9.9 Note the identification letter and number (arrowed) on each holder before removing them

If the cam lobes are facing down and the punch marks are not visible, turn the engine anti-clockwise 360° (one full turn) so that the 'T1' mark again aligns with the static timing mark. The camshaft lobes will now be facing up and slightly towards each other, meaning the No. 1 cylinder is at TDC (top dead centre) on the compression stroke.

5 To remove the front cylinder head camshafts, turn the engine anti-clockwise until the line next to the 'T2' mark on the alternator rotor aligns with the static timing mark (the notch in the inspection hole), and the camshaft lobes for the No. 2 (front left) cylinder are facing away from each other, and the **large** punch mark on the left-hand end of each front cylinder camshaft points up and aligns with the index line on the adjacent camshaft holder **(see illustrations)**. If the cam lobes are facing towards each other and the punch marks are not visible, turn the engine anti-clockwise 360° (one full turn) so that the 'T2' mark again aligns with the static timing mark. The camshaft lobes will now be facing away from each other, meaning the No. 2 cylinder is at TDC (top dead centre) on the compression stroke.

6 If both sets of camshafts are being removed, remove the rear cams first, then turn the engine anti-clockwise 430° (at which point the No. 2 cylinder will be as described in Step 5) and remove the front cams. When turning the engine with one set of camshafts removed, hold the loose cam chain taut to prevent it binding around the bottom of the crankshaft.

7 Remove the cam chain tensioner for the head being worked on (see Section 8).

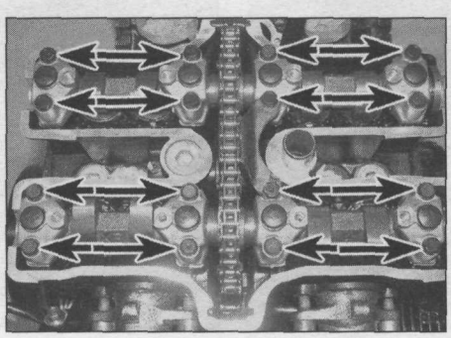
8 Remove the cam chain front guide for the head being worked on (see Section 10).

9 Before removing the camshaft holders, make a note of which fits where. Each holder is marked with a letter and a number to denote its location – 'I' denotes that the holder is for the intake camshaft, 'E' denotes it is for the exhaust camshaft **(see illustration)**. For the rear cylinders the holder numbers run 1 to 4 from right to left. For the front cylinders the holder numbers run 1 to 4 from left to right. If the marks are not visible, make your own before disturbing them – it is essential they are returned to their original locations on installation.

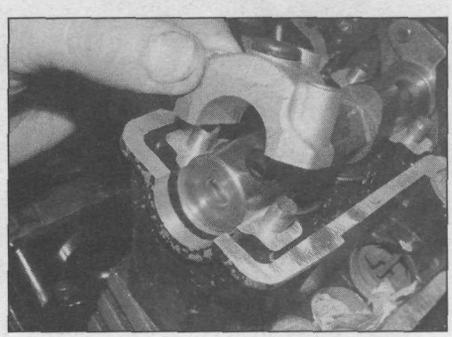
10 When working on the rear cylinder head, remove the exhaust camshaft first. When working on the front head, remove the intake camshaft first.

Caution: When working on the rear cylinder camshafts and the front cylinder exhaust camshaft, all of the valves are closed so there will be no upward pressure on the camshafts and holders, so the order in which they are slackened is not important. When working on the front cylinder intake camshaft, slacken the holders above the closed valves first, and when slackening the holders above the open valves, slacken them evenly and a little at a time in a criss-cross sequence so the camshaft and holders lift up squarely. If the camshaft bends it could break, so makes sure the holder is not sticking on its dowels.

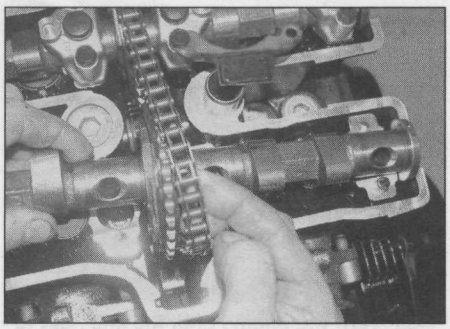
11 Unscrew and remove the camshaft holder bolts and lift off the holders, noting which way round they fit, and how the cam chain top guide is secured by one holder bolt on each camshaft **(see illustration)**. Note the two



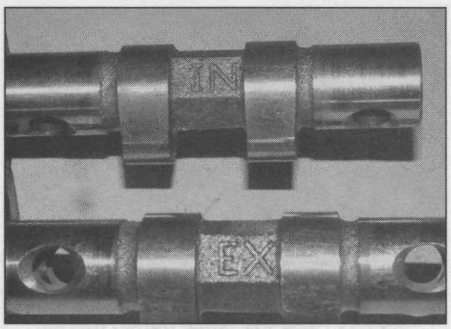
9.11a Camshaft holder bolts (arrowed)



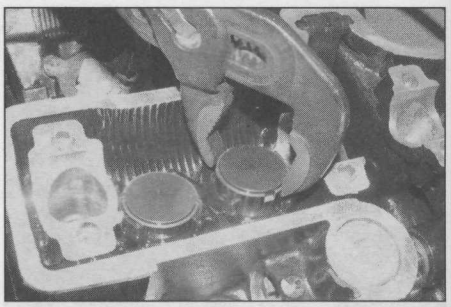
9.11b Remove the holders, noting the dowels



9.12a Disengage the chain and remove the camshafts



9.12b Note the identity mark on each camshaft



9.14 Lift the followers out of their bores – if using a tool as shown do not grip them tightly

dowels for each holder and remove them if they are loose **(see illustration)**.

12 Carefully lift each camshaft off the head in turn and disengage the chain from the sprocket – on the rear head remove the exhaust camshaft first, and on the front head remove the intake camshaft first **(see illustration)**. Allow the chain to rest on the coolant passage plug that crosses the tunnel. The camshafts are marked for identification. The intake camshaft is marked I or IN and the exhaust camshaft is marked E or EX **(see illustration)**. If the marks aren't clear make your own as the camshafts must be installed in their original location. It is worth making a mark to denote whether each shaft is for the front or rear head just in case they get mixed up at some point.

13 While the camshafts are out do not rotate the crankshaft – the chain could bind between the crankshaft and case, which could damage these components. Place rags over the spark plug holes and the cam chain tunnel to prevent anything from dropping into the engine on removal.

14 If the followers and shims are being removed from the cylinder head, obtain two containers (one for the rear head and one for the front), each divided into eight compartments, and label each compartment with the location of a valve, i.e. cylinder number, intake or exhaust camshaft, left or right valve. If a container is not available, use labelled plastic bags (egg cartons also do very well!). Remove the cam follower of the valve in question, leaving the shim in place in the top of the follower **(see illustration)**. The shims can be removed if required, but make sure each mated shim and follower are stored together otherwise the valve clearances will be way out on reassembly.

15 The sprockets can be separated from the camshafts if required by removing the two bolts that hold them **(see illustration)**. Both sprockets are identical and are therefore interchangeable, but mark them according to their camshaft so they can be installed in their original position. Also make alignment marks between the sprocket and the camshaft so that the sprocket can be installed the correct way round to avoid confusion when setting up the timing.

Inspection

16 Inspect the bearing surfaces of the camshaft holders and cylinder head and the corresponding journals on the camshafts. Look for score marks, deep scratches and evidence of spalling (a pitted appearance). Check the oil passages for clogging.

17 Check the camshaft lobes for heat discoloration (blue appearance), score marks, chipped areas, flat spots and spalling. Measure the height of each lobe with a micrometer **(see illustration)** and compare the results to the minimum height listed in this Chapter's Specifications. If damage is noted or wear is excessive, the camshaft must be replaced with a new one.

18 Check the amount of camshaft runout by supporting each end on V-blocks, and measuring any runout using a dial gauge. If the runout exceeds the specified limit the camshaft must be replaced with a new one.

HAYNES HiNT

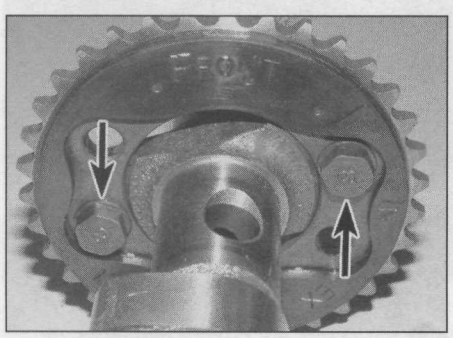
Refer to Tools and Workshop Tips in the Reference section for details of how to read a micrometer and dial gauge.

19 Next, check the camshaft journal oil clearances preferably using Plastigauge (but note that if none is available the oil clearance can be obtained by measuring the journal diameter and holder/head bore as described in Step 22, then calculating the difference, though this method is not as accurate). Check one camshaft at a time. Clean the camshafts and the bearing surfaces in the cylinder head and camshaft holder with a clean lint-free cloth, then lay each camshaft in its correct location in the cylinder head, making sure that the lobes are not contacting the shims/followers (if not removed) or valve stem ends – if they are the shaft will turn as the holder bolts are tightened which will disturb the Plastigauge and lead to a false reading (see Step 12).

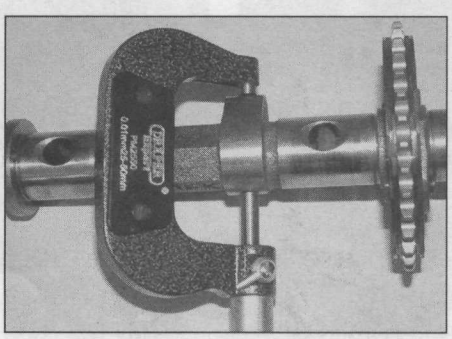
20 Cut some strips of Plastigauge and lay one piece on each journal, parallel with the camshaft centreline. Make sure the camshaft holder dowels are installed. Install the holders and tighten the bolts evenly and a little at a time in a criss-cross sequence, making sure the holders are pulled down squarely onto the dowels **(see illustrations 9.11b and a)**. While doing this, don't let the camshaft rotate, or the Plastigauge will be disturbed and you will have to start again.

21 Now unscrew the camshaft holder bolts evenly and a little at a time in a criss-cross sequence, and lift off the holder.

22 To determine the oil clearance, compare the crushed Plastigauge (at its widest point) on each journal to the scale printed on the Plastigauge container. Compare the results to this Chapter's Specifications. If the oil clearance is greater than specified, measure the diameter of the camshaft journal with a micrometer **(see illustration)**. If the journal diameter is less than the specified limit, replace the camshaft with a new one and recheck the clearance. If the clearance is still too great, or if the camshaft journal is within its limit, replace the cylinder head and holders



9.15 Camshaft sprocket bolts (arrowed)



9.17 Measure the height of the camshaft lobes with a micrometer

as a set with new ones. If required the holder/cylinder head bore sizes can be measured with the camshafts removed and the holders tightened down, using a small bore gauge and micrometer, comparing the results to the specifications.

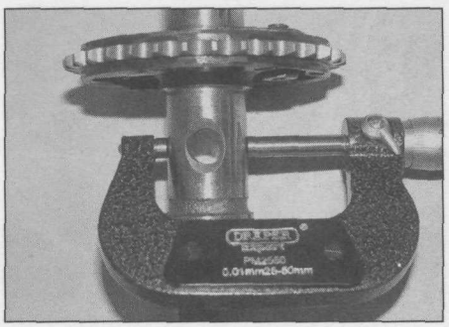
> **HAYNES HINT** ***Before replacing the camshafts, cylinder head or holders because of damage, check with local machine shops specialising in motorcycle engine work. In the case of the camshafts, it may be possible for cam lobes to be metal sprayed or welded, reground and hardened, at a cost far lower than that of a new camshaft. If the bearing surfaces in the head and holders are damaged, it may be possible for them to be bored out to accept bearing inserts. Due to the cost of new components it is recommended that all options be explored before condemning them as trash!***

23 Except in cases of oil starvation, a cam chain should wear very little. If a chain has stretched excessively, which makes it difficult to maintain proper tension, or if it is stiff or the links are binding or kinking, replace it with a new one (see Section 10).

24 Check the sprockets for wear, cracks and other damage, and replace them with new ones if necessary (see Steps 15 and 27). If the sprockets are worn, the cam chain is also worn, and so probably is the sprocket on the crankshaft. If severe wear is apparent, the entire engine should be disassembled for inspection.

25 Inspect the cam chain guides and tensioner blade (see Section 10).

26 Inspect the outer surface of each cam follower for evidence of scoring or other damage. If a follower is in poor condition, it is probable that the bore in the cylinder head in which it works is also damaged. If any



9.22 Measure the diameter of the camshaft journal

follower is worn or damaged replace it with a new one. If any bore is worn or damaged, is seriously out-of-round or tapered, replace the cylinder head with a new one.

Installation

27 If separated, fit the sprockets onto the camshafts. Make sure they are installed the correct way round – the sprockets marked FRONT are for the front cylinder camshafts, and the sprockets marked REAR are for the rear cylinder camshafts. The FRONT or REAR mark on the sprocket must face away from the I/IN or E/EX mark on the camshaft. The sprocket for the intake camshaft must be orientated so the bolt goes in the hole adjacent to the IN mark on the sprocket **(see illustration)**. The sprocket for the exhaust camshaft must be orientated so the bolt goes in the hole adjacent to the EX mark on the sprocket **(see illustration)**. Apply a suitable non-permanent thread locking compound to the sprocket bolts and tighten them to the torque setting specified at the beginning of the Chapter. If necessary, tighten the bolts after the camshafts are installed so the shaft can be counter-held easily.

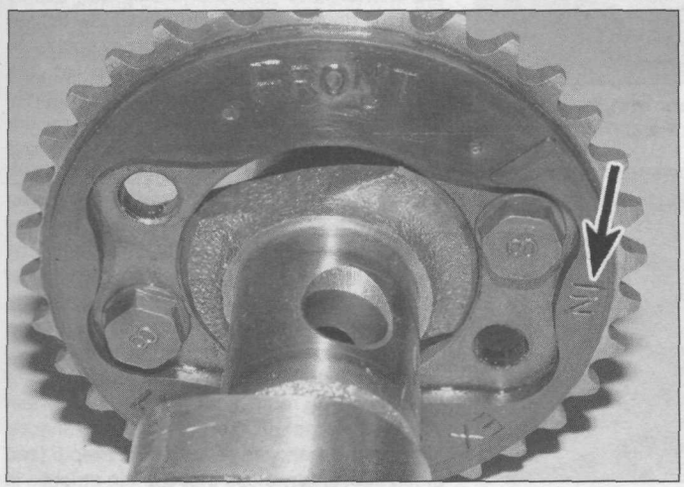
28 If removed, lubricate each shim and its follower with molybdenum disulphide oil (a 50/50 mixture of molybdenum disulphide grease and engine oil) and fit the shim into its recess in the top of the follower with the size marking facing down. Make sure the shim is correctly seated, then install the follower, making sure it fits squarely in its bore **(see illustration 9.14)**. **Note:** *It is most important that the shims and followers are returned to their original valves otherwise the valve clearances will be inaccurate.*

29 If only the rear cylinder camshafts have been removed, remove the front cylinder valve cover (see Section 7) and position the crankshaft at TDC on the compression stroke for the No. 2 cylinder (see Step 5), then rotate the crankshaft anti-clockwise 290° (at which point the line nearest the 'T1' mark on the rotor will align with the notch in the inspection hole). This positions the No. 1 cylinder at TDC, and the rear cylinder camshafts can be installed.

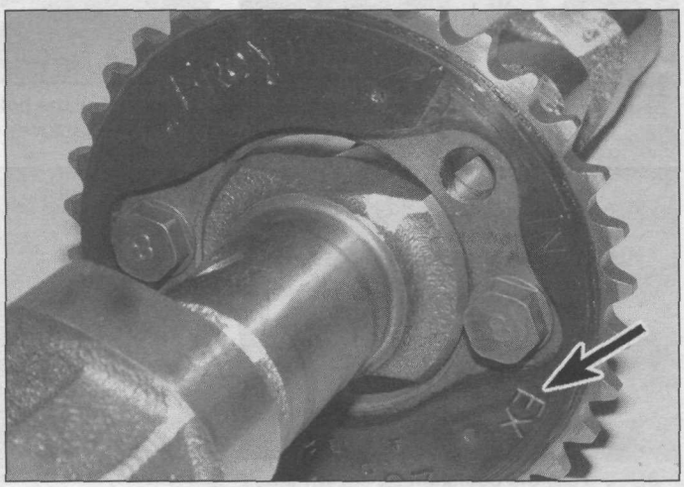
30 If only the front cylinder camshafts have been removed, position the crankshaft at TDC on the compression stroke for the No. 1 cylinder (see Step 4), then rotate the crankshaft anti-clockwise 430° (at which point the line next to the 'T2' mark on the rotor will align with the notch in the inspection hole). This positions the No. 2 cylinder at TDC, and the front cylinder camshafts can be installed.

31 If both sets of camshafts have been removed, install the rear cylinder ones first: rotate the crankshaft so that the line nearest the 'T1' mark on the rotor aligns with the notch in the inspection hole (see Step 4). This positions the No. 1 cylinder at TDC, and the rear cylinder camshafts can be installed (see Step 33). Then rotate the crankshaft anti-clockwise 430° so that the line next to the 'T2' mark on the rotor aligns with the notch in the inspection hole. This positions the No. 2 cylinder at TDC, and the front cylinder camshafts can be installed (see Step 34).

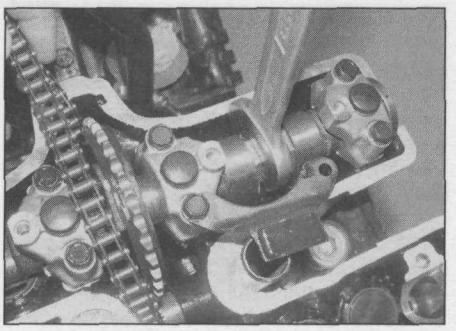
32 Make sure the bearing surfaces on the camshafts and in the cylinder head and holders are clean, then apply molybdenum disulphide oil (a 50/50 mixture of molybdenum



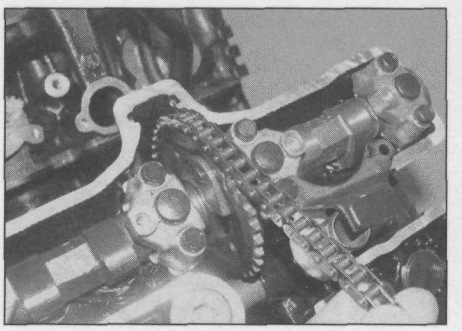
9.27a This is how the front cylinder intake camshaft sprocket must be positioned – note the IN mark (arrowed)



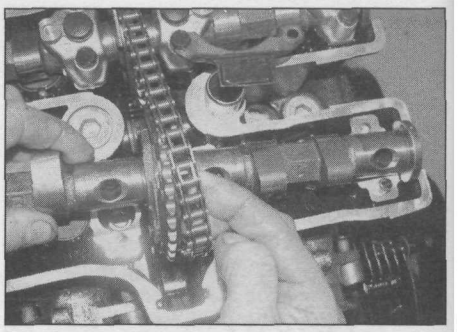
9.27b This is how the front cylinder exhaust camshaft sprocket must be positioned – note the EX mark (arrowed)



9.33a Turn the camshaft as shown and align the timing marks between camshaft and holder



9.33b Pull up on the chain and engage it round the sprocket . . .

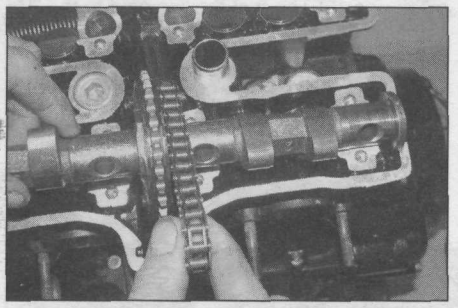


9.33c . . . then fit the exhaust camshaft, making sure the chain is tight between the sprockets

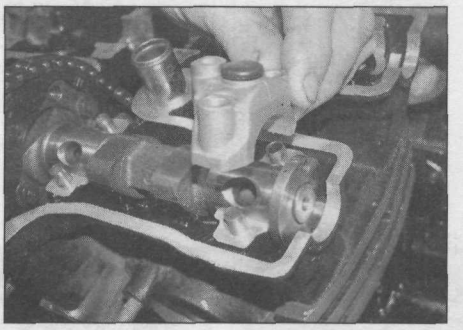
disulphide grease and engine oil) to each of them. Also apply it to the camshaft journals and lobes. Make sure that none gets on the mating surfaces between the holder and the head, or in the bolt holes.

33 To install the rear cylinder camshafts, first fit the intake camshaft (marked I or IN) onto the head, with the flanged end with the timing mark on the right-hand end of the head, and roughly aligning the marks as described in Step 4, but making sure that no lobe is seated on its shim, and do not yet engage the chain. Fit the intake camshaft holder dowels into the head or holder if removed, then install the holders (see Step 9), locating the cam chain top guide with the inner bolt on the inner holder on the right-hand side, making sure the guide surface faces in, and tighten their bolts finger-tight, including the bolt that also holds the cam chain top guide, making sure the holders are pulled down squarely onto the dowels **(see illustrations 9.11b and a)**. Now tighten the bolts evenly and in a criss-cross sequence to the torque setting specified at the beginning of the Chapter. Using a suitable spanner on the large moulded hex on the camshaft turn it until its marks are in exact alignment as described in Step 4 **(see illustration and 9.4c)**. Now fit the cam chain around the sprocket, pulling up on the front run of the chain to remove all slack between the crankshaft and the camshaft **(see illustration)**. Now fit the exhaust camshaft (marked E or EX) onto the head, with the flanged end with the timing mark on the right-hand end of the head, engaging the chain around the sprocket, and pulling on it to remove all slack from between the two camshaft sprockets and exactly aligning the marks as described in Step 4 **(see illustration and 9.4c)**. Any slack in the chain must lie in the rear run of the chain between the exhaust camshaft and the crankshaft so that it is later taken up by the tensioner. Fit the exhaust camshaft holder dowels into the head or holders if removed, then install the holders (see Step 9), again securing the cam chain top guide with its bolt, and tighten their bolts finger-tight, including the bolt that also holds the cam chain top guide. Now tighten the bolts evenly and in a criss-cross sequence to the torque setting specified at the beginning of the Chapter. Make sure the holders are pulled squarely onto the dowels and do not bind. Now install the cam chain tensioner (see Section 8).

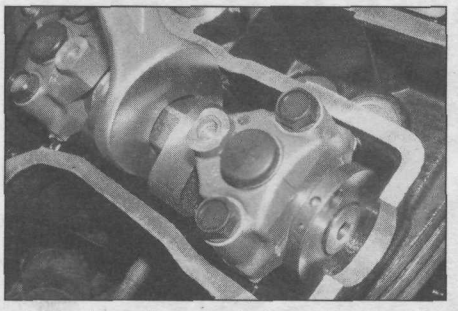
34 To install the front cylinder camshafts, first fit the exhaust camshaft (marked E or EX) onto the head, with the flanged end with the timing mark on the left-hand end of the head, and roughly aligning the marks as described in Step 5, but making sure that no lobe is seated on its shim, and do not yet engage the chain **(see illustration)**. Fit the exhaust camshaft holder dowels into the head or holder if removed, then install the holders (see Step 9), locating the cam chain top guide with the inner bolt on the inner holder on the left-hand side, making sure the guide surface faces in, and tighten their bolts finger-tight, including the bolt that also holds the cam chain top guide **(see illustration and 9.11a)**. Make sure the holders are pulled squarely and evenly onto the dowels and do not bind. Now tighten the bolts evenly and in a criss-cross sequence to the torque setting specified at the beginning of the Chapter. Using a suitable spanner on the large moulded hex on the camshaft turn it until its marks are in exact alignment as described in Step 5 **(see illustration and 9.5c)**. Now fit the cam chain around the sprocket, pulling up on the front run of the chain to remove all slack between the crankshaft and the camshaft. Now fit the intake camshaft (marked I or IN) onto the head, with the flanged end with the timing mark on the left-hand end of the head, engaging the chain around the sprocket, and pulling on it to remove all slack from between the two camshaft sprockets and exactly aligning the marks as described in Step 5 **(see illustration)**. Any slack in the chain must lie in the rear run of the chain between the intake camshaft and the crankshaft so that it is later



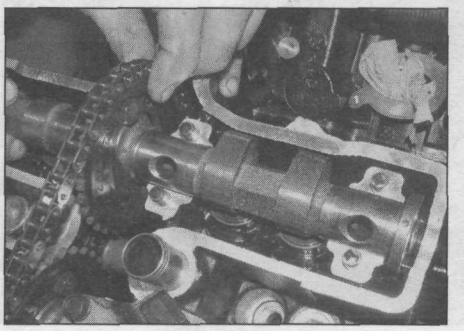
9.34a Lay the exhaust camshaft onto the head, leaving the chain to the side of the sprocket



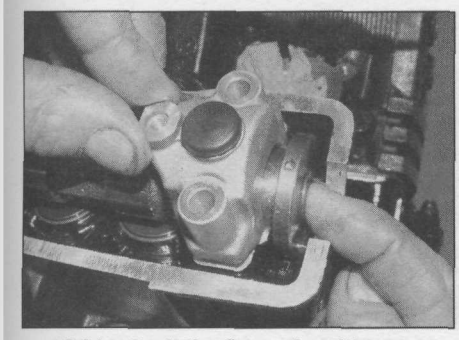
9.34b Install the holders with their dowels



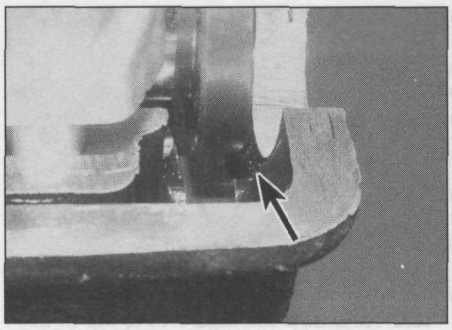
9.34c Turn the camshaft as shown and align the timing marks between camshaft and holder



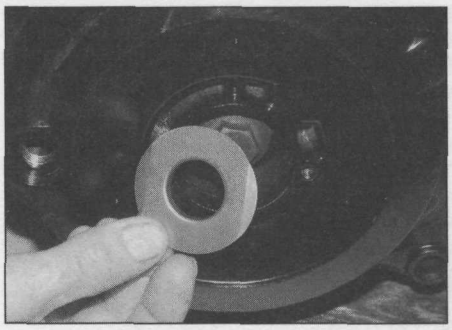
9.34d Fit the intake camshaft, making sure the chain is tight between the sprockets



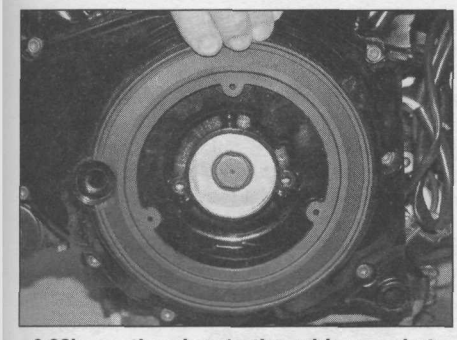
9.34e Push the flanged end in . . .



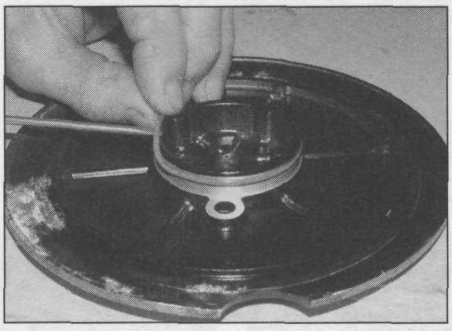
9.34f . . . to prevent the flange catching on the lip (arrowed)



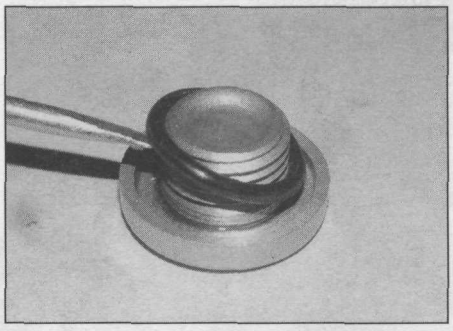
9.38a Fit the washer . . .



9.38b . . . then locate the rubber gasket onto the pegs



9.38c Fit a new O-ring onto the cap . . .



9.38d . . . and the timing inspection plug

taken up by the tensioner. Fit the intake camshaft holder dowels into the head or holders if removed, then install the holders (see Step 9), again securing the cam chain top guide with its bolt, and tighten their bolts finger-tight, including the bolt that also holds the cam chain top guide **(see illustration 9.11b and a)**. Push the flanged end of the shaft in so that the flange is clear of the cylinder head casting, otherwise it can catch on it as the holders are tightened down **(see illustrations)**. Now tighten the holder bolts evenly and a little at a time in a criss-cross sequence to the torque setting specified at the beginning of the Chapter, starting with the ones above the valves which will be depressed by the camshaft lobes on tightening. Make sure the holders are pulled squarely and evenly onto the dowels and do not bind. Now install the cam chain tensioner (see Section 8).

Caution: Whilst tightening the bolts, make sure the holders are being pulled evenly and squarely down and are not binding on the dowels or tilting to one side – if they do, adjust the relevant bolts until the holders are again square to the head. A holder or camshaft is likely to break if they are not tightened down evenly and squarely.

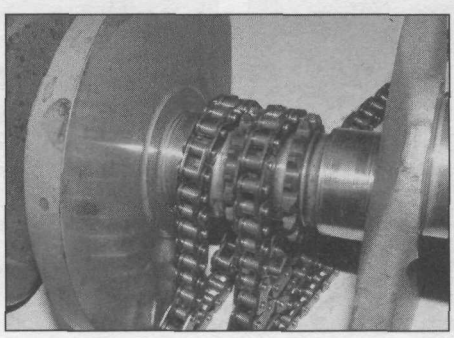
35 At this point check that all the timing marks are still in **exact** alignment as described in Steps 4 and 5 **(see illustrations 9.4a, b and c and 9.5a, b and c)**. Note that it is easy to be slightly out (one tooth on the sprocket) without the marks appearing drastically out of alignment. If the marks are out, verify which sprocket is misaligned, then remove the tensioner (see Section 8). Unscrew the sprocket's bolts and slide it off the camshaft, then disengage it from the chain. Move the camshaft round as required, then fit the sprocket back into the chain and onto the camshaft, and check the marks again. With everything correctly aligned, apply a suitable non-permanent thread locking compound to the sprocket bolts and tighten them to the torque setting specified at the beginning of the Chapter.

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

36 Install the cam chain front guides (see Section 10).

37 Turn the engine anti-clockwise through two full turns and check again that all the timing marks still align (see Steps 4 and 5) **(see illustrations 9.4a, b and c and 9.5a, b and c)**. Check the valve clearances and adjust them if necessary (see Chapter 1).

38 Install the valve covers (see Chapter 2), and the spark plugs (see Section 1). Install the crankshaft end cap collared washer, with the collared section facing in, and the cap, using a new gasket and O-ring – the rubber gasket has three holes which locate over the small pins on the alternator cover **(see illustrations)**. Push the cover on until the O-ring is felt to locate. Install the timing inspection plug using a new O-ring **(see illustration)**.



10.4 Remove the cam chains from the camshaft

10 Cam chain, tensioner blade and guide blades – removal, inspection and installation

Note: *The cam chain, tensioner and guides can be removed with the engine in the frame.*

Cam chain

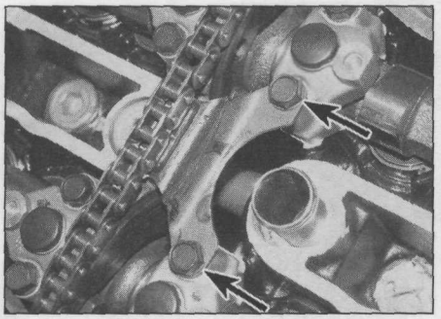
Removal

1 Remove the engine (see Section 5).

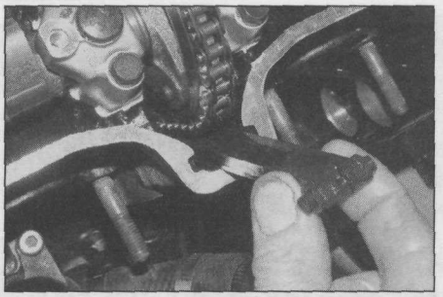
2 Separate the crankcase halves (see Section 25).

3 Remove the crankshaft (see Section 28).

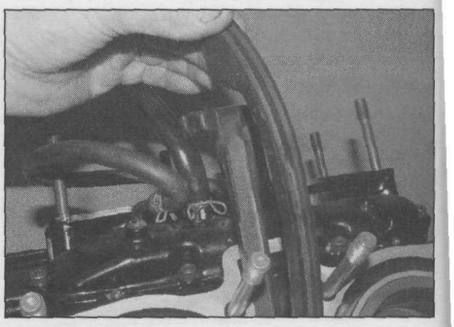
4 Remove the cam chains from the crankshaft **(see illustration)**. If the chains are being reused store them with their related camshafts so they can be installed on their original sprockets.



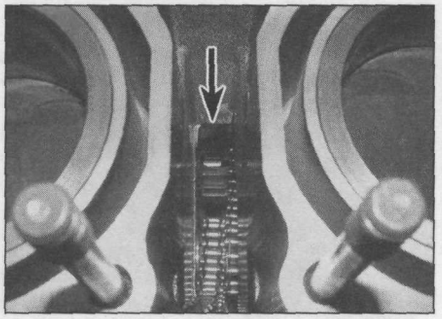
10.8 Cam chain top guide bolts (arrowed)



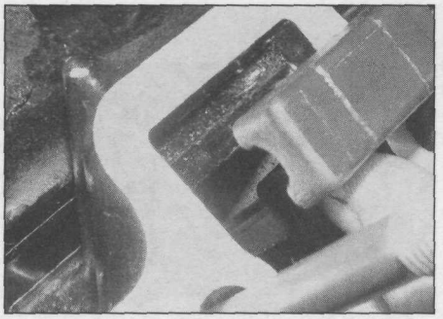
10.9 Note how the lugs on the top of the guide blade locate in the cut-outs in the head



10.10 Lift the tensioner blade out of the engine



10.13a Locate the bottom of the blade in its seat (arrowed) . . .



10.13b . . . and the block on the rear section in its cut-out

Inspection

5 Check the chains for binding, kinks and any obvious damage and replace them with new ones if necessary. Check the camshaft and crankshaft sprocket teeth for wear and renew the cam chain, camshaft sprockets and crankshaft as a set if necessary.

Installation

6 Loop the chains around the crankshaft, then install the crankshaft (see Section 28).

Tensioner blade and guides

Removal

7 Remove the valve cover (see Section 8).

8 To remove the cam chain top guide, unscrew the two camshaft holder bolts that secure it and remove it **(see illustration)**.

9 To remove the cam chain front guide, prise it up out of the cut-out in the cylinder head and withdraw it from the engine, noting which way round it fits and how it locates **(see illustration)**.

10 To remove the cam chain tensioner blade, first remove the cylinder head (see Section 11). Lift the tensioner blade out, noting how it fits **(see illustration)**.

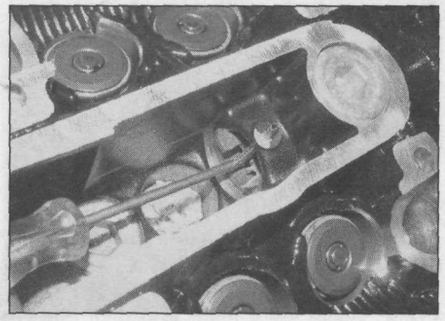
Inspection

11 Check the sliding surfaces of the blade and guides for excessive wear, deep grooves, cracking and other obvious damage, and renew them if necessary.

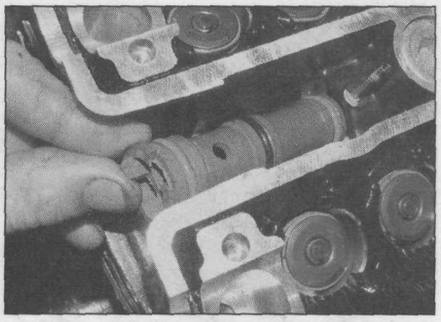
Installation

12 Apply some clean engine oil to the chain and the faces of the blade and guides before installing them.

13 Before installing the tensioner blade, make sure the chain is correctly engaged with its crankshaft sprocket – the chain is likely to slip off when the head and blade are removed.



11.3a Lever the pin up and withdraw it . . .



11.3b . . . then dislodge the plug as described and withdraw it

Install the tensioner blade **(see illustration 10.10)**, making sure the bottom locates in its seat, and the block on its outer section locates correctly in its cut-out **(see illustrations)**. Install the cylinder head (see Section 11).

14 Slide the front guide blade into the front of the cam chain tunnel **(see illustration 10.9)**, making sure it locates correctly in its seat and its lugs locate in their cut-outs.

15 Fit the top guide onto the camshaft holders and tighten the bolts to the torque setting specified at the beginning of the Chapter **(see illustration 10.8)**.

16 Install the valve cover (see Section 8).

11 Cylinder heads – removal and installation

Caution: *To remove the cylinder heads the engine must be removed from the frame.*

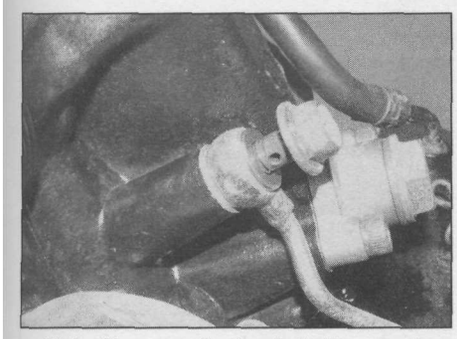
Removal

1 Remove the engine from the frame (see Section 5). If not already done, remove the V-Boost duct assembly (full power models) or intake duct assemblies (restricted power models) (see Chapter 4).

2 Remove the camshafts and followers (see Section 9). Lift the cam chain off the coolant passage plug that it rests on and secure it with a piece of wire or metal bar to prevent it from dropping into the crankcase.

3 Withdraw the pin from the coolant passage plug – lever it up from the bottom using a flat-bladed screwdriver then draw it out the top using pliers **(see illustration)**. If it is stuck, tap it lightly on the top with a hammer to free it up. Grasp the flat section in the face of the plug using suitable pliers and withdraw it from the head, twisting it to ease removal if required but taking care not to break the tabs off (they can become brittle after a while and break easily) – it is best to dislodge the plug slightly first by tapping it out using a drift located against the raised section in the cam chain tunnel **(see illustration)**. Discard the O-rings, noting their different sizes and which fits where, as new ones must be used.

4 Unscrew the oil pipe banjo bolts and



11.4a Unscrew the banjo bolt on each head . . .

remove the pipe **(see illustrations)**. Discard the sealing washers as new ones must be used.

5 Each cylinder head is secured by eight nuts with washers **(see illustration)**. Unscrew and remove the nuts using a hex bit, slackening them evenly and a little at a time in a **reverse** of the numerical tightening sequence shown (i.e. starting from the outsides and working to the middle) until they are all loose, then remove them and their washers. Use either a magnet, a screwdriver, or a piece of wire hooked over at the end to lift the washers out where necessary.

6 Hold the cam chain up and pull the cylinder head up off the studs, then pass the cam chain down through the tunnel – it is best to have an assistant on hand to pass the cam chain through the head and to then secure it to the engine rather than letting it drop down the tunnel **(see illustration)**. If the head is stuck, tap around the joint faces with a soft-faced mallet. Do not attempt to free the head by inserting a screwdriver between the head and block mating surfaces – you'll damage them.

7 Remove the cylinder head gasket and discard it as a new one must be used. If they are loose, remove the dowels from the crankcase or the underside of the cylinder head **(see illustration 11.11)**.

8 Check the cylinder head gasket and the mating surfaces on the cylinder head and crankcase for signs of leakage, which could indicate warpage. Refer to Section 12 and check the cylinder head gasket surface for warpage.

9 Clean all traces of old gasket material from the cylinder head and crankcase. 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 and coolant passages.

Installation

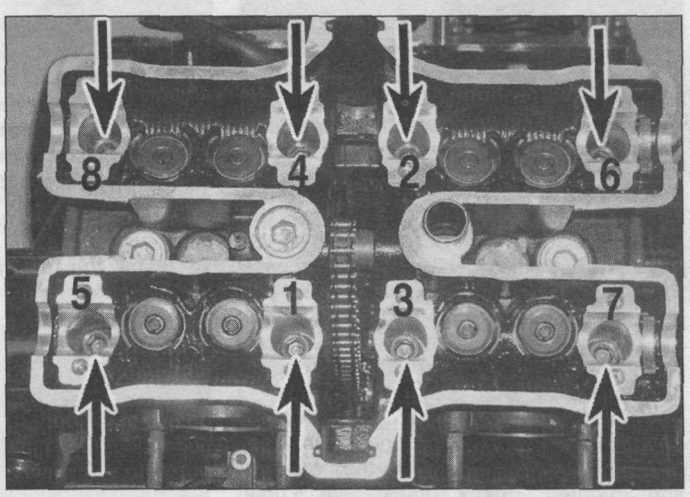
10 Smear the cylinder bores with engine oil.

11 Ensure both cylinder head and crankcase mating surfaces are clean. If removed, fit the dowels into the crankcase **(see illustration)**. Lay the new head gasket over the cam chain and tensioner blade and onto the crankcase, locating its larger holes over the dowels, and making sure the HEAD mark is on the top. Never re-use the old gasket.

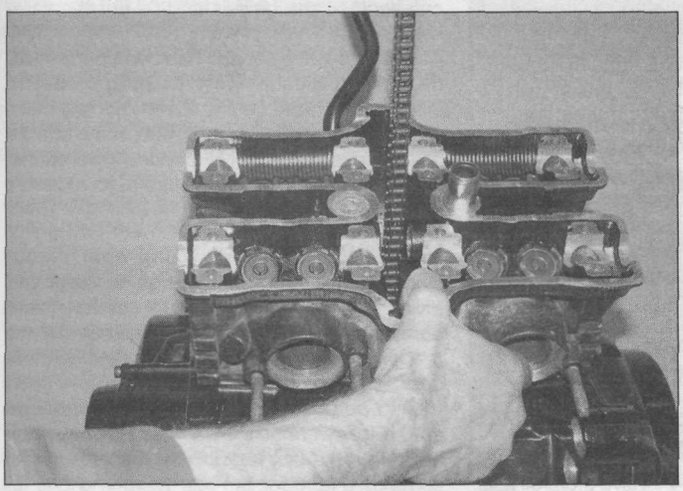
12 Carefully fit the cylinder head over the studs and onto the crankcase, making sure it



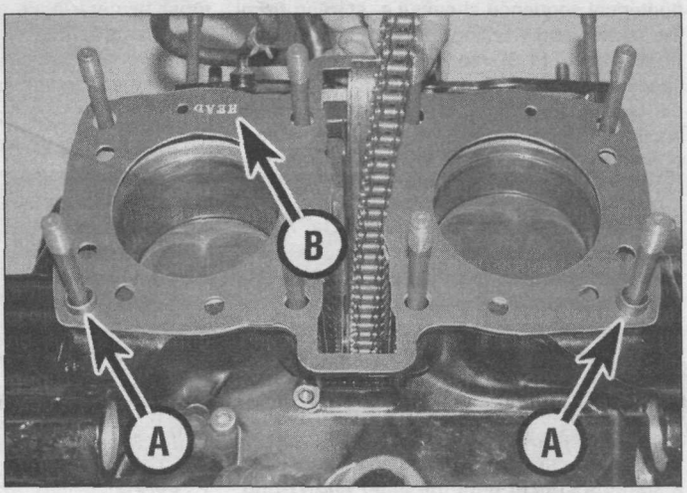
11.4b . . . and the one on the breather housing, and remove the oil pipe



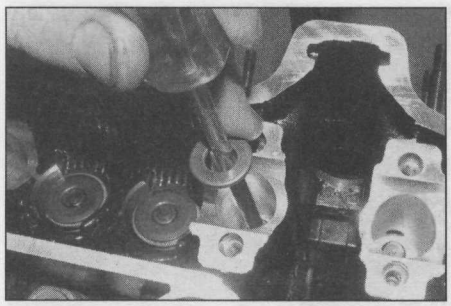
11.5 Cylinder head nuts (arrowed) – the numbers indicate the TIGHTENING order of the nuts – slacken them in REVERSE order



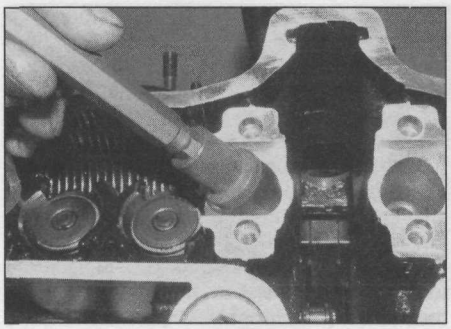
11.6 Carefully lift the head up off the block



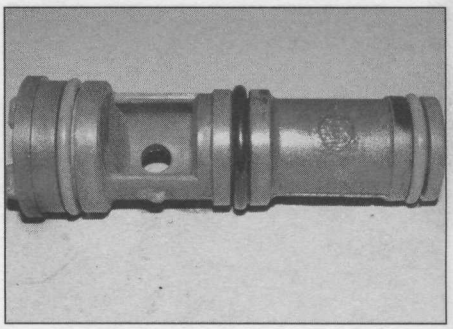
11.11 Install the dowels (A), then lay the new gasket on the block, making sure the HEAD mark (B) is facing up



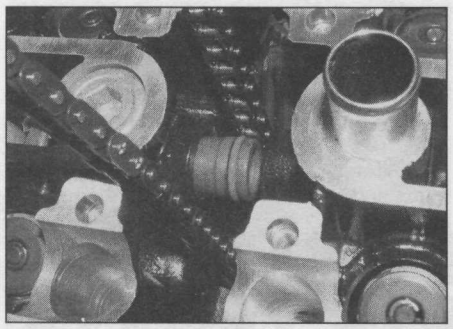
11.13a Fit the washers over the studs, guiding them with a screwdriver as shown to help locate them . . .



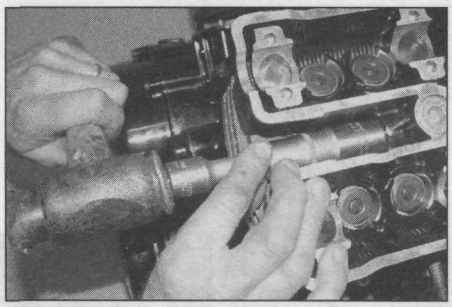
11.13b . . . then fit the nuts and tighten them as described



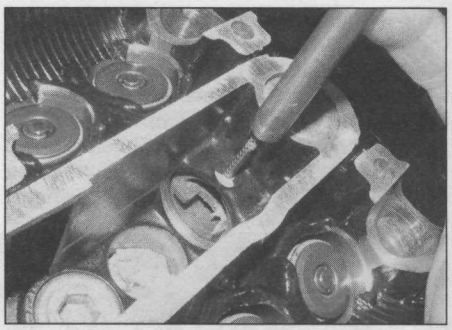
11.15a Fit new O-rings to the plug . . .



11.15b . . . then slide it into the head and through the cam chain . . .



11.15c . . . and gently tap it into place using a suitable socket that bears on the outer rim



11.15d Tap the pin across the front of the plug

locates correctly onto the dowels **(see illustration 11.6)**. You may need to press the tensioner blade in so it doesn't catch on the underside of the head. Have an assistant pass the cam chain up through the head as you lower it – using a piece of wire to hook it up is the best way, then use the piece of wire to secure the chain and prevent it from dropping back down.

13 Lubricate the threads and seating surfaces of the cylinder head nuts with clean engine oil. Install the nuts with their washers and tighten them finger-tight **(see illustrations)**. Now tighten the nuts evenly and a little at a time and in the correct numerical sequence shown (i.e. starting from the middle and working to the outsides) **(see illustration 11.5)**, to the torque setting specified at the beginning of the Chapter.

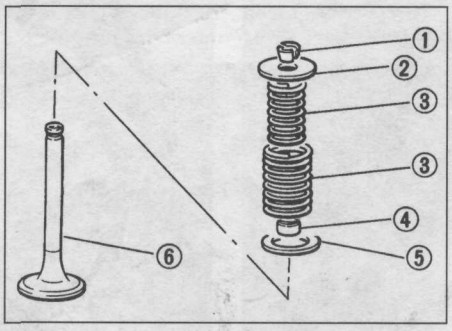
14 Install the oil pipe using new sealing washers on each side of each union and tighten the banjo bolts to the specified torque setting – when applying the torque settings note that the middle bolt is the 10 mm bolt and the outer bolts are 8 mm **(see illustrations 11.4a and b)**.

15 Fit new O-rings onto the coolant passage plug, making sure the different sizes are in their correct position, and lubricate them with engine oil **(see illustration)**. Insert the plug in the head, making sure the small round hole and the cut-out for the roll pin are at the top **(see illustration 11.3b)**, and that it passes through the cam chain loop, and tap it in using a suitable socket until the inner end O-ring locates in its bore and the locating pin can be installed **(see illustrations)**. Tap the pin into place, leaving about 5 mm exposed at the top **(see illustration)**.

16 Install the remaining components in a reverse of their removal sequence, referring to the relevant Sections or Chapters (see Steps 2 and 1).

12 Cylinder head and valves – disassembly, inspection and reassembly

1 Because of the complex nature of this job and the special tools and equipment required, most owners leave servicing of the valves, valve seats and valve guides to a professional. However, you can make an initial assessment of whether the valves are seating correctly, and therefore sealing, 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 is not seating correctly and sealing.



12.5 Valve components

1 Collets
2 Spring retainer
3 Valve springs
4 Valve stem oil seal
5 Spring seat
6 Valve

2 With the correct tools (a valve spring compressor is essential – make sure it is suitable for motorcycle work), you can also remove the valves and associated components from the cylinder head, clean them and check them for wear to assess the extent of the work needed, and, unless seat cutting or guide replacement is required, grind in the valves and reassemble them in the head.

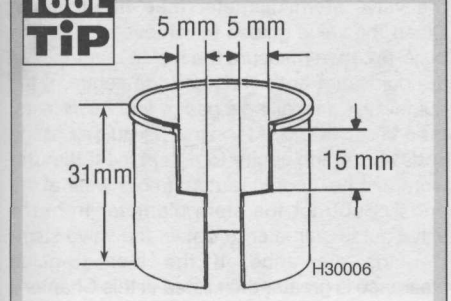
3 A dealer service department or specialist can replace the guides and re-cut the valve seats.

4 After the valve service has been performed, be sure to clean it very thoroughly before installation on the engine to remove any metal particles or abrasive grit that may still be present from the valve service operations. Use compressed air, if available, to blow out all the holes and passages.

Disassembly

5 Before proceeding, arrange to label and store the valves along with their related components in such a way that they can be returned to their original locations without getting mixed up **(see illustration)**. A good way to do this is to use the same containers as the followers and shims are stored in (see Section 9), or to obtain two separate containers (one for the rear head and one for the front), each divided into eight compartments, and label each compartment with the

TOOL TiP



Protect the follower bore in the cylinder head from scratches by the valve spring compressor using a shield made from a 35 mm film canister. Cut the canister to the dimensions shown.

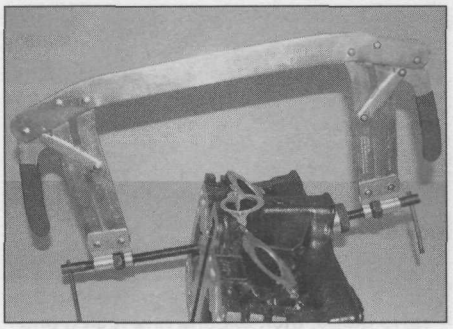
location of a valve, i.e. cylinder number, intake or exhaust camshaft, left or right valve. If a container is not available, use labelled plastic bags (egg cartons also do very well!).

6 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; refer to Tools and Workshop Tips for details of gasket removal methods ***(see Tool tip).***

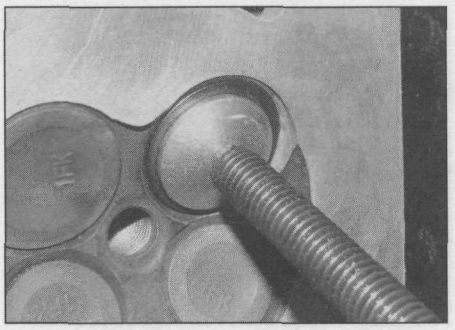
7 First locate the valve spring compressor on each end of the valve assembly, making sure it is the correct size **(see illustration)**. On the underside of the head make sure the plate on *the compressor only contacts the valve and* not the soft aluminium of the head – if the plate is too big for the valve, use a spacer between them **(see illustration)**. On the top of the valve the adaptor needs to be about the same size as the spring retainer – if it is too big it will contact the follower bore and mark it, and if it is too small it will be difficult to remove and install the collets **(see illustration)**. If your adaptor is too big or small, change it for one that is a good fit.

8 Compress the valve springs on the first valve – do not compress the springs any more than is absolutely necessary. Remove the collets, using either needle-nose pliers, tweezers, a mechanic's telescopic magnet, or a screwdriver with a dab of grease on it **(see illustration)**. Carefully release the valve spring compressor and remove it. Remove the spring retainer, noting which way up it fits **(see illustration 12.32c)**. Remove the springs, noting that the closer wound coils are at the bottom **(see illustrations 12.32b and a)**. Press down on the top of the valve stem and draw the valve out from the underside of the head **(see illustration 12.30)**. 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)**.

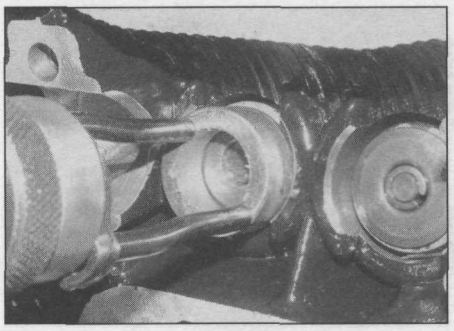
9 Once the valve has been removed, remove the spring seat using a mechanic's telescopic magnet, or turn the head upside down and tip it out, taking care not to lose it **(see illustration)**. Pull the valve stem seal off the top of the valve guide with pliers and discard it – never reuse the old seals **(see illustration)**.



12.7a Compressing the valve springs using a valve spring compressor



12.7b Make sure the compressor locates correctly both on the bottom of the valve . . .



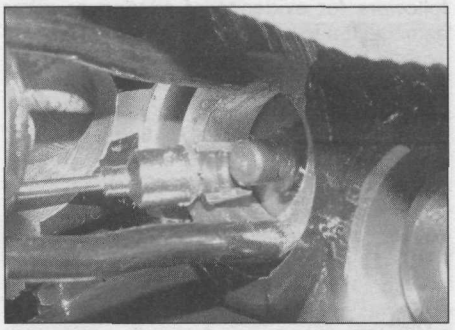
12.7c . . . and on the top of the spring retainer

10 Repeat the procedure for the remaining valves. Remember to keep the parts for each valve together and in order so they can be reinstalled in the same location.

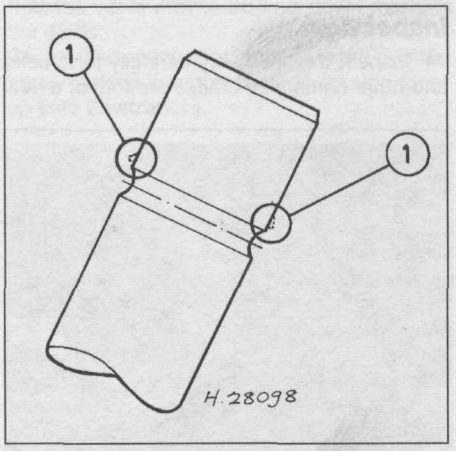
11 Next, clean the cylinder head with solvent and dry it thoroughly. Compressed air will speed the drying process and ensure that all *holes and recessed areas are reached.*

12 Clean all of the valve springs, collets, retainers and spring seats with solvent and dry them thoroughly. Do the parts from one valve at a time so they don't get mixed up.

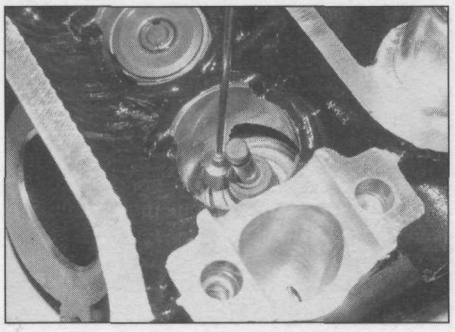
13 Scrape off any deposits that may have formed on the valve, then use a motorised wire brush to remove deposits from the valve heads and stems. Again, make sure the valves do not get mixed up.



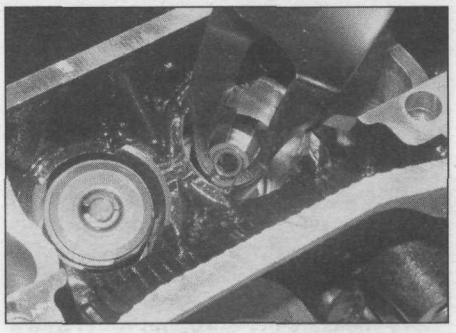
12.8a Remove the collets with needle-nose pliers, tweezers, a magnet or a screwdriver with a dab of grease on it



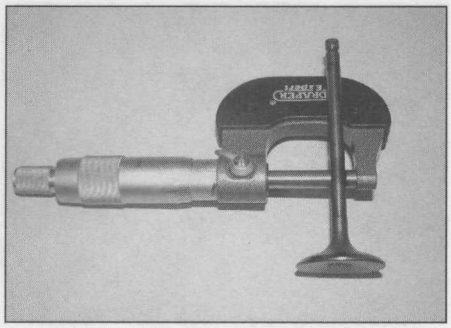
12.8b If the valve stem won't pull through the guide, deburr the area above the collet groove (1)



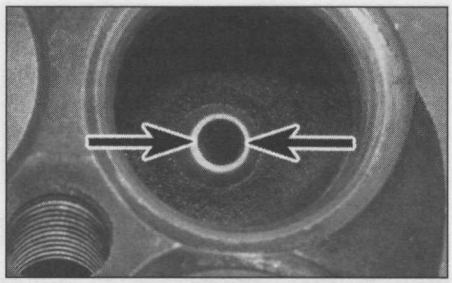
12.9a Remove the spring seat . . .



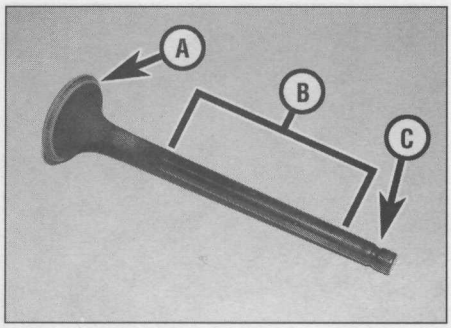
12.9b . . . then pull the seal off the valve stem



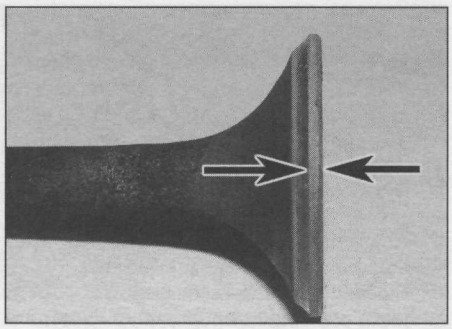
12.17a Measure the valve stem diameter with a micrometer



12.17b Insert a small bore gauge into the valve guide, then expand and lock it and pull it out, then measure the bore gauge with a micrometer



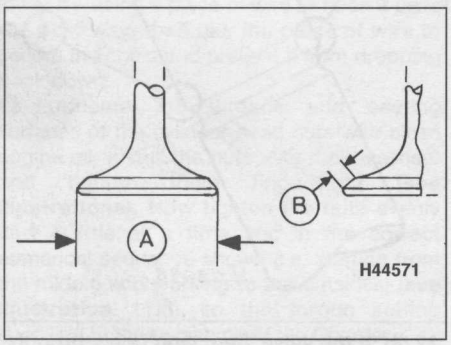
12.18a Check the valve face (A), stem (B) and collet groove (C) for signs of wear and damage



12.18b Measure the valve margin thickness as shown

Inspection

14 Inspect the head very carefully for cracks and other damage. If cracks are found, a new head is required. Check the camshaft bearing surfaces for wear and evidence of seizure. Check the camshafts and holders for wear as well (see Section 9).



12.18c Measure the valve head diameter (A) and face width (B)

15 Inspect the outer surfaces of the cam followers for evidence of scoring or other damage. If a follower is in poor condition, it is probable that the bore in which it works is also damaged. Check for clearance between the followers and their bores. Whilst no specifications are given, if slack is excessive, renew the followers. If the bores are seriously out-of-round or tapered, the cylinder head and the followers must be renewed.

16 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. Refer to *Tools and Workshop Tips* in the Reference section for details of how to use the straight-edge.

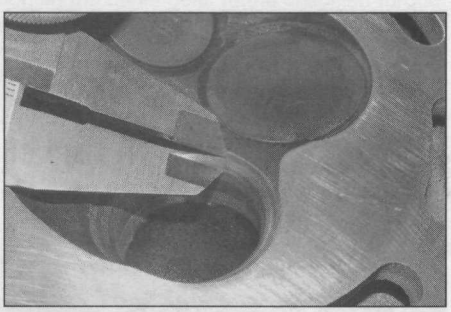
17 Working on one valve at a time, measure the valve stem diameter **(see illustration)**. Clean the valve guides to remove any carbon build-up, then measure the inside diameters of the guides (at both ends and the centre of the guide) with a small hole gauge and micrometer **(see illustration)**. Measure the guides at the ends and at the centre to determine if they are worn in a bell-mouth pattern (more wear at the ends). Subtract the stem diameter from the valve guide diameter to obtain the valve stem-to-guide clearance. If the stem-to-guide clearance is greater than listed in this Chapter's Specifications, renew whichever components are worn beyond their specification limits. If the valve guide is within specifications, but is worn unevenly, it should be renewed.

18 Carefully inspect each valve face, stem and collet groove area for cracks, pits and burned spots **(see illustration)**. Measure the valve head diameter, face width and margin thickness as shown and compare your results to the specifications **(see illustration)**. If any are outside the service limit specified, replace the valve with a new one.

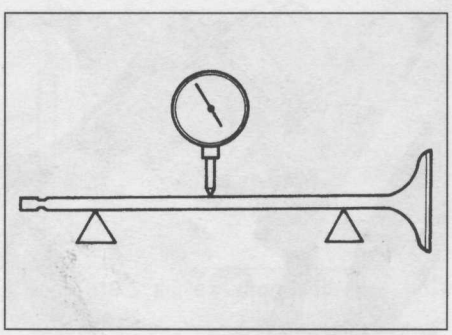
19 Examine the valve seats in each of the combustion chambers. If they are pitted, cracked or burned, the head will require valve service that's beyond the scope of the home mechanic. Measure the valve seat width **(see illustration)** and compare it to this Chapter's Specifications. If it is not within the specified range, or if it varies around its circumference, valve service work is required.

20 Rotate the valve and check for any obvious indication that it is bent. Using V-blocks and a dial gauge if available, measure the valve stem runout and compare the results to the specifications **(see illustration)**. If the measurement exceeds the service limit specified, the valve must be replaced with a new one. Check the end of the stem for pitting and excessive wear. The presence of any of the above conditions indicates the need for valve servicing. The stem end can be ground down, provided that the amount of stem above the collet groove after grinding is within the specified limit.

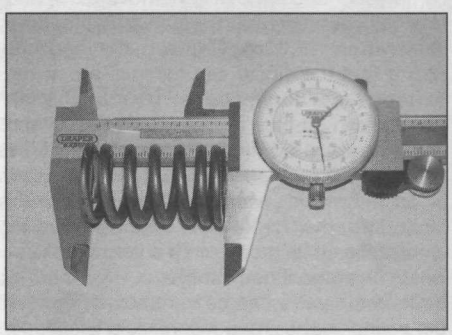
21 Check the end of each valve spring for wear and pitting. Measure the spring free length and compare it to that listed in the specifications **(see illustration)**. If any spring



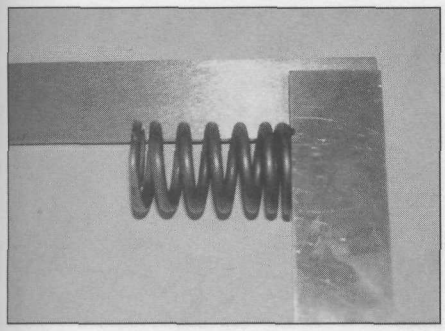
12.19 Measure the valve seat width with a ruler (or for greater precision use a vernier caliper)



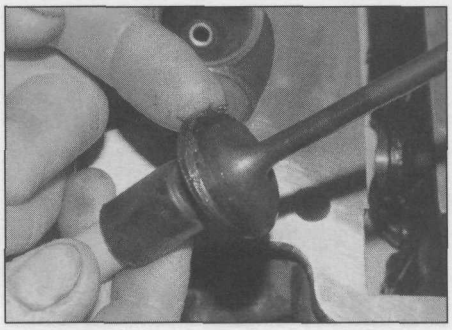
12.20 Check the valve stem for runout using V-blocks and a dial gauge



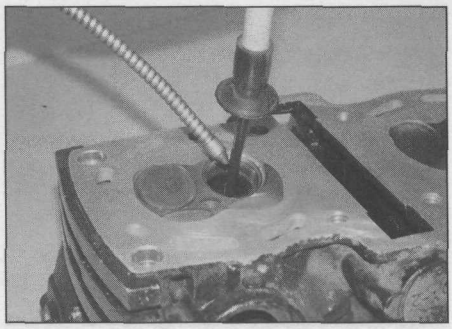
12.21a Measure the free length of the valve springs . . .



12.21b . . . and check them for squareness



12.25a Stick the tool to the valve, then smear some paste onto the face . . .



12.25b . . . and lubricate the stem, and slip the valve into its guide

is shorter than specified it has sagged and must be replaced with a new one. Also place the spring upright on a flat surface and check it for bend by placing a ruler against it **(see illustration)**. If the bend in any spring exceeds the specified limit, it must be replaced with a new one.

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

23 If the inspection indicates that no overhaul work is required, the valve components can be reinstalled in the head.

Reassembly

24 Unless a valve service 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 (either hand-held or drill driven). 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.

25 Attach the grinding tool to the valve. Apply a small amount of coarse grinding compound to the valve face and some molybdenum disulphide oil (a 50/50 mixture of molybdenum disulphide grease and engine oil) to the valve stem, then slip the valve into the guide **(see illustrations)**. **Note:** *Make sure each valve is installed in its correct guide and be careful not to get any grinding compound on the valve stem.*

26 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 (i.e. so that the valve rotates alternately clockwise and anti-clockwise rather than in one direction only) **(see illustration)**. If a motorised tool is being used, take note of the correct drive speed for it – if your drill runs too fast and is not variable, use a hand tool instead. 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.

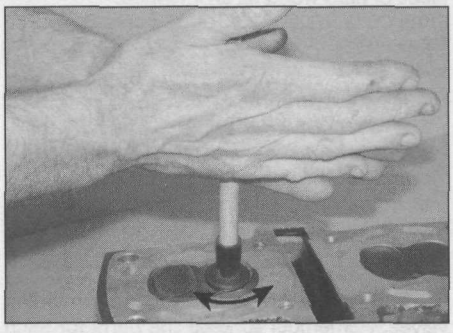
27 Carefully remove the valve and wipe off all traces of grinding compound, making sure none gets in the guide. Use solvent to clean the valve and wipe the seat area thoroughly with a solvent soaked cloth.

28 Repeat the procedure with fine valve grinding compound, then use solvent to clean the valve and flush the guide, and wipe the seat area thoroughly with a solvent soaked cloth. Repeat the entire procedure for the remaining valves. On completion thoroughly clean the entire head again, then blow through all passages with compressed air. Make sure all traces of the grinding compound have been removed before assembling the head.

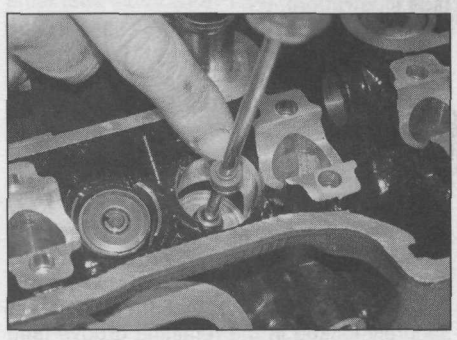
29 *Working on one valve at a time, fit a new* valve stem seal onto the guide **(see illustration)**. Usually finger pressure is sufficient to get it to clip into place, otherwise use a stem seal fitting tool or an appropriate size deep socket to push the seal over the end of the valve guide until it is felt to clip into place. Don't twist or cock the seal, or it will not seal properly against the valve stem – guiding it on using a suitable screwdriver or rod as shown will prevent this happening, but obviously make sure the diameter of the shank is less than that of the seal bore for the valve stem. Also, don't remove the seal again or it will be damaged.

30 Coat the valve stem with molybdenum disulphide oil (a 50/50 mixture of molybdenum disulphide grease and engine oil), then install it into its guide, rotating it slowly to avoid damaging the seal **(see illustration)**. Check that the valve moves up and down freely in the guide.

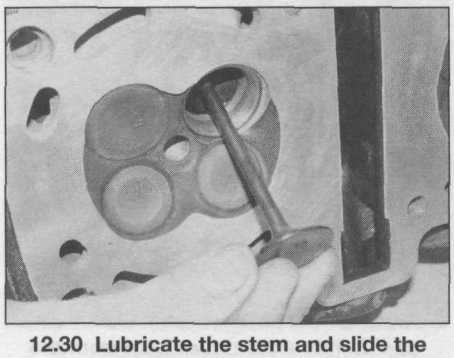
31 Lay the spring seat in place in the cylinder head, making sure the shouldered side faces up **(see illustration)**.



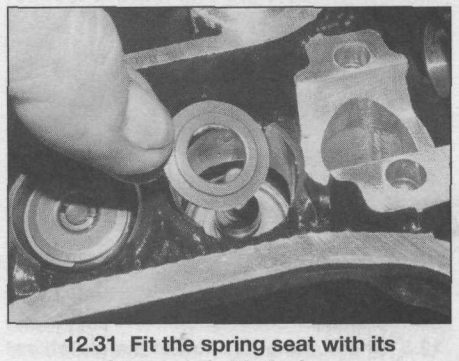
12.26 Rotate the valve grinding tool back and forth between the palms of your hands



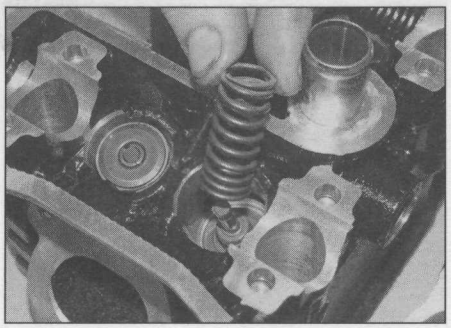
12.29 Fit a new valve stem seal using a rod to guide it if necessary



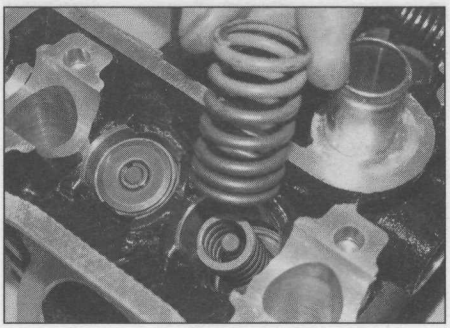
12.30 Lubricate the stem and slide the valve into its correct location



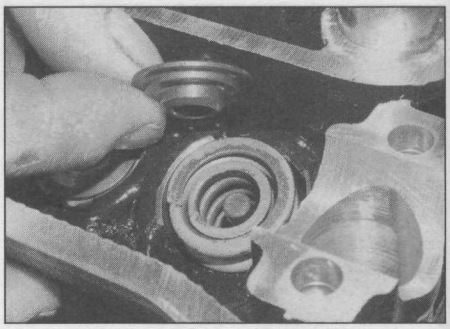
12.31 Fit the spring seat with its shouldered side facing up



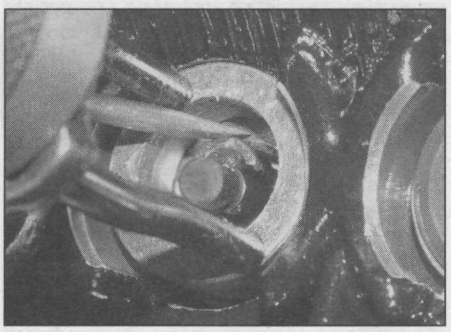
12.32a Fit the inner valve spring . . .



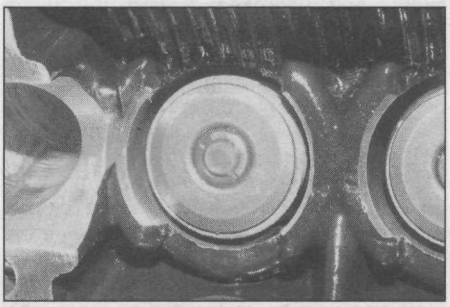
12.32b . . . and the outer valve spring . . .



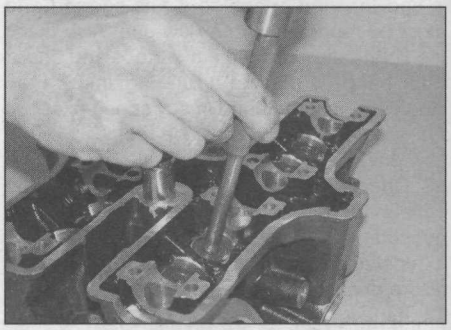
12.32c . . . then fit the spring retainer with its shouldered side facing down



12.33a Locate each collet in its groove in the top of the valve stem



12.33b Check that both collets remain in place and lock into the groove as the compressor is released . . .



12.34 . . . then tap the stem end to make sure

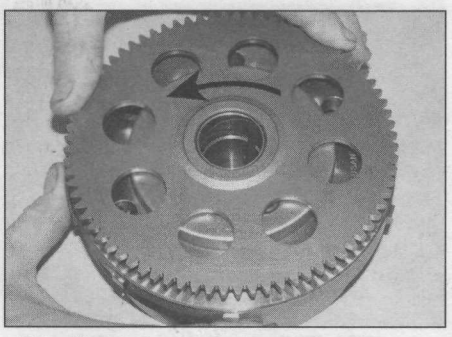
32 Next, install the inner and outer springs, with the closer-wound coils facing down into the cylinder head **(see illustrations)**. Fit the spring retainer, with its shouldered side facing down so that it fits into the top of the springs **(see illustration)**.

33 Compress the valve spring with a spring compressor, making sure it is correctly located onto each end of the valve assembly (see Step 7) **(see illustrations 12.7a, b and c)**. Do not compress the springs any more than is necessary to slip the collets into place. Apply a small amount of grease to the collets to help hold them in place. Locate each collet in turn into the groove in the valve stem **(see illustration)**, then carefully release the compressor, making sure the collets seat and lock as you do. Check that the collets are securely locked in the retaining groove **(see illustration)**.

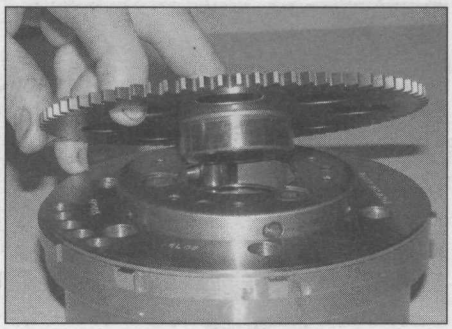
34 Support the cylinder head on blocks so the valves can't contact the workbench top, then tap the top of the valve stem using a brass drift and hammer **(see illustration)**. This will help seat the collets in the groove. If you don't have a brass drift, use a soft-faced hammer and a piece of hard wood as an interface.

> **HAYNES HiNT** ***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.***

35 Repeat the procedure for the remaining valves. Remember to keep the parts for each valve together, and separate from the other valves, so they can be reinstalled in the same location. After the cylinder head and camshafts have been installed, check and adjust the valve clearances as required (see Chapter 1).



13.3 Check the operation of the clutch as described



13.4 Remove the driven gear from the clutch

13 Starter clutch – check, removal, inspection and installation

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

Check

1 The operation of the starter clutch can be checked while it is in situ. Remove the starter motor (see Chapter 9). Check that the idle/reduction gear is able to rotate freely anti-clockwise as you look at it via the starter motor aperture, but locks when rotated clockwise. If not, the starter clutch is faulty and should be removed for inspection.

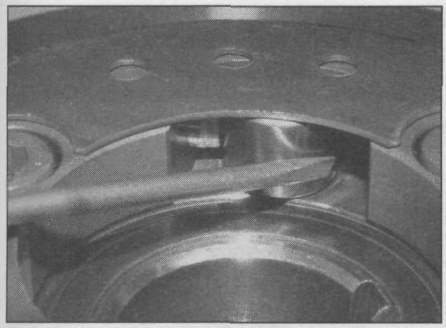
Removal

2 Remove the alternator rotor – the starter clutch is mounted on the back of it (see Chapter 9).

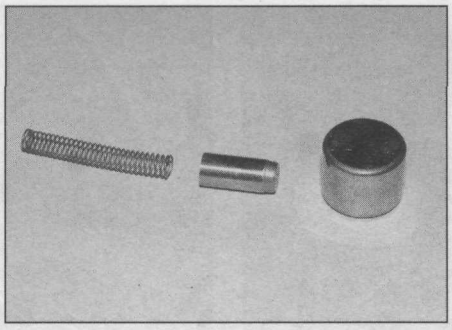
Inspection

3 With the alternator rotor face down on a workbench, check that the starter driven gear rotates freely in an anti-clockwise direction and locks against the rotor in a clockwise direction **(see illustration)**. If it doesn't, dismantle the starter clutch for further investigation.

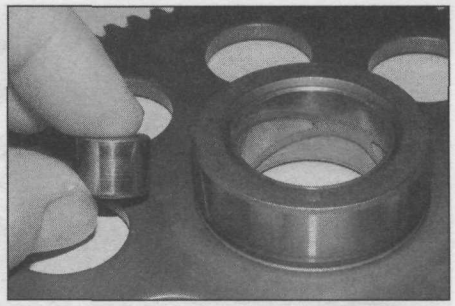
4 Withdraw the starter driven gear from the starter clutch **(see illustration)**. If the gear



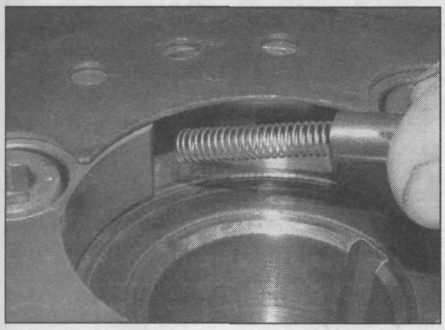
13.5a Check the action of the rollers and springs



13.5b Check the springs and plungers for deformation . . .



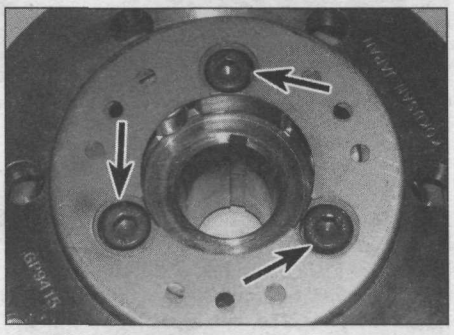
13.5c . . . and check the surface of the rollers and that of the hub and the bush on the inside



13.5d Install the springs and plungers . . .



13.5e . . . and the rollers



13.6 Starter clutch bolts (arrowed)

appears stuck, rotate it anti-clockwise as you withdraw it to free it from the starter clutch.

5 Check the condition of the rollers inside the clutch body, and make sure they move smoothly in and out against the spring – if they are damaged, marked or flattened at any point, replace them with new ones **(see illustration)**. Remove the rollers and check the plungers and springs for signs of deformation or damage **(see illustration)**. Make sure the plungers move freely in their sockets. Also check the corresponding outer surface on the driven gear hub **(see illustration)**. If all is good, fit the springs into the plungers, then fit them into their bores **(see illustration)**. Compress the spring by pushing on the plunger and install the rollers **(see illustration)**.

6 To remove the starter clutch housing, hold the rotor using a holding strap and unscrew the three bolts inside the rotor **(see illustration)**. Separate the housing from the rotor, noting how it fits. Install the new assembly in a reverse sequence. Apply a suitable non-permanent thread locking compound to the bolts and tighten them to the torque setting specified at the beginning of the Chapter. **Note:** *On certain models the heads of the three bolts may have been staked in place, in which case new bolts must be used (with thread locking compound applied) when refitting the housing and the edge of their heads staked in place to lock them in position.*

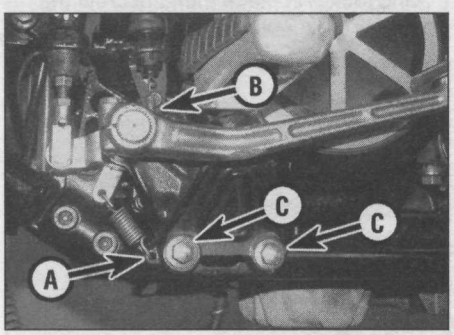
7 Check the bush in the starter driven gear hub and its bearing surface on the crankshaft **(see illustration 13.5c)**. If the bush is worn or damaged, replace the driven gear with a new one. It is unlikely the bearing surface on the crankshaft will be worn unless there has been a lubrication failure.

8 Check the teeth of the starter idle and reduction gears and the corresponding teeth of the starter driven gear and starter motor drive shaft. Replace the gears and/or starter motor armature if worn or chipped teeth are discovered on related gears. Also check the idle gear shaft for damage, and check that the gear is not a loose fit on the shaft. Replace the shaft with a new one if necessary. Similarly check the splines on the reduction gears and their shaft.

Installation

9 Lubricate the bearing surface on the crankshaft with clean engine oil. Lubricate the outside of the starter driven gear hub with clean engine oil, then fit the gear into the clutch, rotating it anti-clockwise as you do so to spread the rollers and allow the hub to enter **(see illustration 13.4)**.

10 Install the alternator rotor (see Chapter 9).



14.2 Unhook the pedal return spring (A) and the switch spring (B), then unscrew the bolts (C) and remove the footrest assembly

14 Clutch – removal, inspection and installation

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

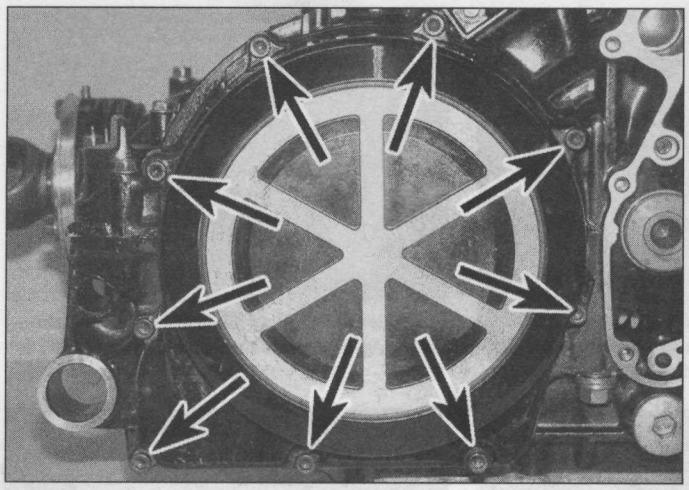
Removal

1 Drain the engine oil (see Chapter 1).

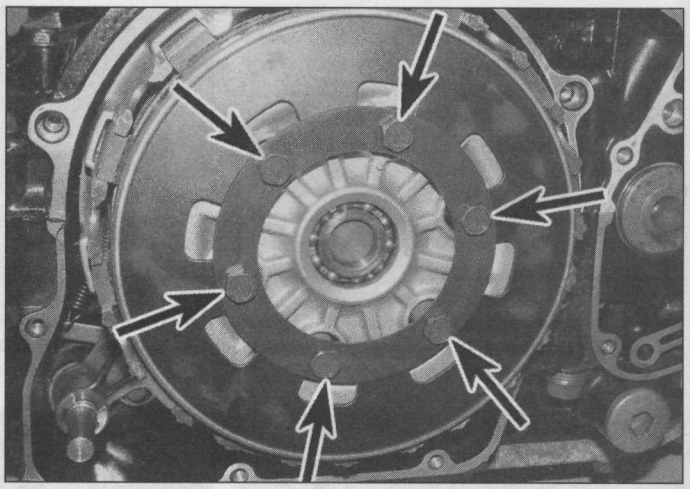
2 Remove the brake pedal (see Chapter 6). Unhook the pedal return spring from the footrest bracket and the brake light switch spring from the pedal pivot, then unscrew the two bolts securing the bracket and draw the footrest assembly off the pedal shaft, which you can let dangle **(see illustration)**.

3 Working evenly in a criss-cross pattern, unscrew the clutch cover bolts, if the engine is in the frame noting how one secures the brake light switch **(see illustration)**. Remove the cover, being prepared to catch any residual oil. Remove the gasket and discard it **(see illustration 14.28a)**. Note the positions of the two locating dowels and remove them for safe-keeping if they are loose – they could be in either the cover or the crankcase.

4 Working in a criss-cross pattern, gradually



14.3 Unscrew the bolts (arrowed) and remove the cover



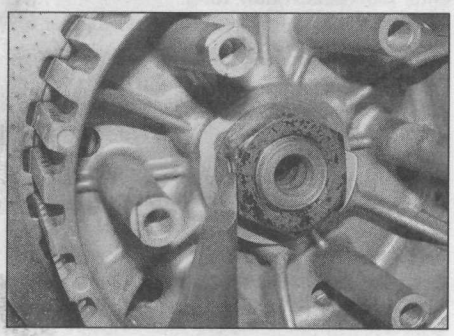
14.4 Unscrew the bolts (arrowed) and remove the retainer, spring and pressure plate

slacken the clutch diaphragm spring retainer bolts until the spring pressure is released **(see illustration)**. Counter-hold the clutch housing to prevent it turning. Remove the bolts, retainer, diaphragm spring and spring seat, then remove the clutch pressure plate **(see illustrations 14.27e, d, c and b)**.

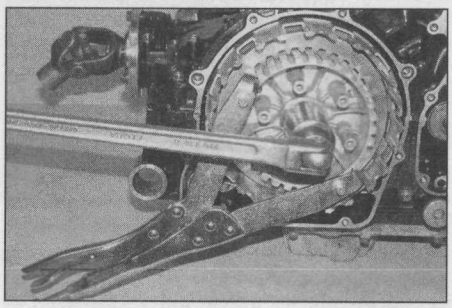
5 Remove the short pushrod and steel ball **(see illustrations 14.26b and a)**. There's another, longer pushrod behind the steel ball which can be removed for inspection after removing the release cylinder (see Section 16).

6 Grasp the complete set of clutch plates and remove them as a pack. Unless the plates are being replaced with new ones, keep them in their original order – note that on 1985 to 1996 models the outermost friction plate is different to the rest, and must be installed in its correct position. Do not yet remove the inner plain and friction plates that are part of the anti-judder assembly.

7 Bend back the tabs on the clutch nut lockwasher **(see illustration)**. To remove the clutch nut the transmission input shaft must be locked. This can be done in several ways. If the engine is in the frame, engage 5th gear and have an assistant hold the rear brake on hard with the rear tyre in firm contact with the ground. Alternatively, the Yamaha service tool (Pt. No. 90890-04086), or a similar commercially available and inexpensive tool can be used to stop the clutch centre from turning whilst the nut is slackened **(see illustration)**. Unscrew the nut and remove the lockwasher from the input shaft, noting how it fits. Discard the lockwasher as a new one should be used on installation.



14.7a Bend back the lockwasher tabs



14.7b Locate the tool on the clutch centre and lock it in place then unscrew the clutch nut

8 Slide the clutch centre and the thrust washer off the shaft **(see illustrations 14.24a and 23)**.

9 Slide the clutch housing off the shaft **(see illustration 14.22)**.

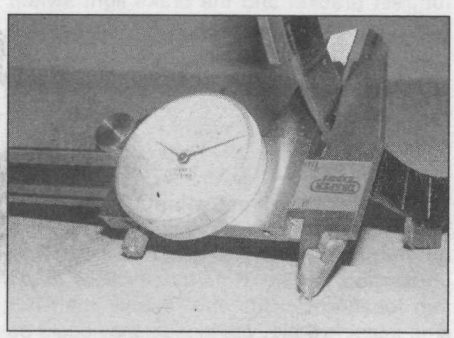
10 Release the wire retainer ends from inside the clutch centre and remove it, then slide off the inner plain plate and friction plate, the anti-judder spring and spring seat **(see illustrations 14.21g, d, c, b and a)**. Keep all components in order and the correct way round – note that the friction plate has a slightly larger internal diameter so it can fit over the anti-judder spring and seat.

11 If required, release the circlip securing the oil pump drive gear and remove the gear, noting how the drive pins locate **(see illustration 14.16b)**. Remove the pins for safekeeping if they are loose.

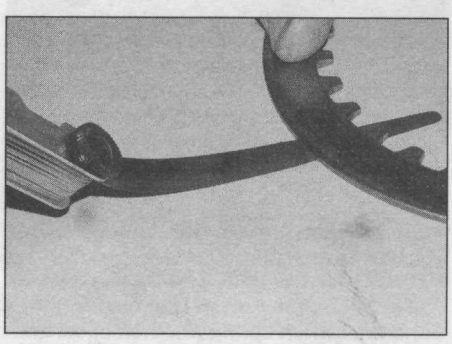
Inspection

12 After an extended period of service the clutch friction plates will wear and cause clutch slip. Measure the thickness of each friction plate using a vernier caliper **(see illustration)**. If any plate has worn to or beyond the service limit given in the Specifications at the beginning of the Chapter, the friction plates must be renewed as a set. Also, if any of the plates smell burnt or are glazed, they must be renewed as a set.

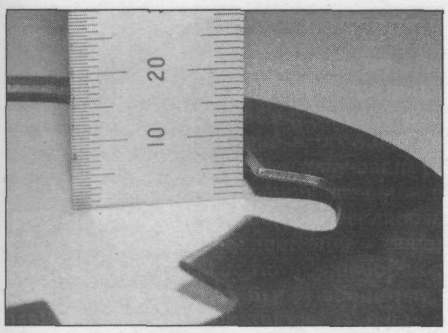
13 Lay the plain (metal) plates, one at a time, on a perfectly flat surface (such as a piece of plate glass) and check for warpage by trying to slip a gauge between the flat surface and the plate **(see illustration)**. The feeler gauge should be the same thickness as the warpage limit listed in this Chapter's Specifications. Do this at several places around the plate's circumference. If the feeler gauge can be



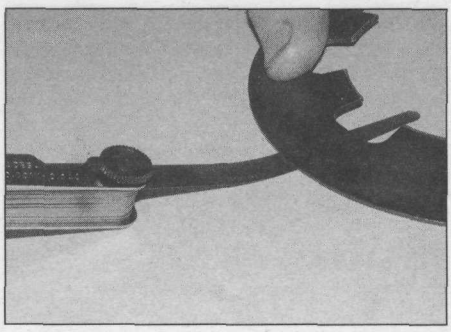
14.12 Measure the clutch friction plate thickness



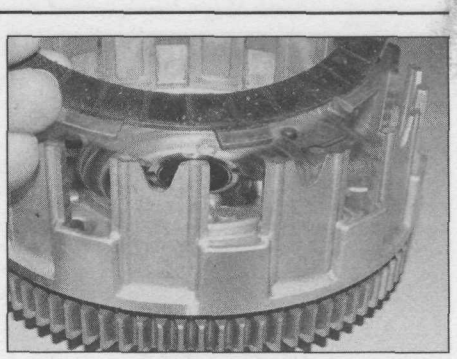
14.13 Check the plain plates for warpage



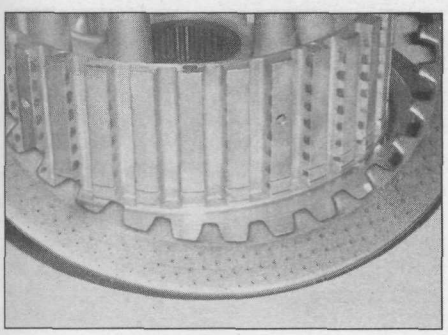
14.14a Measure the free height of the spring as shown . . .



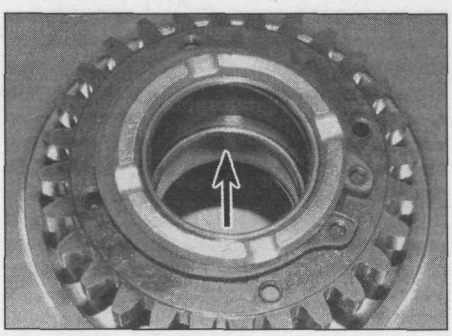
14.14b . . . then check it for warpage



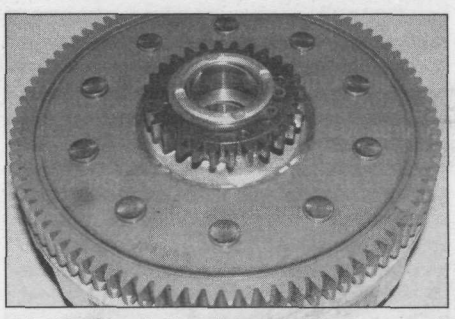
14.15a Check the friction plate tabs and clutch housing slots as described



14.15b Check the plain plate tongues and the clutch centre slots as described



14.16a Check the bush (arrowed) for wear



14.16b Check the oil pump drive gear and primary driven gear teeth for damage and wear

slipped under the plate, it is warped. The plates should not show any signs of excess heating (bluing).

14 Check the clutch diaphragm spring and spring seat for wear, damage or deformation and replace them with new ones if necessary. Place the spring on the bench and measure its height at the inner rim **(see illustration)**. If it is less than the minimum specified at the beginning of the Chapter, replace the spring with a new one. Check for warpage of the spring using a flat surface and feeler gauges in the same way as the plain plates (see Step 13) **(see illustration)**. If it exceeds the maximum permissible amount of warpage, replace the spring with a new one.

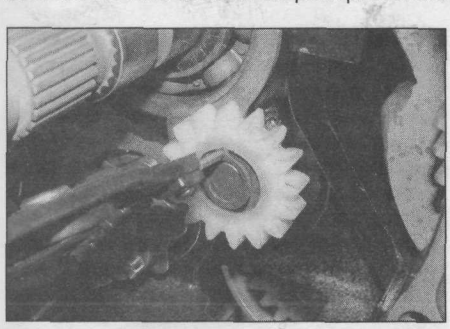
15 Inspect the edges of the tabs on the friction plates and the corresponding slots in the clutch housing for burrs and indentations **(see illustration)**. Similarly check for wear between the inner teeth of the plain plates and the slots in the clutch centre **(see illustration)**. Wear of this nature will cause clutch drag and slow disengagement during gear changes as the plates will snag when the pressure plate is lifted. With care a small amount of wear can be corrected by dressing with a fine file, but if wear is excessive new components should be installed.

16 Inspect the bush in the clutch housing and its bearing surface on the input shaft **(see illustration)**. If the bush is worn or damaged, replace the housing with a new one. It is unlikely the bearing surface on the crankshaft will be worn unless there has been a lubrication failure. Also check the oil pump drive gear teeth and those of the intermediate gear in the crankcase, and the primary driven gear teeth **(see illustration)**. The oil pump drive gear is not listed as being available separately from the clutch housing, though it is unlikely to wear. It is more likely that wear will occur in the intermediate gear, which can be removed by releasing the circlip that secures it on its shaft **(see illustration)**.

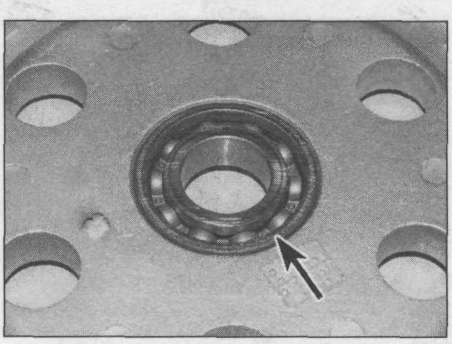
17 Check the pressure plate bearing for signs of wear or damage and roughness **(see illustration)**. Replace it with a new one if necessary.

18 Check the anti-judder spring and seat for wear, damage and deformation. If any is found, or the clutch has been juddering, replace them with new ones. Check the plain and friction plates incorporated in the anti-judder assembly as described above. Check the wire retainer ring for deformation.

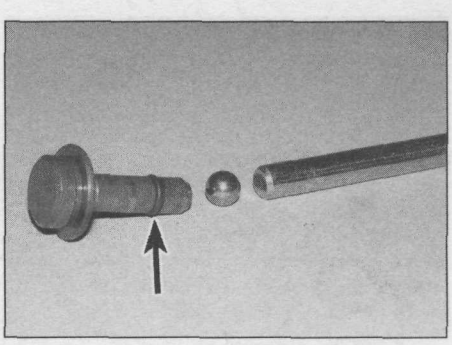
19 Check the short pushrod and steel ball for wear or damage and replace them with new ones if defects are visible **(see illustration)**. Fit a new O-ring onto the pushrod if necessary. If you removed the long pushrod, make sure it isn't bent (roll it on a perfectly flat surface or use V-blocks and a dial gauge).



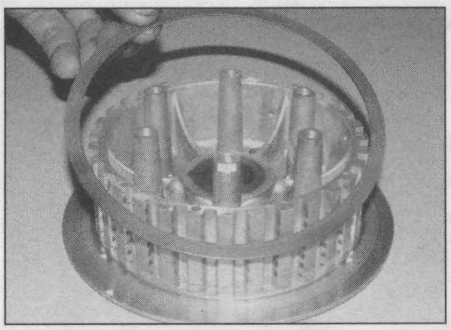
14.16c Remove the circlip to release the intermediate gear, noting the flats that lock it to the shaft



14.17 Check the pressure plate bearing (arrowed)



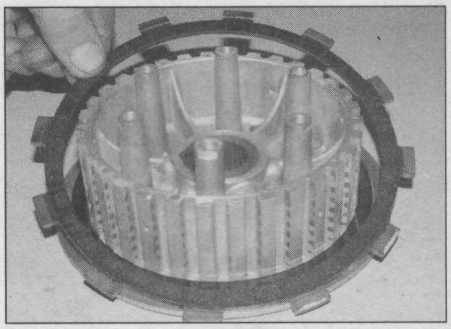
14.19 Check the pushrods, ball and O-ring (arrowed)



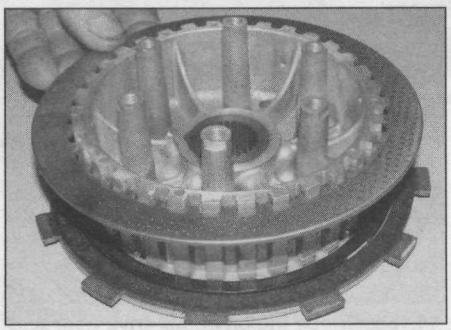
14.21a Lay the spring seat onto the clutch centre . . .



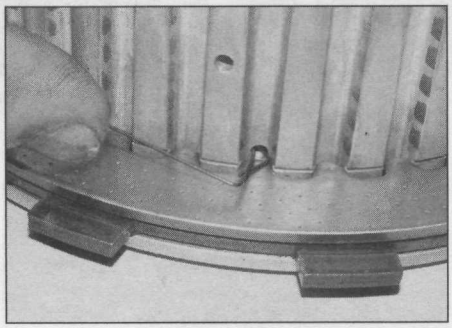
14.21b . . . followed by the anti-judder spring, with the OUTSIDE mark facing out



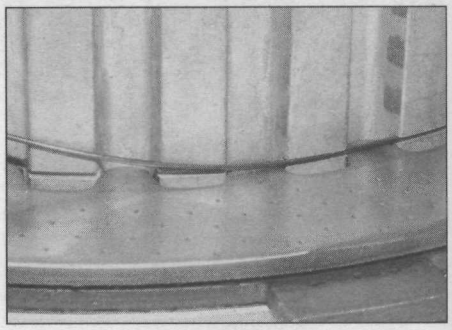
14.21c Fit the friction plate over the spring and seat . . .



14.21d . . . then fit the plain plate



14.21e Push one end of the wire retainer into the hole . . .



14.21f . . . then feed the retainer round, locating it in the groove . . .

Installation

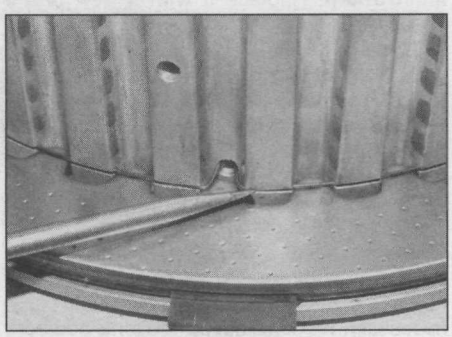
20 Remove all traces of old gasket from the crankcase and clutch cover surfaces.

21 Fit the anti-judder spring seat and spring onto the clutch centre, with the OUTSIDE mark on the spring facing out **(see illustrations)**. Fit the innermost friction plate, identifiable by its larger internal diameter, over the spring and spring seat, then fit the plain plate **(see illustrations)**. Secure the assembly with the retainer ring, making sure it locates properly in its groove and the ends are pushed fully into and are secure in the hole in the centre **(see illustrations)**.

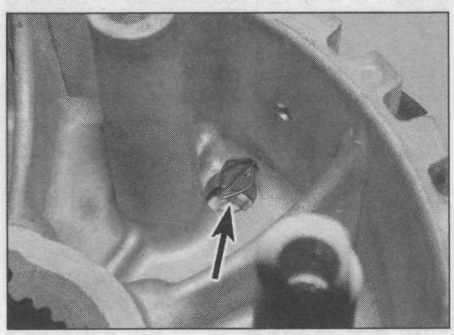
22 Lubricate the clutch housing bush with clean engine oil. Install the housing, making sure the primary drive and driven gears and the oil pump drive and middle gears engage correctly **(see illustration)**.

23 Lubricate the thrust washer with clean engine oil and fit it onto the shaft **(see illustration)**.

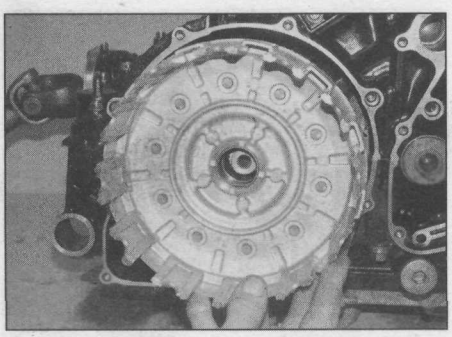
24 Slide the clutch centre onto the shaft splines, locating the friction plate tabs in the housing slots, then fit a new lockwasher with the tabs raised away from the centre **(see illustrations)**. Install the clutch nut with the unthreaded section innermost, and using the method employed on removal to lock the input shaft (see Step 7), tighten the nut to the



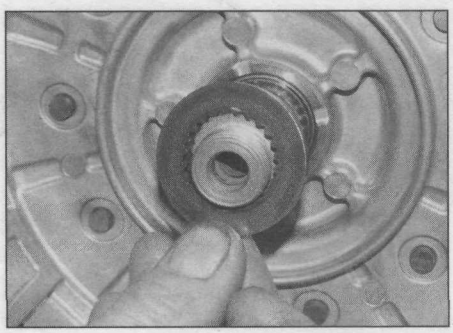
14.21g . . . and push the other end into the hole



14.21h Check that the ends (arrowed) have located correctly



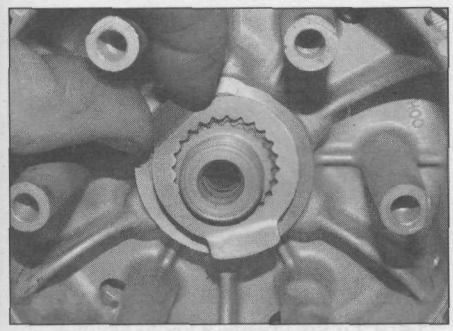
14.22 Slide the housing onto the shaft . . .



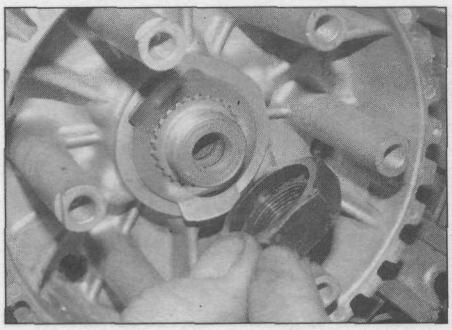
14.23 . . . followed by the thrust washer



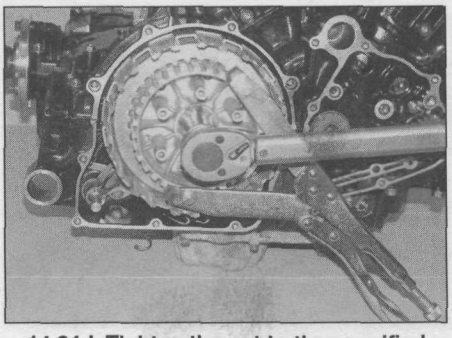
14.24a Slide the clutch centre onto the shaft, locating the friction plate tabs in the slots in the housing . . .



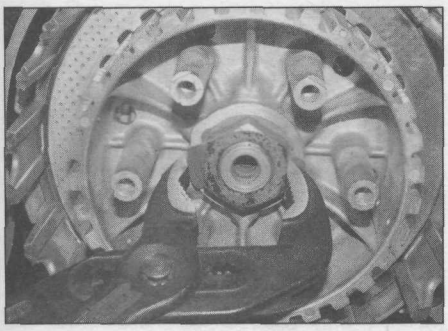
14.24b . . . then fit the new lockwasher with its tabs raised away from the centre . . .



14.24c . . . and the nut with its unthreaded section innermost



14.24d Tighten the nut to the specified torque setting . . .

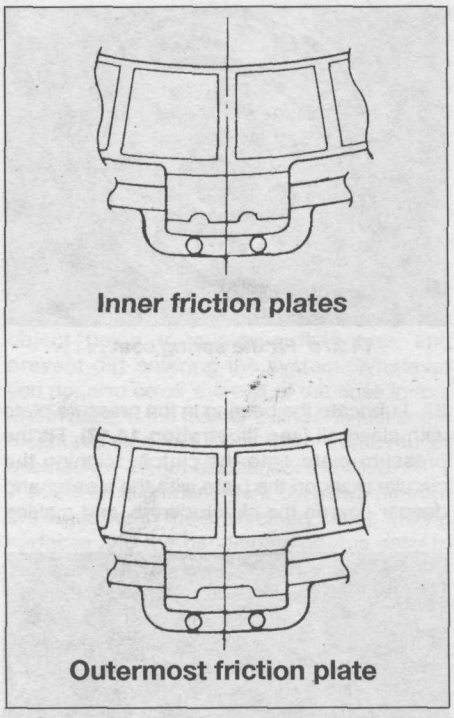


14.24e . . . then bend up the lockwasher tabs

torque setting specified at the beginning of the Chapter **(see illustrations)**. **Note:** *Check that the clutch housing rotates freely after tightening.* Bend up the tabs of the lockwasher to secure the nut **(see illustration)**.

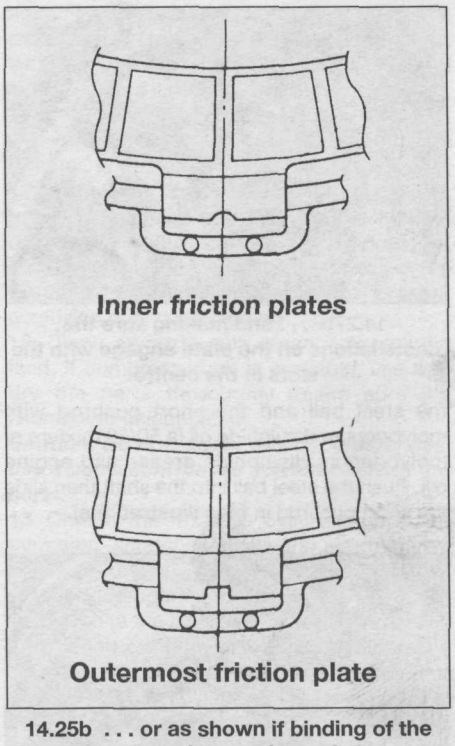
25 Coat each plain and friction plate with engine oil prior to installation. Build up the plates as follows: first fit a friction plate, then a plain plate, then alternate friction and plain plates until all are installed. The friction plates must be aligned as follows:

• On 1985 to 1996 models align the **two** semi-circular slots in the edge of one tab on each of the six inner friction plates with the two circular marks on the clutch housing, and align the **wide** oblong cut-out on the outermost friction plate with the same marks **(see illustration)**. Note that if the friction plates are felt to bind when the release lever is pulled in (due to tabs being tight in their slots), each plate must be repositioned so that the



14.25a On 1985 to 1996 models align the friction plates as shown . . .

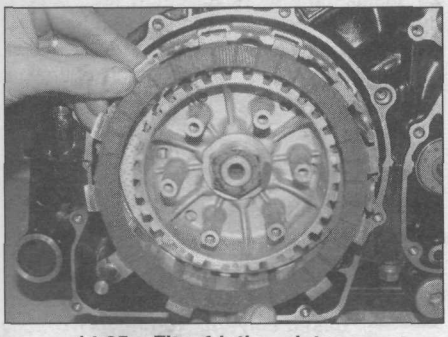
single semi-circular slot in the tab on each of the six inner friction plates aligns with the two circular marks on the clutch housing, and the **narrow** oblong cut-out on the outermost friction plate aligns with the same marks **(see illustration)**.



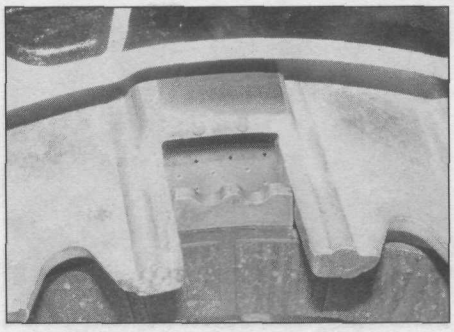
14.25b . . . or as shown if binding of the plates is experienced

• On 1997 to 2003 models, align the two semi-circular slots in the edge of one tab on each of the friction plates with the circular marks on the clutch housing **(see illustrations)**.

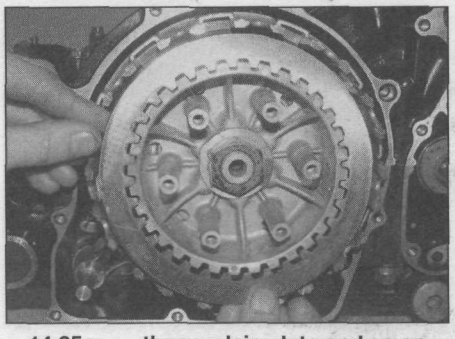
26 If removed fit the O-ring onto the short pushrod **(see illustration 14.19)**. Lubricate



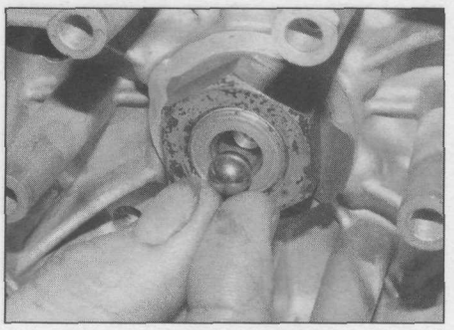
14.25c Fit a friction plate . . .



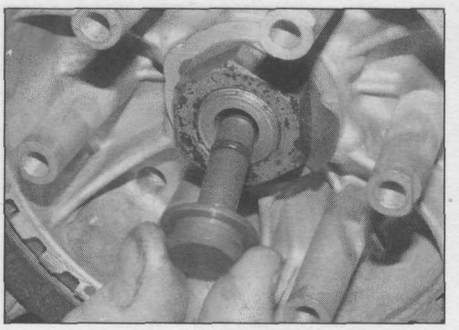
14.25d . . . aligning the tab with the double cut-out with the slot with the two dots . . .



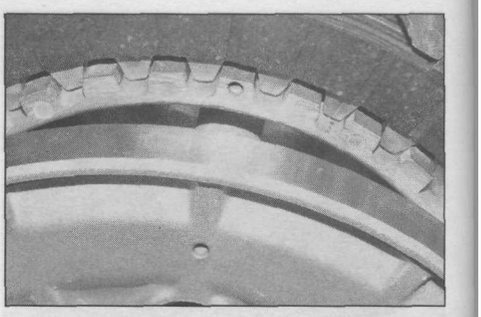
14.25e . . . then a plain plate and so on



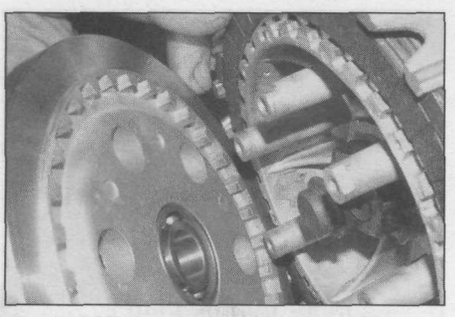
14.26a Insert the ball . . .



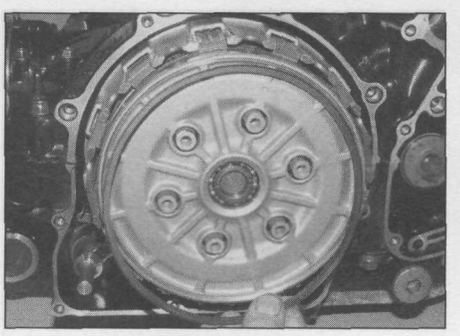
14.26b . . . and the short pushrod



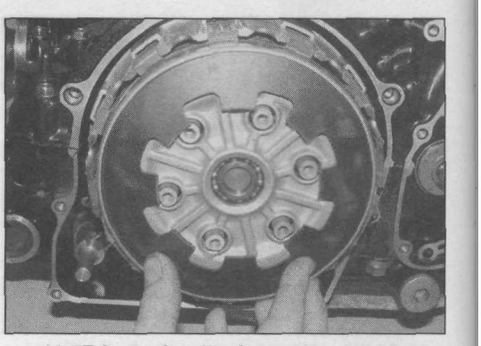
14.27a Fit the pressure plate, aligning the punch mark on the plate with the small deep one on the centre . . .



14.27b . . . and making sure the castellations on the plate engage with the slots in the centre



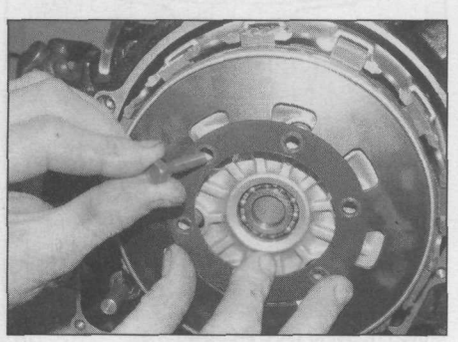
14.27c Fit the spring seat . . .



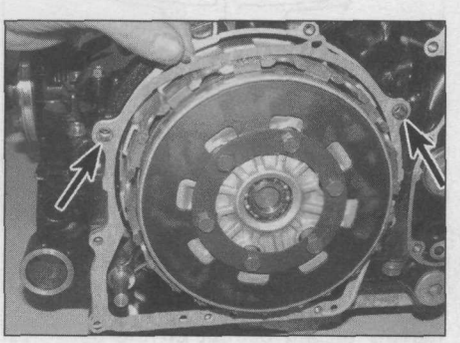
14.27d . . . the diaphragm spring . . .

the steel ball and the short pushrod with molybdenum disulphide oil (a 50/50 mixture of molybdenum disulphide grease and engine oil). Push the steel ball into the shaft then slide the short pushrod in **(see illustrations)**.

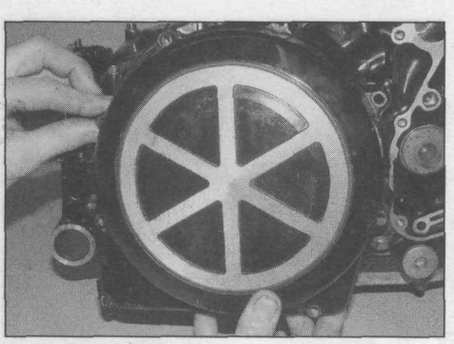
27 Lubricate the bearing in the pressure plate with clean oil **(see illustration 14.17)**. Fit the pressure plate onto the clutch, aligning the circular mark on the plate with the smaller and deeper one on the clutch centre, and making sure it seats correctly with its inner rim castellations locating in the slots in the clutch centre – if there is any clearance between the clutch plates as you push on the pressure plate then it has not located properly **(see illustration)**. Fit the spring seat, diaphragm spring, spring retainer and the retainer bolts and tighten them evenly and a little at a time in a criss-cross sequence to the specified torque setting **(see illustrations)**. Counter-hold the clutch housing to prevent it turning when tightening the spring bolts.



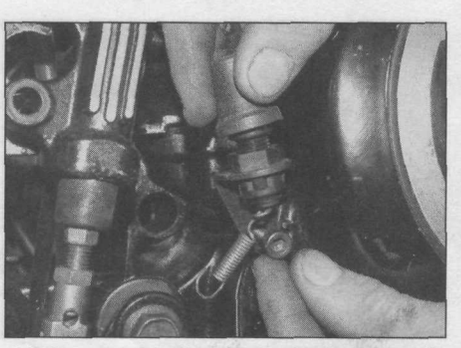
14.27e . . . and the retainer and bolts



14.28a Locate the new gasket onto the dowels (arrowed) . . .



14.28b . . . then install the cover . . .



14.28c . . . securing the brake light switch if the engine is in the frame

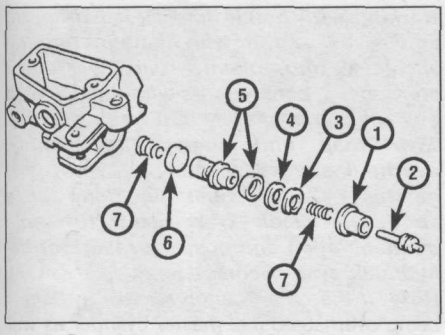
28 Fit the dowels into the crankcase. Install the clutch cover using a new gasket and tighten its bolts evenly in a criss-cross sequence to the specified torque setting – the two longer bolts fit in the ten and two o'clock positions where the dowels are located, and if the engine is in the frame do not forget to secure the brake light switch with its bolt **(see illustrations)**.

29 Install the footrest assembly and hook up the springs **(see illustration 14.2)**, then install the brake pedal (see Chapter 6).

30 Refill the engine with the specified amount and type of oil (see Chapter 1).

15 Clutch master cylinder – removal, overhaul and installation

Warning: Do not, under any circumstances, use petroleum-based solvents to clean hydraulic parts. Use clean brake and clutch fluid, brake cleaner or denatured alcohol only.



15.2 Clutch master cylinder components

1 *Rubber boot*
2 *Pushrod*
3 *Circlip*
4 *Washer*
5 *Piston and seal*
6 *Primary cup*
7 *Spring*

Use care when working with brake fluid as it can injure your eyes and it will damage painted surfaces and plastic parts – cover surrounding components with rag, wipe up any spills immediately and wash the area with soap and water. Disassembly, overhaul and reassembly of the clutch master cylinder must be done in a spotlessly clean work area to avoid contamination and possible failure of the hydraulic system components.

Note: *If the entire clutch release system is being overhauled (i.e. release cylinder as well as master cylinder), or if you intend to change the clutch fluid as part of the master cylinder overhaul (which is advisable), drain the fluid completely from the system (see Section 17), as opposed to retaining the old fluid within it by blocking the hose as described (Step 6).*

1 If the master cylinder is leaking fluid, or if the clutch does not work properly when the lever is applied, and bleeding the system does not help (see below), and the hydraulic hoses are all in good condition, then master cylinder overhaul is recommended.

2 Before disassembling the master cylinder, read through the entire procedure and make sure that you have the correct rebuild kit **(see illustration)**. Also, you will need some new DOT 4 hydraulic brake and clutch fluid, some clean rags and internal circlip pliers.

Removal

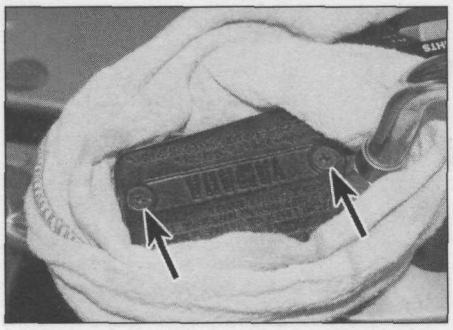
Note: *If the master cylinder is being displaced from the handlebar and not being removed completely or overhauled, follow Steps 4 and 7 only.*

3 Support the motorcycle on its centrestand. Slacken the reservoir cover screws, then lightly tighten them again **(see illustration)**. Turn the handlebars as required so that the top of the reservoir is level.

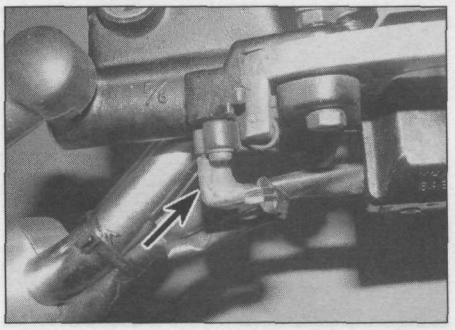
4 Disconnect the clutch switch wiring connectors **(see illustration)**. If required, remove the clutch switch (see Chapter 9).

5 If the master cylinder is being overhauled, remove the clutch lever (see Chapter 6). If it is just being displaced it can remain in situ.

6 If the master cylinder is being completely



15.3 Slacken the reservoir cover screws



15.4 Disconnect the clutch switch wiring connectors (arrowed)

removed or overhauled, pull the rubber boot off the clutch hose banjo bolt, then unscrew the bolt and separate the hose from the master cylinder, noting its alignment **(see illustration)**. Discard the sealing washers as they must be replaced with new ones. Either plug the hose using another suitable short piece of hose fitted through the eye of the banjo union (it must be a tight fit to seal it properly), block it using a suitable bolt with sealing washers and a capped (domed) nut, or wrap some clingfilm tightly around (a finger cut off a latex glove also works well), the object being to minimise fluid loss and prevent dirt entering the system. Whatever you do, also cover the end of the hose in rag, just in case. If the master cylinder is just being displaced and not completely removed or overhauled, do not disconnect the hose.

7 Make an alignment mark between the front brake master cylinder assembly clamp mating surfaces and the handlebars so it is easy to set them in the same position later. Unscrew the master cylinder clamp bolts, then lift the master cylinder and reservoir away from the handlebar **(see illustration)**.

Caution: Do not tip the master cylinder or brake fluid will run out.

8 Remove the reservoir cover and rubber diaphragm **(see illustration 15.24)**. If the system hasn't been drained, tip the brake fluid from the reservoir into a suitable container. Wipe any remaining fluid out of the reservoir with a clean rag.

Overhaul

9 Draw the pushrod out of the master cylinder, noting how it locates in the rubber boot. The boot may come away with the pushrod, along with the spring that the inner end of the rod locates in **(see illustration 15.2)**.

10 If they didn't come with the pushrod, remove the rubber boot from the end of the cylinder, and remove the spring.

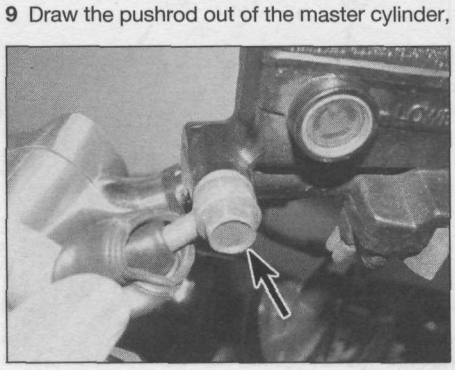
11 Push the piston in and, using circlip pliers, remove the circlip, then slide out the washer, piston and seal, primary cup, and spring, noting how they fit. Lay the parts out in the proper order and way round to prevent confusion during reassembly.

12 Clean all parts with clean brake/clutch fluid. If compressed air is available, use it to dry the parts thoroughly (make sure it's filtered and unlubricated).

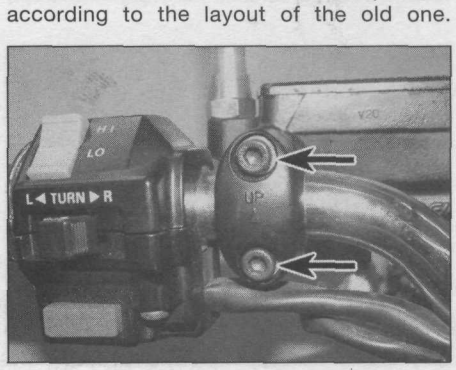
Caution: Do not, under any circumstances, use a petroleum-based solvent to clean the parts.

13 Check the master cylinder bore for corrosion, scratches, nicks and score marks. If the necessary measuring equipment is available, compare the diameter of the bore to that given in the Specifications Section of this Chapter. If damage or wear is evident, the master cylinder must be replaced with a new one. If the master cylinder is in poor condition, then the release cylinder should be checked as well. Check that the fluid inlet and outlet ports in the master cylinder are clear.

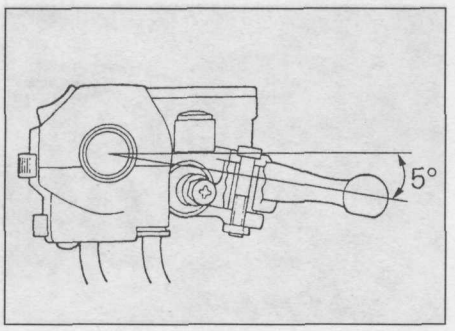
14 The pushrod and spring, dust boot, circlip, seal, piston, primary cup and spring are included in the rebuild kit. Use all of the new parts, regardless of the apparent condition of the old ones. Fit all components according to the layout of the old one.



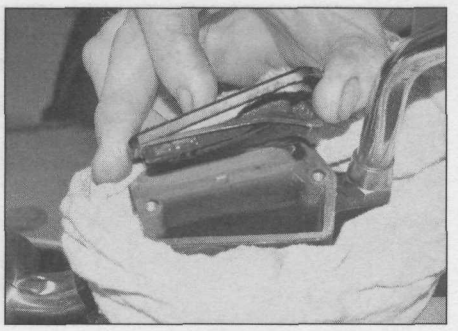
15.6 Clutch hose banjo bolt (arrowed)



15.7 Master cylinder clamp bolts (arrowed)



15.19 Clutch master cylinder and lever position



15.24 Make sure the diaphragm is properly seated before fitting the cover

Lubricate the seal, piston and primary cup with clean brake/clutch fluid.

15 Fit the main (piston) spring into the master cylinder so that its narrow end faces out. Slip the primary cup into the bore and locate it against the spring. Make sure the cup lips do not turn inside out as you slide it in.

16 If not already done, fit the seal onto the end of the piston. Fit the piston into the master cylinder, making sure it is the correct way round and the seal lips do not turn inside out. Slide the washer into the cylinder. Depress the piston and install the new circlip, making sure that it locates in the groove.

17 Apply some silicone grease to the inside of the rubber boot and to the pushrod. Fit the boot over the pushrod, locating the narrow rim of the boot into the groove, then fit the spring onto the inner end of the rod. Install the pushrod, making sure the wide rim of the boot locates correctly in the groove in the end of the master cylinder.

18 Inspect the reservoir cover rubber diaphragm and replace it with a new one it if it is damaged or deteriorated.

Installation

19 Locate the master cylinder on the handlebar and fit the clamp with its UP mark facing up, aligning the clamp mating surfaces with the mark made earlier on the handlebar **(see illustration 15.7)**. Tighten the upper bolt first, then the lower bolt, to the torque setting specified at the beginning of the Chapter. If no alignment marks were made, and after installing the lever if removed, set the angle of the lever at 5° below the horizontal with the handlebar **(see illustration)**.

20 If detached, connect the clutch hose to the master cylinder, using new sealing washers on each side of the union, and aligning the hose as noted on removal **(see illustration 15.6)**. Tighten the banjo bolt to the specified torque setting, then fit the rubber boot over it.

21 If removed, install the clutch switch (see Chapter 9). Otherwise, connect the clutch switch wiring connectors **(see illustration 15.4)**.

22 If removed, install the clutch lever (see Chapter 6).

23 Fill the fluid reservoir with new DOT 4 brake/clutch fluid as described in *Daily (pre-ride) checks*. Bleed the air from the system (see Section 17).

24 Fit the rubber diaphragm, making sure it is correctly seated, and the cover onto the master cylinder reservoir, and tighten the cover screws (do not overtighten) **(see illustration)**.

25 Check the operation of the clutch before riding the motorcycle.

16 Clutch release cylinder – removal, overhaul and installation

Warning: Do not, under any circumstances, use petroleum-based solvents to clean brake parts. Use clean brake fluid, brake cleaner or denatured alcohol only. Use care when working with brake fluid as it can injure your eyes and it will damage painted surfaces and plastic parts – cover surrounding components with rag, wipe up any spills immediately and wash the area with soap and water. Disassembly, overhaul and reassembly of the brake master cylinder must be done in a spotlessly clean work area to avoid contamination and possible failure of the hydraulic system components.

Note: *If the entire clutch release system is being overhauled (i.e. master cylinder as well as release cylinder), or if you intend changing the clutch fluid as part of the release cylinder overhaul (which is advisable), drain the fluid completely from the system (see Section 17), as opposed to retaining the old fluid within it by blocking the hose as described (Step 4).*

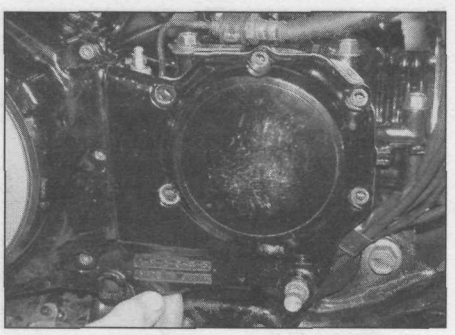
Removal

1 Unscrew the two bolts securing the rider's left-hand footrest bracket and remove the footrest assembly **(see illustration 5.14)**.

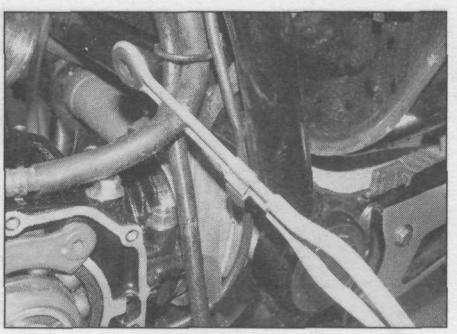
2 Unscrew the gearchange linkage arm pinch bolt and slide the arm off the shaft, noting how the slot in the arm aligns with the punch mark on the shaft **(see illustration 5.15a)**. Unscrew the two bolts securing the gearchange lever pivot bracket and remove the lever assembly **(see illustration 5.15b)**.

3 Remove the rubber fillet from the top of the middle gear assembly cover, noting how it locates around the pipe and over the bleed valve. Unscrew the remaining cover bolts and remove the cover, being prepared to catch any oil **(see illustration)**. Discard the gasket as a new one must be used. Note the two locating dowels and remove them for safekeeping if they are loose. Release the wiring from the guide below the release cylinder.

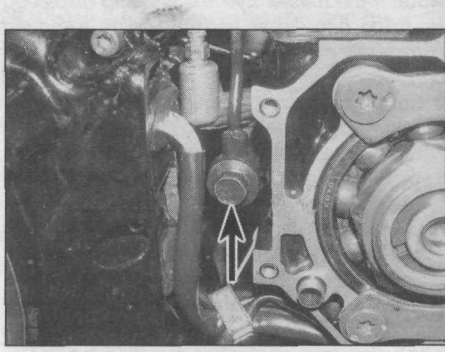
4 It is not possible to displace the clutch release cylinder with the hydraulic pipe connected, so it must be detached. First clamp the hydraulic hose close to the pipe joint **(see illustration)**. Unscrew the pipe banjo bolt, being prepared for a small amount of fluid spillage, and detach the pipe **(see illustration)**. Discard the sealing washers as new ones must be used. Unscrew the



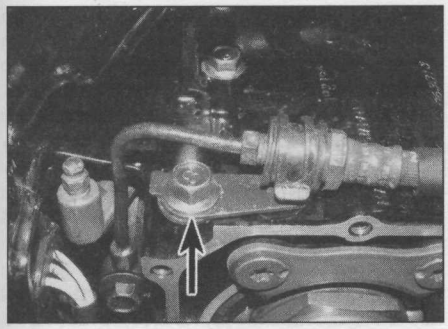
16.3 Unscrew the remaining bolts and remove the cover



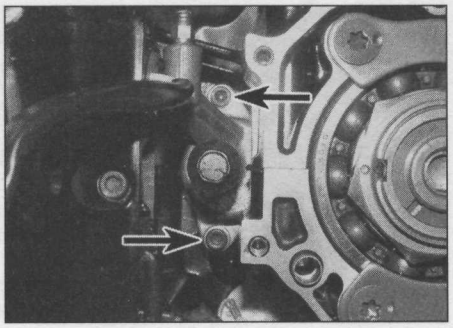
16.4a Fit a hose clamp . . .



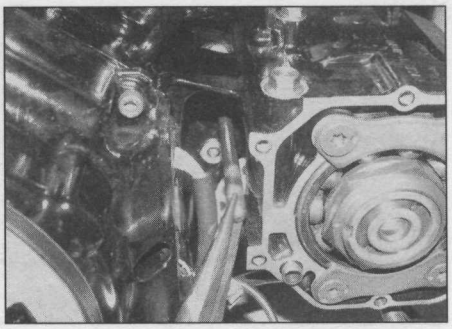
16.4b . . . then unscrew the banjo bolt . . .



16.4c . . . followed by the holder bolt



16.5 Release cylinder bolts (arrowed)



16.6 Remove the pushrod if required

crankcase bolt that secures the hose holder and secure the pipe/hose clear, keeping the open end upright **(see illustration)**. Replace the bolt in the crankcase for safekeeping. Either plug the hose using another suitable short piece of hose fitted through the eye of the banjo union (it must be a tight fit to seal it properly), block it using a suitable bolt with sealing washers and a capped (domed) nut, or wrap some clingfilm tightly around (a finger cut off a latex glove also works well), the object being to minimise fluid loss and prevent dirt entering the system. Whatever you do, also cover the end of the hose in rag, just in case. **Note:** *If you're planning to overhaul the release cylinder and don't have a source of compressed air to blow out the piston, the hydraulic system can be used to force the piston out of the body – reconnect the hose once the release cylinder has been removed, then disconnect it again once the piston has been pumped out (see Step 8).*

5 Unscrew the release cylinder bolts and manoeuvre it down and out from the bottom **(see illustration)**.

6 If required, withdraw the pushrod, noting which way round it fits **(see illustration)**. Do not operate the clutch lever with the release cylinder removed.

HAYNES HiNT ***If the release cylinder is not being disassembled, wrap some cable ties around the piston and through the mounting bolt holes to prevent the piston creeping out, or from being displaced should the lever be accidentally pulled in.***

Overhaul

7 Remove the dust seal from the release cylinder **(see illustrations)**. Discard it as a new one must be used.

8 Have a supply of clean rags on hand, then expel the piston, either by reconnecting the clutch hose (see Step 4) and pumping the clutch lever, or by using a jet of compressed air directed into the fluid inlet.

Warning: Use only low air pressure, otherwise the piston may be forcibly expelled and cause damage or injury. Wrap the cylinder in a rag before applying the air. Never place your fingers in front of the piston in an attempt to catch or protect it when applying compressed air, as serious injury could result.

Caution: Do not try to remove the piston by levering it out, or by using pliers or any other grips.

9 Separate the spring from the piston, noting how it fits, or withdraw it from the cylinder if it is still in there. Using a plastic or wooden tool, remove the piston seal from the groove in the piston, noting which way round it fits. Discard it as new ones must be used.

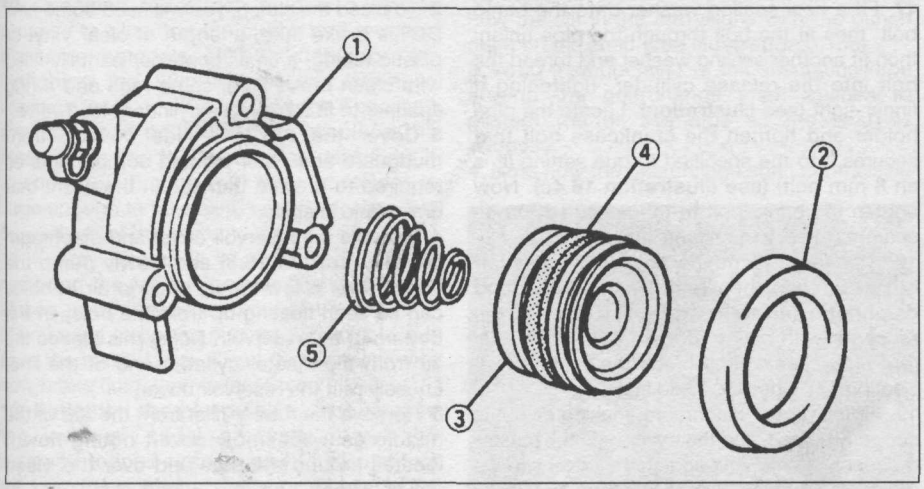
10 Clean the piston and release cylinder bore with clean hydraulic fluid.

Caution: Do not, under any circumstances, use a petroleum-based solvent to clean hydraulic parts.

11 Inspect the piston and release cylinder bore for signs of corrosion, nicks and burrs and loss of plating. If the necessary measuring equipment is available, compare the diameter of the bore to that given in the Specifications Section of this Chapter. If surface defects are found, the piston and cylinder should be replaced with new ones. If the release cylinder is in poor condition the master cylinder should also be overhauled (see Section 15).

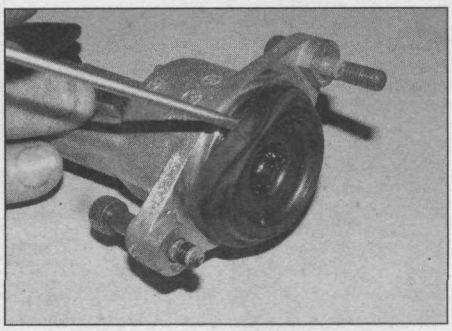
12 Check that the pushrod is straight by rolling it on a flat surface – if it is bent, replace it with a new one. Check the pushrod oil seal in the crankcase for signs of leakage. Replace it with a new one if necessary – lever out the old seal using a seal hook or a flat-bladed screwdriver and press or drive the new one into place.

13 Lubricate the new piston seal with clean hydraulic fluid and fit it into the groove in the piston with the wider side facing its inner end.

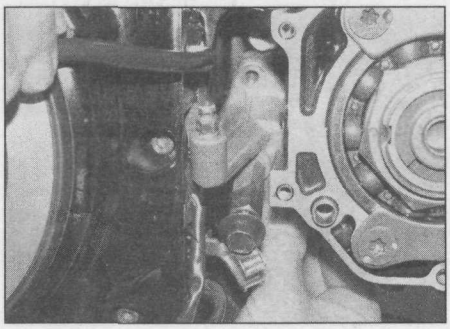


16.7a Clutch release cylinder components

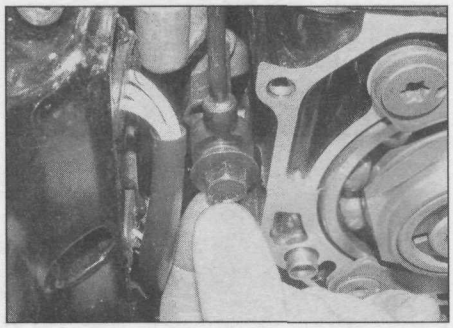
1 Release cylinder
2 Dust seal
3 Piston
4 Piston seal
5 Spring



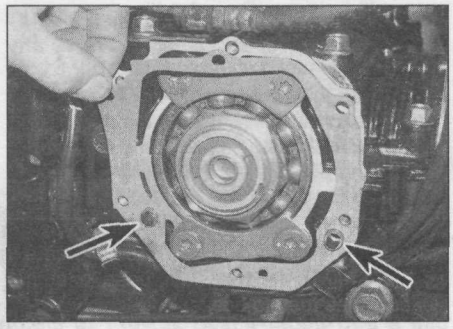
16.7b Remove the dust seal



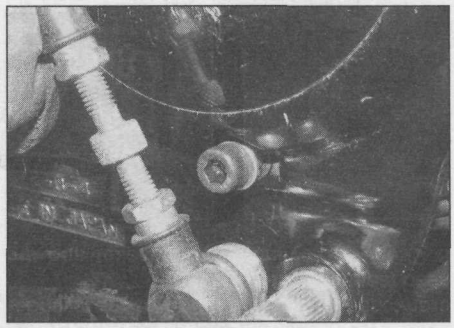
16.16 Install the release cylinder



16.17 Fit a new sealing washer on each side of the union



16.20a Locate the new gasket over the dowels (arrowed)



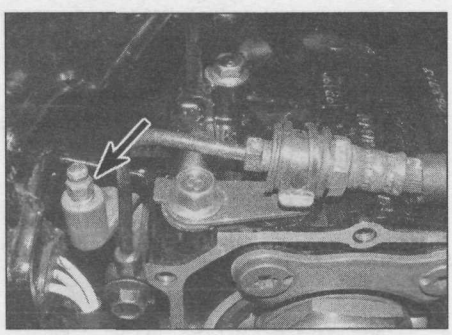
16.20b Use a new sealing washer on the bottom bolt

Fit the narrow end of the spring over the lug on the inner end of the piston. Lubricate the piston and seal with clean hydraulic fluid and insert the assembly into the cylinder, making sure the spring stays in place on the piston and the rim of the seal does not turn inside out. Use your thumbs to press it fully in.

14 Fit a new dust seal onto the release cylinder.

Installation

15 If removed, lubricate the pushrod with molybdenum disulphide oil (a 50/50 mixture of molybdenum disulphide grease and engine oil). Note the differences in the ends of the clutch pushrod – the rounded end faces the left-hand side of the engine (towards the release mechanism), the flatter end faces the right-hand side (towards the clutch). Slide the pushrod flat end first through the seal and into the engine **(see illustration 16.6)**. Wipe the outer end of the pushrod clean and smear silicon grease onto it.



17.5 Clutch release cylinder bleed valve

16 Check that the joint piece which the clutch pipe banjo bolt threads into is tight, and that there is no sign of fluid leakage from around its base. If it is loose or leaking, fully unscrew it, then fit a new sealing washer between it and the release cylinder and tighten it to the torque setting specified at the beginning of the Chapter. Remove the cable ties from the release cylinder if used, then install the cylinder and tighten the bolts to the torque setting specified at the beginning of the Chapter **(see illustration)**.

17 Fit a new sealing washer onto the banjo bolt, then fit the bolt through the pipe union, then fit another sealing washer and thread the bolt into the release cylinder, tightening it finger-tight **(see illustration)**. Locate the pipe holder and tighten the crankcase bolt that secures it to the specified torque setting (it is an 8 mm bolt) **(see illustration 16.4c)**. Now tighten the banjo bolt to the specified torque setting. Release the hose clamp if used.

18 Slacken the master cylinder reservoir cover screws, then remove the cover and diaphragm **(see illustration 15.3)**. Fill the reservoir with new hydraulic fluid (see *Daily (pre-ride) checks*) and bleed the system (see Section 17). Check for fluid leaks.

19 Fit the rubber diaphragm, making sure it is correctly seated, and the cover onto the master cylinder reservoir, and tighten the cover screws (do not overtighten) **(see illustration 15.24)**.

20 The remainder of the installation procedure is the reverse of removal, noting the following points:

- Locate the wiring in the guide below the release cylinder.
- Use a new gasket on the middle gear assembly cover, and do not forget the cover locating dowels **(see illustration 16.20a)**.
- Install the bottom cover bolt using a new sealing washer **(see illustration 16.20b)**.
- When fitting the gearchange linkage arm onto the gearchange shaft, align the slit in the arm with punch mark on the shaft **(see illustration 5.15a)**.
- Fit the rubber fillet onto the top of the middle gear assembly cover, locating it around the pipe and over the bleed valve.
- Check the operation of the clutch before riding the motorcycle.

17 Clutch – bleeding and fluid change

Note: *If bleeding the system using the conventional method does not work sufficiently well, it is advisable to obtain a commercially available vacuum-type brake bleeding tool and repeat the procedure detailed below. Follow the manufacturer's instructions for using the tool.*

Warning: Use care when working with brake fluid as it can injure your eyes and it will damage painted surfaces and plastic parts.

Bleeding

1 Bleeding the clutch is simply the process of removing all the air bubbles from the fluid reservoir, the hoses and the release cylinder. Bleeding is necessary whenever a hydraulic connection is loosened, when a component or hose is renewed, or when the master cylinder or release cylinder is overhauled. Leaks in the system may also allow air to enter, but leaking clutch fluid will reveal their presence and warn you of the need for repair.

2 To bleed the clutch, you will need some new DOT 4 brake fluid, a length of clear vinyl or plastic tubing, a small container partially filled with clean brake fluid, some rags and a ring spanner to fit the release cylinder bleed valve.

3 Cover the top and side covers, front mudguard and other painted components as required to prevent damage in the event that brake fluid is spilled.

4 Remove the reservoir cover and diaphragm **(see illustration 15.3)** and slowly pump the clutch lever a few times, until no air bubbles can be seen floating up from the holes in the bottom of the reservoir. Doing this bleeds the air from the master cylinder end of the line. Loosely refit the reservoir cover.

5 Remove the rubber fillet from the top of the middle gear assembly cover, noting how it locates around the pipe and over the bleed valve. Attach one end of the clear vinyl or plastic tubing to the bleed valve and submerge the other end in the brake fluid in the container **(see illustration)**.

6 Check the fluid level in the reservoir – do not allow it to drop below the lower mark during the bleeding process.
7 Carefully pump the clutch lever three or four times and hold it in while opening the bleed valve. When the valve is opened, clutch fluid will flow into the clear tubing and the lever will move toward the handlebar.
8 Retighten the bleed valve, then release the clutch lever gradually. Repeat the process until no air bubbles are visible in the fluid leaving the release cylinder and the lever is firm when applied. On completion, disconnect the bleeding equipment, then tighten the bleed valve to the torque setting specified at the beginning of the chapter. Fit the rubber fillet onto the top of the middle gear assembly cover, locating it around the pipe and over the bleed valve.
9 Fit the rubber diaphragm, making sure it is correctly seated, and the cover onto the master cylinder reservoir, and tighten the cover screws (do not overtighten) **(see illustration 15.24)**. Wipe up any spilled brake fluid and check the entire system for leaks.

HAYNES HiNT

If it's not possible to produce a firm feel to the lever the fluid my be aerated. Let the brake fluid in the system stabilise for a few hours and then repeat the procedure when the tiny bubbles in the system have settled out. Also check to make sure that there are no 'high-spots' in the hose in which an air bubble can become trapped – this will occur most often in an incorrectly mounted hose union. Displacing and moving the offending component around will normally dislodge any trapped air.

Changing the fluid

10 Changing the clutch fluid is a similar process to bleeding the clutch and requires the same materials, plus a suitable tool for siphoning the fluid out of the hydraulic reservoir (such as a syringe, though if one isn't available it is no problem to displace the reservoir and tip the fluid out as described in Section 15). Ensure that your container is large enough to take all the old fluid when it is flushed out of the system.
11 Follow Steps 3, 4 and 5, but after removing the reservoir cover and diaphragm siphon or tip the old fluid out of the reservoir (if you want to tip the contents out displace it from the handlebars). Clean the reservoir with new brake fluid, then follow Step 7.
12 Retighten the bleed valve, then release the lever or pedal gradually. Keep the reservoir topped-up with new fluid to above the LOWER level at all times or air may enter the system and greatly increase the length of the task. Repeat the process until new fluid can be seen emerging from the bleed valve.

HAYNES HiNT

Old brake fluid is invariably much darker in colour than new fluid, making it easy to see when all old fluid has been expelled from the system.

13 Disconnect the hose, then tighten the bleed valve to the specified torque setting and install the dust cap.
14 Top-up the reservoir then install the diaphragm and cover **(see illustration 15.24)**. Wipe up any spilled clutch fluid and check the entire system for leaks.
15 Check the operation of the clutch before riding the motorcycle.

Draining the system for overhaul

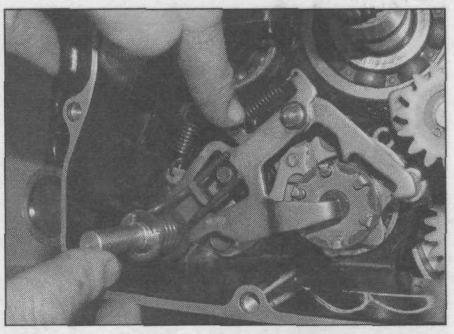
16 Draining the clutch fluid is again a similar process to bleeding the clutch. The quickest and easiest way is to use a commercially available vacuum-type bleeding tool (see **Note**) – follow the manufacturer's instructions. Otherwise follow the procedure described above for changing the fluid, but quite simply do not put any new fluid into the reservoir – the system fills itself with air instead.

18 Gearchange mechanism – removal, inspection and installation

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

Removal

1 Make sure the transmission is in neutral. Remove the clutch (see Section 14). Block the hole into the sump with clean rag to prevent anything falling in.
2 Unscrew the gearchange linkage arm pinch bolt and slide the arm off the shaft, noting how the slit in the arm aligns with the punch mark on the shaft **(see illustration 5.15a)**.
3 Wrap a single layer of thin insulating tape around the gearchange shaft splines to protect the oil seal lips as the shaft is removed.
4 Note how the gearchange shaft centralising

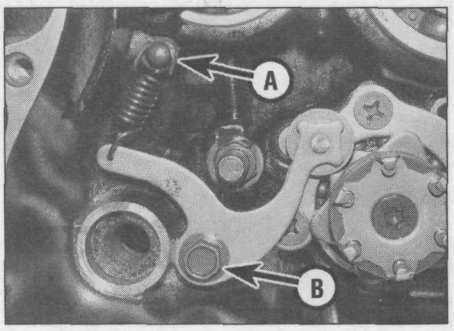


18.4 Lift the arm off the drum and withdraw the shaft

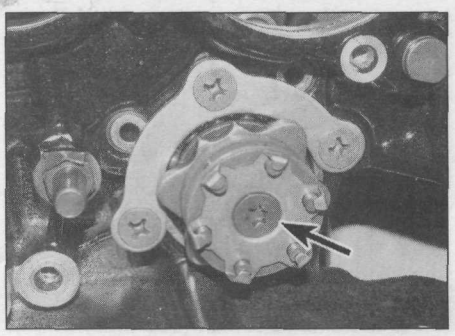
spring ends fit on each side of the locating pin in the casing, and how the pawls on the selector arm locate onto the pins on the end of the selector drum. Lift the selector arm, then grasp the end of the shaft and withdraw the shaft/arm assembly **(see illustration)**.
5 If required, note how the stopper arm spring ends locate and how the roller on the arm locates in the neutral detent on the selector drum cam, then unhook the spring, unscrew the stopper arm bolt and remove the arm, the washer and the spring, noting how they fit **(see illustration)**.

Inspection

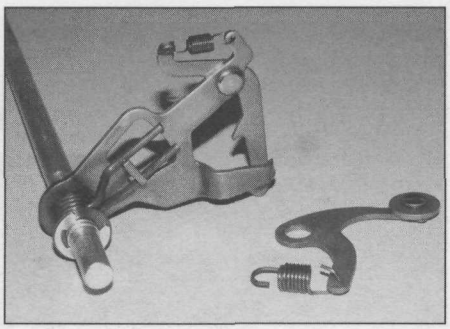
6 Check the selector arm for cracks, distortion and wear of its pawls, and check for any corresponding wear on the pins in the selector drum. Also check the stopper arm roller and the detents in the selector drum cam for any wear or damage, and make sure the roller turns freely. Replace any components that are worn or damaged with new ones. To access the pins and cam, unscrew the centre screw and remove the drum end, taking care not to let the pins drop out, then remove the pins, noting the location of the longer one, and cam, again taking care not to let the locating pin between the inner face of the cam and the selector drum body drop out **(see illustration)**. On reassembly, apply a suitable non-permanent thread locking compound to the centre screw.
7 Inspect the shaft centralising spring and the stopper arm and selector arm return springs for fatigue, wear or damage **(see illustration)**.



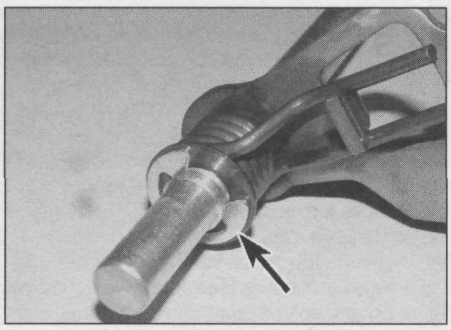
18.5 Unhook the spring (A) then unscrew the bolt (B) and remove the arm



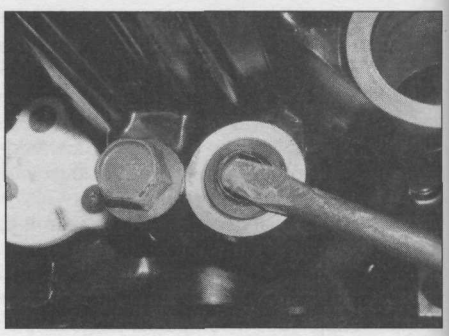
18.6 Undo the Torx screw (arrowed) to access the pins and cam



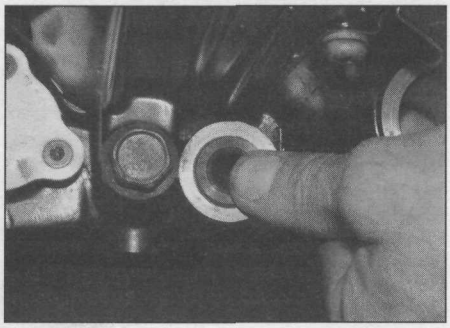
18.7a Check the components as described



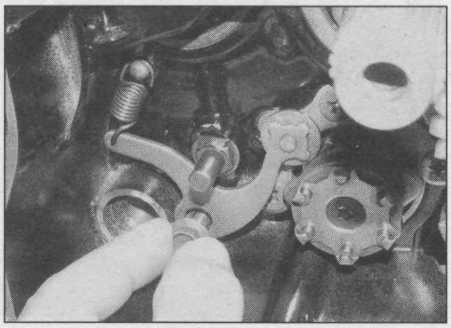
18.7b Remove the E-clip (arrowed) to release the spring



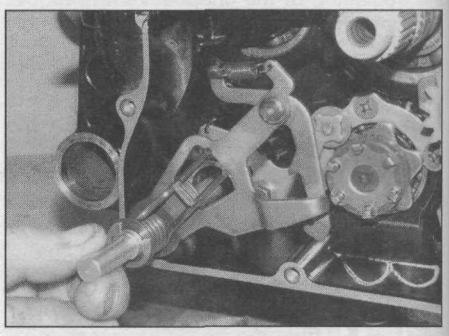
18.8a Lever out the old seal . . .



18.8b . . . and press the new one into place



18.9 Install the stopper arm as shown



18.10 Slide the shaft into the engine

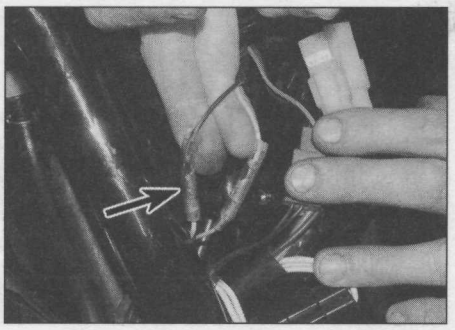
If defective in any way they must be replaced with new ones. To replace the shaft spring, remove the E-clip then slide the washer spring off the shaft, noting how its ends locate **(see illustration)**. Fit the new spring, locating the ends on each side of the tab, and secure it with the washer and E-clip, making sure it locates in its groove. Also check that the centralising spring locating pin in the crankcase is securely tightened. If it is loose, remove it and apply a non-permanent thread locking compound to its threads, then tighten it.

8 Check the gearchange shaft for straightness and damage to the splines. If the shaft is bent you can attempt to straighten it, but if the splines are damaged the shaft must be replaced with a new one. Also check the condition of the shaft oil seal in the left-hand side of the crankcase. If it is damaged, deteriorated or shows signs of leakage it must be replaced with a new one, as follows: unscrew the two bolts securing the rider's left-hand footrest bracket and remove the footrest assembly **(see illustration 5.14)**; unscrew the bolts securing the gearchange lever pivot bracket and middle gear cover and remove them – discard the gasket as a new one must be used **(see illustrations 5.15b and 16.3)**. Lever out the old seal with a seal hook or flat-bladed screwdriver **(see illustration)**. Press or drive the new seal squarely into place using your fingers, a seal driver or suitable socket **(see illustration)**. Use a new gasket on the middle gear assembly cover, and install the bottom bolt using a new sealing washer **(see illustrations 16.20a and b)**.

Installation

9 If removed, fit the bolt through the stopper arm, then apply a suitable non-permanent thread locking compound to the bolt. Install the arm, locating the roller onto the neutral detent on the selector drum and tighten the bolt to the torque setting specified at the beginning of the Chapter **(see illustration)**. Locate the spring top end onto its hook. Check the action of the arm and return spring.

10 Check that the shaft centralising spring is properly positioned **(see illustration 18.7b)**. Apply some grease to the lips of the gearchange shaft oil seal in the left-hand side of the crankcase. Slide the shaft into place and push it all the way through the case until the splined end comes out the other side **(see illustration)**. Locate the selector arm onto the pins in the selector drum and the centralising spring ends onto each side of the locating pin in the crankcase **(see illustration 18.4)**.



19.2 Oil level sensor wiring connector (arrowed)

11 Remove the rag that was blocking the sump, then install the clutch (see Section 14).

12 Remove the insulating tape from around the gearchange shaft splines. Slide the gearchange linkage arm onto the shaft, aligning its slit with the punch mark on the shaft, and secure it with the pinch bolt **(see illustration 5.15a)**.

19 Oil pump and pipes – removal and installation

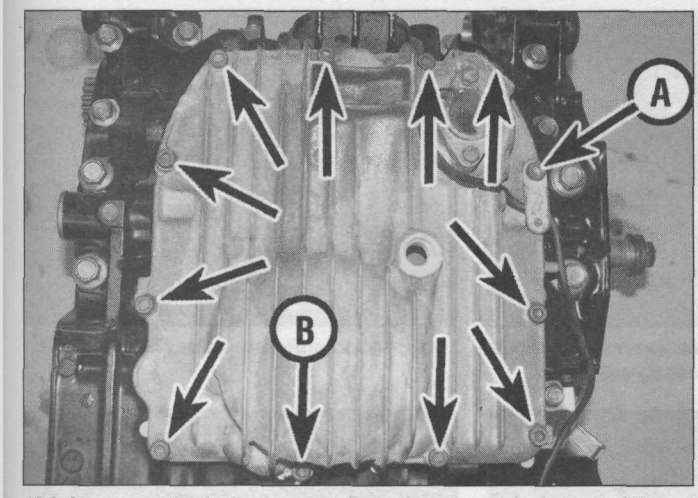
Note: *The oil sump, strainer and pressure relief valve can be removed with the engine in the frame. If the engine has been removed, ignore the steps which don't apply.*

Removal

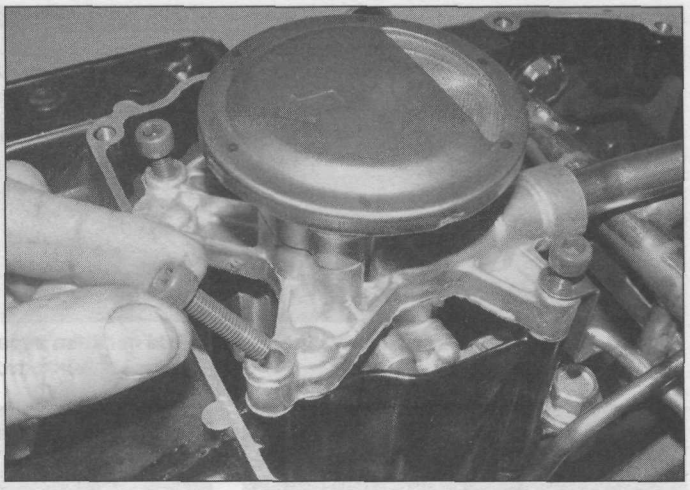
1 Remove the exhaust system (see Chapter 4).

2 Drain the engine oil (see Chapter 1). Either remove the oil level sensor if required (see Chapter 9), or trace the wire from the switch and disconnect it at the single bullet connector **(see illustration)**. Free the wire from its ties and guides and feed it down to the sensor, noting its routing.

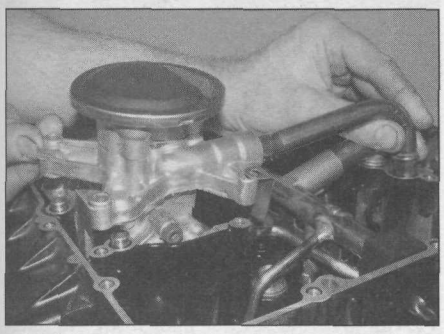
3 Unscrew the sump bolts, slackening them evenly in a criss-cross sequence to prevent distortion, and remove the sump **(see illustration)**. Note the positions of the wiring clamp and the hose guide. Discard the gasket,



19.3 Unscrew the bolts (arrowed), noting the wiring clamp (A) and hose guide (B)



19.4a Unscrew the pump bolts . . .



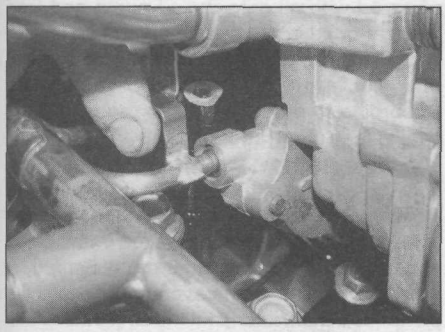
19.4b . . . and displace it along with the large pipe . . .

as a new one must be used. Note the positions of the dowels and remove them if they are loose.

4 Unscrew the bolts securing the oil pump, noting how one secures the scavenge pipe bracket **(see illustration)**. Lift the pump off its dowels, pulling the large bore feed pipe out of the crankcase and the small bore scavenge pipe out of the pump as you do **(see illustrations)**. Remove the pump and pull the feed pipe out of it **(see illustration)**. Discard the pipe O-rings. Remove the pump dowels for safekeeping if they are loose **(see illustration 19.13)**.

5 Carefully draw the scavenge pipe out, noting that it is held in a hole in the crankcase by a rubber fillet – either pull the pipe to draw the fillet through the hole, in which case take care not to bend the bracket on the pipe, or remove the fillet then draw the pipe out **(see illustration)**.

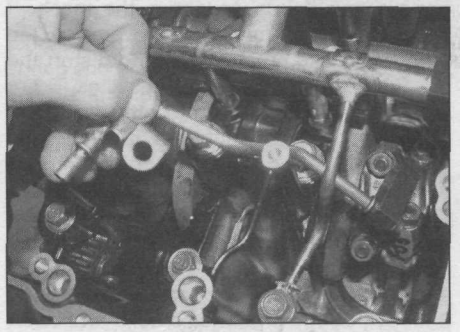
6 To remove the main oil pipe assembly, first bend across the bolt retainer tabs to access the two front bolts (6 mm), then unscrew them **(see illustration)**. Also unscrew and remove the crankcase bolt (8 mm) that secures the rear of the small bore pipe – place a screwdriver against the sealing washer assembly tab to prevent it distorting **(see illustration)**. Draw the vertical small-bore pipe out of the crankcase **(see illustration)**. Now



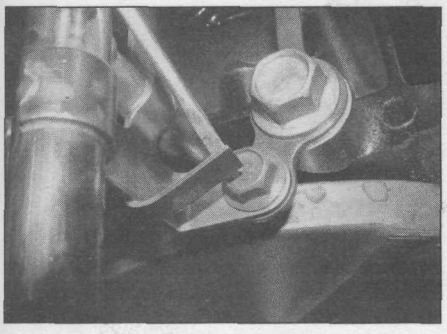
19.4c . . . then pull the scavenge pipe out



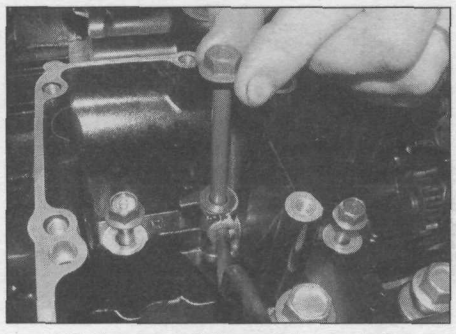
19.4d Pull the large pipe out of the pump



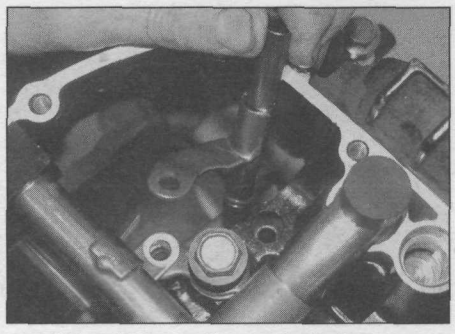
19.5 Remove the scavenge pipe as described



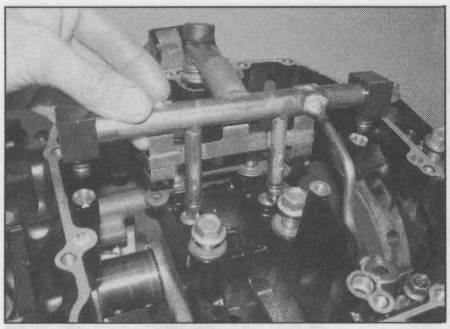
19.6a Bend the tabs across then unscrew the bolts . . .



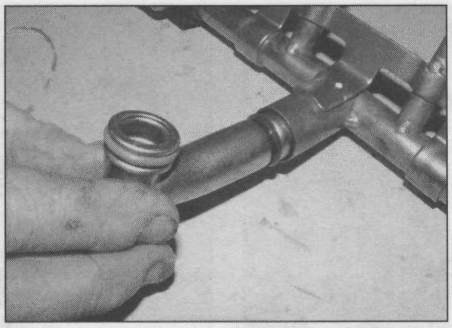
19.6b . . . and the crankcase bolt



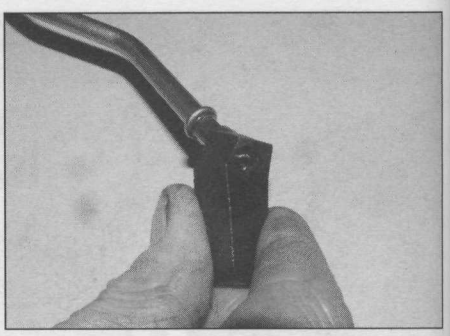
19.6c Remove the vertical pipe . . .



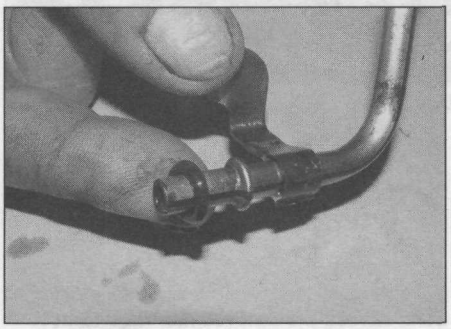
19.6d . . . followed by the main pipe assembly . . .



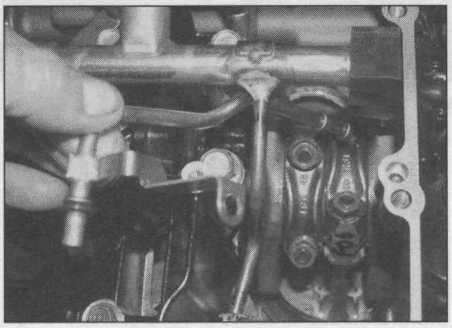
19.6e . . . then separate the front section from it



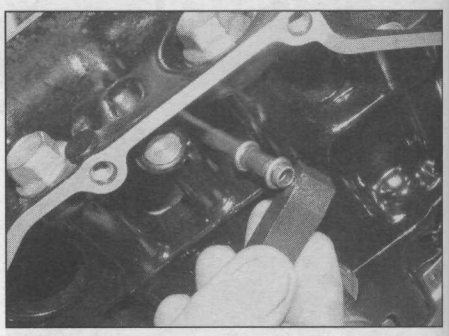
19.11a Remove the fillet . . .



19.11b . . . then fit a new O-ring



19.11c Install the pipe . . .



19.11d . . . then fit the fillet onto the end . . .

draw the main pipe assembly out **(see illustration)**. Separate the front section of the large bore pipe from the main section **(see illustration)**. Discard all the O-rings.

7 Clean the oil pump strainer in solvent and remove any debris caught in the mesh. If necessary the strainer can be levered off the pump, but take great care not to distort the rim when doing this – the strainer is not available separately from the pump, and if it is distorted to the extent that it cannot be securely fitted back onto the pump, a complete new pump will have to be fitted. When fitting the strainer, note that the arrow must point to the rear of the pump and engine. Refer to Section 20 for disassembly and inspection of the oil pump.

8 Check all the pipes for cracks and other damage.

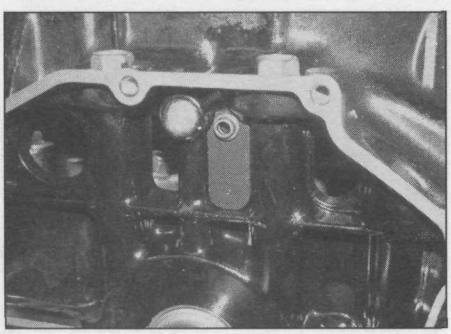
Installation

9 Remove all traces of gasket from the sump and crankcase mating surfaces, and clean the inside of the sump with solvent. Also clean through all of the oil pipes, then blow them dry with compressed air if available.

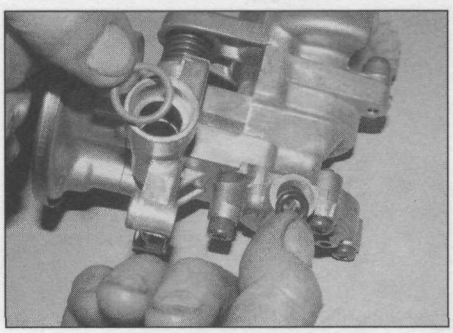
10 Fit a new O-ring onto each end of each oil pipe section and smear them with oil. Fit the front section of the large bore pipe into the main section **(see illustration 19.6e)**. Check that all the O-rings, the two rubber fillets and the rubber cap are all in place, then install the main oil pipe assembly, making sure each O-ring enters its passage correctly **(see illustration 19.6d)**. Install the vertical small-bore pipe, then secure the assembly with its three bolts and tighten them to the torque settings specified at the beginning of the Chapter – the two front bolts are the 6 mm bolts, and the rear one is the 8 mm crankcase bolt **(see illustrations 19.6c, b and a)**. Bend the retainer tabs back over the front bolts.

11 Remove the rubber fillet from the outer end of the scavenge pipe, noting which way round it fits **(see illustration)**. Fit a new O-ring smeared with oil onto the oil pump end **(see illustration)**. Locate the pipe in the crankcase and poke its end out through the hole and refit the fillet, with its only or larger cut-out (according to model) facing to the rear of the engine **(see illustrations)**. Draw the pipe back into the crankcase so the fillet locates in the hole **(see illustration)**.

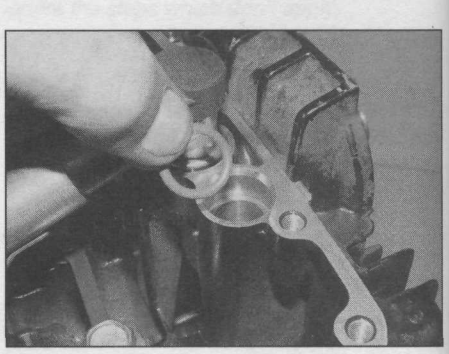
12 Fit new O-rings smeared with oil into the large bore oil feed pipe passages in the pump and the crankcase **(see illustration)**. Similarly fit a new O-ring for the scavenge pipe into the pump **(see illustration)**. Fit the straighter end of the pipe into the pump **(see illustration 19.4d)**.



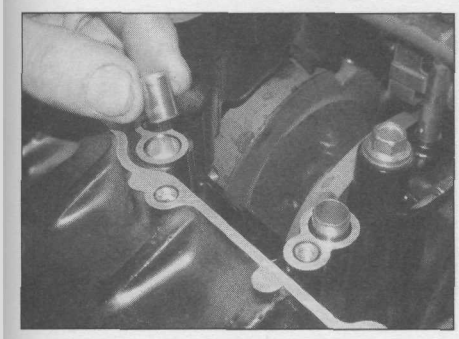
19.11e . . . and draw it back so it locates in the crankcase



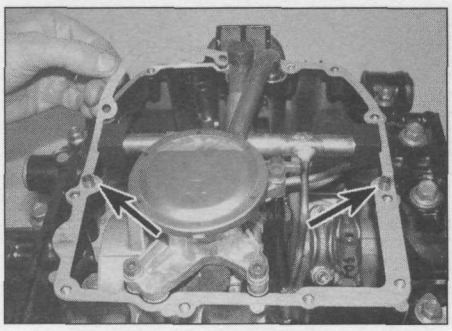
19.12a Fit the new O-rings into the pump . . .



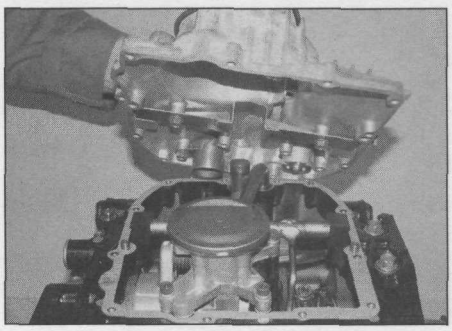
19.12b . . . and crankcase



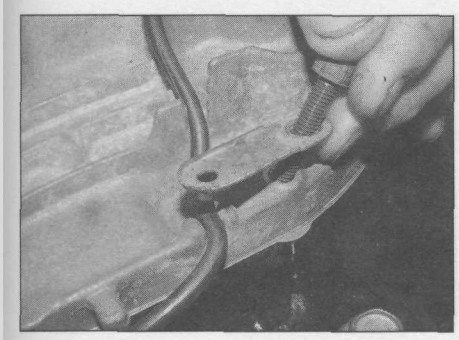
19.13 Fit the dowels into the crankcase



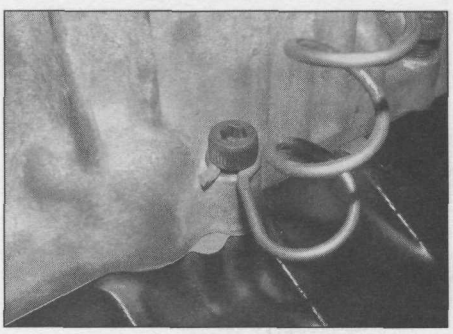
19.14 Fit the dowels (arrowed), then locate the gasket over them



19.15a Install the sump . . .



19.15b . . . not forgetting the wiring clamp . . .



19.15c . . . and the hose guide

13 If removed, fit the pump dowels into the crankcase **(see illustration)**. Install the pump, making sure the arrow on the strainer points to the back of the engine, locating the scavenge pipe into the pump and the feed pipe into the crankcase as you do **(see illustrations 19.4c and b)**. Install the bolts, not forgetting to secure the scavenge pipe bracket, and tighten them to the torque setting specified at the beginning of the Chapter **(see illustration 19.4a)**.

14 If removed, fit the sump dowels into the crankcase **(see illustration)**. Lay a new gasket onto the sump (if the engine is in the frame) or onto the crankcase (if the engine has been removed and is positioned upside down on the work surface). Make sure the holes in the gasket align correctly with the bolt holes.

15 Position the sump onto the crankcase **(see illustration)**. Install the bolts, not forgetting the wiring clamp and the hose guide **(see illustrations)**. Tighten the bolts evenly and a little at a time in a criss-cross pattern to the specified torque setting.

16 Either install the oil level sensor if removed (see Chapter 9), or connect the wire at the connector **(see illustration 19.2)**.

17 Fill the engine with the correct type and quantity of oil (see Chapter 1).

18 Install the exhaust system (see Chapter 4). Start the engine and check for leaks around the sump.

20 Oil pump – disassembly, inspection and reassembly

Note 1: *The oil pump can be disassembled for inspection and cleaning, but note that no individual components are available. If the pump is worn or damaged a complete new one must be installed..*

Note 2: *When removing the rotors from the oil pump, note the punch mark in the outer rotor and which way it faces – it must be installed the same way round so that mated surfaces continue to run together.*

Disassembly and inspection

1 Remove the pump (see Section 19).

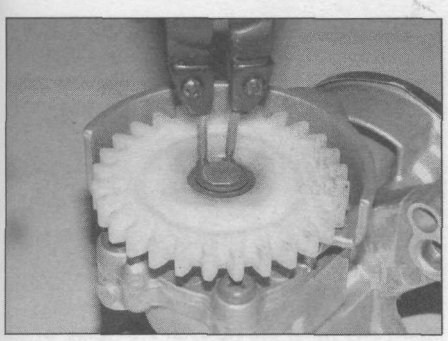
2 Remove the circlip securing the driven gear and slide the gear off the shaft **(see illustration)**.

3 Undo the screws and bolt securing the scavenge rotor cover and remove it **(see illustration)**. Remove the outer and inner rotors, noting which way round they fit, then withdraw the pin from the drive shaft. Remove the rotor housing and its locating pin.

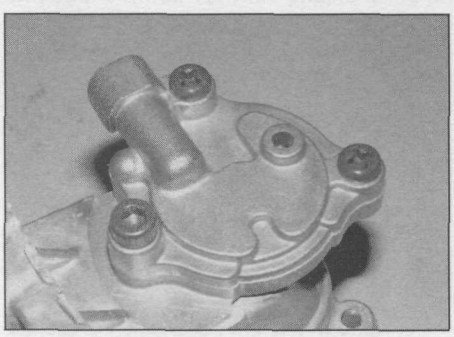
4 Undo the screws securing the feed rotor cover and draw it up off the shaft, noting that it is under pressure from the relief valve plunger spring **(see illustration)**. Remove the spring and plunger, noting which way round it fits. Remove the cover locating pins.

5 With the rotors positioned as shown measure the clearance between the inner rotor tip and the outer rotor with a feeler gauge and compare it to the service limit listed in the specifications at the beginning of the Chapter **(see illustration)**. If the clearance measured is greater than the maximum listed, replace the pump with a new one.

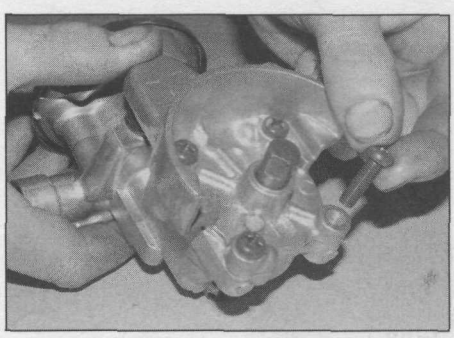
6 Measure the clearance between the outer rotor and the rotor housing with a feeler gauge



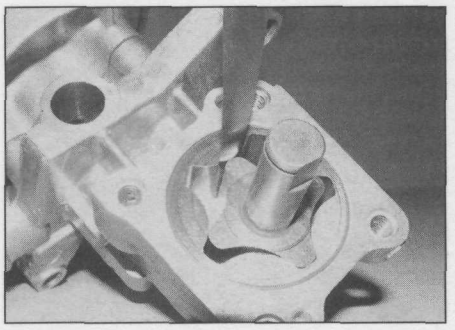
20.2 Release the circlip and remove the gear



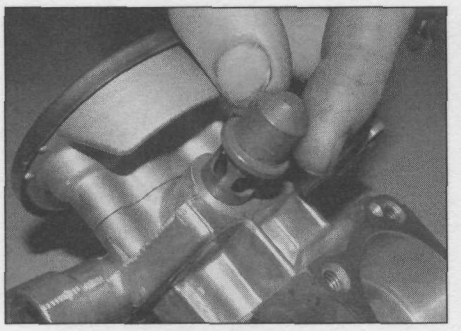
20.3 Undo the screws and bolt and remove the scavenge pump cover



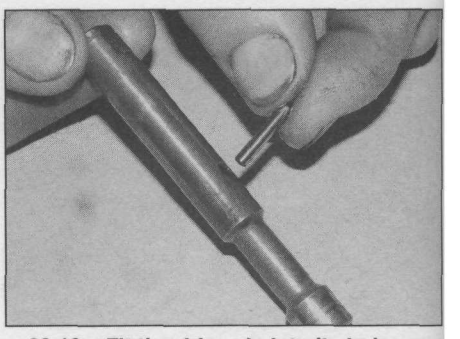
20.4 Undo the screws and remove the feed pump cover



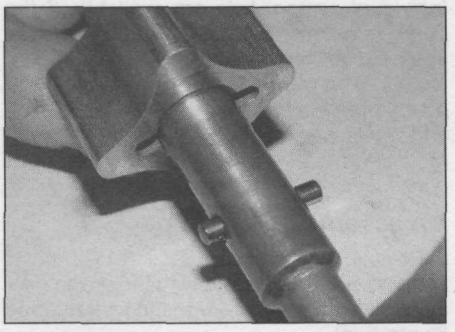
20.5 Measure the inner rotor tip-to-outer rotor clearance



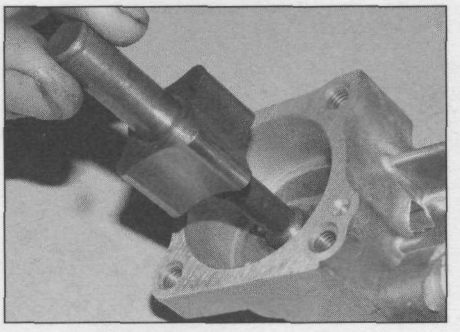
20.9 Check the action of the relief valve plunger in its bore



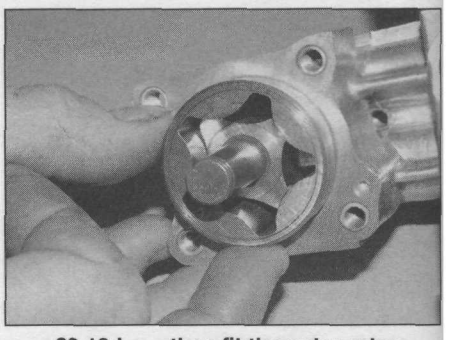
20.12a Fit the drive pin into its hole . . .



20.12b . . . then slide the inner rotor onto it



20.12c Slide the shaft into the pump . . .



20.12d . . . then fit the outer rotor

and compare it to the service limit listed in the specifications at the beginning of the Chapter. If the clearance measured is greater than the maximum listed, replace the pump with a new one.

7 Remove the outer rotor from the housing, then draw out the shaft and remove the inner rotor and its drive pin.

8 Inspect the rotors and their housings and covers for scoring and wear. If any damage, scoring or uneven or excessive wear is evident, replace the pump with a new one (individual components are not available).

9 Check that the relief valve plunger moves smoothly in its bore **(see illustration)**.

10 Check the pump driven gear for wear or damage, and renew it if necessary. If it is worn it is worth checking the drive and intermediate gears as well. The drive gear is on the back of the clutch housing **(see illustration 14.16b)**, and the two intermediate gears are on each end of a shaft that passes through the crankcase wall. Remove the clutch to access the drive gear and outer intermediate gear, which is held on the shaft by a circlip (see Section 14) **(see illustration 14.16c)**. To access the inner intermediate gear and to remove it and the shaft the crankcase halves must be separated and the transmission shafts removed.

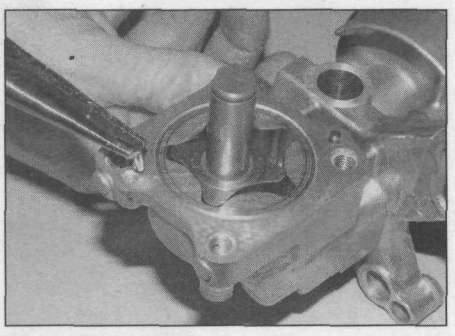
Reassembly

11 If the pump is good, make sure all the components are clean, then lubricate them with new engine oil.

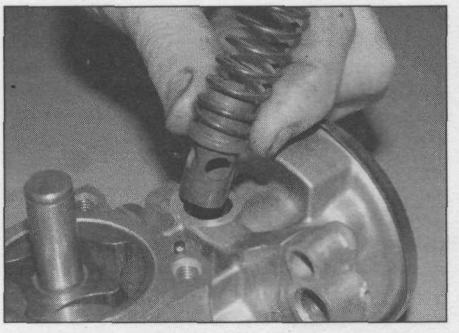
12 Fit the feed rotor drive pin into the shaft, then fit the inner rotor, locating the cut-outs over the drive pin **(see illustrations)**. Slide the shaft into the pump with the narrower section going through to the scavenge side **(see illustration)**. Fit the outer rotor over the inner rotor and into the housing, making sure it is the same way as noted on removal (see **Note 2**) **(see illustration)**.

13 Install the feed rotor cover locating pins **(see illustration)**. Fit the relief valve plunger and spring into their passage, with the holed side of the plunger going into the passage **(see illustration)**. Fit the feed rotor cover over the shaft and onto the spring, making sure the spring locates correctly in its hole, then push the cover down the shaft to compress the spring, making sure it locates on the pins, and hold it there while you install and tighten the screws **(see illustration and 20.4)**.

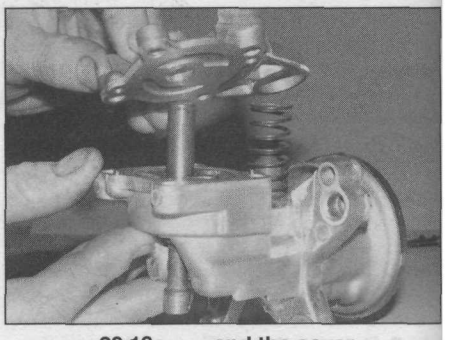
14 Install the scavenge rotor housing locating pin, then fit the housing over the shaft and



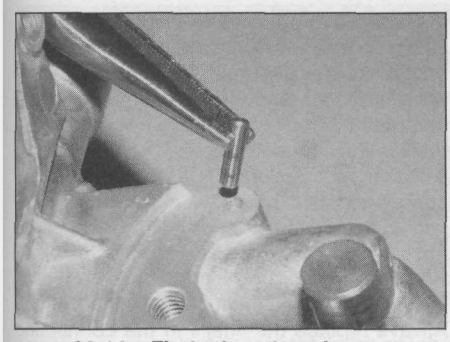
20.13a Fit the locating pins . . .



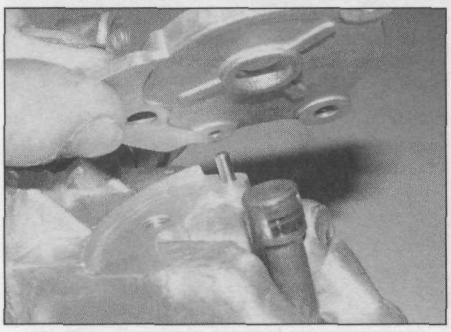
20.13b . . . then install the plunger and spring . . .



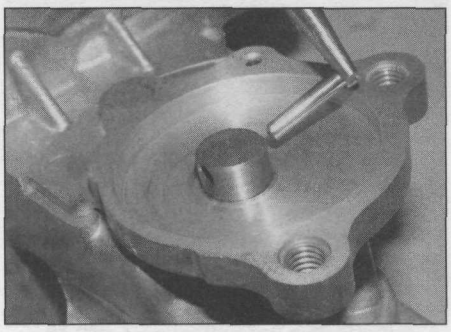
20.13c . . . and the cover



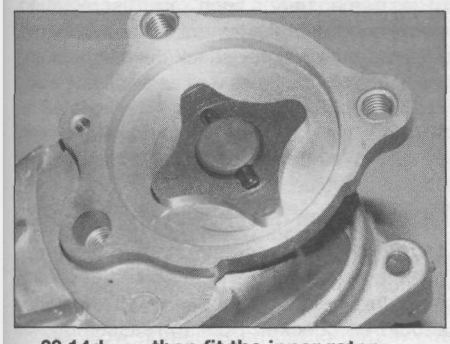
20.14a Fit the locating pin . . .



20.14b . . . and the housing



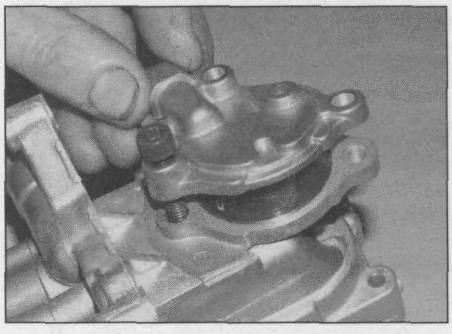
20.14c Fit the drive pin into its hole . . .



20.14d . . . then fit the inner rotor . . .



20.14e . . . and the outer rotor . . .



20.14f . . . and the cover

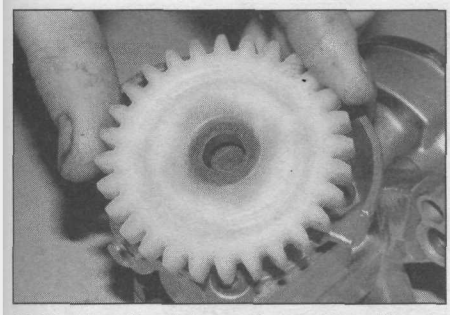
onto the pin **(see illustrations)**. Slide the drive pin into its hole in the driveshaft, then fit the inner rotor, with the triangular mark facing out, locating its cut-outs over the pin **(see illustrations)**. Fit the inner rotor with the triangular marking facing out **(see illustration)**. Fit the rotor cover and tighten its screws **(see illustration and 20.3)**.

15 Slide the driven gear onto the shaft, making sure the recessed side of the centre bush is on the outside for the circlip to sit in **(see illustration)**. Secure the gear with the circlip, making sure it locates in the groove in the shaft **(see illustration 20.2)**.

16 Rotate the pump gear by hand and check it turns the rotors smoothly and freely.

17 Pour some clean engine oil into the pump and rotate the shaft to prime it.

18 Install the pump (see Section 19).



20.15 Align the flats on the shaft and bush, and make sure the recessed side of the bush faces out

21 Connecting rods and bearings – removal, inspection and installation

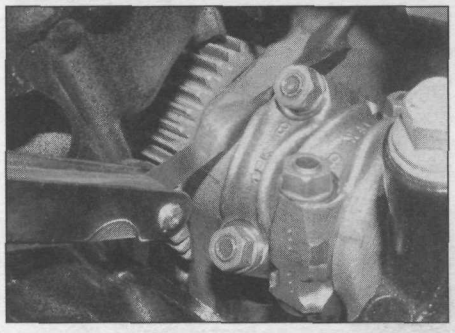
Note: *To remove the connecting rods the engine must be removed from the frame.*

Removal

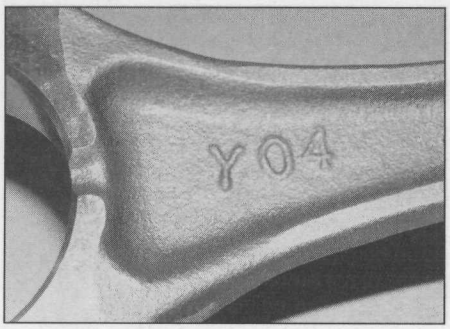
1 Remove the engine from the frame (see Section 5). Remove the cylinder heads (see Section 11). Remove the oil pump (see Section 19). Undo the screws securing the crankshaft end cap to the alternator cover on the left-hand side of the engine and remove it – this allows the engine to be turned for best access to the connecting rod cap nuts **(see illustration 9.2)**. Discard the rubber gasket and O-ring as new ones must be used, and remove the collared washer, noting which way round it fits. Turn the engine using an offset 32 mm ring spanner or socket on the hex on the alternator rotor boss (do not turn the engine using the rotor bolt itself) **(see illustration 9.3)**.

2 Before removing the rods from the crankshaft, measure the side clearance (the gap between the connecting rod big-end and the crankshaft web) with a feeler gauge **(see illustration)**. If the clearance is greater than the service limit listed in this Chapter's Specifications, replace the rods with new ones. If the clearance is still excessive, replace the crankshaft with a new one.

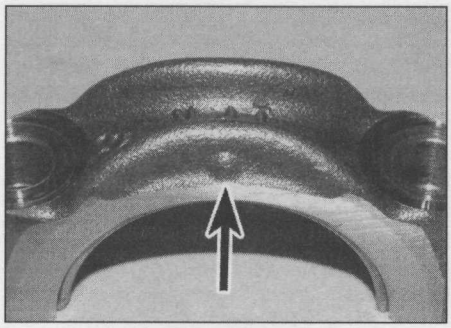
3 Using paint or a felt marker pen, mark the relevant cylinder identity on each connecting rod and cap – mark across the cap-to-connecting rod join, and note which side of the rod faces the front of the engine to ensure that the cap and rod are fitted the correct way around on reassembly. Note that the number already across each rod and cap indicates rod size grade, and this mark faces the same way as its piston, i.e. to the front for the front cylinders and to the rear for the rear **(see illustration 21.23b)**. Each connecting rod is marked with a Y, which for cylinders 1 and 3 faces the left-hand side of the engine, and for cylinders 2 and 4 faces the right-hand side **(see illustration)**. Each connecting rod cap has a small projection which points to its adjacent crank web **(see illustration)**. Each piston crown is marked IN and EX, with the IN mark facing the intake side and the EX mark facing the exhaust.



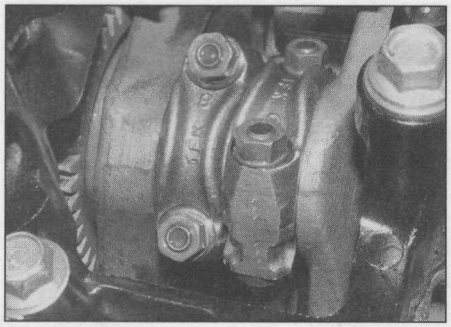
21.2 Measure the side clearance on each pair of rods using a feeler gauge



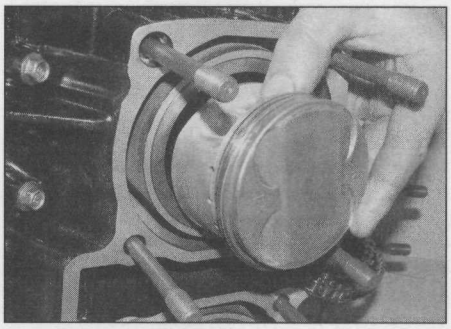
21.3a Note the Y mark on each rod . . .



21.3b . . . and the projection (arrowed) on each cap



21.4a Unscrew the nuts and remove the cap . . .



21.4b . . . then push the piston and connecting rod assembly up and withdraw it from the top of the cylinder

4 Place the engine on its side. Work on one rod at a time. Unscrew the connecting rod cap nuts and separate the cap from the crankpin **(see illustration)**. Push the piston/connecting rod assembly up the bore and remove it from the top, making sure the connecting rod does not mark the cylinder wall **(see illustration)**.

> **HAYNES HINT** *To ease removal of the pistons, carefully remove any ridge of carbon built up on the top of each cylinder bore using a scraper. If there is a pronounced wear ridge, remove it using a ridge reamer.*

5 Immediately install the relevant bearing shells (if removed), bearing cap, and nuts on each piston/connecting rod assembly so that they are all kept together as a matched set. Store the rods in such a way that their location identity is easily recognised, for example on a marked piece of card.

6 Remove the pistons from the connecting rods if required (see Section 22), but note that if you are doing a big-end oil clearance check they are best left installed as they will prevent the rod rotating on the crankpin and disturbing the Plastigauge.

Inspection

7 Check the connecting rods for cracks and other obvious damage.

8 For this check the piston must be removed from the rod (see Section 22). Apply clean engine oil to the piston pin, then insert it into the connecting rod small-end and check for any freeplay between the two **(see illustration)**. If there is play, measure the pin external diameter and compare the result to the specifications at the beginning of the Chapter **(see illustration)**. If it has worn beyond its specified limit replace it with a new one and check again for freeplay. If there is still play evident, or if the pin is not worn, replace the connecting rod with a new one.

9 Refer to Section 27 and examine the connecting rod bearing shells. If they are scored, badly scuffed, corroded, or appear to have seized, new shells must be installed. Remove them by pushing their centres out to the side then lifting them out **(see illustration)**. Always replace the shells in the connecting rods as a set. If they are badly damaged, check the corresponding crankpin. Evidence of extreme heat, such as discoloration, indicates that lubrication failure has occurred. Be sure to thoroughly check the oil pump and pressure relief valve as well as all oil holes and passages before reassembling the engine.

10 Have the rods checked for twist and bend by a Yamaha dealer if you are in doubt about their straightness.

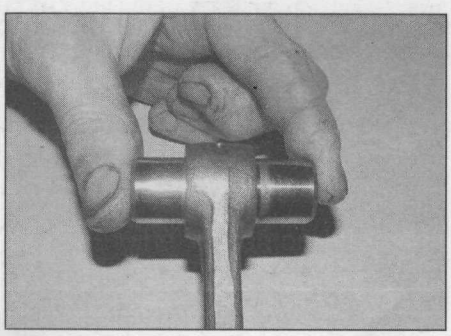
Oil clearance check

11 Whether new connecting rod big-end bearing shells are being fitted or the original ones are being re-used, the oil clearance should be checked prior to reassembly. Oil clearance is measured with a product known as Plastigauge. Note that Plastigauge comes in two different sizes, graded according to a range of clearances it can measure – make sure you order the correct one according to the oil clearance figure specified. Check the clearance on one rod at a time.

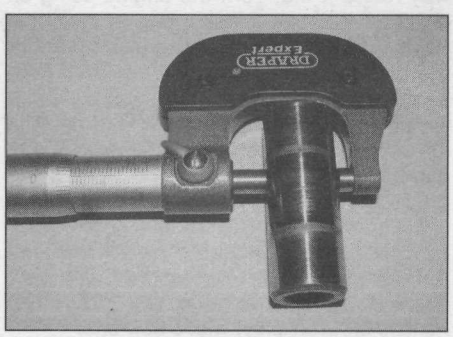
12 Remove the bearing shells from the rod and cap, keeping them in order **(see illustration 21.9)**. Clean the backs of the shells and the bearing locations in both the connecting rod and cap, and the crankpin journal.

13 Press the bearing shells into their locations, ensuring that the tab on each shell engages the notch in the connecting rod/cap **(see illustration)**. Make sure the bearings are fitted in the correct locations and take care not to touch any shell's bearing surface with your fingers.

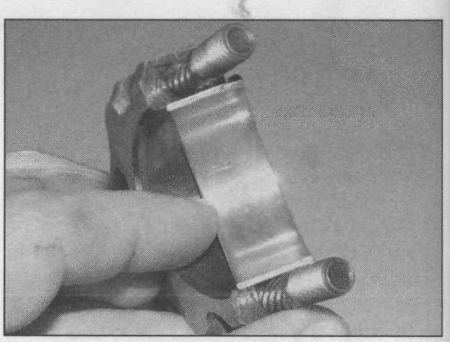
14 Cut a length of the appropriate size Plastigauge (it should be slightly shorter than the width of the crankpin) and lay it on the crankpin journal.



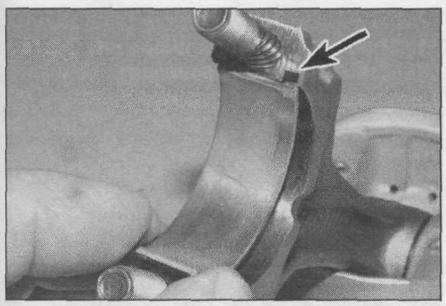
21.8a Fit the pin into the rod and check for play



21.8b Measure the diameter of the pin



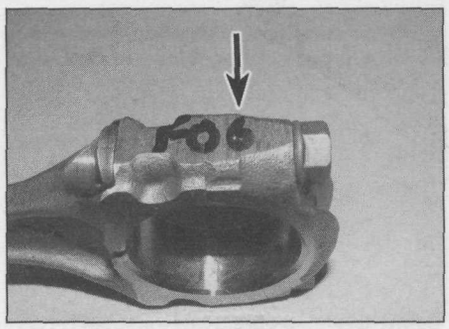
21.9 Remove the shells as shown



21.13 Fit each shell into its housing making sure each tab locates in its notch (arrowed)



21.23a Crankpin journal size numbers



21.23b Connecting rod size number (arrowed)

15 Refer to Step 27 and fit the rod and piston into its bore. Pull the connecting rod onto the crankpin, then fit the cap onto the rod, making sure the crankshaft does not turn **(see illustrations 21.28 and 29a)**. Apply molybdenum disulphide grease to the bolt shanks and threads and to the seats of the nuts. Fit the nuts and tighten them finger-tight, making sure the connecting rod does not rotate on the crankshaft **(see illustration 21.29b)**.

16 Tighten the cap nuts to the initial torque setting specified at the beginning of the Chapter, making sure the crankshaft does not rotate. Now tighten each nut in turn in one continuous movement to the final torque setting specified. If tightening is paused between the initial and final settings, slacken the nut to below the initial setting and repeat the procedure.

17 Slacken the cap nuts and remove the cap, again taking great care not to rotate the crankshaft.

18 Compare the width of the crushed Plastigauge on the crankpin to the scale that comes with the Plastigauge to obtain the connecting rod bearing oil clearance. Compare the reading to the specifications at the beginning of the Chapter.

19 On completion carefully scrape away all traces of the Plastigauge material from the crankpin and bearing shells using a fingernail or other object which is unlikely to score the shells.

20 If the clearance is within the range listed in this Chapter's Specifications and the bearings are in perfect condition, they can be reused. If the clearance is beyond the service limit, replace the bearing shells with new ones (see Steps 23 and 24). Check the oil clearance once again (the new shells should be thick enough to bring bearing clearance within the specified range). Always renew all of the shells at the same time.

21 If the clearance is still greater than the service limit listed in this Chapter's Specifications, the crankpin is worn and the crankshaft should be replaced with a new one, but note that there are specialists who can build up worn pins using a metal spraying technique.

22 Repeat the procedure for the remaining connecting rods.

Bearing shell selection

23 Replacement bearing shells for the big-end bearings are supplied on a selected fit basis. Code numbers are used to identify the correct replacement bearings. The crankshaft journal size numbers are stamped on the outside of the crankshaft web on the right-hand end. The left-hand block of two numbers are for the big-end bearing (crankpin) journals (the right-hand block of four numbers are for the main bearing journals) **(see illustration)**. The first number of the two is for the left-hand (Nos. 1 and 2 cylinder) journal, and the second number is for the right-hand (Nos. 3 and 4 cylinder) journal. Each connecting rod size number is marked in ink across the flat face of the connecting rod and cap **(see illustration)**.

24 A range of bearing shells is available. To select the correct bearing for a particular connecting rod, subtract the big-end bearing journal number (stamped on the crank web) from the connecting rod number (marked on the rod), i.e. connecting rod number minus crank web number. Compare the bearing number calculated with the table below to find the colour coding of the replacement bearing required. The colour is marked on the side of each bearing **(see illustration)**.

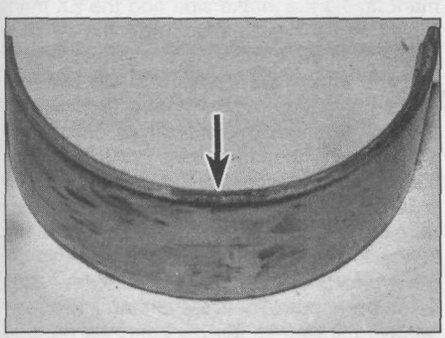
Number	Colour
1	Blue
2	Black
3	Brown
4	Green
5	Yellow
6	Pink
7	Red

Installation

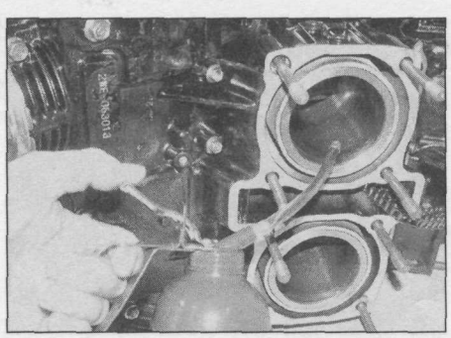
25 Fit the pistons onto the connecting rods (see Section 22).

26 Clean the backs of the bearing shells and the bearing housings in both cap and rod. If new shells are being fitted, ensure that all traces of the protective grease are cleaned off using paraffin (kerosene). Wipe the shells, cap and rod dry with a clean lint free cloth. Install the bearing shells in the connecting rods and caps, making sure the tab on each shell engages the notch in the connecting rod/cap **(see illustration 21.13)**. Lubricate the shells with molybdenum disulphide oil (a 50/50 mixture of molybdenum disulphide grease and clean engine oil).

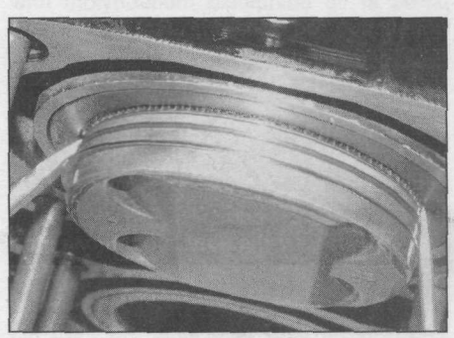
27 Lubricate the pistons, rings and cylinder bore with clean engine oil **(see illustration)**. Make sure the marks on the piston crown, and the connecting rod and cap marks are correctly orientated (see Step 3). Insert the



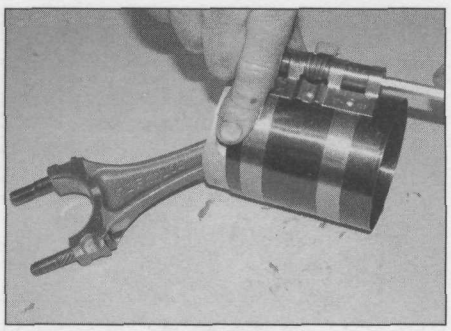
21.24 The colour code is on the edge of the shell (arrowed)



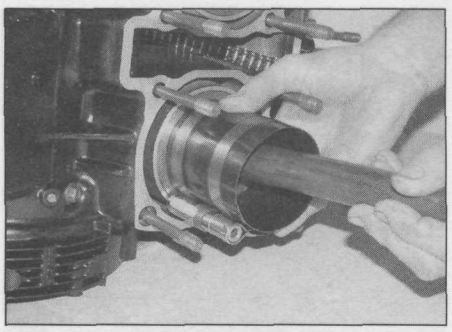
21.27a Lubricate the pistons and rings and the bore with clean engine oil



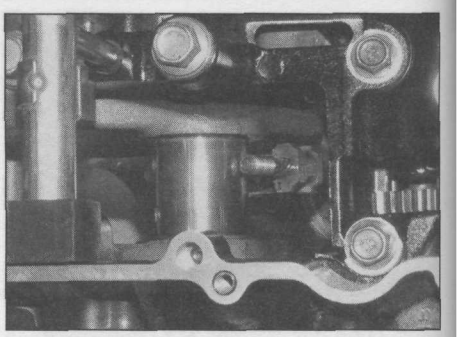
21.27b Carefully feed each ring into the bore



21.27c Fit the compressor over the piston and rings and compress the rings by tightening the bands on the compressor using an Allen key



21.27d Tap the top of the piston with a soft tool



21.28 Pull the rod onto the crankpin . . .

piston/connecting rod assembly into the top of its bore, taking care not to allow the connecting rod to mark the cylinder wall **(see illustration 21.4b)**. Carefully compress and feed each piston ring into the bore until the piston crown is flush with the top of the bore **(see illustration)**. If available, a piston ring compressor makes installation easier, though there is a good lead-in for the rings so is not essential **(see illustrations)**.

28 Lubricate the crankpin with molybdenum disulphide oil (a 50/50 mixture of molybdenum disulphide grease and clean engine oil). Pull the connecting rod onto the crankpin **(see illustration)**.

29 Apply molybdenum disulphide grease to the bolt threads and to the seats of the nuts. Fit the cap onto the connecting rod and crankpin, making sure it is the correct way around so the markings align (see Step 3) **(see illustration)**. Fit the nuts and tighten them finger-tight **(see illustration)**. Check again to make sure all components have been returned to their original locations using the marks made on disassembly.

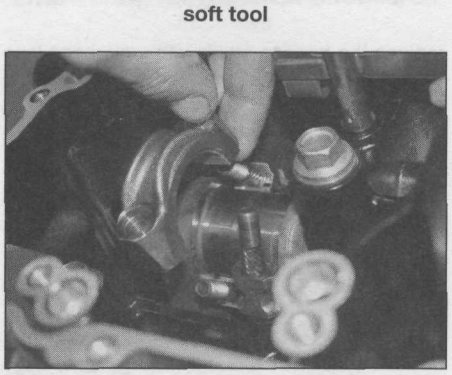
30 Tighten the cap nuts to the initial torque setting specified at the beginning of the Chapter. Now tighten each nut in turn in one continuous movement to the final torque setting specified. If tightening is paused between the initial and final settings, slacken the nut to below the initial setting and repeat the procedure.

31 Check that the crankshaft is free to rotate easily, then install the other connecting rods in the same way. Check again to make sure that all components have been returned to their original locations using the marks made on disassembly.

32 Check again that the crankshaft rotates smoothly and freely. If there are any signs of roughness or tightness, remove the rods and re-check the torque setting and if necessary the bearing oil clearance. Sometimes tapping the bottom of the connecting rod cap will relieve tightness, but if in doubt, recheck the clearances.

33 Install the crankshaft end cap collared washer, with the collared section facing in, and the cap, using a new gasket and O-ring – the rubber gasket has three holes which locate over the small pins on the alternator cover **(see illustrations 9.38a, b and c)**. Push the cover on until the O-ring is felt to locate.

34 Install the oil pump and cylinder heads (see Sections 19 and 11).



21.29a . . . then fit the cap . . .



21.29b . . . and the nuts, and tighten them as described

22 Pistons – removal, inspection and installation

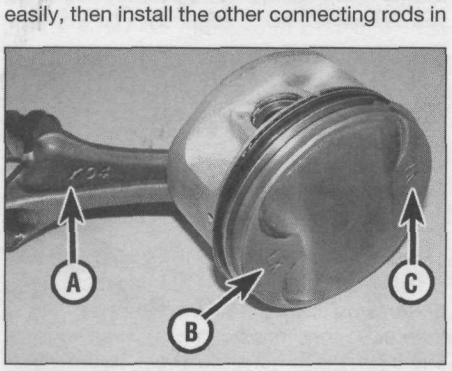
Note: *To remove the pistons the engine must be removed from the frame.*

Removal

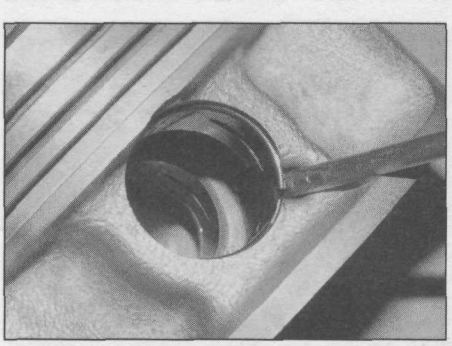
1 Remove the connecting rods (see Section 21).

2 Before removing the piston from the connecting rod, use a sharp scriber or felt marker pen to write the cylinder identity on the skirt of each piston) – match each piston to its cylinder from the identity mark made when removing the connecting rods. Each piston crown should already be marked IN and EX (though the marks are likely to be invisible until the piston is cleaned) – the IN mark facing the intake side and the EX mark facing the exhaust. Also note the relative positions of the Y mark on the connecting rod and the IN and EX marks with the rod and piston positioned as shown **(see illustration)**.

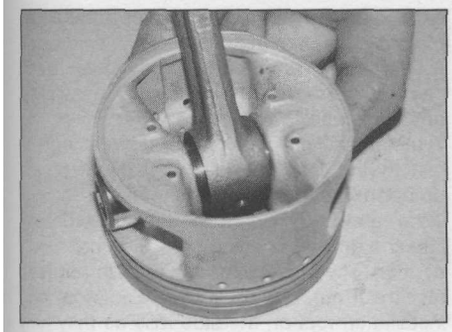
3 Carefully prise out the circlip on one side of the piston using needle-nose pliers or a small flat-bladed screwdriver inserted into the notch **(see illustration)**. Push the piston pin out from the other side to free the piston from the connecting rod **(see illustration)**. Remove the other circlip and discard them as new ones must be used. When the piston has been removed, install its pin back into its bore so that related parts do not get mixed up, and keep it with its rod.



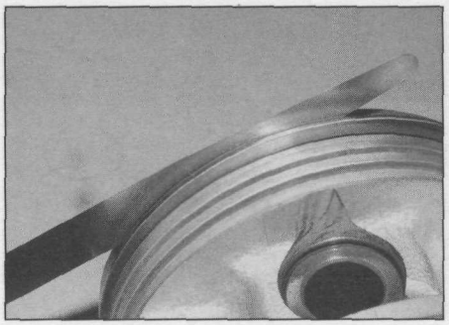
22.2 Note the relative positions of the Y mark (A), the EX mark (B) and the IN mark (C)



22.3a Prise out the circlip as shown . . .



22.3b . . . then push out the pin and separate the piston from the rod



22.10 Measure the piston ring-to-groove clearance with a feeler gauge



22.11 Measure the piston diameter with a *micrometer* at the specified distance from the bottom of the skirt

HAYNES HiNT

If a piston pin is a tight fit in the piston bosses, soak a rag in boiling water then wring it out and wrap it around the piston – this will expand the alloy piston sufficiently to release its grip on the pin. If the piston pin is particularly stubborn, extract it using a drawbolt tool, but be careful to protect the piston's working surfaces.

Inspection

4 Using your thumbs or a piston ring removal and installation tool, carefully remove the rings from the pistons **(see illustrations 23.10, 9c, and 7c, b and a)**. Do not nick or gouge the pistons in the process. 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 with a letter or letters (R or RN), and these marks face up **(see illustration 23.9a)**. The top and middle rings can also be identified by their different profiles and thickness **(see illustration 23.9b)** – refer to the Specifications for thickness.

5 Scrape all traces of carbon from the tops of the pistons. 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 pistons; the piston material is soft and will be eroded away by the wire brush.

6 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.

7 Once the deposits have been removed, clean the pistons with solvent and dry them thoroughly. If the identification mark previously made on the piston is cleaned off, be sure to re-mark it with the correct identity. Make sure the oil return holes below the oil ring groove and on the underside are clear.

8 Carefully inspect each 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. 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. The oil pump should be checked thoroughly. Also check that the circlip grooves are not damaged.

9 A hole in the piston crown, an extreme to be sure, is an indication 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.

10 Measure the piston ring-to-groove clearance by laying each piston ring in its groove and slipping a feeler gauge in beside it **(see illustration)**. Make sure you have the correct ring for the groove (see Step 4). Check the clearance at three or four locations around the groove. If new rings are being used, measure the clearance using the new rings. If the clearance is greater than specified with the old rings, measure the thickness of the rings and replace them with new ones if worn below the specified limit, then check the clearance again. If the clearance is greater than that specified with new rings, or if the old rings are not worn, the piston is worn and must be replaced with a new one. If you are fitting new pistons, fit new rings with them rather than using the old ones.



22.12 Slip the pin into the piston and check for any play between them

11 Check the piston-to-bore clearance by measuring the bore (see Section 26) and the piston diameter. Make sure each piston is matched to its correct cylinder. Refer to the Specifications at the beginning of the Chapter and measure the piston the correct distance up from the bottom of the skirt 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 replaced with a new one (assuming the bore itself is within limits).

12 Apply clean engine oil to the piston pin, insert it into the piston and check for any freeplay between the two **(see illustration)**. Measure the pin external diameter **(see illustration 21.8b)**, and the pin bore in the piston. Calculate the difference to obtain the piston pin-to-piston pin bore clearance. Compare the result to the specifications at the beginning of the Chapter. If the clearance is greater than specified, replace the components that are worn beyond their specified limits. If not already done, repeat the check between the pin and the connecting rod small-end (see Section 21).

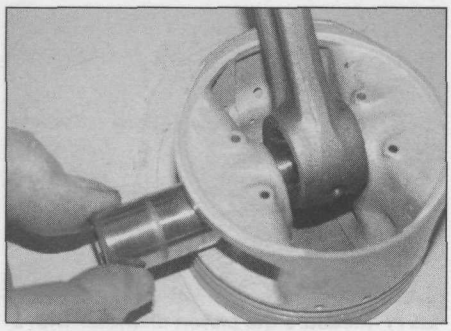
Installation

13 Inspect and install the piston rings (see Section 23).

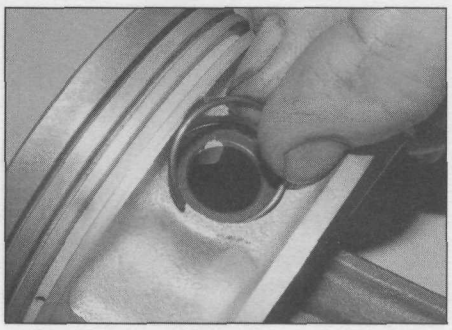
14 Lubricate the piston pin, the piston pin bore and the connecting rod small-end bore with molybdenum disulphide oil (a 50/50 mixture of molybdenum disulphide grease and clean engine oil).

15 When installing the pistons onto the connecting rods, make sure the IN and EX marks on the piston crown are orientated correctly in relation to the Y mark on the connecting rod (see Step 2) **(see illustration 22.2)**.

16 Install a ***new*** circlip in one side of the piston (do not re-use old circlips) **(see illustration 22.3a)**. Line up the piston on its correct connecting rod, and insert the piston pin from the other side **(see illustration)**. Secure the pin with the other ***new*** circlip **(see illustration)**. When installing the circlips,



22.16a Slide the pin through the piston and rod



22.16b Make sure the circlips locate in their groove

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.

17 Install the connecting rods (see Section 21).

23 Piston rings – inspection and installation



1 It is good practice to fit new piston rings when an engine is being overhauled. Before installing the new rings, check the end gaps with the rings installed in the bore, as follows.

2 If new rings are being used, lay out each piston with a new ring set and keep them together so the rings will be matched with the same piston and bore during the end gap measurement procedure and engine assembly. If the old rings are being reused, make sure they are matched with their correct piston and cylinder.

3 Insert the top ring into the top of the bore and square it up with the wall by pushing it in with the top of the piston **(see illustrations)**. The ring should be about 20 mm below the top edge of the bore. Slip a feeler gauge between the ends of the ring and compare the measurement to the specifications at the beginning of the Chapter **(see illustration)**.

4 If the gap is larger or smaller than specified, double check to make sure that you have the correct ring before proceeding; excess end gap is not critical unless it exceeds the service limit. If the service limit is exceeded with new rings, check the bore for wear (see Section 26). If the gap is too small, the ring ends may come in contact with each other during engine operation, which can cause serious damage.

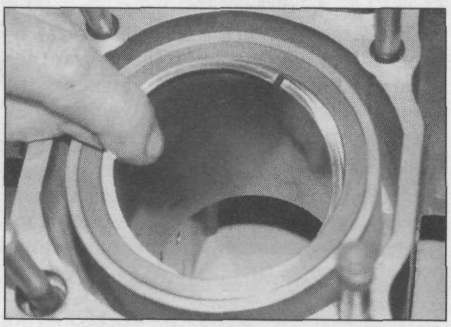
5 Repeat the procedure for the middle ring and the oil control ring side rails, but not the expander ring. Remember to keep the rings, pistons and bores matched up.

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

7 Install the oil control ring (lowest on the piston) first. It is composed of three separate components, namely the expander and the upper and lower side rails. Slip the expander into the groove, making sure the ends don't overlap, then install the lower side rail **(see illustrations)**. Do not use a piston ring installation tool on the side rails as they may be damaged. Instead, place one end of the side rail into the groove between the expander and the ring land. Hold it firmly in place and slide a finger around the piston while pushing the rail into the groove. Next, install the upper side rail in the same manner **(see illustration)**. Check that the ends of the expander have not overlapped.

8 After the three oil ring components have been installed, check to make sure that both the upper and lower side rails can be turned smoothly in the ring groove.

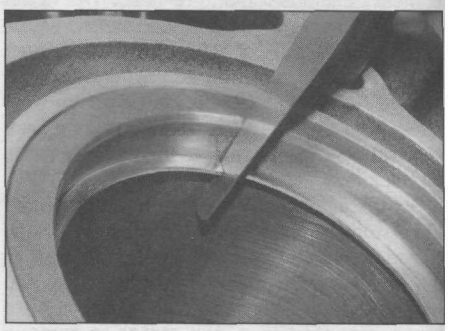
9 The upper surface of each middle and top ring should be marked with a letter or letters (R or RN), and these marks face up **(see illustration)**. The top and middle rings can be identified by their different profiles and thickness **(see illustration)** – refer to the Specifications for thickness. Install the second (middle) ring next. Make sure that the identification letter near the end gap is facing up. Fit the ring into the middle groove in the piston **(see illustration)**. Do not expand the



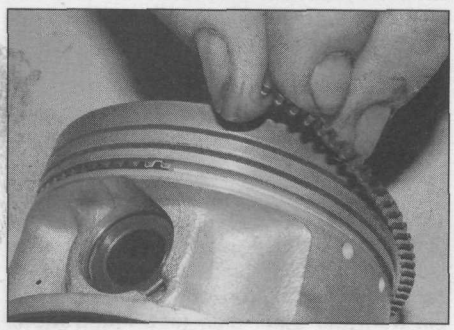
23.3a Fit the ring into the bore . . .



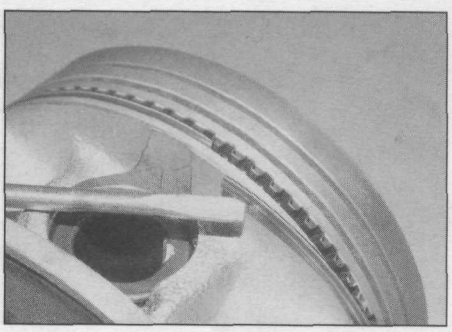
23.3b . . . and square it up using the piston . . .



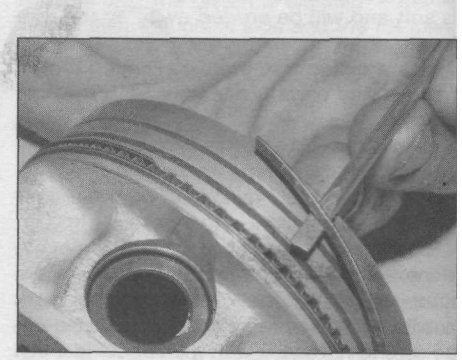
23.3c . . . then measure the end gap



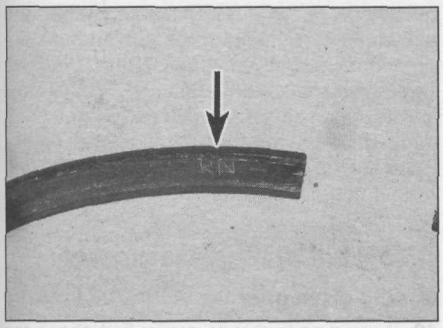
23.7a Install the oil ring expander in its groove . . .



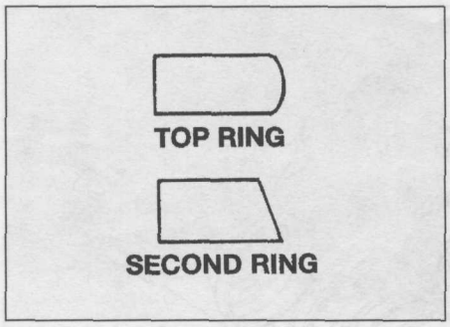
23.7b . . . then fit the lower side rail . . .



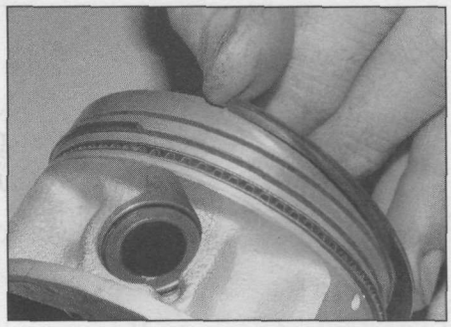
23.7c . . . and the upper side rail on each side of it



23.9a Note the letter(s) near the ring end (arrowed) . . .



23.9b . . . and the different profiles of the rings



23.9c Install the middle ring . . .

ring any more than is necessary to slide it into place. To avoid breaking the ring, use a piston ring installation tool.

10 Finally, install the top ring in the same manner into the top groove in the piston **(see illustration)**. Make sure the identification letter near the end gap is facing up.

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

24 Middle gear assembly – removal, inspection and installation

Note: *The middle driven gear assembly can be removed with the engine in the frame. If work is being carried out with the engine removed ignore the preliminary steps. To remove the middle drive gear assembly, which is integral with the transmission output shaft, the engine must be removed and the crankcases separated.*

Removal

Middle drive gear

1 Remove the engine and separate the crankcase halves (see Sections 5 and 25).

2 Remove the transmission output shaft (see Section 30).

Middle driven gear

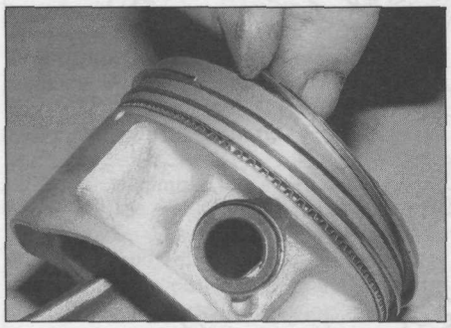
3 Drain the engine oil (see Chapter 1).

4 Remove the swingarm (see Chapter 6).

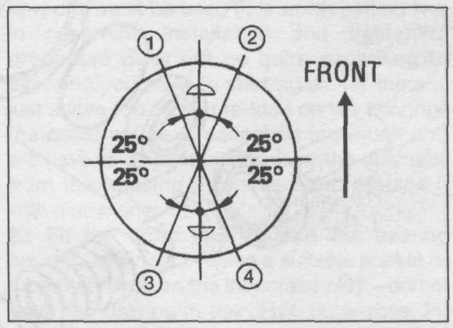
5 Slacken the crankcase bolt on each side of the middle driven gear assembly **(see illustration)**.

6 Unscrew the three bolts securing the middle driven gear assembly to the rear of the crankcase, noting the washer with the bottom right bolt where fitted **(see illustration 24.5)**. Note the positions of the shims between the housing and the crankcase as these must be installed in the same way.

7 Grasp the shaft output flange or the universal joint and withdraw the driven gear assembly from the crankcase, removing the shims as you do **(see illustration)**. If removal is difficult, tap around the housing using a soft mallet. Discard the O-ring as a new one must be used.



23.10 . . . and the top ring as described



23.11 Piston ring installation details – stagger the ring end gaps as shown

1 Top ring
2 Oil ring lower side rail
3 Oil ring upper side rail
4 Second (middle) ring

Inspection

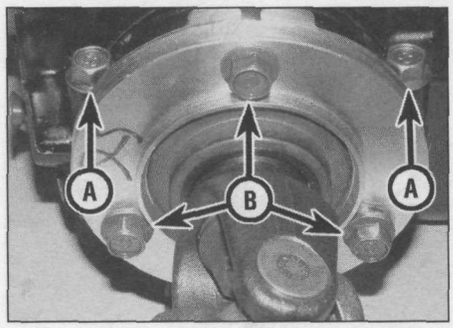
8 During the normal course of events the middle gear assemblies should last the life of the motorcycle without the need for overhaul or component replacement. The weakest component in the train is the universal joint, though this is unlikely to fail unless it has suffered abuse.

9 Inspect the drive and driven shaft bevel gears for signs of wear or damage **(see illustration overleaf)**. Check that the shafts rotate freely in their bearings. Also check the universal joint on the driven shaft – there should be no noticeable play between the couplings, and the joints should move smoothly and freely with no signs of roughness, stiffness or notchiness.

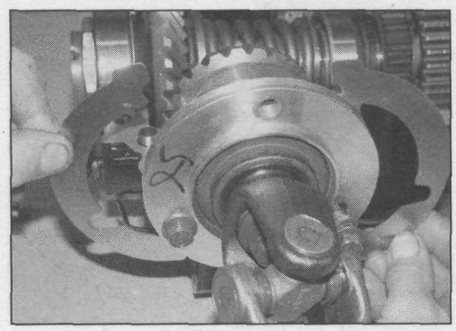
10 Check the drive shaft damper assembly for signs of wear or damage. In particular, check the damper spring and the contact surfaces between the damper cam and the bevel gear face.

11 If any wear or damage is evident in the drive gear assembly, or if the shaft bearing shows signs of roughness or play, and you do not have an hydraulic press and a suitable tool to locate between the press and the gear, or a suitable gear puller, take the assembly to a Yamaha dealer or specialist repair shop. If you have a suitable tool and press or puller, refer below. **Note:** *The drive and driven shaft bevel gears are only available as a matched pair. If one is renewed, the other must also be renewed.*

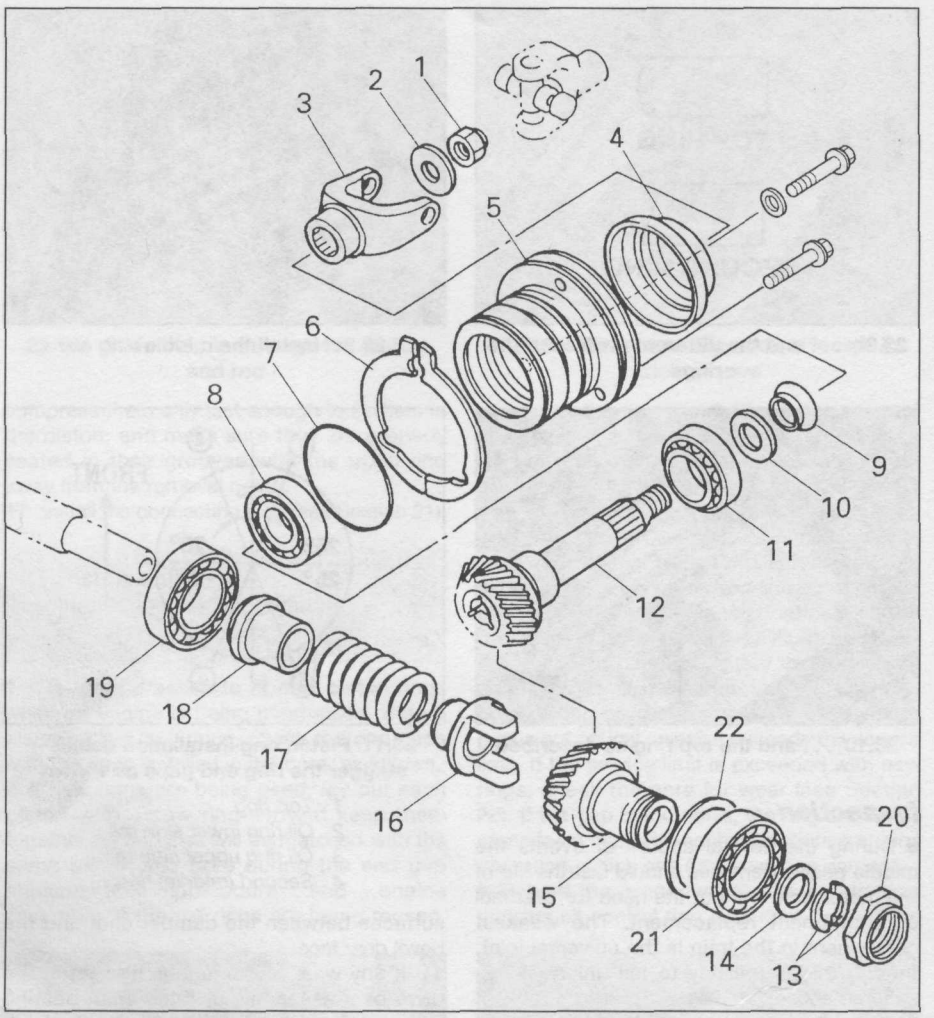
12 If any wear or damage is evident in the driven gear assembly (other than the UJ itself),



24.5 Slacken the crankcase bolts (A), then unscrew the driven gear bolts (B)



24.7 Remove the shims, noting how they locate



24.9 Middle gear assembly components

1 Nut	*6 Shims*	*12 Driven bevel gear shaft*	*17 Spring*
2 Washer	*7 O-ring*	*13 Spring retainers*	*18 Spring seat*
3 Yoke	*8 Outer bearing*	*14 Thrust washer*	*19 Bearing*
4 Dust seal	*9 Collapsible collar*	*15 Drive bevel gear*	*20 Nut*
5 Driven gear bearing housing	*10 Spacer*	*16 Damper cam*	*21 Bearing*
	11 Inner bearing		*22 Shim*

or if the shaft bearings show signs of roughness or play, it can be disassembled, but note that assembly is a precise procedure requiring the use of a torque wrench which is accurate at less than 1 Nm, and if not done correctly will result either in play in the bearings (the pre-load is critical) and oil leakage, or overtight bearings which will quickly wear, so it is advisable to take the assembly to a Yamaha dealer, though the procedure is detailed below. **Note:** *The drive and driven shaft bevel gears are only available as a matched pair. If one is renewed, the other must also be renewed.* If there is wear or play in the UJ bearings, these can be removed and new ones installed relatively easily (see below).

Disassembly and reassembly

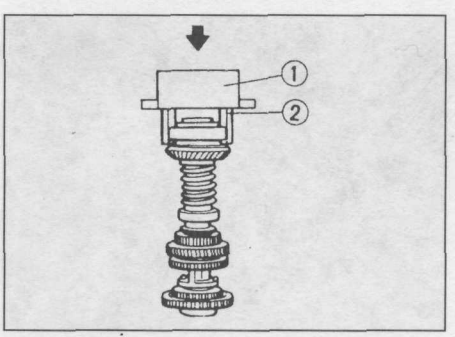
Middle drive gear

13 If using an hydraulic press, first obtain the Yamaha special tools (pt. nos. 90890-04080 and 04090), or obtain or fabricate a suitable equivalent adaptor that locates between the end of the hydraulic compressor rod and the outer flat rim of the bevel gear **(see illustration)**. Although it is easier to fit an adaptor that locates on the rim of the bevel gear shaft end (around which the large nut is threaded) or the large nut itself, bear in mind that you need room to access and remove the retainers in the end of the shaft, and note that the rim of the nut is chamfered and so is not ideal. Do not set any adaptor on the outer race of the bearing as it will probably be damaged. If using the Yamaha tools set them up on the end of the shaft according to the instructions with the tools and as shown. If using a gear puller, set the plates on the outside of the bevel gear and the bolt on the right-hand end of the shaft so that the plates pull the gear in and compress the spring when the bolt is turned.

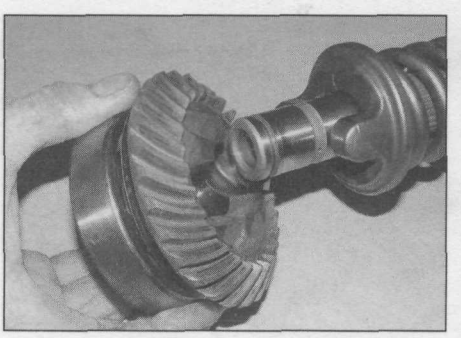
14 Set the assembly up as described, then compress the spring until the retainers are free and remove them and the thrust washer. Slowly release the press or puller and allow the spring to relax, then remove the assembly from the press.

15 Remove the drive gear and bearing assembly, the damper cam, the spring and the spring seat, noting how they fit **(see illustrations)**. The bearing that is behind the spring seat is covered with the transmission shaft components (see Section 31).

16 To remove the bearing from the bevel gear shaft, first unstake the nut **(see illustration)**. Set the assembly up in a vice equipped with soft jaws, clamping the rim of



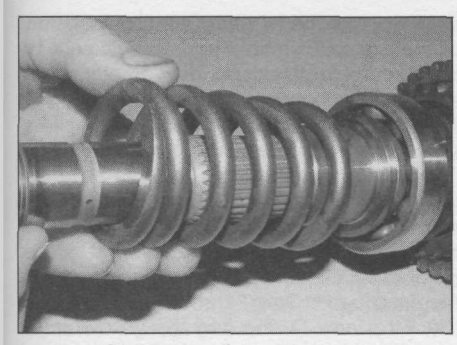
24.13 Yamaha tools (1 and 2) set up for compressing the spring



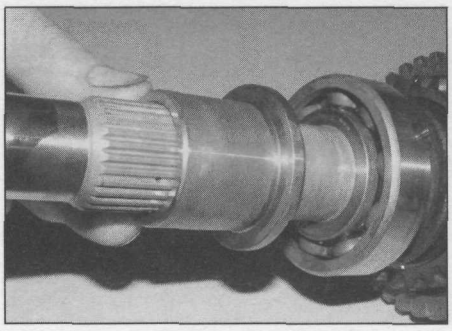
24.15a Remove the bevel gear . . .



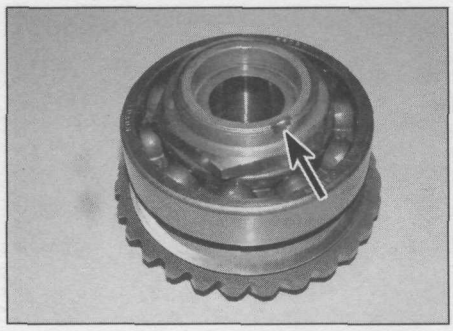
24.15b . . . the damper cam . . .



24.15c . . . the spring . . .



24.15d . . . and the spring seat



24.16 Unstake the nut (arrowed) before unscrewing it

the bevel gear, then unscrew the nut and remove the bearing and shim(s).

17 Inspect all components again as described above. Replace any worn or damaged components with new ones as required, then reassemble them in a reverse of the above procedures, noting the following:

• Do not forget to fit the shim(s) between the bevel gear and the bearing **(see illustration 24.9)**. If any of the components stated in Step 26 have been replaced with new ones, it is necessary to calculate whether new shims are required – do this as described in Step 26 before reassembly.

• Apply a suitable non-permanent thread locking compound to the bearing nut and tighten it to the torque setting specified at the beginning of the Chapter, then stake its rim into the shaft to lock it **(see illustration 24.16)**.

• When compressing the spring, make sure the retainers locate fully in their groove in the end of the shaft.

18 If any of the middle drive gear assembly or output shaft components have been replaced with new ones, measure the length of the combined assembly from the outside edge of the bearing on the right-hand end to the outer edge of the bevel gear, and compare it to the length specified at the beginning of the Chapter. If the measured length is less than the minimum specified, you need to add shims between the 1st gear pinion and the bearing on the right-hand end of the shaft as required to restore the length (see Section 31). If it is greater than the maximum specified, and shims are already installed, remove or change them as required to restore the length. Three shims are available in sizes of 0.5 mm, 0.9 mm and 1.3 mm. Use one or more as required. Note that if the measured length is greater than the maximum specified and no shims are installed, you have probably assembled the shaft incorrectly.

Middle driven gear

19 To disassemble the UJ for replacement of its needle bearings, clamp the UJ yoke or bevel gear in a soft-jawed vice (do not clamp the bearing housing) so the shaft cannot turn, then remove the circlips **(see illustration)**. Tap the bearings out from the underside, noting that the needles may well not be caged, in which case they will drop everywhere on removal of the race **(see illustration)**. Lubricate and install the new bearings, making sure all the needles remain correctly positioned, and secure them with new circlips, making sure they locate in the groove.

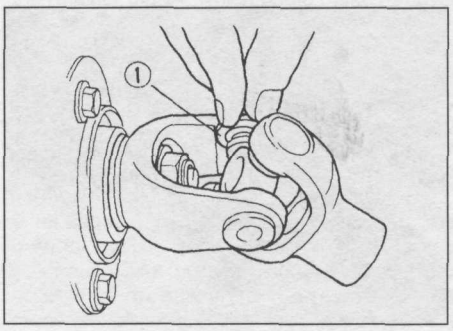
20 To disassemble the shaft and bearing housing, you need to disassemble the universal joint (UJ) for access to the nut (see above). While this is not essential for unscrewing the nut (a ring spanner can be used), when tightening it is essential to get a torque wrench and socket onto the nut, which cannot be done with the UJ intact.

21 To unscrew the nut, obtain a holding tool with which to clamp the UJ yoke – you can clamp it in the vice if you have a suitable extension to reach the nut. UJ holders are commercially available, though probably not worth the expense for a one-off operation. Alternatively pass a bar through the yoke, or use a very large adjustable spanner to hold it. Do not clamp the bevel gear in the vice to hold the shaft as the nut is tight and it is unlikely the vice will hold the shaft without it slipping and scoring or damaging the gear. Unscrew the nut and remove the washer, and slide the yoke off the shaft **(see illustration 24.9)**.

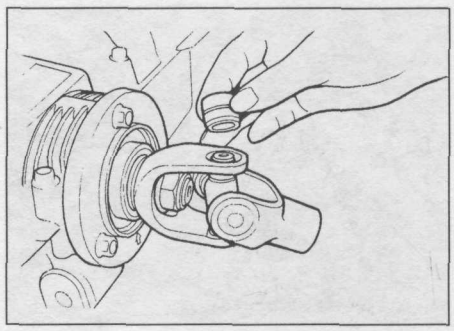
22 Withdraw the shaft from the bearing housing. The housing contains an inner bearing (which may stay on the shaft), a spacer, a collapsible collar, and an outer bearing. Remove these components – the outer bearing will have to be driven from the housing. Discard the collapsible collar as a new one must be used (it is worth getting two in case the installation and tightening procedure does not go quite according to plan and you have to start again – if there is just a little too much pre-load on the bearings the collar will have collapsed too much and will have to discarded). Remove the dust seal from the housing if required and replace it with a new one.

23 Fit the outer bearing into the bearing housing, driving it in using a suitable socket or tube that bears on the inner race only – do not drive the bearing in using the outer race. Fit the inner bearing, spacer and collapsible collar onto the shaft. Slide the shaft into the housing and thread the nut onto its end.

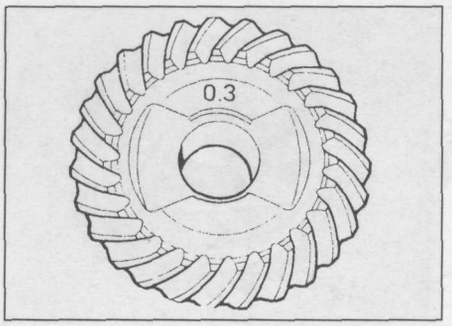
24 The tightening procedure must be carried out as follows. Begin by clamping the UJ yoke in a vice as before, then apply a suitable non-permanent thread locking compound to the nut and begin tightening it, doing so until play in the shaft is just eliminated. Now reposition the assembly in the vice so that the bearing housing flange is clamped (do not clamp the housing itself), allowing the shaft to turn. Using an accurate low spec torque wrench set to 0.45 Nm on the nut, check the torque required to turn the shaft – this is not the torque required to overcome any stiction and start the shaft turning, which will be slightly higher, but the torque required to keep the shaft turning. If it is less than 0.4 Nm, reposition the assembly in the vice again and tighten the nut a little more, then recheck the torque required for turning the shaft. Keep tightening the nut a very little at a time until the turning torque is achieved. If you



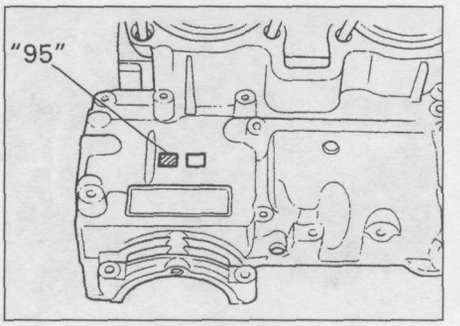
24.19a Remove the circlip (1) to free the bearing . . .



24.19b . . . then remove the bearing



24.26a Drive bevel gear number



24.26b Crankcase number

overtighten the nut and the torque required to turn the shaft is over 0.5 Nm, the collapsible collar will have deformed too much, and you will have to disassemble the shaft again, fit a new collar and start over.

25 On completion, reassemble the UJ (see Step 19).

Installation

Middle drive gear

26 If either the drive and driven bevel gears, the driven gear bearing housing or the crankcases have been replaced with new ones, it is necessary to check the thickness of shim required for the middle drive gear before installing it and to replace the existing shim if necessary – the shim lies between the bearing and the bevel gear (see above).

The shim size required is calculated using the formula **T = A – B**, where **T** is the unknown shim size, **A** is a number (sometimes pre-fixed by a – (minus) sign) etched into the end of the drive shaft bevel gear **(see illustration)**, which must be divided by 100 then added to (or subtracted from if it has a – (minus) sign in front of it) 54.5, and **B** is the number etched into the top of the upper crankcase half above the middle gear housing and in front of the stamped engine number **(see illustration)**, which must be divided by 100 then added to 53.

For example, if the number on the drive shaft bevel gear is 03, then **A** = 54.5 + 0.03, which means **A** is 54.53. If the number on the crankcase is 95, then **B** = 53 + 0.95 = 53.95. Therefore **T** = 54.53 – 53.95, which means **T** is 0.58. Shims are available in sizes of 0.15, 0.30, 0.40 and 0.50 mm. If the shim size **T** required does not end in 5 or zero, it must be rounded up or down according to the table:

Last digit of shim size T	Round off to
0, 1, 2	0
3, 4, 5, 6,	5
7, 8, 9	10

27 If none of the components mentioned in Step 26 have been renewed, install the transmission output shaft (see Section 30).

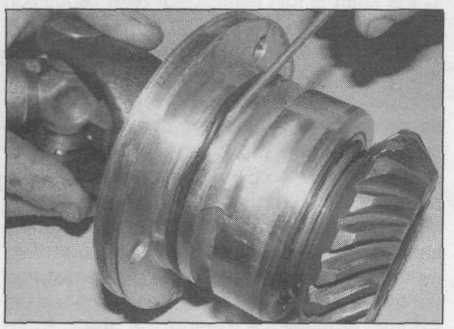
Middle driven gear

28 If either the drive and driven bevel gears, the driven gear bearing housing or the crankcases have been replaced with new ones, or any of the drive or driven gear components have been disturbed, it is necessary to repeatedly check the amount of backlash between the bevel gears as you install the driven gear assembly and to calculate the required shim thickness between the driven gear bearing housing flange and the crankcase as described in Steps 32 to 35.

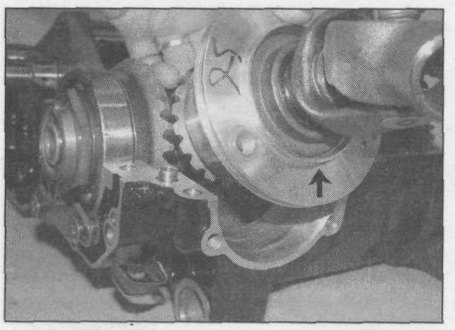
29 If none of the components have been replaced or disturbed, the amount of backlash should not have changed (though it is advisable to check it as a matter of course), so install the middle driven gear as described in Step 30, then check the backlash if required as described in Step 31.

30 Fit a new O-ring into the groove in the middle driven gear bearing housing and smear it with oil **(see illustration)**. Install the driven gear assembly in the crankcase, making sure the arrow on the flange is at the bottom and pointing up **(see illustration)**. Fit the shims between the flange and the crankcase, aligning the cut-outs in each half with the bolt holes **(see illustration 24.7)**. Install the housing bolts, not forgetting the washer with the right-hand bolt where fitted, and tighten them to the specified torque setting **(see illustration)**. Also tighten the two crankcase bolts on each side of the housing to the specified torque setting, noting that they are 8 mm bolts **(see illustration 24.5)**.

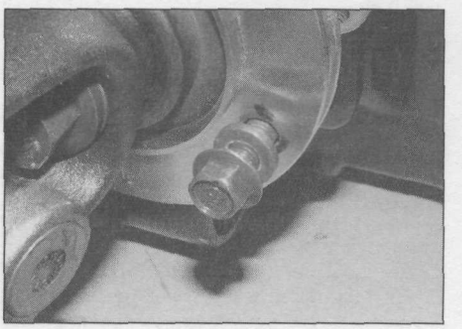
31 To check the amount of backlash, a dial gauge mounted on a stand and a method of securing the middle drive gear so that it does not rotate are required **(see illustration)**. A Yamaha special tool (pt. no. 90890-04080) can be obtained for securing the drive gear. Alternatively it should be possible to secure it using a spanner on the gear nut, with the grip wedged against the bench or crankcase. Set up the dial gauge, using the stand to position the gauge end against the edge of one of the arms on the universal joint yoke, immediately above the centreline of one of the UJ bearings in the yoke. With the middle drive gear locked, rotate the universal joint gently back and forward between the extremes of its free movement. Note the reading on the gauge. Remove the drive shaft holding tool and turn the driven shaft through 90°and repeat the measurement. Do this two more times, so that in all four measurements are taken, each 90° apart. If the amount of backlash measured is outside the limit specified at the beginning of the Chapter,



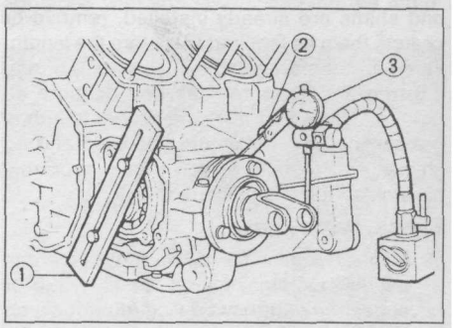
24.30a Fit a new O-ring . . .



24.30b . . . then install the assembly with the arrow (highlighted) at the bottom



24.30c On later models the bottom right bolt has a washer



24.31 Backlash measurement set-up

1 Yamaha holding tool
2 Feeler gauge
3 Dial gauge

the driven gear assembly must be re-shimmed to bring it back within limits. Slacken the two crankcase bolts on each side of the housing **(see illustration 24.5)**. Unscrew the three bolts securing the assembly and withdraw it from the crankcase just far enough to remove the existing shims **(see illustration 24.7)**.

32 To re-shim the driven gear assembly, set it so that there is a gap of about 2 mm between the bearing housing flange and the crankcase, then install the housing bolts and screw them in until their shoulders just contact the housing face.

33 Using the dial gauge arrangement and with the drive shaft locked (see Step 31), repeatedly check the amount of backlash whilst screwing in the housing bolts a fraction at a time. When the amount of backlash is within the limits specified, measure the clearance between the housing and the crankcase using feeler gauges. The clearance measured indicates the shim thickness required. Note that if you overtighten the flange bolts and the backlash is reduced to zero, it is possible that the collapsible collar in the bearing housing will have deformed excessively, meaning it will have to be replaced with a new one (see above).

34 Shims are available in sizes of 0.10, 0.15, 0.30, 0.40, 0.50 and 0.60 mm. If the shim size required does not end in 5 or zero, it must be rounded up or down according to the table in Step 26.

35 Obtain the correct shims, then install them and the housing as described in Step 30.

25 Crankcase halves – separation and reassembly

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

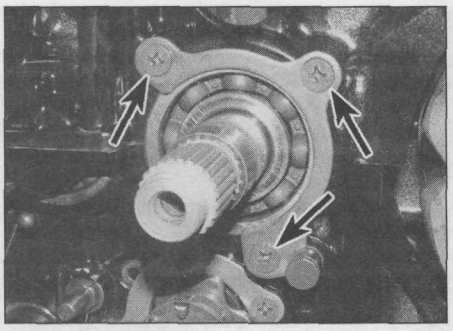
Separation

1 To access the crankshaft, balancer shaft, transmission shafts and the selector drum and forks the crankcases must be separated. The connecting rods and pistons can be removed and installed with the crankcases joined.

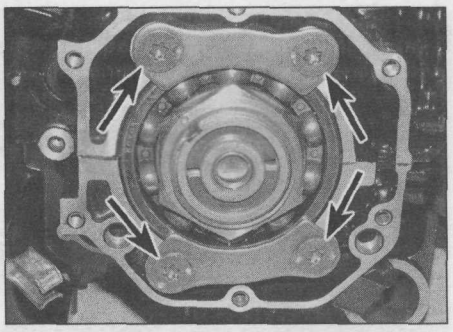
2 To enable the crankcases to be separated, the engine must be removed from the frame (see Section 5). Before the crankcases can be separated the following components must be removed:

Valve covers (Section 7)
Camshafts (Section 9)
Cylinder heads (Section 11)
Alternator/starter clutch (Chapter 9)
Water pump and thermostat housing (Chapter 3)
Clutch release cylinder (Section 16)
Clutch (Section 14)
Oil pump and pipes (Section 19)
Connecting rods and pistons (Section 21)
*Gearchange mechanism (Section 19)**
*Starter motor (Chapter 9)**

**The gearchange mechanism can remain in situ unless the selector drum and forks are being removed. The starter motor can remain in situ if required.*



25.3 Undo the screws (arrowed) and remove the plate



25.4 Undo the screws (arrowed) and remove the plates

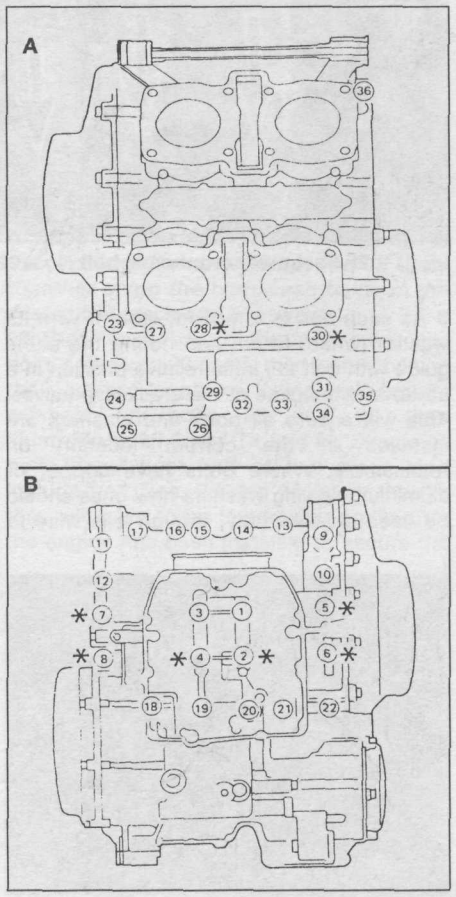
HAYNES HiNT ***Before starting, spray some penetrating fluid or light lubricating oil (such as WD40) into the tops of the bores for bolts 13 to 17 – these are the lower crankcase bolts at the front. Because the bore ends are exposed, they can become corroded and make the bolts difficult to remove – the last thing you want to do is shear one off. If the bolts still feel tight when unscrewing them, screw them back in a bit and work them in and out as required to cut through the corrosion, which will drop out the bottom, until they loosen up – do not try to wind them out in one go, especially if they tighten up as you unscrew them.***

3 Remove the circlip securing the oil pump outer intermediate gear and slide the gear off the shaft **(see illustration 14.16c)**. Undo the screws securing the transmission input shaft bearing retainer plate and remove the plate, noting how it locates in the groove in the intermediate gear shaft **(see illustration)**. You may need an impact driver to slacken the screws. Note that Yamaha specify new screws should be used on installation.

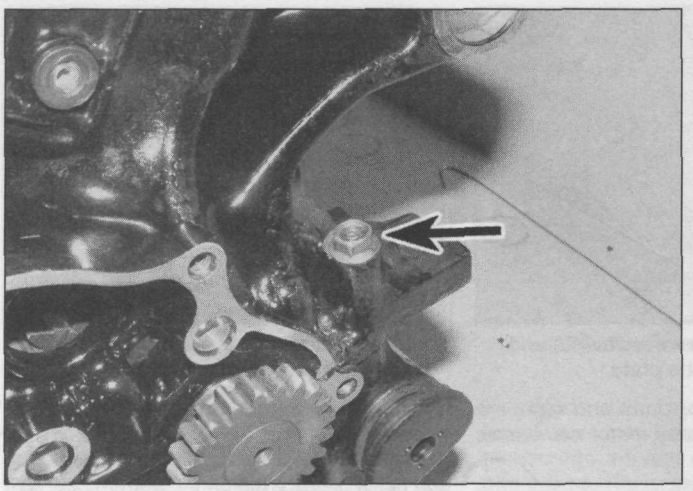
4 Undo the four Torx screws securing the middle drive gear bearing retainer plates to the crankcase **(see illustration)**. Note that these screws are staked into indentations in the retainer plates, which could make removal difficult. To avoid having to use too much force and possibly stripping the heads of the screws, it may be necessary to carefully drill out the staked areas of the screws, taking care not to drill into the retainer plates. Using an impact driver will help to slacken the screws. Note that Yamaha specify new screws should be used on installation.

5 All crankcase bolts are numbered, with the number for each cast into the crankcase adjacent to its bolt **(see illustration)**. The bolts must be slackened in a **reverse** of the numerical order, and tightened in their correct numerical order. When separating the halves start with the upper crankcase bolts, then turn the engine over and continue with the lower case bolts.

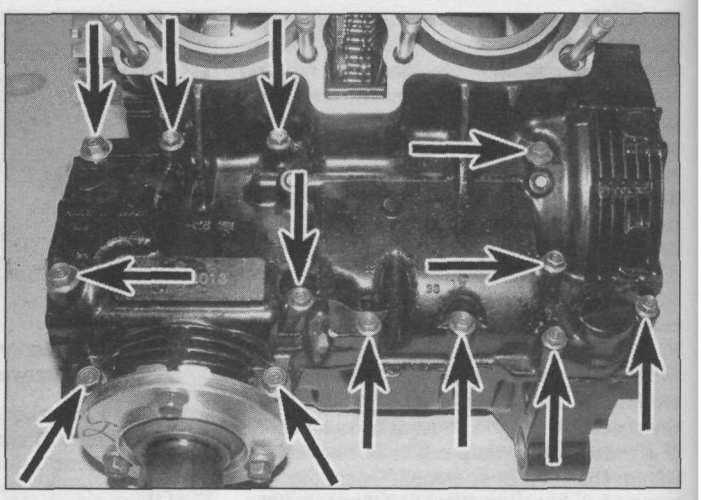
Note: *When separating the crankcases, the top half must be lifted off the bottom half, so it is recommended that the upper crankcase bolts are merely slackened (just so the tension is taken out of them, but without creating a gap between the bolt and the crankcase) and not removed until the engine is again upright. Doing this will avoid the crankcases coming apart and the components falling out when it is turned over after removing the lower bolts. When joining the halves this procedure must be followed in reverse.*



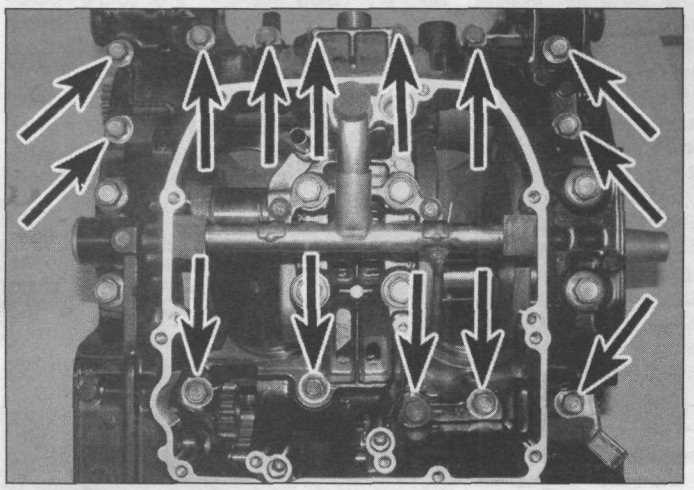
25.5 Upper crankcase bolt numbers (A), lower crankcase bolt numbers (B)



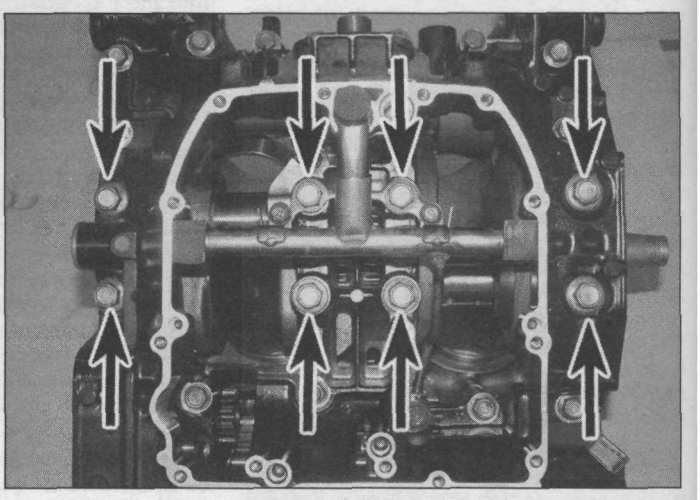
25.7a Upper crankcase bolt No. 36 (arrowed)



25.7b Upper crankcase bolt Nos. 35 to 23 (arrowed)

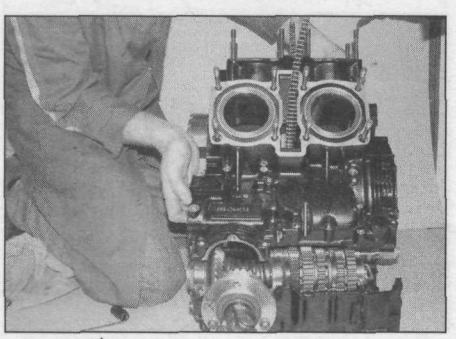


25.9a Lower crankcase bolt Nos. 22 to 9 (arrowed)



25.9b Lower crankcase bolt Nos. 8 to 1 (arrowed)

6 As each bolt is removed, store it with its washer (where fitted, and noting the cable guide with bolt 22) in its relative position in a cardboard template of the crankcase halves. This will ensure all bolts and washers are installed in the correct location on reassembly. Where bolts have copper or aluminium sealing washers new ones should be used on assembly, though it is wise to keep the old ones with the bolts for the time being as a pattern for the new ones.



25.11 Carefully lift the upper crankcase half off the lower half

7 Begin by slackening the upper crankcase bolts numbered 36 to 23, but only a little (see **Note** above) **(see illustrations)**. Do not remove them. Bolt nos. 23 and 35 will already have been slackened to release the clutch hose and earth lead when removing the engine, but obviously slacken them again if you retightened them at the time.

8 Unscrew and remove the middle driven gear assembly top mounting bolt, and slacken the bottom two **(see illustration 24.5)**. Grasp the shaft output flange or the universal joint and pull the driven gear assembly slightly out of the crankcase, removing the shims when they are free **(see illustration 24.7)**. Note how the shims fit as they must be installed the same way.

9 Turn the engine upside down. Unscrew and remove the lower crankcase bolts numbered 22 to 9, noting the cable guide with bolt 22 **(see illustration)**. Bolt No. 20 will already have been removed to release the oil pipe. Now unscrew the eight bolts numbered 8 to 1 evenly and a little at a time until they are finger-tight, then remove them with their washers, and noting the oil pipe bracket with bolts 1 and 3 **(see illustration)**.

10 Turn the engine the right way up. Remove the upper crankcase bolts numbered 36 to 23.

11 Carefully lift the upper crankcase half off the lower half, using a soft-faced hammer to tap around the joint to initially separate the halves if necessary **(see illustration)**. **Note:** *If the halves do not separate easily, make sure all fasteners have been removed. Do not try and separate the halves by levering against the crankcase mating surfaces as they are easily scored and will leak oil in the future if damaged.* Pass the cam chains down through the crankcase as you remove it. The upper crankcase half will come away leaving the crankshaft, balancer shaft, transmission shafts, selector drum and forks, and middle driven gear in the lower crankcase half.

12 Remove the locating dowel from the rear left corner of the crankcase if it is loose (it could be in either crankcase half) **(see**

illustration). Remove the clutch pushrod oil seal and the pushrod bearing **(see illustrations)**. Discard the seal and the O-ring around the bearing as new ones must be used. Check that the oil nozzle for the right-hand end of the transmission output shaft is threaded into the upper crankcase half – it is possible for this to work loose, and if it has it will probably just be sitting in the shaft end cut-out in the lower half **(see illustration)**. If it has worked loose and is not there you have probably dislodged it when separating the halves. Note that if it is loose, the oil feed to the 1st gear pinion bush will have been disrupted and so the bush will be worn – check this before reassembling the crankcases, and replace the pinion with a new one if necessary. Refer to Sections 30 and 31 – the 1st gear pinion is on the end of the shaft, and can be removed after sliding off the bearing.

13 Refer to Sections 24 and 26 to 32 for the removal and installation of the components housed within the crankcases.

Reassembly

14 Remove all traces of sealant from the crankcase mating surfaces.

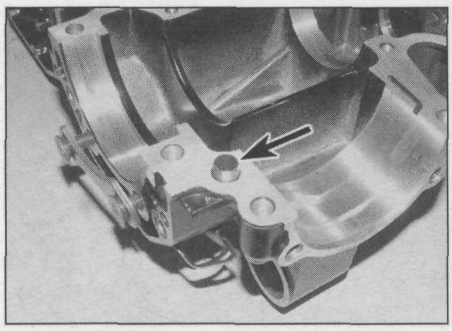
15 Refer to Sections 26 to 32 and check that all components and their bearings are in place in the upper and lower crankcase halves. Check the oil nozzles (Section 26, Step 7). Check that the selector drum is in the neutral position (see Section 32).

16 Refer to Section 19, Step 10, and fit new O-rings onto the oil pipe assembly, but do not yet install it – fitting the O-rings now minimizes the time the crankcase sealant has to dry before the bolts are tightened down. Smear the O-rings with oil.

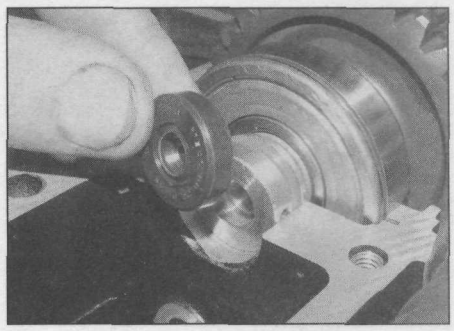
17 Fit a new O-ring into the groove in the middle driven gear bearing housing and smear it with oil **(see illustration 24.30a)**. Position the middle driven gear assembly in the lower crankcase half, making sure the arrow on the flange is a the bottom and pointing up **(see illustration 24.30b)**. Fit the shims between the flange and the crankcase, aligning the cut-outs in each half with the bolt holes **(see illustration 24.7)**. Secure the two bottom mounting bolts finger-tight, not forgetting the washer with the right-hand bolt **(see illustration 24.30c)**.

18 Generously lubricate the crankshaft, balancer shaft and transmission shafts, particularly around the bearings, with clean engine oil, then use a rag soaked in high flash-point solvent to wipe over the mating surfaces of both crankcase halves to remove all traces of oil.

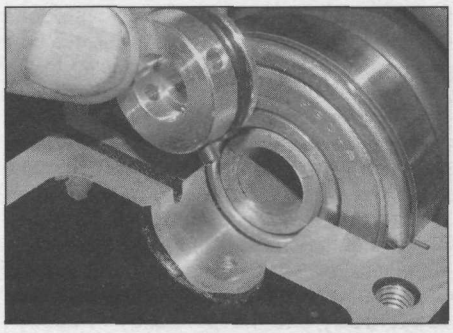
19 Fit a new O-ring onto the clutch pushrod bearing **(see illustration)**. Install the bearing, locating the pin in the hole in the crankcase **(see illustration 25.12c)**. Fit a new oil seal outside the bearing, making sure it is pushed up against it **(see illustration 25.12b)**. If removed, fit the locating dowel in the lower crankcase half **(see illustration 25.12a)**.



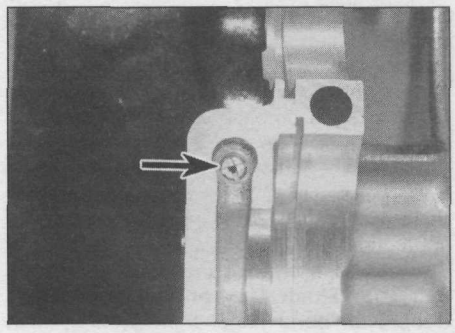
25.12a Remove the dowel (arrowed) if loose



25.12b Remove the oil seal . . .



25.12c . . . and the bearing, noting how it locates



25.12d Check the oil nozzle (as described)

20 Apply a small amount of a suitable RTV sealant (such as Yamaha Bond 1215 or equivalent) to the outer mating surface of the lower crankcase half as shown.

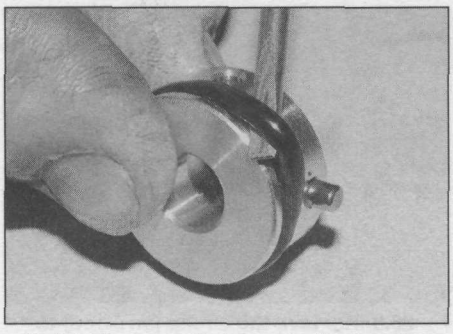
Caution: Do not apply an excessive amount of sealant as it will ooze out when the case halves are assembled and may obstruct oil passages. Do not apply the sealant on or too close (within 2 to 3 mm) to any of the bearing shells or surfaces.

21 Check again that all components are in position, and that the bearing shells are still correctly located in the upper crankcase half. Make sure that each cam chain is looped around its sprocket on the crankshaft, then attach a length of wire to each one, so that they can be passed easily up through the upper crankcase half as it is installed – it is best to have an assistant to help do this. Carefully fit the upper crankcase half down onto the lower half, making sure the dowel locates correctly **(see illustration 25.11)**. Wire the cam chains to the engine to prevent them falling back down.

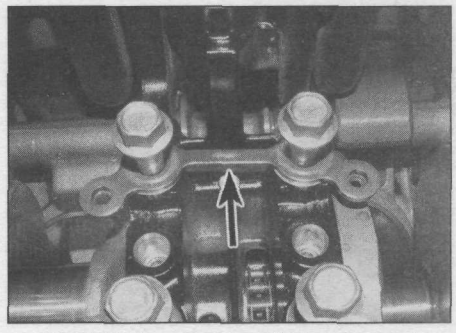
22 Check that the upper crankcase half is correctly seated.

Caution: The crankcase halves should fit together without being forced. If the casings are not correctly seated, remove the upper crankcase half and investigate the problem. Do not attempt to pull them together using the crankcase bolts as the casing will crack and be ruined.

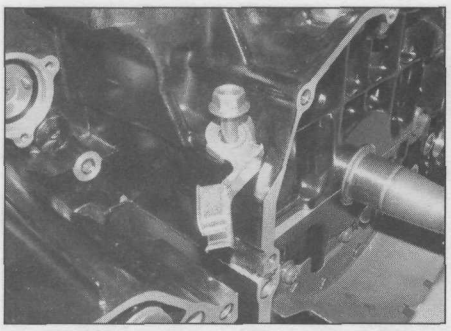
23 Clean the threads of the upper crankcase bolts numbered 23 to 36, then install them in their correct locations, using new copper washers on bolts 28 and 30 **(see illustrations 25.5 and 7a and b)**. Secure all bolts finger-tight only at this stage, and include bolt Nos. 23 and 35, even though they will have to be unscrewed again after the engine has been installed to secure the



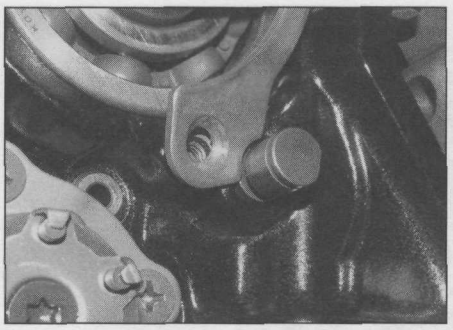
25.19 Fit a new O-ring onto the bearing



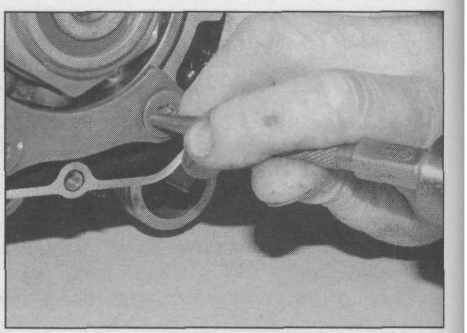
25.25 Make sure the oil pipe bracket (arrowed) is the correct way round



25.28 Do not forget the cable guide



25.32 Pull the shaft out and locate the cut-out in the plate in the groove in the shaft



25.33 Stake each screw into its indentation in the plate

clutch hose and earth lead – it is necessary to tighten them to ensure an even seating and sealing of the crankcase halves. Also install and finger-tighten the top middle driven gear assembly bolt.

24 Turn the engine upside down.

25 Clean the threads of the lower crankcase bolts numbered 1 to 8, then lightly smear them with oil and insert them in their original locations, not forgetting the oil pipe bracket with bolts 1 and 3 and the washers with the rest **(see illustration and 25.5 and 9b)**. Secure all bolts finger-tight at first, then tighten the bolts evenly and a little at a time in correct numerical sequence to the torque setting specified at the beginning of the Chapter.

26 Now tighten the middle driven gear assembly mounting bolts evenly and a little at a time to the specified torque setting **(see illustration 24.5)**.

27 Refer to Section 19, Step 10, and install the oil pipe assembly, but do not yet tighten the bolts.

28 Clean the threads of the lower crankcase bolts numbered 9 to 22 and insert them in their original locations, not forgetting the cable guide with bolt 22 **(see illustration and 25.5 and 9a)**. Secure all bolts finger-tight at first, then tighten the bolts evenly and a little at a time in correct numerical sequence to the torque settings specified at the beginning of the Chapter, taking care to distinguish correctly between the 6 mm thread bolts and the 8 mm thread bolts.

29 Turn the engine over.

30 Now tighten the upper crankcase bolts numbered 23 to 36 evenly and a little at a time in correct numerical sequence shown to the torque settings specified at the beginning of the Chapter, again taking care to distinguish correctly between the 6 mm thread bolts and the 8 mm thread bolts **(see illustrations 25.5 and 7a and b)**.

31 With all crankcase fasteners tightened, check that the crankshaft, balancer shaft and transmission shafts rotate smoothly and easily. Check that the transmission shafts rotate freely and independently in neutral, then rotate the selector drum by hand and select each gear in turn whilst rotating the input shaft. Check that all gears can be selected and that the shafts rotate freely in every gear. If there are any signs of undue stiffness, tight or rough spots, or of any other problem, the fault must be rectified before proceeding further.

32 Pull the oil pump intermediate gear shaft as far out of the crankcase as possible, then install the transmission input shaft bearing retainer plate, locating its bottom corner in the groove in the shaft **(see illustration)**. Apply a suitable non-permanent thread locking compound to the new Torx screws and tighten them to the specified torque setting **(see illustration 25.3)**. Slide the gear onto the shaft, aligning the flats, and secure it with the circlip **(see illustration 14.16c)**.

33 Apply a suitable non-permanent thread locking compound to the new middle drive gear bearing retainer plate Torx screws, then install the plates and tighten the screws to the specified torque setting **(see illustration 25.4)**. Using a centre punch, stake the screws into the indentations in the retainer plates **(see illustration)**.

34 Install all other removed assemblies in a reverse of the sequence given in Step 2.

26 Crankcase halves and cylinder bores – inspection and servicing

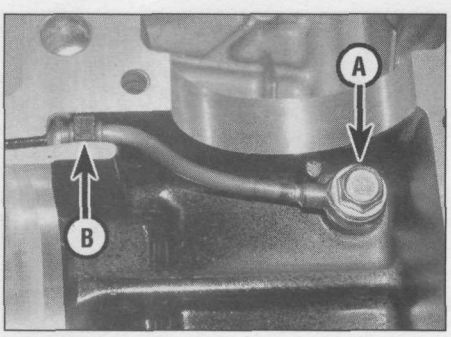
Crankcase halves

1 After the crankcases have been separated, remove the crankshaft, balancer shaft, transmission shafts, middle driven gear, selector drum and forks, and neutral switch, referring to the relevant Sections of this Chapter, and to Chapter 9 for the neutral switch. If there are any other components or assemblies that have not been removed as part of your strip-down procedure, for example the starter motor, remove these as well, referring to the relevant Section or Chapter.

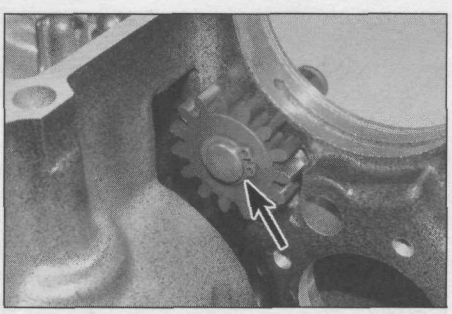
2 Unscrew the oil pipe banjo bolt and remove the pipe, noting how the rubber fillet around its end locates **(see illustration)**.

3 Remove the circlip securing the oil pump inner intermediate gear and remove it, then draw the shaft out of the crankcase, noting which way round it fits **(see illustration)**.

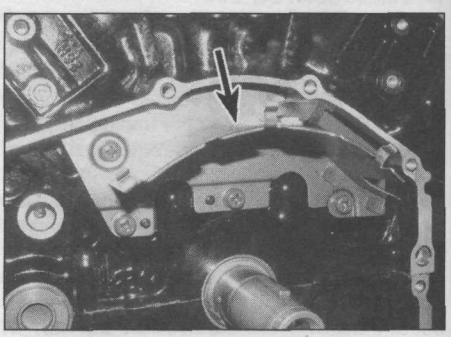
4 If required, undo the screws securing the alternator housing oil baffle plate and remove it, noting how it fits **(see illustration)**.



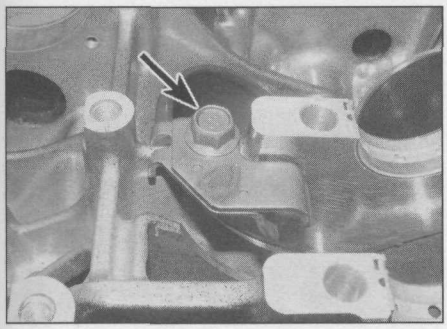
26.2 Unscrew the bolt (A) and remove the pipe, noting how the fillet (B) locates



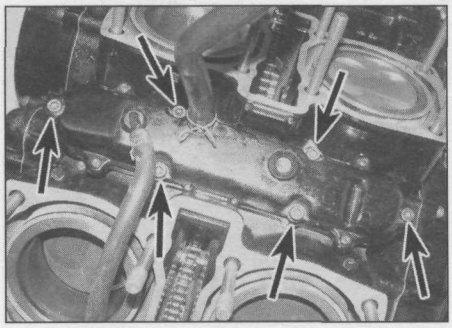
26.3 Remove the circlip (arrowed) to release the gear and draw the shaft out from the outside



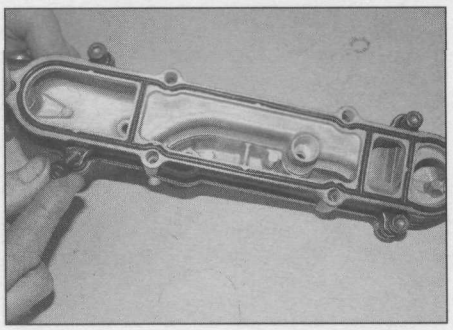
26.4 Remove the baffle plate (arrowed) if required



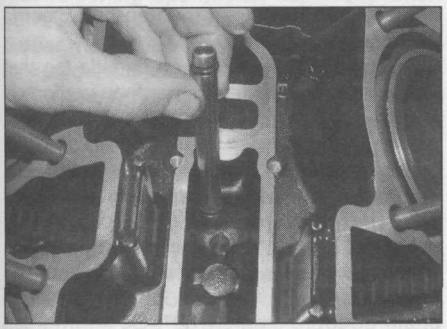
26.5 Cam chain tensioner blade seat bolt (arrowed)



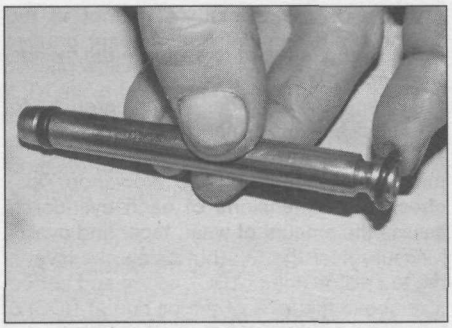
26.6a Unscrew the bolts (arrowed) and remove the housing



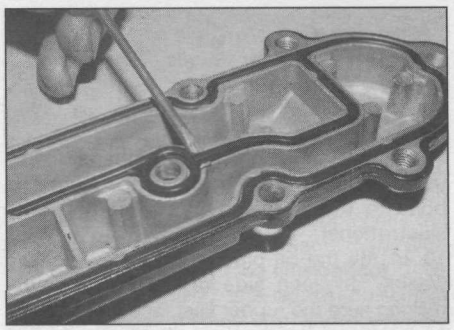
26.6b Unscrew the bolts and separate the halves



26.6c Withdraw the oil pipe



26.6d Fit new O-rings onto the pipe



26.6e Fit a new rubber gasket into the groove . . .

5 If required, unscrew the bolt securing the cam chain tensioner blade seat and remove it, noting how it fits **(see illustration)**.

6 Unscrew the bolts securing the crankcase breather housing to the top of the upper crankcase half and remove it **(see illustration)**. Discard the rubber gasket as a new one must be used. Unscrew the four bolts securing the housing halves and separate them – the housing acts not only as a breather chamber, but also as a transfer port for coolant and oil, and consequently has three separate chambers within it **(see illustration)**. Discard the rubber gasket that seals the halves. Pull the oil pipe out of the crankcase and discard its O-rings **(see illustration)**. Clean the various chambers within the housing halves, and clean the pipe. Fit new O-rings onto the oil pipe and fit it into the crankcase, pushing it down until the bottom O-ring seats **(see illustration)**. Fit a new rubber gasket into the groove in the top half of the housing, then join the halves and tighten the bolts to the torque setting specified at the beginning of the Chapter **(see illustrations)**.

7 Clean the crankcases thoroughly with new solvent and dry them with compressed air. Blow out all oil nozzles (there are three) and passages with compressed air **(see illustration and 25.12d)**. Check that the two threaded oil nozzles, particularly the one for the right-hand end of the transmission output shaft in the upper crankcase half, are tight. If not, unscrew and clean it/them, then apply a smear of a suitable non-permanent thread locking compound to the centre portion of the threads and re-install it/them. It is worth doing this as a matter of course to the transmission output shaft nozzle as it threads into the upper crankcase half and gravity will lend a hand to its working loose.

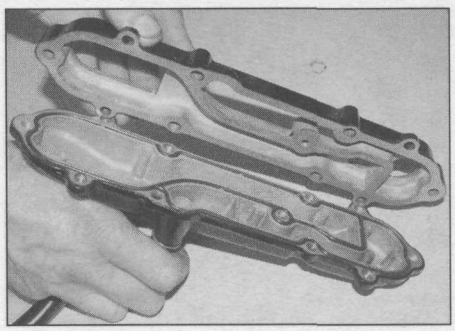
8 Remove all traces of old gasket sealant from the mating surfaces. Clean up minor damage to the surfaces with a fine sharpening stone or grindstone.

Caution: Be very careful not to nick or gouge the crankcase mating surfaces or oil leaks will result. Check both crankcase halves very carefully for cracks and other damage.

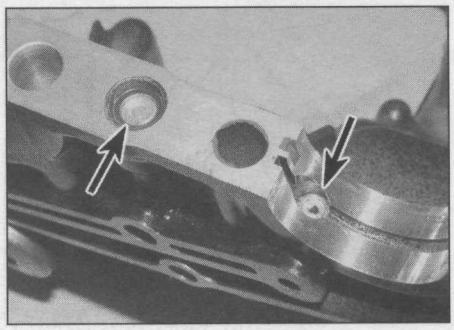
9 Small cracks or holes in aluminium castings can be repaired with an epoxy resin adhesive as a temporary measure. Permanent repairs can only be done by argon-arc welding, and only a specialist in this process is in a position to advise on the economy or practical aspect of such a repair. If any damage is found that can't be repaired, renew the crankcase halves as a set.

10 Damaged threads can be economically reclaimed using a diamond section wire insert, for example of the Heli-Coil type (though there are other makes), which are easily fitted after drilling and re-tapping the affected thread.

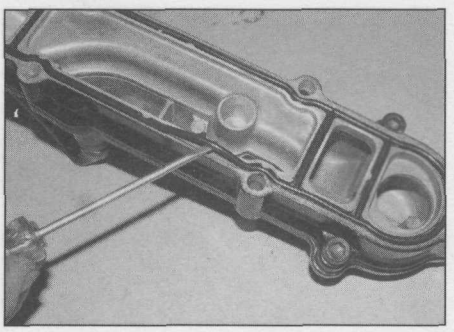
11 A stud or screw that has sheared below the top of its bore (i.e. there is nothing protruding from the crankcase) can usually be removed with an extractor, which consists of a tapered, left-hand thread screw of very hard steel. This is inserted into a pre-drilled hole in the stud, and usually succeeds in dislodging it. If a stud has sheared above the top of its bore, it can be removed using a conventional stud extractor which avoids the need for drilling.



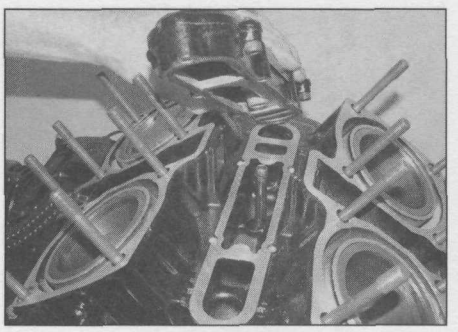
26.6f . . . then join the halves



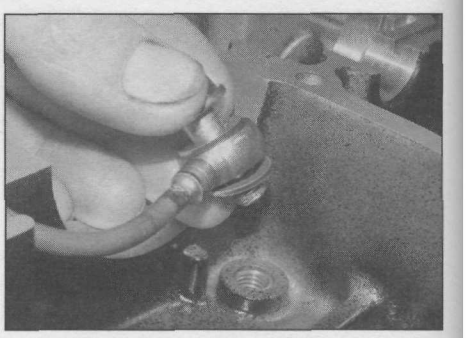
26.7 Clean the oil nozzles (arrowed) and check them as described



26.12a Fit a new rubber gasket into the groove . . .



26.12b . . . then install the housing



26.13 Install the pipe using new sealing washers

HAYNES HiNT

Refer to Tools and Workshop Tips for details of installing a thread insert and using screw extractors.

12 Install the crankcase breather housing using a new rubber gasket and tighten its bolts to the specified torque setting **(see illustrations)**.

13 Install the oil pipe using a new sealing washer on each side of the banjo union, making sure the rubber fillet locates correctly, and tighten the banjo bolt to the torque setting specified at the beginning of the Chapter **(see illustration and 26.2)**.

14 Slide the oil pump intermediate gear shaft into the crankcase, making sure the groove for the transmission input shaft bearing retainer plate is on the outside. Slide the inner intermediate gear onto the shaft, aligning the flats, and secure it with the circlip, making sure it locates correctly in its groove **(see illustration 26.3)**.

15 If removed, install the oil baffle plate and tighten its screws to the specified torque **(see illustration 26.4)**.

16 If removed, install the cam chain tensioner blade seat, making sure it locates correctly **(see illustration 26.5)**. Apply a suitable non-permanent thread locking compound to the threads of its bolt and tighten it to the specified torque setting.

17 Install all other components and assemblies, referring to the relevant Sections of this and the other Chapters, before reassembling the crankcase halves.

Cylinder bores

Note: *Do not attempt to separate the cylinder liners from the cylinder block.*

18 Check the cylinder walls carefully for scratches and score marks.

19 Using telescoping gauges and a micrometer (see *Tools and Workshop Tips*), check the dimensions of each 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 oil ring at BDC) of the bore, both parallel to and across the crankshaft axis **(see illustrations)**. Compare the results to the specifications at the beginning of the Chapter. If the cylinders are worn, oval or tapered beyond the service limit they can be rebored – two oversize (+0.25 and +0.50) sets of pistons and rings are available. Note that the person carrying out the rebore must be aware of the piston-to-bore clearance (see Specifications).

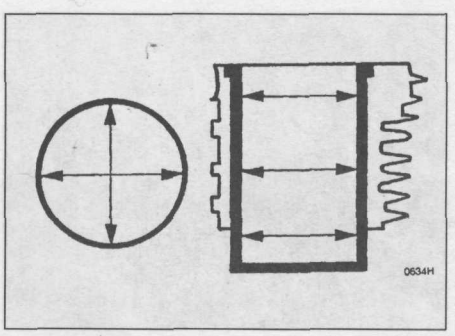
20 If the precision measuring tools are not available, take the upper crankcase to a Yamaha dealer or specialist motorcycle repair shop for assessment and advice.

21 If the cylinder bores are in good condition and the piston-to-bore clearance is within specifications (see Section 22), the cylinders should ideally be honed (de-glazed). The honing process will remove any glazing from the bore surface and provide a fine cross-hatch pattern to allow the new rings to bed in. To perform this operation you will need the proper size flexible hone with fine stones, or a bottle-brush type hone, plenty of light oil or honing oil, some clean rags and an electric drill motor.

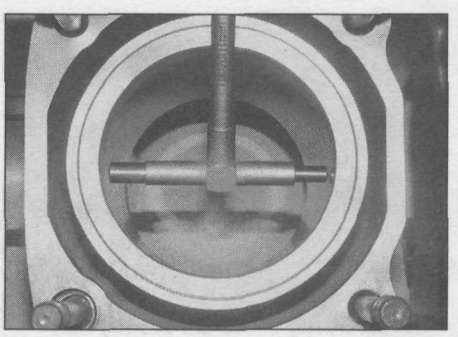
22 Secure the crankcase on its side (so that the bores are horizontal rather than vertical) in a vice with soft jaws or cushioned with wooden blocks. Mount the hone in the drill motor. Thoroughly lubricate the cylinder, then compress the stones and insert the hone. Turn on the drill and move the hone up and down in the cylinder at a pace which produces a fine cross-hatch pattern on the cylinder wall with the lines intersecting at an angle of approximately 60°. Be sure to use plenty of lubricant and do not take off any more material than is necessary to produce the desired effect. Do not withdraw the hone from the cylinder while it is still turning. Switch off the drill and continue to move it up and down in the cylinder until it has stopped turning, then compress the stones and withdraw the hone. Wipe the oil from the cylinder and repeat the procedure on the other cylinders. Remember, do not take too much material from the cylinder wall.

23 Wash the bores thoroughly with warm soapy water to remove all traces of the abrasive grit produced during the honing operation. After rinsing, dry the cylinders thoroughly and apply a thin coat of light, rust-preventative oil to all machined surfaces.

24 If you do not have the equipment or desire to perform the honing operation, take the crankcase to a motorcycle engineering specialist.



26.19a Measure each cylinder bore in the directions shown . . .



26.19b . . . using a telescoping gauge, then measure the gauge with a micrometer

27 Main and connecting rod bearings – general information

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

2 Bearing failure can occur for many reasons: a of lack of lubrication, the presence of dirt or other foreign particles, overloading the engine, and corrosion. Regardless of the cause of bearing failure, it must be corrected before the engine is reassembled to prevent it from happening again.

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

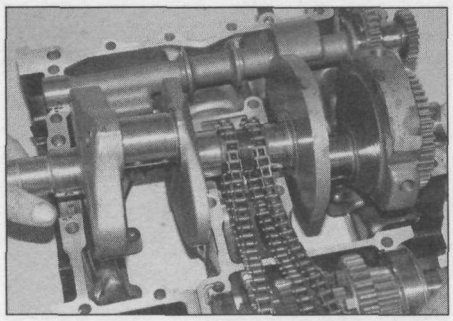
4 Dirt and other foreign particles get into the engine in a variety of ways. It may be left in the engine during assembly or it may pass through filters or breathers. It may get into the oil and from there into the bearings. Metal chips from machining operations and normal engine wear are often present.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

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

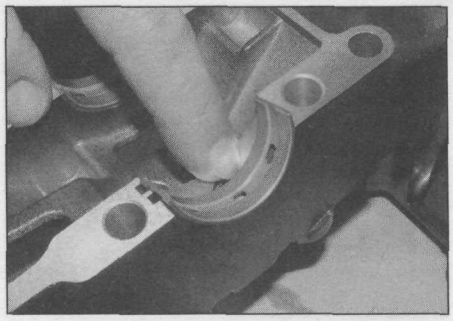
HAYNES HINT *Refer to Tools and Workshop Tips for bearing fault finding.*

6 Riding habits can have a definite effect on bearing life. Full throttle low speed operation, or labouring the engine, puts very high loads on bearings, which tend to squeeze out the oil film. These loads cause the bearings to flex, which produces fine cracks in the bearing face (fatigue failure). Eventually the bearing material will loosen in pieces and tear away from the steel backing. Short trip riding leads to corrosion of bearings, as insufficient engine heat is produced to drive off the condensed water and corrosive gases produced. These products collect in the engine oil, forming acid and sludge. As the oil is carried to the engine bearings, the acid attacks and corrodes the bearing material.

7 Incorrect bearing installation during engine assembly will lead to bearing failure as well. Tight fitting bearings which leave insufficient bearing oil clearances result in oil starvation.



28.2 Lift the crankshaft out of the crankcase



28.3 Remove the shells as shown

Dirt or foreign particles trapped behind a bearing insert result in high spots on the bearing which lead to failure.

8 To avoid bearing problems, clean all parts thoroughly before reassembly, double check all bearing clearance measurements and lubricate the new bearings with clean engine oil during installation.

28 Crankshaft and main bearings – removal, inspection and installation

Note: *To remove the crankshaft the engine must be removed from the frame and the crankcase halves separated.*

Removal

1 Remove the engine from the frame (see Section 5) and separate the crankcase halves (see Section 25).

2 Lift the crankshaft out of the lower crankcase half, bringing the cam chains with it, and taking care not to dislodge the main bearing shells **(see illustration)**.

3 The main bearing shells can be removed from the crankcase halves by pushing their centres to the side, then lifting them out **(see illustration)**. Keep the shells in order.

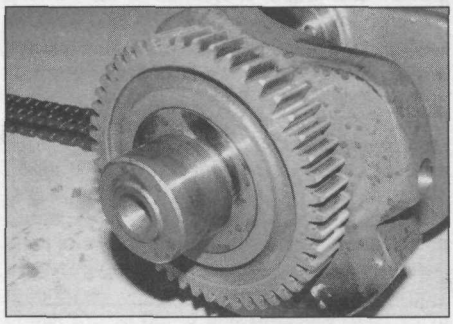
Inspection

4 Clean the crankshaft with solvent, squirting it under pressure through all the oil passages. If available, blow the crank dry with compressed air, and also blow through the oil passages. Check the primary drive gear for wear or damage **(see illustration)**. If any of the gear teeth are excessively worn, chipped or broken, the crankshaft must be replaced with a new one. If wear or damage is found, also inspect the primary driven gear on the back of the clutch housing (see Section 14). Similarly check the cam chain sprockets on the crankshaft and camshafts, and check the chains themselves, and replace them with new ones if necessary **(see illustration)**.

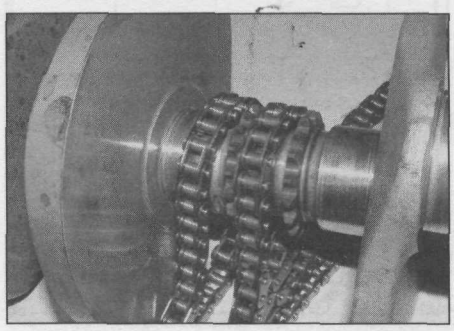
5 Refer to Section 27 and examine the main bearing shells. If they are scored, badly scuffed or appear to have been seized, new bearings must be installed. Always renew the main bearings as a set. If they are badly damaged, check the corresponding crankshaft journals. Evidence of extreme heat, such as discoloration, indicates that lubrication failure has occurred. Be sure to thoroughly check the oil pump and pressure relief valve as well as all oil holes and passages before reassembling the engine.

6 Give the crankshaft journals a close visual examination, paying particular attention where damaged bearings have been discovered. If the journals are scored or pitted in any way a new crankshaft will be required. Note that undersizes are not available, precluding the option of re-grinding the crankshaft.

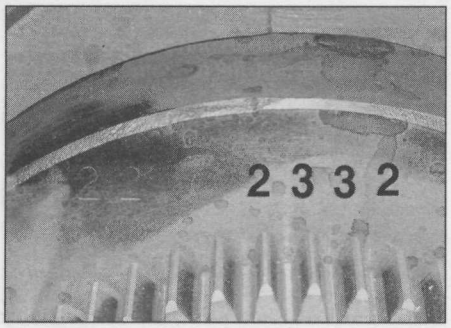
7 Place the crankshaft on V-blocks and check the runout at the main bearing journals using a dial gauge. Compare the reading to the maximum specified at the beginning of the Chapter. If the runout exceeds the limit, the crankshaft must be replaced with a new one.



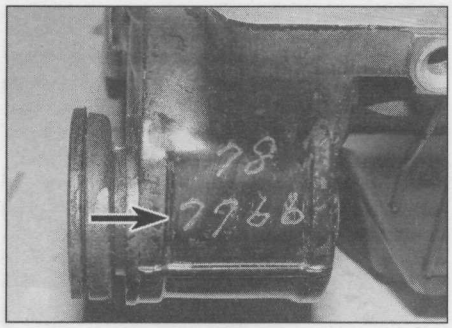
28.4a Check the primary drive and driven gears . . .



28.4b . . . and the cam chains and sprockets



28.21 Main bearing journal size numbers (highlighted)



28.22a Main bearing housing size letters (arrowed)

Oil clearance check

8 Whether new main bearing shells are being fitted or the original ones are being re-used, the oil clearance should be checked before the engine is reassembled. Oil clearance is measured with a product known as Plastigauge. Note that Plastigauge comes in two different sizes, graded according to a range of clearances it can measure – make sure you order the correct one according to the oil clearance figure specified.

9 If not already done, remove the bearing shells from the crankcase halves (see Step 3). Clean the backs of the shells and the bearing housings in both crankcase halves, and the main bearing journals on the crankshaft.

10 Press the bearing shells into their cut-outs, ensuring that the tab on each shell engages in the notch in the crankcase **(see illustration 28.25)**. Make sure the bearings are fitted in the correct locations and take care not to touch any shell's bearing surface with your fingers.

11 Ensure the shells and crankshaft are clean and dry. Position the upper crankcase upside down on the bench, then lay the crankshaft in it.

12 Cut four lengths of the appropriate size Plastigauge (they should be slightly shorter than the width of the crankshaft journals). Place a strand of Plastigauge on each journal, making sure it will be clear of the oil holes in the shells when the lower crankcase is installed. Make sure the crankshaft is not rotated.

13 If removed, fit the dowel into the crankcase **(see illustrations 25.12a)**. Carefully fit the lower crankcase half onto the upper half, making sure the dowel locates correctly and the Plastigauge is not disturbed. Check that the lower crankcase half is correctly seated. **Note:** *Do not tighten the crankcase bolts if the casing is not correctly seated.*

14 Clean the threads of the lower crankcase bolts numbers 1 to 8 and apply a smear of new engine oil to their threads. Install the bolts, not forgetting the oil pipe bracket with bolts 1 and 3 and the washers with the rest **(see illustration 25.9b)**. Secure the bolts finger-tight at first, then tighten them evenly and a little at a time in correct numerical sequence to the torque setting specified at the beginning of the Chapter **(see illustration 25.5)**. Make sure that the crankshaft does not turn as the bolts are tightened.

15 Slacken each bolt in **reverse** sequence starting at number 8 and working backwards to number 1. Slacken each bolt 1/2 a turn at a time until they are all finger tight, then remove them. Carefully lift off the lower crankcase half, making sure the Plastigauge is not disturbed.

16 Compare the width of the crushed Plastigauge on each crankshaft journal to the scale that comes with the Plastigauge to obtain the main bearing oil clearance. Compare the reading to the specifications at the beginning of the Chapter.

17 On completion carefully scrape away all traces of the Plastigauge material from the crankshaft journal and bearing shells; use a fingernail or other object which is unlikely to score them.

18 If the oil clearance falls into the specified range, no bearing shell replacement is required (provided they are in good condition). If the clearance is beyond the service limit, refer to the marks on the crankcase and the marks on the crankshaft and select new bearing shells (see Steps 20 to 23). Fit the new shells and check the oil clearance once again (the new shells should bring the bearing clearance within the specified range). Always renew all of the shells at the same time.

19 If the clearance is still greater than the service limit listed in this Chapter's Specifications (even with replacement shells), the crankshaft journals are worn and the crankshaft should be replaced with a new one.

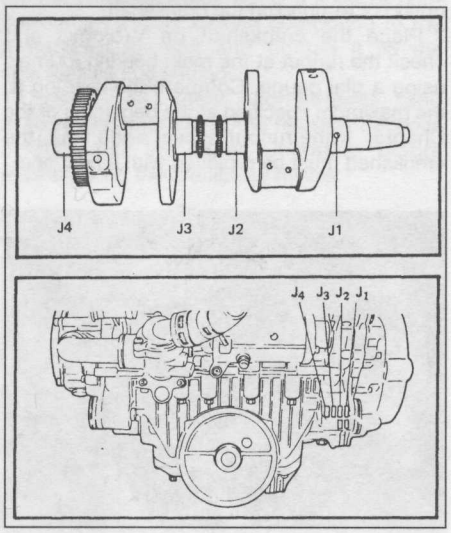
Main bearing shell selection

20 Replacement shells for the main bearings are supplied on a selective fit basis. Code numbers are used to identify the correct replacement bearings.

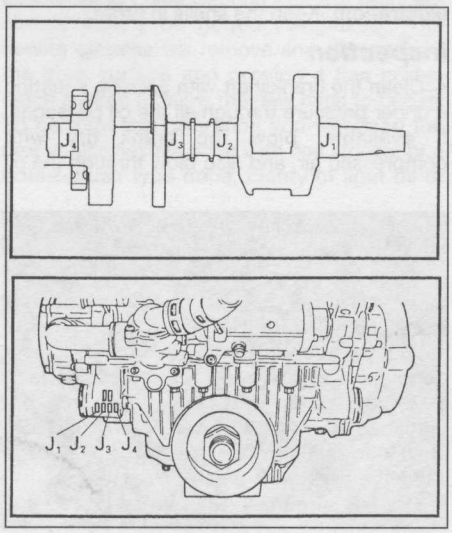
21 The crankshaft journal size numbers are stamped on the outside of the crankshaft web on the right-hand end **(see illustration)**. The right-hand block of four numbers are for the main bearing journals (the left-hand block of two numbers are for the big-end bearing journals). The first number of the four is for the left-hand (No. 1) journal, and so on.

22 The main bearing housing numbers are stamped into the front of the lower crankcase half on one of the engine mounting lugs **(see illustration)**. The block of four numbers are for the main bearings (the block of two numbers are for the balancer shaft bearings). Note that if there is only one number stamped into the crankcase, it means that all journals have the same number.

- If the numbers are etched into the left-hand (alternator) side of the crankcase, the main bearing numbers are above the balancer shaft numbers, and the first number of the four as you look at them is for the right-hand (No. 4) journal, and so on **(see illustration)**.
- If the numbers are etched into the right-hand (clutch) side of the crankcase, the main bearing numbers are below the balancer shaft numbers, and the first number of the four as you look at them is for the left-hand (No. 1) journal, and so on **(see illustration)**.



28.22b Main bearing housing code number location on left-hand side



28.22c Main bearing housing code number location on right-hand side

23 A range of bearing shells is available. To select the correct bearing for a particular journal, subtract the main bearing journal number (stamped on the crank web) from the main bearing housing number (stamped on the crankcase), i.e. crankcase number minus crank web number. Compare the result with the table below to find the colour coding of the replacement bearing required. The colour is marked on the side of each bearing **(see illustration 21.24)**.

Number	Colour
1	Blue
2	Black
3	Brown
4	Green
5	Yellow
6	Pink
7	Red

Installation

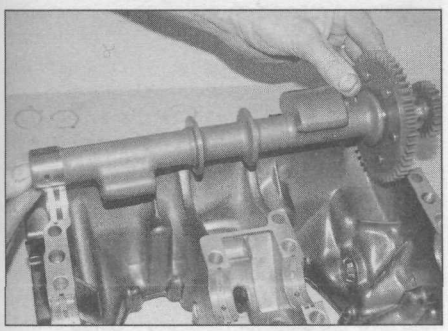
24 If not already done, remove the bearing shells from the crankcase halves (see Step 3). Clean the backs of the shells and the bearing housings in both crankcase halves. If new shells are being fitted, ensure that all traces of the protective grease are cleaned off using paraffin (kerosene). Wipe the shells and crankcase halves dry with a lint-free cloth. Make sure all the oil passages and holes are clear, and blow them through with compressed air if it is available.

25 Press the bearing shells into their locations. Make sure the tab on each shell engages in the notch in the housing **(see illustration)**. If the original shells are being used, make sure they are fitted in the correct locations and take care not to touch any shell's bearing surface with your fingers. Lubricate each shell with molybdenum disulphide oil (a 50/50 mixture of molybdenum disulphide grease and clean engine oil).

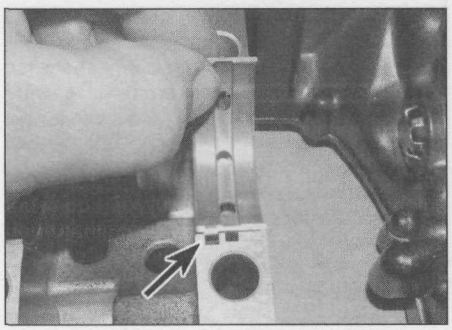
26 Loop the cam chains around the sprockets on the crankshaft. If the balancer shaft is in the crankcase, rotate it so that the alignment mark on its driven gear is facing back and level with the crankcase mating surface **(see illustration)**. If the balancer shaft has been removed, install it now (see Section 29).

27 Identify the corresponding alignment mark on the primary drive/balancer drive gear on the crankshaft. Lower the crankshaft into position in the lower crankcase, making sure all bearings remain in place, and aligning the mark on the primary drive/balancer drive gear with that on the balancer driven gear **(see illustration 28.2)**.

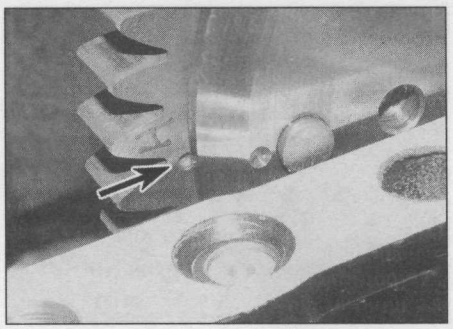
28 Reassemble the crankcase halves (see Section 25).



29.2 Lift the balancer shaft out of the crankcase



28.25 Fit the shells, locating the tabs in the notches (arrowed)



28.26 Rotate the balancer shaft so the alignment punch mark (arrowed) is facing back and level with the surface

29 Balancer shaft and bearings – removal, inspection and installation

Note: *To remove the balancer shaft the engine must be removed from the frame and the crankcase halves separated.*

Removal

1 Remove the engine from the frame (see Section 5) and separate the crankcase halves (see Section 25).

2 Lift the balancer shaft out of the lower crankcase half, taking care not to dislodge its bearing shells **(see illustration)**.

3 The bearing shells can be removed from the crankcase halves by pushing their centres to the side, then lifting them out **(see illustration 28.3)**. Keep the shells in order.

Inspection

4 Clean the balancer shaft with solvent. If available, blow it dry with compressed air. Check the driven gear for wear or damage **(see illustration)**. If any of the gear teeth are excessively worn, chipped or broken, the balancer shaft must be replaced with a new one. If wear or damage is found, also inspect the drive gear on the crankshaft. Similarly check the water pump drive gear on the end of the shaft, and its driven gear in the pump housing.

5 Refer to Section 27 and examine the bearing shells. If they are scored, badly scuffed or appear to have been seized, new bearings must be installed. Always replace the bearings as a set. If they are badly damaged, check the corresponding balancer shaft journals. Evidence of extreme heat, such as discoloration, indicates that lubrication failure has occurred. Be sure to thoroughly check the oil pump and pressure relief valve as well as all oil holes and passages before reassembling the engine.

6 Give the balancer shaft journals a close visual examination, paying particular attention where damaged bearings have been discovered. If the journals are scored or pitted in any way a new shaft will be required. Note that undersizes are not available, precluding the option of re-grinding the journals.

Oil clearance check

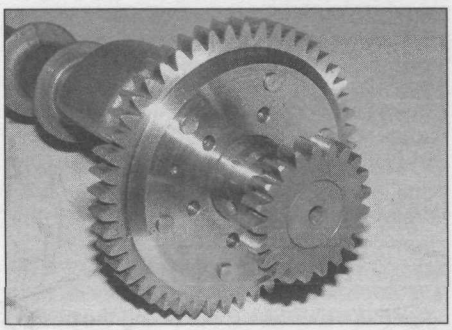
7 Whether new bearing shells are being fitted or the original ones are being re-used, the bearing oil clearance should be checked before the engine is reassembled. Bearing oil clearance is measured with a product known as Plastigauge. Note that Plastigauge comes in two different sizes, graded according to a range of clearances it can measure – make sure you order the correct one according to the oil clearance figure specified.

8 If not already done, remove the bearing shells from the crankcase halves (see Step 3). Clean the backs of the shells and the bearing housings in both crankcase halves, and the bearing journals on the balancer shaft.

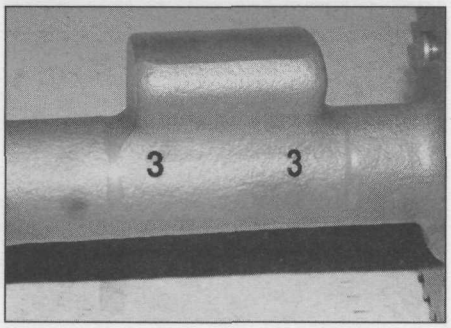
9 Press the bearing shells into their cut-outs, ensuring that the tab on each shell engages in the notch in the crankcase **(see illustration 28.25)**. Make sure the bearings are fitted in the correct locations and take care not to touch any shell's bearing surface with your fingers.

10 Ensure the shells and balancer shaft are clean and dry. Position the upper crankcase upside down on the bench, then lay the balancer shaft in it.

11 Cut two lengths of the appropriate size



29.4 Check the driven gear and water pump drive gear for wear and damage



29.20 Balancer shaft bearing journal size numbers

Plastigauge (they should be slightly shorter than the width of the balancer shaft journals). Place a strand of Plastigauge on each journal, making sure it will be clear of the oil holes in the shells when the lower crankcase is installed. Make sure the balancer shaft is not rotated.

12 If removed, fit the dowel into the crankcase **(see illustration 25.12a)**. Carefully fit the lower crankcase half onto the upper half, making sure the dowel locates correctly and the Plastigauge is not disturbed. Check that the lower crankcase half is correctly seated. **Note:** *Do not tighten the crankcase bolts if the casing is not correctly seated.*

13 Clean the threads of the lower crankcase bolts numbers 9 to 12 and apply a smear of new engine oil to their threads **(see illustration 25.5 and 9a)**. Install the bolts and secure them finger-tight at first, then tighten them evenly and a little at a time in correct numerical sequence to the torque setting specified at the beginning of the Chapter, noting that they are 8 mm bolts. Make sure that the balancer shaft does not turn as the bolts are tightened.

14 Slacken each bolt in reverse sequence. Slacken each bolt 1/2 a turn at a time until they are all finger-tight, then remove them. Carefully lift off the lower crankcase half, making sure the Plastigauge is not disturbed.

15 Compare the width of the crushed Plastigauge on each journal to the scale that comes with the Plastigauge to obtain the bearing oil clearance. Compare the reading to the specifications at the beginning of the Chapter.

16 On completion carefully scrape away all traces of the Plastigauge material from the crankshaft journal and bearing shells; use a fingernail or other object which is unlikely to score them.

17 If the oil clearance falls into the specified range, no bearing shell replacement is required (provided they are in good condition). If the clearance is beyond the service limit, refer to the marks on the crankcase and the marks on the balancer shaft and select new bearing shells (see Steps 19 to 22). Fit the new shells and check the oil clearance once again (the new shells should bring the bearing clearance within the specified range). Always renew all of the shells at the same time.

18 If the clearance is still greater than the service limit listed in this Chapter's Specifications (even with replacement shells), the balancer shaft journals are worn and the balancer shaft should be replaced with a new one.

Bearing shell selection

19 Replacement shells for the bearings are supplied on a selective fit basis. Code numbers are used to identify the correct replacement bearings.

20 The balancer shaft journal size numbers are stamped on the right-hand balance weight on the shaft **(see illustration)**. The first number of the two is for the left-hand journal, and the second is for the right journal.

21 The bearing housing numbers are stamped into the front of the lower crankcase half on one of the engine mounting lugs **(see illustration)**. The block of two numbers are for the balancer shaft bearings (the block of four numbers are for the main bearings). Note that if there is only one number stamped into the crankcase, it means that both journals have the same number.

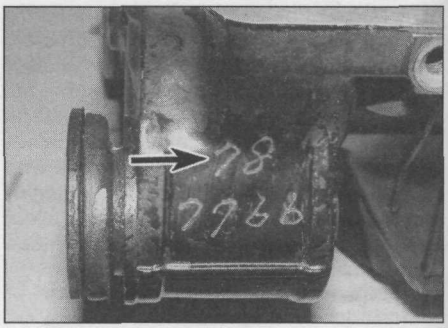
- If the numbers are etched into the left-hand (alternator) side of the crankcase, the balancer shaft numbers are below the main bearing numbers, and the first number of the two as you look at them is for the right-hand journal, and the second is for the left journal.
- If the numbers are etched into the right-hand (clutch) side of the crankcase, the balancer shaft numbers are above the main bearing numbers, and the first number of the two as you look at them is for the left-hand journal, and the second is for the right journal.

22 A range of bearing shells is available. To select the correct bearing for a particular journal, subtract the balancer shaft bearing journal number (stamped on the shaft balance weight) from the bearing housing number (stamped on the crankcase), i.e. crankcase number minus shaft number. Compare the result with the table below to find the colour coding of the replacement bearing required. The colour is marked on the side of each bearing **(see illustration 21.24)**.

Number	Colour
1	Blue
2	Black
3	Brown
4	Green
5	Yellow
6	Pink
7	Red

Installation

23 If not already done, remove the bearing shells from the crankcase halves (see Step 3). Clean the backs of the shells and the bearing housings in both crankcase halves. If new shells are being fitted, ensure that all traces of the protective grease are cleaned off using paraffin (kerosene). Wipe the shells and crankcase halves dry with a lint-free cloth.



29.21 Balancer shaft bearing housing size letters (arrowed)

Make sure all the oil passages and holes are clear, and blow them through with compressed air if it is available.

24 Press the bearing shells into their locations. Make sure the tab on each shell engages in the notch in the housing **(see illustration 28.25)**. If the original shells are being used, make sure they are fitted in the correct locations and take care not to touch any shell's bearing surface with your fingers. Lubricate each shell with molybdenum disulphide oil (a 50/50 mixture of molybdenum disulphide grease and clean engine oil).

25 If the crankshaft is in the crankcase, rotate it so that the alignment mark on the primary drive/balancer shaft drive gear is facing forward and level with the crankcase mating surface. Identify the corresponding alignment mark on the balancer driven gear **(see illustration 28.26)**. Lower the balancer shaft into position in the lower crankcase, making sure all bearings remain in place, and aligning the mark on the balancer driven gear with that on the primary drive/balancer drive gear.

26 If the crankshaft has been removed, lay the balancer shaft in the lower crankcase, then rotate it so that the alignment mark on its driven gear is facing back and level with the crankcase mating surface **(see illustration 28.26)**. Now install the crankshaft (see Section 28).

27 Reassemble the crankcase halves (see Section 25).

30 Transmission shafts and bearings – removal and installation

Note: *To remove the transmission shafts the engine must be removed from the frame and the crankcases separated. If the engine has already been removed, ignore the steps which do not apply.*

Removal

1 Remove the engine from the frame (see Section 5) and separate the crankcase halves (see Section 25). Before removing the shafts note how the selector forks are located in their respective pinion grooves.

2 Lift the input shaft out of the crankcase

(see illustration). If it is stuck, use a soft-faced hammer and gently tap on the ends of the shaft to free it. Remove the bearing half-ring retainer from the bearing on the left-hand end of the shaft or from the crankcase, noting how it fits **(see illustration)**.

3 Lift the output shaft out of the crankcase **(see illustration)**. If it is stuck, use a soft-faced hammer and gently tap on the ends of the shaft to free it. Remove the bearing half-ring retainer from the bearing on the right-hand end of the shaft or from the crankcase, noting how it fits **(see illustration)**.

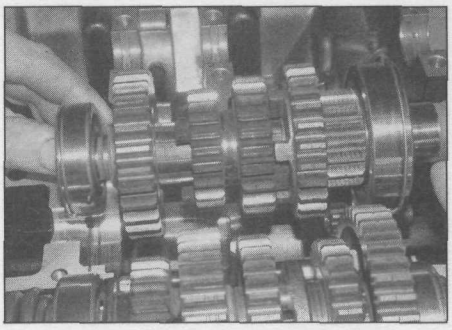
4 Refer to Section 31 for disassembly and inspection of the transmission shafts.

Installation

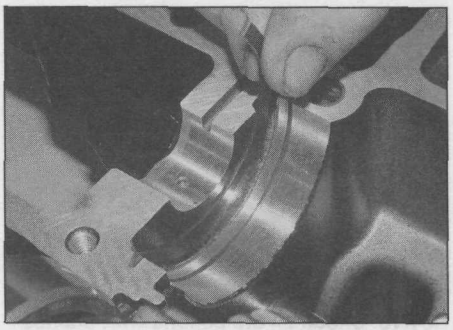
5 Fit the half-ring retainers for the output shaft right-hand bearing and the input shaft left-hand bearing into their slots in the bearing housings in the crankcase **(see illustrations 30.3b and 2b)**.

6 Rotate the bearing on the right-hand end of the output shaft so that its locating pin faces back, and the bearing in the middle of the shaft so that its locating pin faces forwards. Lower the shaft into position in the lower crankcase **(see illustration 30.3a)**, making sure the selector forks locate in their pinion groove, the locating pin for each bearing locates in its cut-out in the crankcase, and the groove in the right-hand bearing engages correctly with the retainer in the bearing housing **(see illustrations)**. Also ensure that the shim between the bearing and the middle drive gear on the left-hand end of the shaft locates on the outside of the crankcase wall between it and the bearing **(see illustration)**.

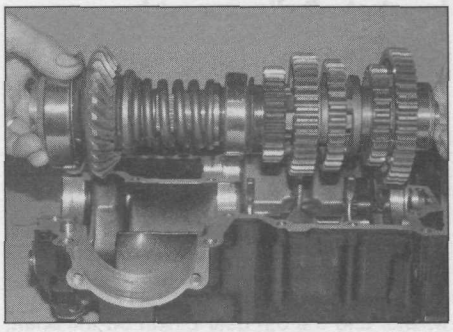
7 Rotate the bearing on the left-hand end of the input shaft so that is locating pin faces back, and the bearing on the right-hand end of the shaft so that is locating pin faces forwards. Lower the shaft into position in the lower crankcase **(see illustration 30.2a)**, making sure the selector fork locates in its pinion groove, the groove in the left-hand bearing engages correctly with the retainer in the bearing housing, and the retaining ring around the right-hand bearing locates in its groove in the bearing housing, and the locating pin for each bearing locates in its cut-out in the crankcase **(see illustrations)**.



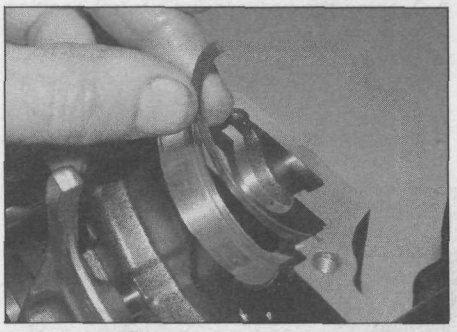
30.2a Lift the input shaft out of the crankcase . . .



30.2b . . . and remove the half-ring retainer



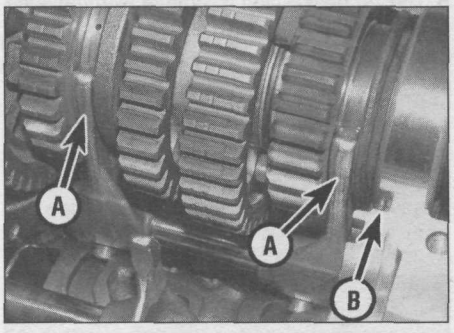
30.3a Lift the output shaft out of the crankcase . . .



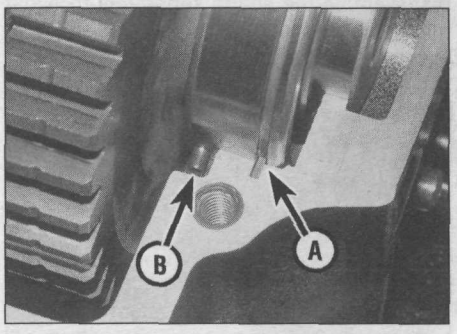
30.3b . . . and remove the half-ring retainer

Caution: If the bearing retainers or pins do not locate correctly, the crankcase halves will not seat properly.

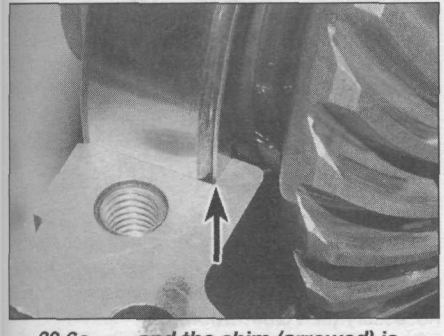
8 Make sure both transmission shafts are correctly seated and their related pinions are correctly engaged.



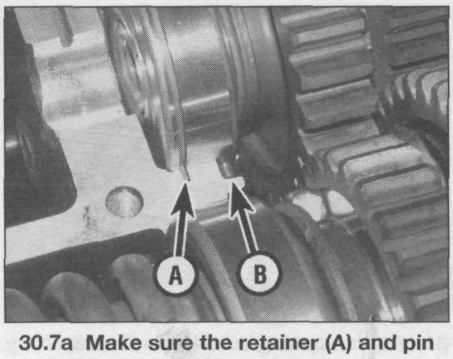
30.6a Make sure the selector forks (A) locate correctly in their grooves and the pin on the middle bearing locates in its cut-out (B) . . .



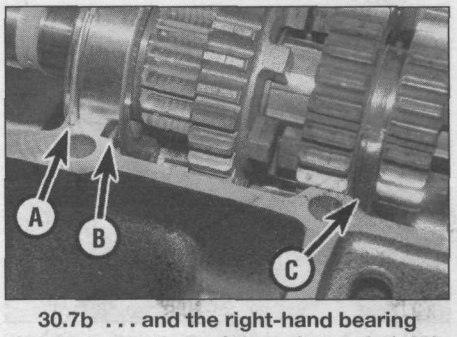
30.6b . . . the retainer locates in its slot in the right-hand bearing (A) and the pin locates in its cut-out (B) . . .



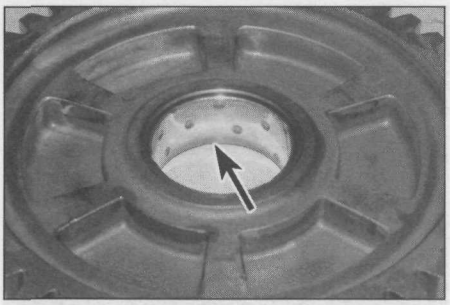
30.6c . . . and the shim (arrowed) is correctly positioned



30.7a Make sure the retainer (A) and pin (B) on the left-hand bearing . . .



30.7b . . . and the right-hand bearing locate correctly, and the selector fork (C) locates in its groove

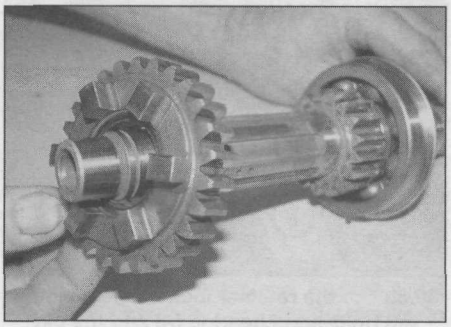


31.10 Check all the pinions with bushes (arrowed) as described for wear and play on the shaft

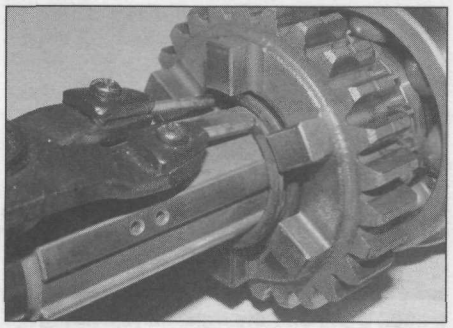
9 Position the gears in the neutral position (this is when the pinions that carry the selector forks are positioned between the gears either side of them so that none of the dogs are engaged in the holes) and check the shafts are free to rotate easily and independently (i.e. the input shaft can turn whilst the output shaft is held stationary) before proceeding further.
10 Reassemble the crankcase halves (see Section 25).

31 Transmission shafts – disassembly, inspection and reassembly

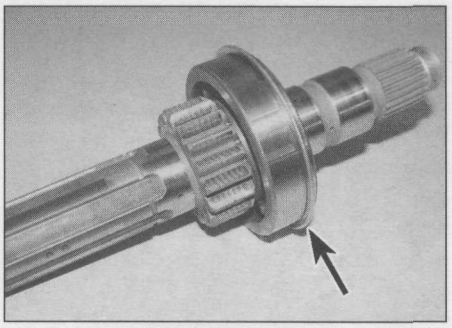
1 Remove the transmission shafts from the crankcase (see Section 30). Always disassemble the shafts separately to avoid mixing up the components.



31.16a Slide the 4th gear pinion . . .



31.16c . . . then fit the circlip . . .

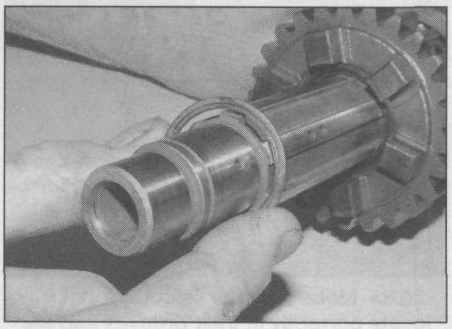


31.15 Make sure the retainer (arrowed) faces away from the 1st gear pinion

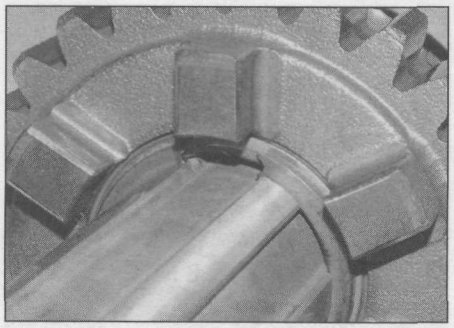
Input shaft disassembly

> **HAYNES HiNT** ***When disassembling the transmission shafts, place the parts on a long rod or thread a wire through them to keep them in order and facing the proper direction.***

2 Remove the bearing from the left end of the shaft **(see illustration 31.19)**.
3 Remove the circlip, then slide the thrust washer and the 5th gear pinion off the shaft, followed by the combined 2nd/3rd gear pinion **(see illustrations 31.18c, b and a and 31.17)**.
4 Remove the circlip securing the 4th gear pinion, then slide the splined washer and the pinion off the shaft **(see illustrations 31.16c, b and a)**.
5 The 1st gear pinion is integral with the shaft **(see illustration 31.15)**.



31.16b . . . and the splined washer onto the shaft . . .



31.16d . . . making sure it locates correctly in the groove

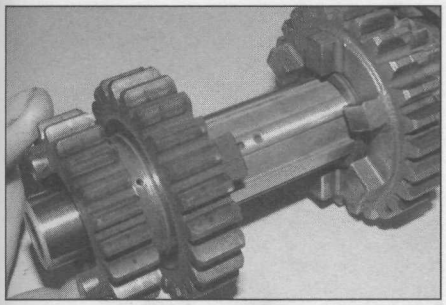
6 If required, remove the bearing from the right-hand end of the shaft, referring to *Tools and Workshop Tips* (Section 5) in the Reference Section if necessary **(see illustration 31.15)**.

Input shaft inspection

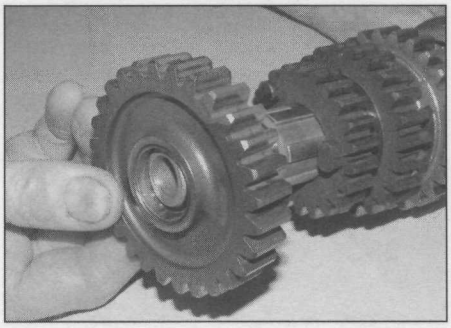
7 Wash all of the components in clean solvent and dry them off.
8 Check the gear teeth for cracking, chipping, pitting and other obvious wear or damage. Any pinion that is damaged as such must be replaced with a new one.
9 Inspect the dogs and the dog holes in the gears for cracks, chips, and excessive wear especially in the form of rounded edges. Make sure mating gears engage properly. Replace the paired gears as a set with new ones if necessary.
10 Check for signs of wear, scoring or bluing on the pinions, their bushes (where fitted) and shaft **(see illustration)**. This could be caused by overheating due to inadequate lubrication. In particular check the pinion bushes for signs of wear, evident by a reduction in the depth of the oil holes, and any play between the pinion and its portion of the shaft when fitted on. Once the bush starts to wear and the holes are less and less able to hold oil, which will then leak out due to the poor fit of the pinion on the shaft, the wear rate increases. Replace any worn or damaged pinions with new ones.
11 Check that each pinion moves freely on the shaft but without undue freeplay. Refer to *Tools and Workshop Tips* (Section 5) in the Reference Section and check the bearings as described. Replace them with new ones if necessary.
12 Check the surface of the shaft and replace it with a new one if it has scored or picked up, or if there are any cracks. Place the shaft on V-blocks and check for runout at the centre using a dial gauge. Compare the reading to the maximum specified at the beginning of the Chapter. If the runout exceeds the limit, the shaft must be replaced with a new one.
13 Check the washers and circlips and discard any that are bent or appear weakened or worn. Use new ones if in any doubt. Note that it is good practice to renew all circlips when overhauling gearshafts.

Input shaft reassembly

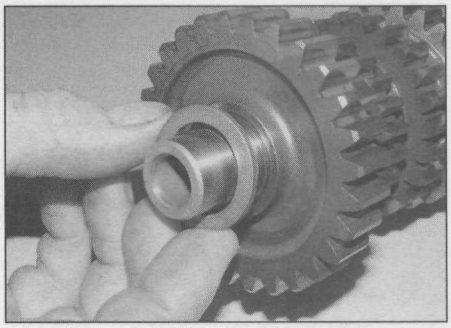
14 During reassembly, apply molybdenum disulphide oil (a 50/50 mixture of molybdenum disulphide grease and clean engine oil) to the mating surfaces of the shaft, pinions and bushes. When installing the circlips, do not expand their ends any further than is necessary. Install the stamped circlips and washers so that their chamfered side faces the pinion it secures.
15 If removed, fit the bearing onto the right-hand end of the shaft, making sure the locating pin is facing the 1st gear pinion and the retainer is on the outside. Refer to *Tools and Workshop Tips* (Section 5) in the Reference Section if necessary **(see illustration)**.
16 Slide the 4th gear pinion onto the left hand end of the shaft with its dogs facing



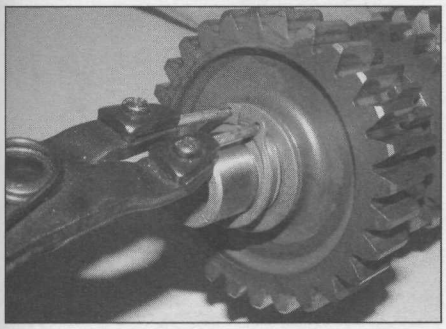
31.17 Slide the combined 2nd/3rd gear pinion onto the shaft, aligning the oil holes . . .



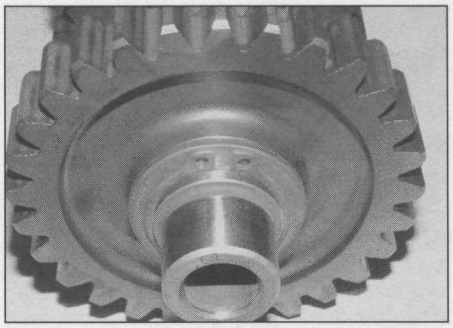
31.18a . . . followed by the 5th gear pinion . . .



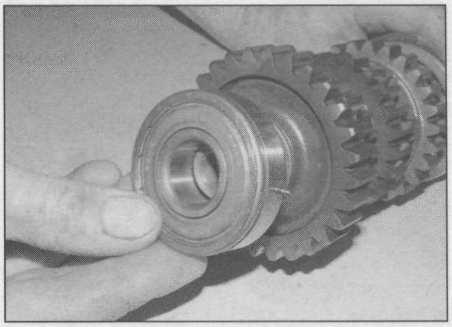
31.18b . . . and the thrust washer . . .



31.18c . . . then fit the circlip . . .



31.18d . . . making sure it locates correctly in the groove



31.19 Slide the bearing onto the shaft

away from the integral 1st gear pinion **(see illustration)**. Slide the splined washer onto the shaft, then fit the circlip, making sure it locates correctly in its groove **(see illustrations)**.

17 Slide the combined 2nd/3rd gear pinion onto the shaft so that the larger (3rd) gear pinion faces the 4th gear pinion, and aligning the oil holes **(see illustration)**.

18 Slide the 5th gear pinion onto the shaft so that its dog holes face the 2nd gear pinion, then follow this with the thrust washer **(see illustrations)**. Secure them in place with the circlip, making sure it locates correctly in its groove **(see illustration)**.

19 Slide the bearing onto the shaft, making sure the locating pin is facing the 5th gear pinion and the retainer groove is on the outside **(see illustration)**.

20 Check that all components have been correctly installed **(see illustration)**.

Output shaft disassembly

21 Slide the bearing off the right-hand end of the shaft, and where fitted remove the shim(s) **(see illustration 31.35)**.

22 Slide the 1st gear pinion and the 4th gear pinion off the shaft **(see illustrations 31.34 and 33)**.

23 Remove the circlip securing the 3rd gear pinion, then slide the splined washer and the pinion off the shaft **(see illustrations 31.32c, b and a)**.

24 Remove the middle drive gear assembly from the left-hand end of the shaft (see Section 24).

25 Slide the bearing and the 5th gear pinion off the shaft **(see illustrations 31.30 and 29)**.

26 Remove the circlip securing the 2nd gear pinion, then slide the splined washer and the pinion off the shaft **(see illustrations 31.28c, b and a)**.

Output shaft inspection

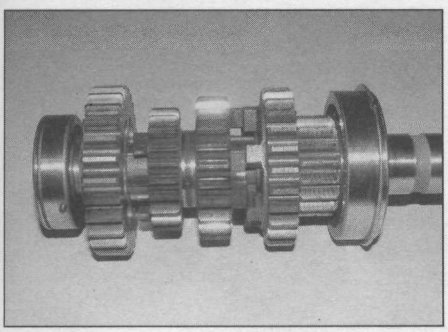
26 Refer to Steps 7 to 13 above.

Output shaft reassembly

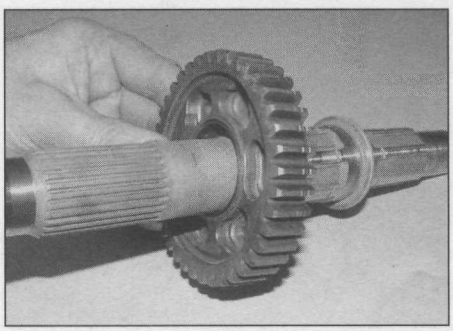
27 During reassembly, apply engine oil to the mating surfaces of the shaft and pinions. When installing the circlips, do not expand the ends any further than is necessary. Install the stamped circlips and washers so that their chamfered side faces the pinion it secures.

28 Slide the 2nd gear pinion onto the shaft with its dog holes facing away from the centre ridge, followed by the splined washer **(see illustrations)**. Fit the circlip, making sure it is locates correctly in its groove in the shaft **(see illustrations)**.

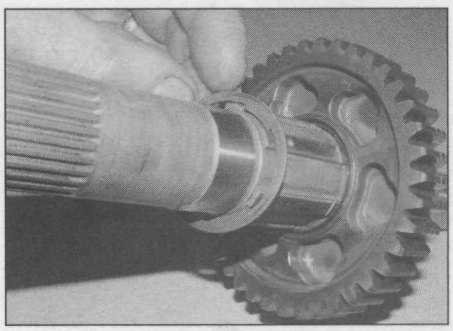
29 Slide the 5th gear pinion onto the shaft with its selector fork groove facing away from the 2nd gear pinion **(see illustration)**.



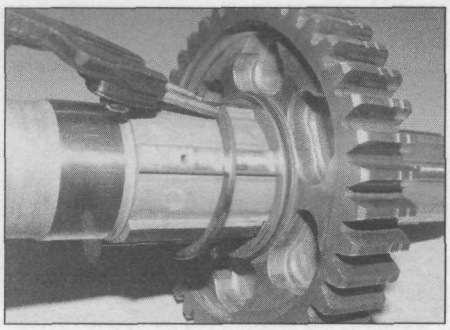
31.20 The assembled input shaft should be as shown



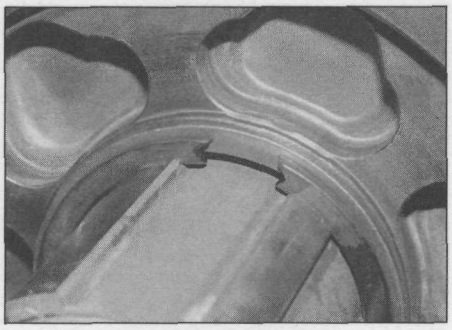
31.28a Slide the 2nd gear pinion . . .



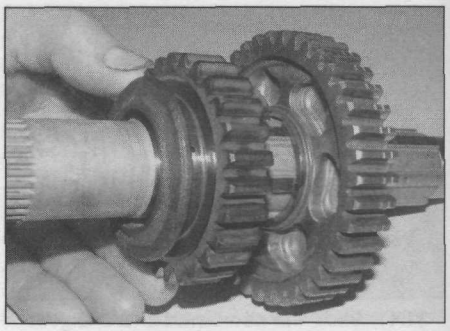
31.28b . . . and the splined washer onto the shaft . . .



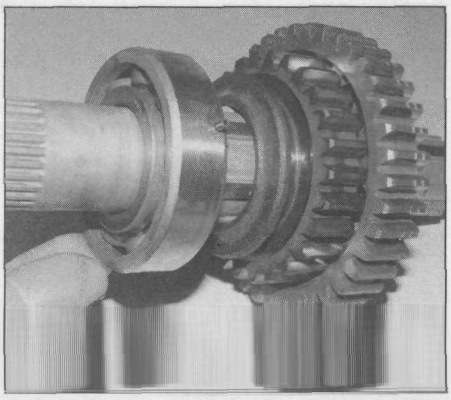
31.28c . . . then fit the circlip . . .



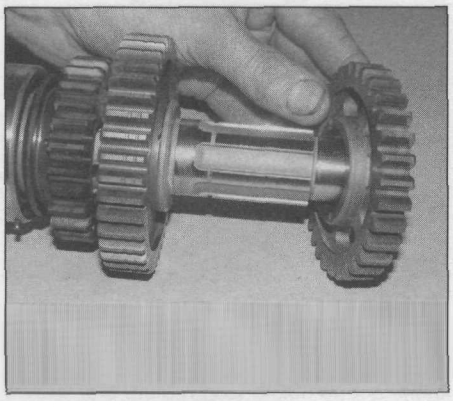
31.28d . . . making sure it locates in its groove



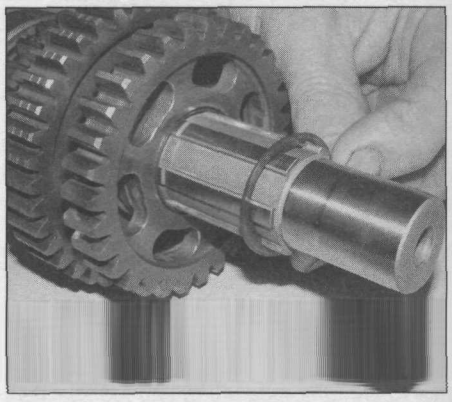
31.29 Slide the 5th gear pinion onto the shaft . . .



31.30 . . . followed by the bearing



31.32a Slide the 3rd gear pinion . . .



31.32b . . . and the splined washer onto the shaft . . .

30 Slide the bearing onto the shaft, making sure the locating pin is facing the 5th gear pinion **(see illustration)**.

31 Install the middle drive gear assembly on the left-hand end of the shaft (see Section 24).

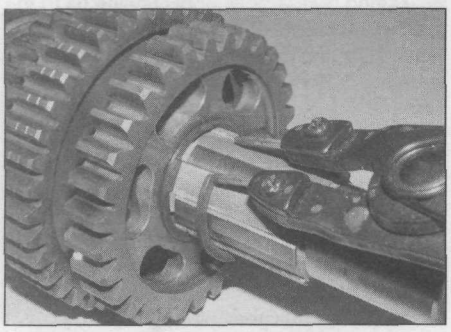
32 Slide the 3rd gear pinion onto the right-hand end of the shaft with its raised hub facing the central ridge, followed by the splined washer **(see illustrations)**. Fit the circlip, making sure it is locates correctly in its groove in the shaft **(see illustrations)**.

33 Slide the 4th gear pinion onto the shaft, with its selector fork groove facing the 3rd gear pinion **(see illustration)**.

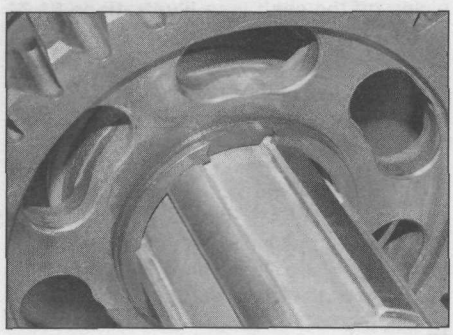
34 Slide the 1st gear pinion onto the shaft with its dog holes facing the 4th gear pinion **(see illustration)**.

35 Where removed, slide the shim(s) onto the shaft. Slide the bearing onto the shaft, making sure the locating pin is facing the 1st gear pinion and the retainer groove is on the outside **(see illustration)**.

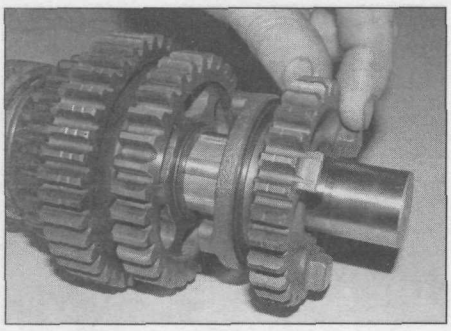
36 If any of the middle drive gear assembly or output shaft components have been replaced with new ones, measure the length of the combined assembly from the outside edge of the bearing on the right-hand end to the outer edge of the bevel gear, and compare it to the



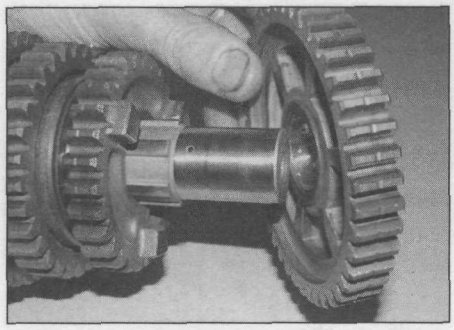
31.32c . . . then fit the circlip . . .



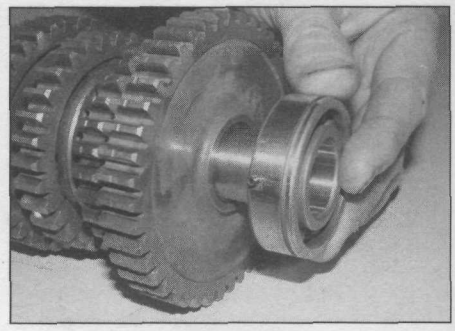
31.32d . . . making sure it locates in its groove



31.33 Slide the 4th gear pinion onto the shaft . . .



31.34 . . . followed by the 1st gear pinion . . .



31.35 . . . then fit the bearing

length specified at the beginning of the Chapter **(see illustration)**. If the measured length is less than the minimum specified, you need to add shims between the 1st gear pinion and the bearing on the right-hand end of the shaft as required to restore the length. If it is greater than the maximum specified, and shims are already installed, remove or change them as required to restore the length. Three shims are available in sizes of 0.5 mm, 0.9 mm and 1.3 mm. Use one or more as required. Note that if the measured length is greater than the maximum specified and no shims are installed, you have probably assembled the shaft incorrectly.

37 Check that all components have been correctly installed **(see illustration)**.

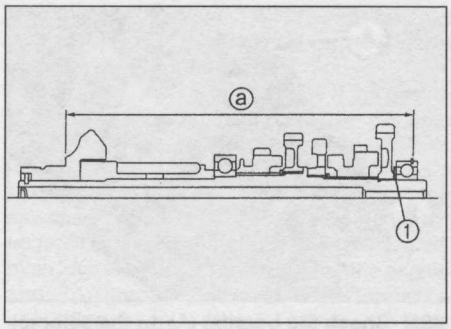
32 Selector drum and forks – removal, inspection and installation

Note: *To remove the selector drum and forks the engine must be removed from the frame and the crankcase halves separated.*

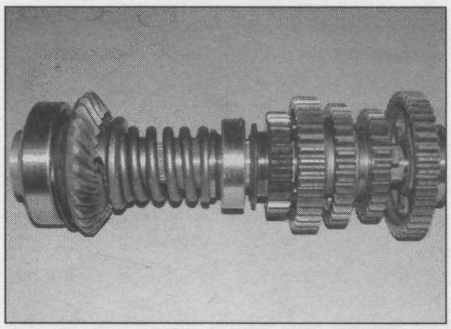
Removal

1 Separate the crankcase halves (see Section 25). The selector drum and forks are located in the lower half. If not already done, remove the gearchange mechanism (see Section 18).

2 Undo the screws securing the selector drum bearing/fork shaft retainer plate and remove it **(see illustration)**. If the screws are difficult to remove use an impact driver.



31.36 Output shaft combined length measurement (a) and shim location (1)



31.37 The assembled output shaft should be as shown

3 Before removing the selector forks, note that each fork is numbered for identification. The left-hand fork (on the rear shaft) is numbered 1, the centre fork (front shaft) 2, and the right-hand fork (rear shaft) 3 **(see illustration)**. These letters face the left-hand side of the engine. If no numbers are visible, mark them yourself using a felt pen. Withdraw the selector fork shafts from the right-hand side and remove the forks **(see illustration, 32.12 and 32.13a and b)**. Install the forks back on their shaft in their correct positions as a reminder for installation. Note that on later models the forks may be lettered instead of numbered – if so, the left-hand fork (on the rear shaft) is lettered L, the centre fork (front shaft) C, and the right-hand fork (rear shaft) R. These letters face the right-hand side of the engine.

4 Withdraw the selector drum from the crankcase **(see illustration)**.

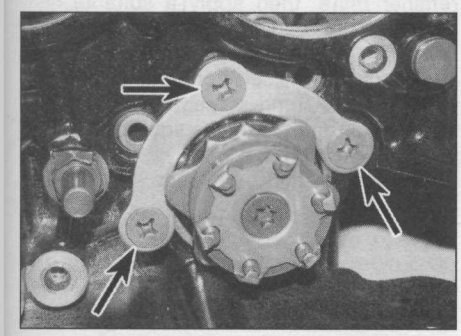
Inspection

5 Inspect the selector forks for any signs of wear or damage, especially around the fork ends where they engage with the groove in the pinion **(see illustration)**. Check that each fork fits correctly in its pinion groove. Check closely to see if the forks are bent. If the forks are in any way damaged they must be replaced with new ones.

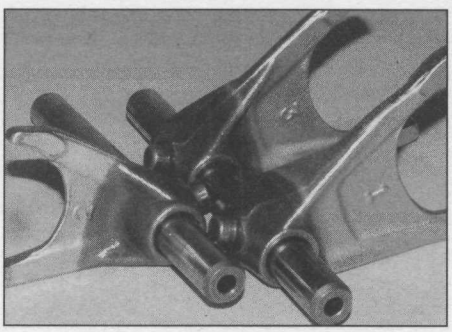
6 Check that the forks fit correctly on their shaft **(see illustration)**. They should move freely with a light fit but no appreciable freeplay. Check that the fork shaft holes in the casing are not worn or damaged.

7 The selector fork shafts can be checked for trueness by rolling them along a flat surface. A bent rod will cause difficulty in selecting gears and make the gearchange action heavy. Replace the shafts with new ones if bent.

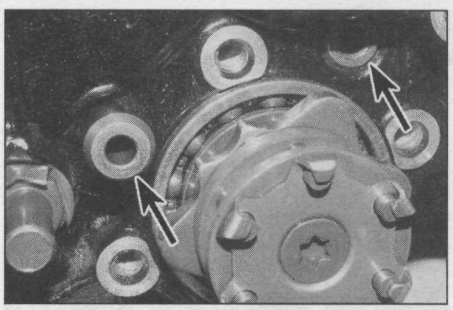
8 Inspect the selector drum grooves and selector fork guide pins for signs of wear or



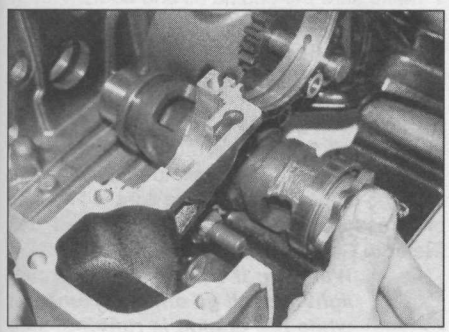
32.2 Undo the screws (arrowed) and remove the plate



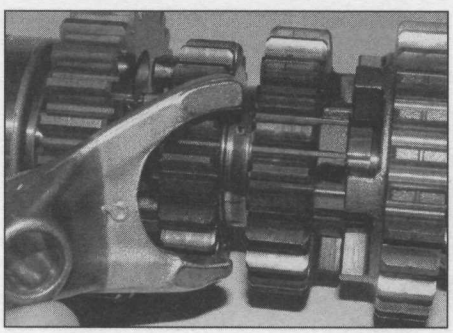
32.3a Note the number or letter on each fork denoting its position



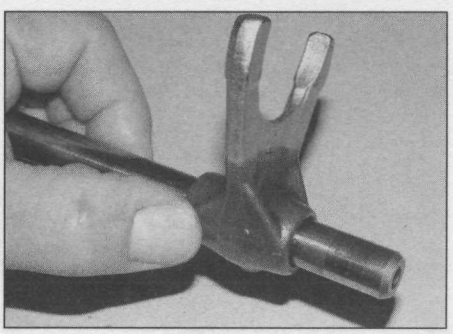
32.3b The fork ends (arrowed) may be recessed, in which case push them out from the inside



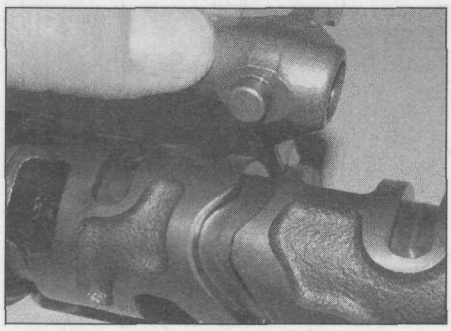
32.4 Withdraw the selector drum from the crankcase



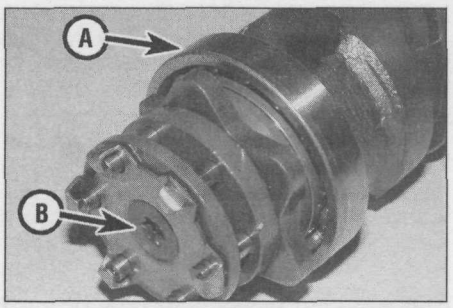
32.5 Check the fork ends and the grooves in the pinions they locate in



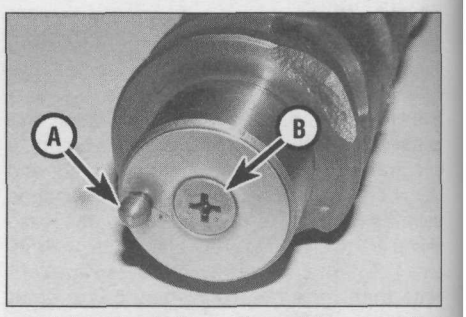
32.6 Check the fit of each fork on its shaft



32.8 Check the fork guide pins and the grooves in the selector drum



32.9 Check the bearing (A) on the selector drum. Remove the screw (B) and components as described to remove it



32.10 Check the action of the neutral contact (A). Remove the screw (B) and plate to remove it, noting the spring

damage **(see illustration)**. If either show signs of wear or damage they must be replaced with new ones.

9 Check that the selector drum bearing rotates freely and has no signs of roughness or excessive freeplay between it and the drum or crankcase (when installed) (see *Tools and Workshop Tips* (Section 5) in the Reference Section for more information on bearings) **(see illustration)**. Replace the bearing with a new one if necessary – undo the centre Torx screw and remove the drum end, taking care not to let the pins drop out, then remove the pins, noting the location of the longer one, and cam, again taking care not to let the locating pin between the inner face of the cam and the selector drum body drop out. Remove the spacer and the bearing. On reassembly, apply a suitable non-permanent thread locking compound to the Torx screw.

10 Check the action of the neutral switch contact in the left-hand end of the drum – it should move in smoothly when pushed and return under spring pressure **(see illustration)**. Also check that the tip is not worn. To replace it with a new one, undo the screw in the centre of the plate, then remove the plate, noting how the plunger locates in the cut-out, and taking care not to lose the spring which may ping out. On reassembly, apply a suitable non-permanent thread locking compound to the screw.

Installation

11 Slide the selector drum into the crankcase **(see illustration 32.4)**, aligning it so that the contact for the neutral switch points to the front of the engine and slightly down (8 o'clock position as you look at it) and aligns with the corresponding contact on the neutral switch if it is installed, and the neutral detent for the stopper arm points to the 11 o'clock position **(see illustration)**.

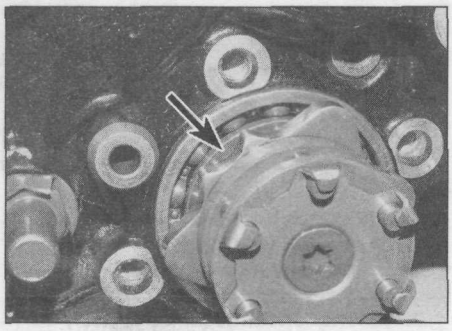
12 Refer to Step 3 for the correct location of each fork. Lubricate the front selector fork shaft with clean engine oil. Slide the shaft into the crankcase from the right-hand side and through the number 2 or C fork, making sure the number faces the left-hand side of the crankcase or the letter faces the right, locating the guide pin on the end of the fork in its groove in the drum as you do **(see illustration)**.

13 Lubricate the rear selector fork shaft with clean engine oil. Slide the shaft into the crankcase from the right-hand side and through the numbers 3 and 1 (or R and L) forks in turn, making sure the numbers face the left-hand side of the crankcase or the letters face the right, locating the guide pin on the end of each fork in its groove in the drum as you do **(see illustrations)**.

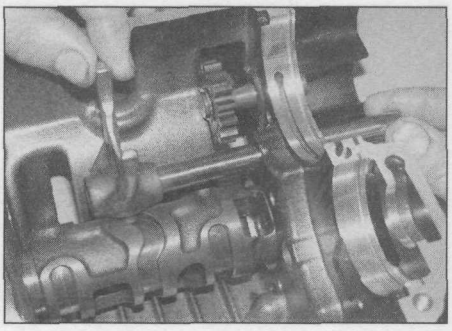
14 Check again that the forks are correctly positioned (see Step 3). Fit the bearing retainer plate, then apply a suitable non-permanent threadlock to the screws and tighten them **(see illustration 32.2)**.

15 Check that the selector drum and selector forks all rotate or move freely, then re-position the selector drum in the neutral position **(see illustration 32.11)**.

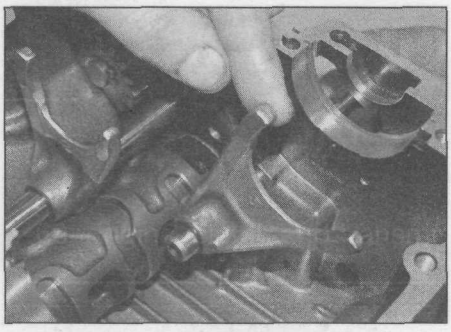
16 Assemble the crankcase halves (see Section 25).



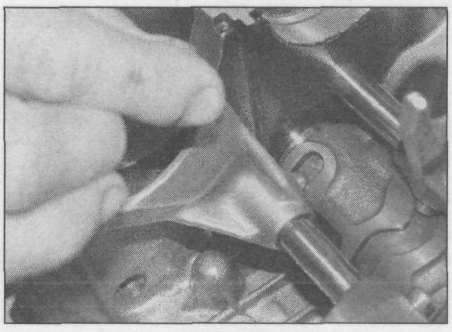
32.11 Set the drum so that the neutral detent (arrowed) is positioned as shown



32.12 Slide the front shaft in and through the No. 2 or C fork



32.13a Slide the rear shaft through the No. 3 or R fork . . .



32.13b . . . and the No. 1 or L fork

33 Initial start-up after overhaul

1 Make sure the engine oil and coolant levels are correct (see *Daily (pre-ride) checks*). Make sure there is fuel in the tank.

2 Ensure the engine kill switch is in the RUN position and select neutral.

3 Start the engine as normal using the choke and allow it to run at a moderately fast idle until it reaches operating temperature.

4 As no oil pressure warning light is fitted, an oil pressure check should be carried out. (Refer to Chapter 1 for details of the check).

Warning: If the oil level warning light doesn't go off, or it comes on while the engine is running, stop the engine immediately.

5 Check carefully for oil and coolant leaks

and make sure the transmission and controls, especially the brakes, function properly before road testing the machine. Refer to Section 34 for the recommended running-in procedure.

6 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 and coolant levels (see *Daily (pre-ride) checks*).

34 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 extensively overhauled – the bike will have to be run in as when new. This means greater use of the transmission and a restraining hand on the throttle until the specified mileage has 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 according to the table. These recommendations apply less when only a partial overhaul has been done, though it does depend to an extent on the nature of the work carried out and which components have been renewed. Experience is the best guide, since it's easy to tell when an engine is running freely. If in any doubt, consult a Yamaha dealer. The table below shows the maximum engine speed limitations, which Yamaha provide for new motorcycles, can be used as a guide.

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.

4 After 600 miles (1000 km) change the engine oil and filter (see Chapter 1).

Up to 100 miles (150 km)	4500 rpm max	Vary throttle position/speed. Do not use full throttle. Stop after every hour and let engine cool for 5 to 10 minutes.
100 to 300 miles (150 to 500 km)	5500 rpm max	Vary throttle position/speed. Do not use full throttle. Higher revs can be used for short periods, as long as the engine is not laboured
300 to 600 miles (500 to 1000 km)	6500 rpm max	Vary throttle position/speed. Full throttle can be used for short periods, as long as the engine is not laboured
Over 600 miles (1000 km)	Do not exceed tachometer red line	