

Chapter 2

Engine, clutch and transmission

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Degrees of difficulty

Easy, suitable for
novice with little
experience



Fairly easy, suitable
for beginner with
some experience



Fairly difficult,
suitable for competent
DIY mechanic



Difficult, suitable for
experienced DIY
mechanic



Very difficult,
suitable for expert DIY
or professional



Specifications

General

Type	Four-stroke parallel twin
Capacity	
TDM and TRX models	849 cc
XTZ models	749 cc
Bore	
TDM and TRX models	89.5 mm
XTZ models	87.0 mm
Stroke	
TDM and TRX models	67.5 mm
XTZ models	63 mm
Compression ratio	
1991 to 1995 TDM models	9.2 to 1
1996-on TDM models and TRX models	10.5 to 1
XTZ models	9.5 to 1
Cylinder numbering	No. 1 (left-hand), No. 2 (right-hand)
Cooling system	Liquid cooled
Clutch	Wet multi-plate
Transmission	Five-speed constant mesh
Final drive	Chain

Camshafts

Inlet lobe height

1991 to 1995 TDM models and XTZ models

Standard	35.7 to 35.8 mm
Service limit (min)	35.6 mm

1996-on TDM models and TRX models

Standard	35.95 to 36.05 mm
Service limit (min)	35.85 mm

Exhaust lobe height – all models

Standard	35.95 to 36.05 mm
Service limit (min)	35.85 mm

Journal diameter	24.967 to 24.980 mm
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Journal holder diameter	25.000 to 25.021 mm
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Journal oil clearance	0.020 to 0.054 mm
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Runout (max)	0.03 mm
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Cylinder head

Warpage (max)	0.03 mm
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Valves, guides and springs

Valve clearances	see Chapter 1
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Inlet valve

Stem diameter	
Standard	5.475 to 5.490 mm
Service limit (min)	5.445 mm

Guide bore diameter	
Standard	5.500 to 5.512 mm
Service limit (max)	5.55 mm

Stem-to-guide clearance	
Standard	0.010 to 0.037 mm
Service limit (max)	0.08 mm

Head diameter	25.9 to 26.1 mm
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Face width	2.06 to 2.46 mm
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Seat width	0.9 to 1.1 mm
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Margin thickness	0.8 to 1.2 mm
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Exhaust valve

Stem diameter	
Standard	5.460 to 5.475 mm
Service limit (min)	5.43 mm

Guide bore diameter	
Standard	5.500 to 5.512 mm
Service limit (max)	5.55 mm

Stem-to-guide clearance	
Standard	0.025 to 0.052 mm
Service limit (max)	0.10 mm

Head diameter	27.9 to 28.1 mm
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Face width	2.06 to 2.46 mm
------------------	-----------------

Seat width	0.9 to 1.1 mm
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Margin thickness	0.8 to 1.2 mm
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Valve stem runout (max)	0.01 mm
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Valve springs free length (inlet and exhaust)

Standard	37.29 mm
Service limit (min)	35.2 mm

Valve spring bend (max)	1.7 mm
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Cylinder block

Bore

TDM and TRX models	
Standard	89.500 to 89.505 mm
Service limit (max)	89.6 mm

XTZ models	
Standard	87.000 to 87.005 mm
Service limit (max)	87.1 mm

Warpage (max)	0.03 mm
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Ovality (out-of-round) (max)	0.03 mm
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Taper (max)	0.05 mm
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Cylinder compression	see Chapter 1
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Pistons

Piston diameter (measured 4.5 mm (TDM and TRX models) or 4.7 mm (XTZ models) up from skirt, at 90° to piston pin axis)

TDM and TRX models	89.420 to 89.435 mm	
XTZ models	86.920 to 86.935 mm	
	Standard	Service Limit
Piston-to-bore clearance	0.065 to 0.085 mm	0.15 mm
Piston pin diameter	19.991 to 20.000 mm	19.975 mm
Piston pin bore diameter in piston	20.002 to 20.013 mm	20.043 mm (max)
Piston pin-to-piston pin bore clearance	0.002 to 0.022 mm	0.07 mm

Piston rings

Top ring

TDM and TRX models

Ring width	3.5 mm
Ring thickness	1.0 mm
Ring end gap (installed)	
Standard	0.30 to 0.45 mm
Service limit (max)	0.70 mm
Piston ring-to-groove clearance	
Standard	0.035 to 0.070 mm
Service limit (max)	0.12 mm

XTZ models

Ring width	3.3 mm
Ring thickness	1.0 mm
Ring end gap (installed)	
Standard	0.30 to 0.50 mm
Service limit (max)	0.70 mm
Piston ring-to-groove clearance	
Standard	0.03 to 0.07 mm
Service limit (max)	0.12 mm

2nd (middle) ring

1991 to 1995 TDM models

Ring width	3.5 mm
Ring thickness	1.0 mm
Ring end gap (installed)	
Standard	0.30 to 0.45 mm
Service limit (max)	0.70 mm
Piston ring-to-groove clearance	
Standard	0.02 to 0.055 mm
Service limit (max)	0.12 mm

1996-on TDM models and TRX models

Ring width	3.5 mm
Ring thickness	1.0 mm
Ring end gap (installed)	
Standard	0.30 to 0.45 mm
Service limit (max)	0.70 mm
Piston ring-to-groove clearance	
Standard	0.035 to 0.070 mm
Service limit (max)	0.12 mm

XTZ models

Ring width	3.3 mm
Ring thickness	1.0 mm
Ring end gap (installed)	
Standard	0.30 to 0.50 mm
Service limit (max)	0.70 mm
Piston ring-to-groove clearance	
Standard	0.02 to 0.06 mm
Service limit (max)	0.12 mm

Oil ring

TDM and TRX models

Ring width	2.85 mm
Ring thickness	2.0 mm
Side-rail end gap (installed)	0.20 to 0.70 mm

XTZ models

Ring width	2.80 mm
Ring thickness	2.0 mm
Side-rail end gap (installed)	0.20 to 0.70 mm

2•4 Engine, clutch and transmission

Clutch

Friction plate thickness – all models

Standard	2.9 to 3.1 mm
Service limit (min)	2.8 mm

Plain plates

1991 to 1995 TDM models and all XTZ models

Thickness (special 'slick' plate)	2.2 to 2.4 mm
Thickness (all other plates)	1.9 to 2.1 mm
Warp (max)	0.1 mm

1996-on TDM models and all TRX models

Thickness	1.9 to 2.1 mm
Warp (max)	0.1 mm

Clutch springs

Spring free length

1991 to 1998 TDM and all TRX models

Standard	55 mm
Service limit (min)	53 mm

1999 TDM models

Standard	50 mm
Service limit (min)	48 mm

XTZ models

Standard	51.8 mm
Service limit (min)	50 mm

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)	0.15 mm

Rotor end-float

0.03 to 0.08 mm

Connecting rods

Big-end side clearance

Standard	0.160 to 0.272 mm
Service limit (max)	0.5 mm

Big-end oil clearance

Standard	0.026 to 0.050 mm
Service limit (max)	0.09 mm

Crankshaft and bearings

Main bearing oil clearance

Standard	0.020 to 0.038 mm
Service limit (max)	0.1 mm

Runout (max)

1991 to 1995 TDM models and all XTZ models	0.02 mm
1996-on TDM models and all TRX models	0.035 mm

Transmission

Gear ratios (no. of teeth)

1991 to 1995 TDM models

Primary reduction	1.718 to 1 (67/39T)
Final reduction	2.750 to 1 (44/16T)
1st gear	2.846 to 1 (37/13T)
2nd gear	1.850 to 1 (37/20T)
3rd gear	1.318 to 1 (29/22T)
4th gear	1.074 to 1 (29/27T)
5th gear	0.900 to 1 (27/30T)

1996 to 1998 TDM models

Primary reduction	1.718 to 1 (67/39T)
Final reduction	2.471 to 1 (42/17T)
1st gear	2.846 to 1 (37/13T)
2nd gear	1.850 to 1 (37/20T)
3rd gear	1.429 to 1 (30/21T)
4th gear	1.174 to 1 (27/23T)
5th gear	1.037 to 1 (28/27T)

1999 TDM models	
Primary reduction	1.718 to 1 (67/39T)
Final reduction	2.688 to 1 (43/16T)
1st gear	2.643 to 1 (37/14T)
2nd gear	1.947 to 1 (37/19T)
3rd gear	1.500 to 1 (30/20T)
4th gear	1.174 to 1 (27/23T)
5th gear	0.964 to 1 (27/28T)
TRX models	
Primary reduction	1.718 to 1 (67/39T)
Final reduction	2.294 to 1 (39/17T)
1st gear	2.571 to 1 (36/14T)
2nd gear	1.850 to 1 (37/20T)
3rd gear	1.429 to 1 (30/21T)
4th gear	1.174 to 1 (27/23T)
5th gear	1.037 to 1 (28/27T)
XTZ models	
Primary reduction	1.718 to 1 (67/39T)
Final reduction	2.875 to 1 (46/16T)
1st gear	2.846 to 1 (37/13T)
2nd gear	1.850 to 1 (37/20T)
3rd gear	1.429 to 1 (30/21T)
4th gear	1.174 to 1 (27/23T)
5th gear	1.037 to 1 (28/27T)
Shaft runout (max)	0.08 mm
Selector fork shaft runout (max)	0.03 mm

Torque settings

Engine mounting bolts

TDM models	
Small triangular engine bracket bolts to engine	30 Nm
Engine bracket bolts to underside of engine at back	30 Nm
Lower rear mounting bolt	64 Nm
Upper rear mounting bolt nut	89 Nm
Engine bracket to engine bolts	60 Nm
Engine bracket to frame bolts	30 Nm
TRX models	
Lower rear mounting bolt nut	75 Nm
Upper rear mounting bolt nut	75 Nm
Upper front mounting bolts	55 Nm
Engine bracket to engine bolts (left-hand side)	30 Nm
Engine bracket to frame bolt (left-hand side)	55 Nm
Engine bracket to engine bolt (with collar) (right-hand side)	55 Nm
Engine bracket to frame bolts (right-hand side)	30 Nm
XTZ models	
Swingarm pivot bolt nut	90 Nm
Lower rear mounting bolt nut	58 Nm
Upper rear mounting bolt nut	58 Nm
Frame downtube bolts/nuts	32 Nm
Lower front mounting bolt nut	58 Nm
Valve cover bolts	10 Nm
Camshaft holder bolts	10 Nm
Camshaft sprocket bolts	24 Nm
Cam chain tensioner mounting bolts	10 Nm
Cam chain tensioner cap bolt	20 Nm
Cylinder head nuts	40 Nm
Cylinder head bolts	10 Nm
Oil pipe banjo bolt to cylinder head	21 Nm
Coolant hose union bolts (cylinder block)	10 Nm
Clutch nut	70 Nm
Clutch spring bolts	8 Nm
Clutch cover bolts	10 Nm
Starter clutch bolts	10 Nm
Selector drum retainer plate bolts	12 Nm
Stopper arm bolt	
1991 to 1995 TDM models and XTZ models	12 Nm
1996-on TDM models and TRX models	10 Nm
Gearchange linkage arm pinch bolt	12 Nm

Torque settings (continued)

Outer sprocket cover bolts	5 Nm
Oil pump mounting screws	6 Nm
Oil pump assembly screw	6 Nm
Oil pump cover bolts	10 Nm
Oil pipe to oil pump cover bolts	10 Nm
Oil pipe banjo bolts to crankcase cover/oil tank and cylinder head	21 Nm
Oil pipe to oil tank bolts	10 Nm
Oil pressure relief valve holder bolt	10 Nm
Oil strainer cover screws	7 Nm
Oil sump bolts	10 Nm
Oil hose union to crankcase bolts	10 Nm
Balancer shaft holder bolts	10 Nm
Balancer shaft retainer plate Torx bolt	12 Nm
Oil strainer holder bolts	10 Nm
Crankcase top cover bolts (1991 to 1995 TDM models and all XTZ models)	10 Nm
Crankcase 6 mm bolts	12 Nm
Crankcase 8 mm bolts	24 Nm
Crankcase 10 mm bolts	40 Nm
Connecting rod cap nuts	
Initial setting	
1991 to 1995 TDM models and all XTZ models	46 Nm
1996-on TDM models and all TRX models	35 Nm
Final setting (all models)	48 Nm
Transmission output shaft retainer plate bolts (left-hand side)	10 Nm
Transmission input shaft bearing retainer Torx screws	12 Nm
Oil gallery bolt	10 Nm

1 General information

The engine/transmission unit is a liquid-cooled parallel twin with five valves per cylinder (three inlet and two exhaust). The valves are operated by double overhead camshafts which are chain driven off the crankshaft. The engine/transmission assembly is constructed from aluminium alloy. The crankcase is divided horizontally.

The crankcase incorporates a dry sump, pressure-fed lubrication system which uses two gear-driven oil pumps, one a feed pump to lubricate the engine, the other a scavenge pump to return oil to the tank, both driven off the crankshaft. The sump houses the oil filter, by-pass valve assembly and relief valve. The oil tank is mounted behind the engine on 1991 to 1995 TDM models and all XTZ models, and on the engine behind the cylinders on later TDM models and all TRX models. The oil pumps are gear driven off the crankshaft.

The crankshaft also drives two balancer shafts which eliminate the vibration inherent in parallel twin engines

The alternator and starter clutch are on the left-hand end of the crankshaft.

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 transmission is a five-speed constant-mesh unit. Final drive to the rear wheel is by chain and sprockets.

2 Operations possible with the engine in the frame

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

Valve cover
Camshafts
Cylinder head
Cylinder block, pistons and piston rings
Pick-up coil assembly
Clutch
Gearchange mechanism (external components)
Alternator
Starter clutch
Oil filter
Oil pumps, oil strainer, oil pressure relief valve and by-pass valve
Starter motor
Water pump
Balancer shafts (1991 to 1995 TDM and all XTZ models)
Cam chain

3 Operations requiring engine removal

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

Transmission shafts
Selector drum and forks
Connecting rods and bearings
Crankshaft and bearings
Balancer shafts (1996-on TDM models and all TRX models)

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 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 rates 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 renewed and the cylinder walls honed or, if necessary, re-bored 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 assistant; personal injury or damage could occur if the engine falls or is dropped. An hydraulic or mechanical floor jack should be used to support and lower or raise the engine if possible.*

Removal

1 Support the bike securely in an upright position using an auxiliary stand. 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 (see *Tools and Workshop Tips* in the Reference section). When disconnecting any wiring, cables and hoses, it is advisable to mark or tag them as a reminder to where they connect.

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

3 Remove the seat, side covers, fairing side panels (TDM and XTZ models), fairing, and engine bashplate (1991 to 1995 TDM models and XTZ models) (see Chapter 8). On 1996-on TDM models and XTZ models, the fairing can be left in situ, though it is advisable to remove

it to avoid the possibility of damaging it while removing the engine.

4 Remove the fuel tank (see Chapter 4).

5 Drain the engine oil and the coolant (see Chapter 1).

6 Disconnect the negative (-ve) lead from the battery, then disconnect the positive (+ve) lead (see Chapter 9). On 1991 to 1995 TDM models, remove the battery and the battery box (see Chapter 9).

7 Remove the radiator (see Chapter 3).

8 Remove the exhaust system (see Chapter 4).

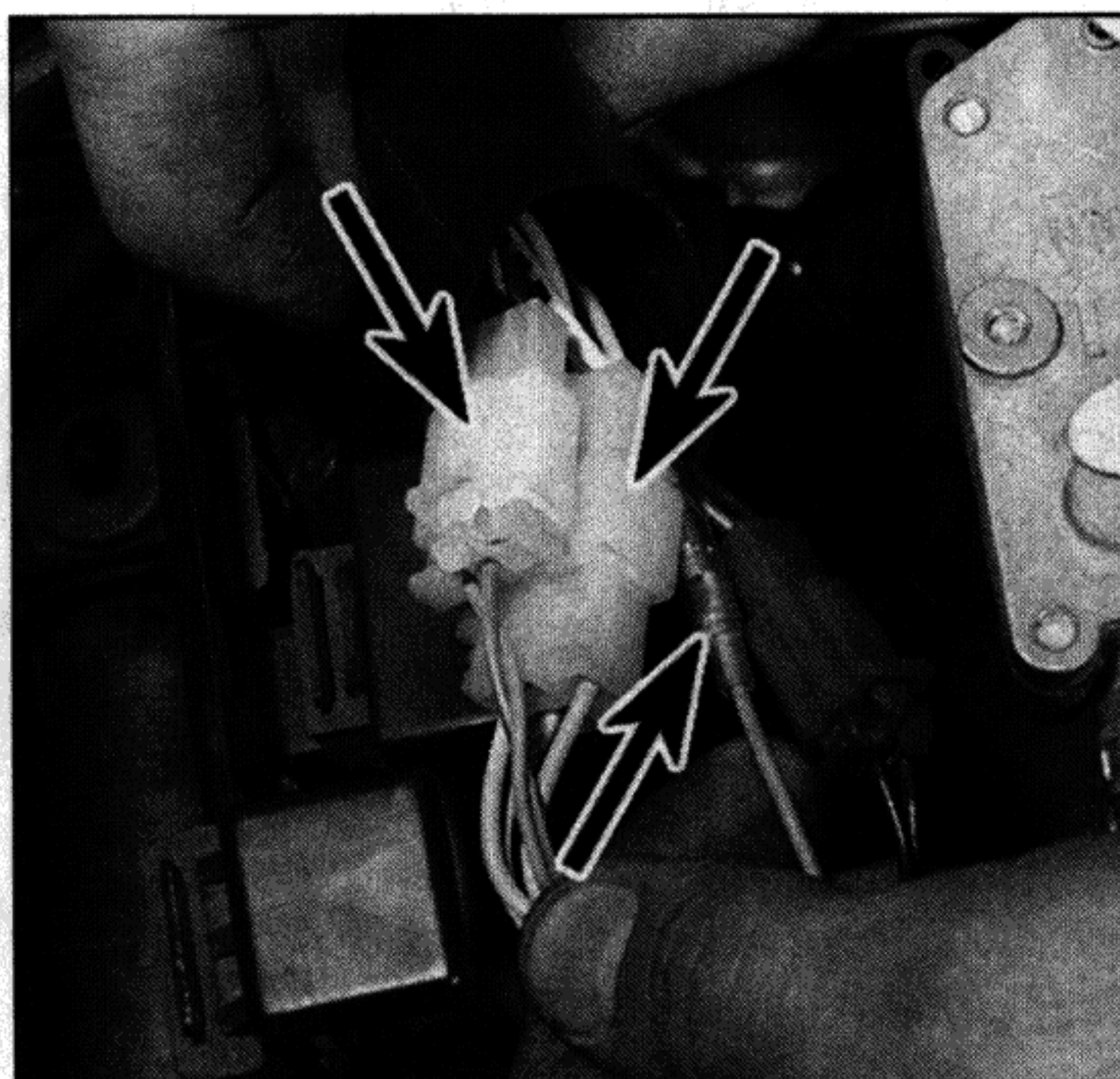
9 Remove the carburettors (see Chapter 4). Detach the vacuum hose(s) from the inlet manifolds. On 1991 to 1995 TDM models, unscrew the bolts securing the choke knob to the left-hand engine mounting bracket and position it clear. Plug the engine inlet manifolds with clean rag. On 1999 TDM remove the fuel pump and fuel filter as a unit complete with their mounting bracket (see Chapter 4).

10 On TDM and TRX models, remove the thermostat housing (see Chapter 3). When removing the housing, remove it along with the pipe that bolts onto the valve cover, rather than separating the hose from the pipe. The pipe is secured by a bolt – make sure the pipe O-ring does not fall into the engine when easing out the pipe (**see illustration 7.2**). Discard the O-ring as a new one must be used.

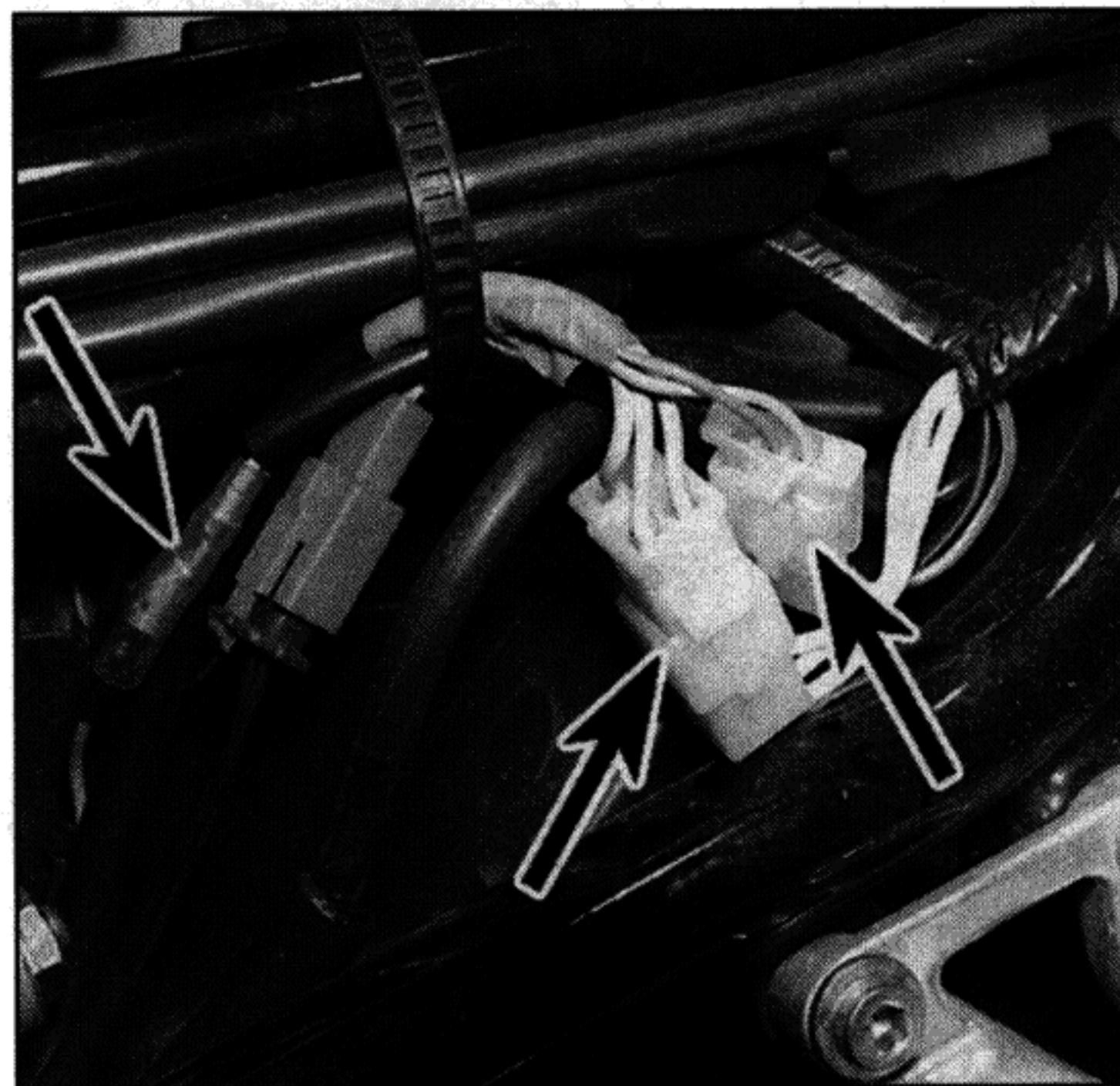
11 On XTZ models, unscrew the bolt securing the coolant pipe to the valve cover and ease the pipe out, making sure the O-ring does not fall into the engine. Discard the O-ring as a new one must be used.

12 Trace the alternator, ignition pick-up coil and neutral switch wiring from the top of the alternator cover and disconnect it at the connectors (**see illustrations**). Release the wiring from any clips or ties, noting its routing, and coil it so that it does not impede engine removal.

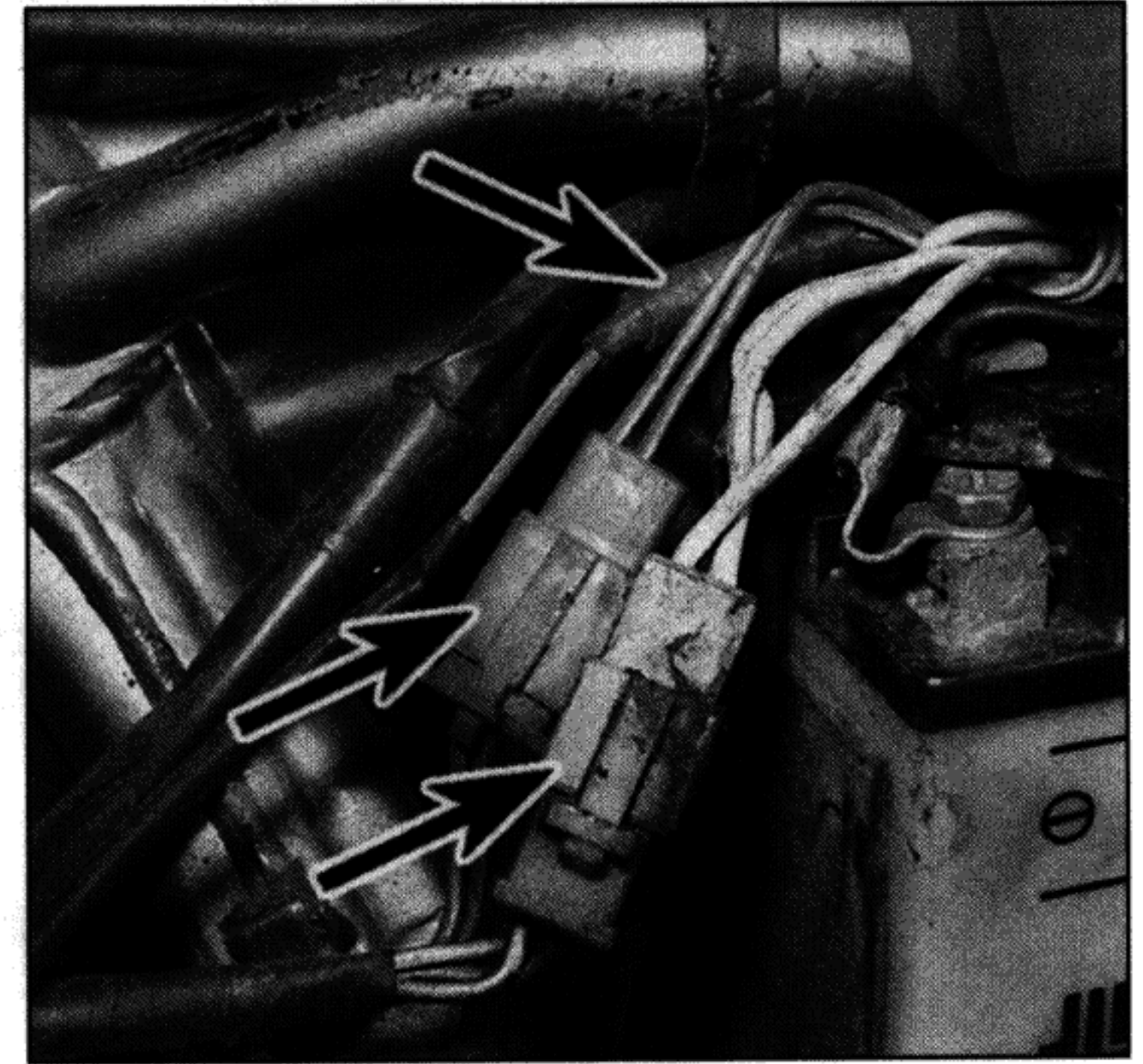
13 Disconnect the spark plug caps from the spark plugs and secure them clear of the engine.



5.12a Alternator/pick-up coil/neutral switch wiring connectors (arrowed) – TDM models



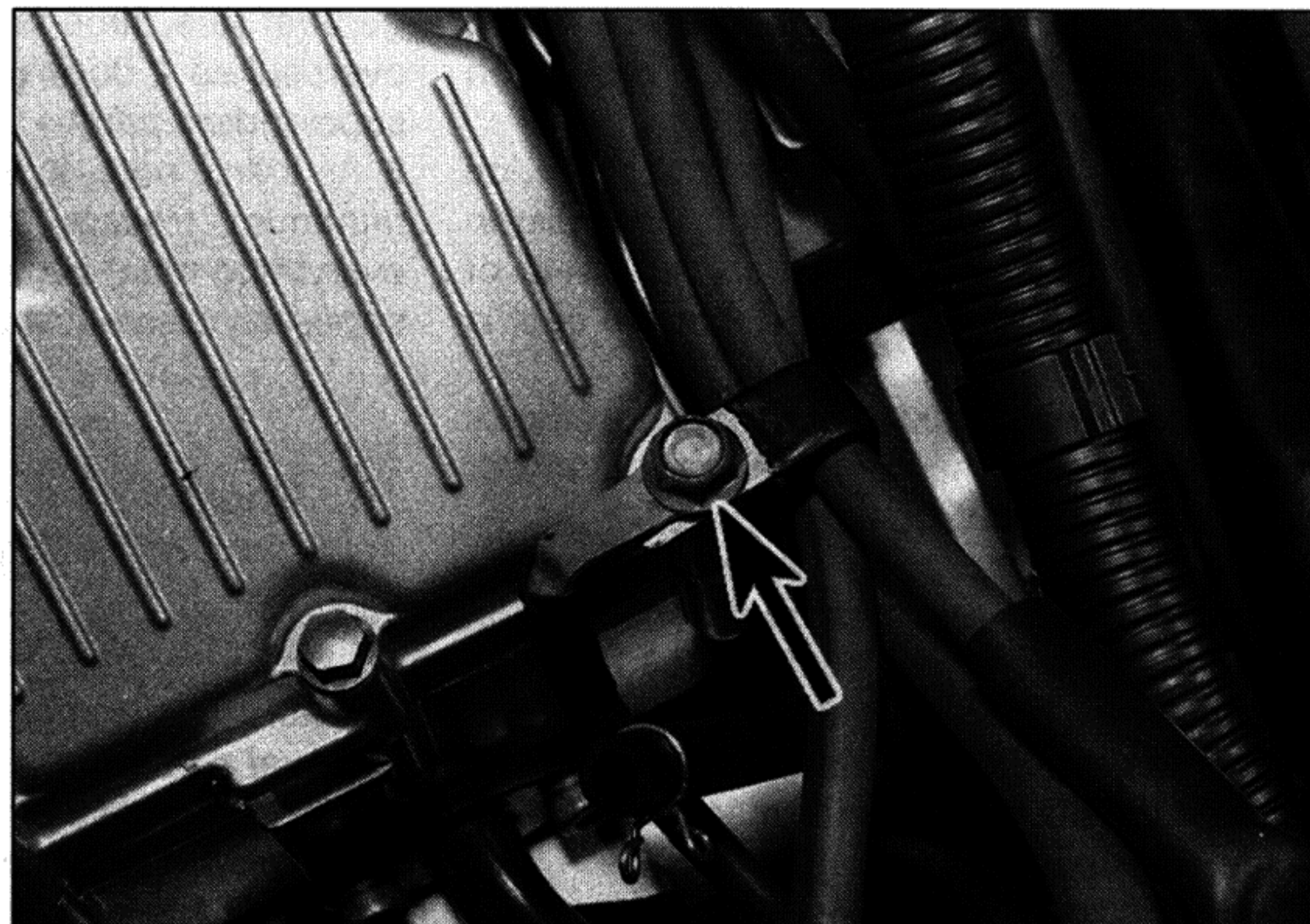
5.12b Alternator/pick-up coil/neutral switch wiring connectors (arrowed) – TRX models



5.12c Alternator/pick-up coil/neutral switch wiring connectors (arrowed) – XTZ models



5.14 Unscrew the nut and detach the starter motor lead from the starter relay



5.16 Unscrew the bolt (arrowed) and detach the cable and hose clip

14 Disconnect the starter motor lead from the starter relay (**see illustration**).

15 Disconnect the earth wiring connector from the main wiring loom.

16 On 1991 to 1995 TDM models and all XTZ models, the battery's main earth cable can remain attached to the engine. On 1996-on TDM models and all TRX models, unscrew the bolt securing the cable to the back of the engine and detach it along with the clip securing the hoses (**see illustration**).

17 Detach the clutch cable from the release lever on the clutch cover (see Section 17).

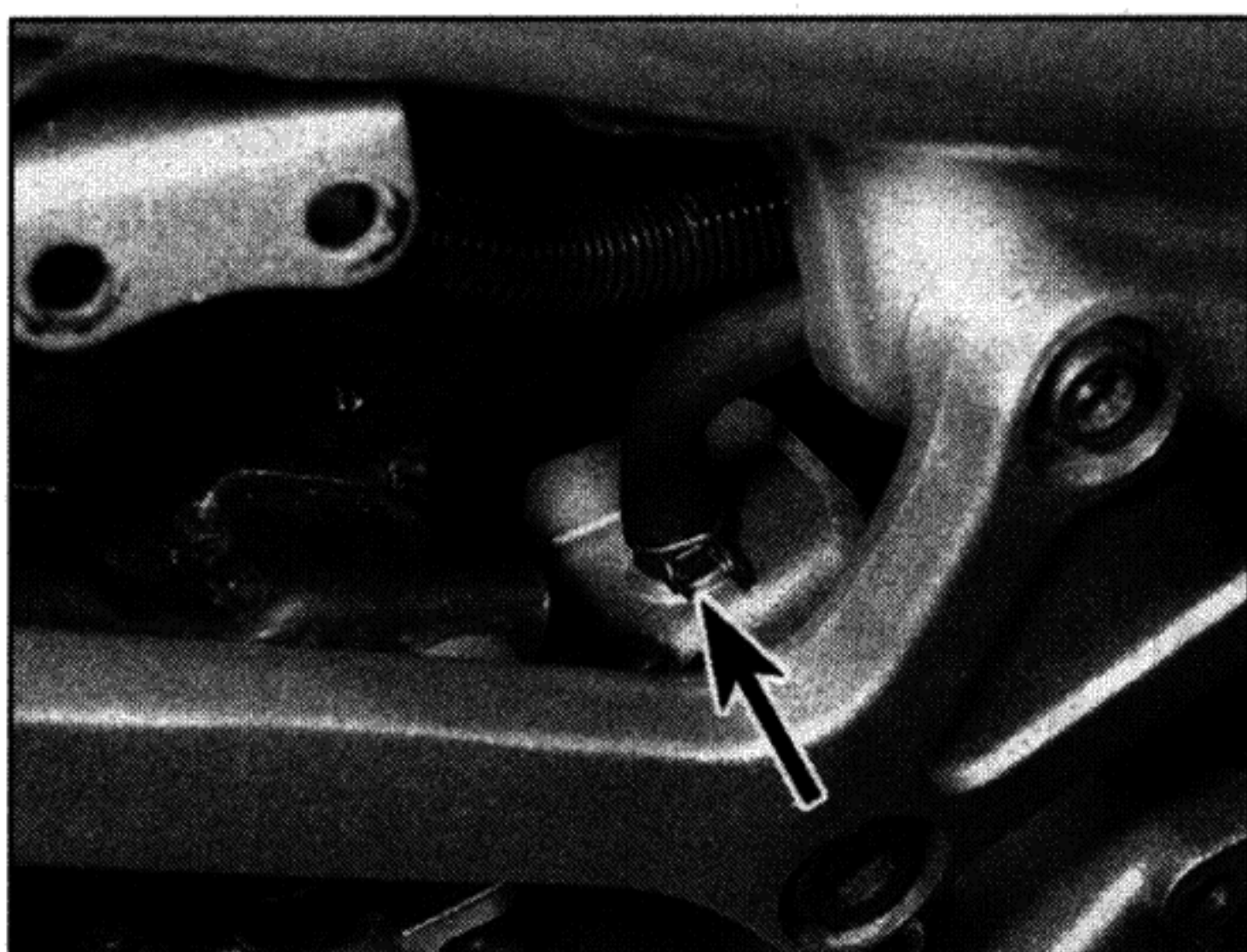
18 Remove the front sprocket (see Chapter 6). On TDM and XTZ models, also remove the gearchange lever (see Chapter 6).

19 On 1991 to 1995 TDM models and all XTZ models, disconnect the crankcase breather hose from the crankcase (**see illustration**). Also slacken the clamp and detach the hose from its union on the oil filter housing (**see illustration**). Now unscrew the bolts and detach the oil pipe from the oil pump cover

(**see illustration**). Discard the O-ring as anew one must be used.

20 At this point, position an hydraulic or mechanical jack under the engine with a block of wood between the jack head and crankcase (**see illustration**). Make sure the jack is centrally positioned so the engine will not topple in any direction when the last mounting bolt is removed. Take the weight of the engine on the jack. It is also advisable to place a block of wood between the rear wheel and the ground, or under the swingarm, to prevent the bike tilting back onto the rear wheel when the engine is removed. Check around the engine and frame to make sure that all wiring, cables and hoses that need to be disconnected have been disconnected, and that any remaining connected to the engine are not retained by any clips, guides or brackets. Check that any protruding mounting brackets will not get in the way and remove them if necessary.

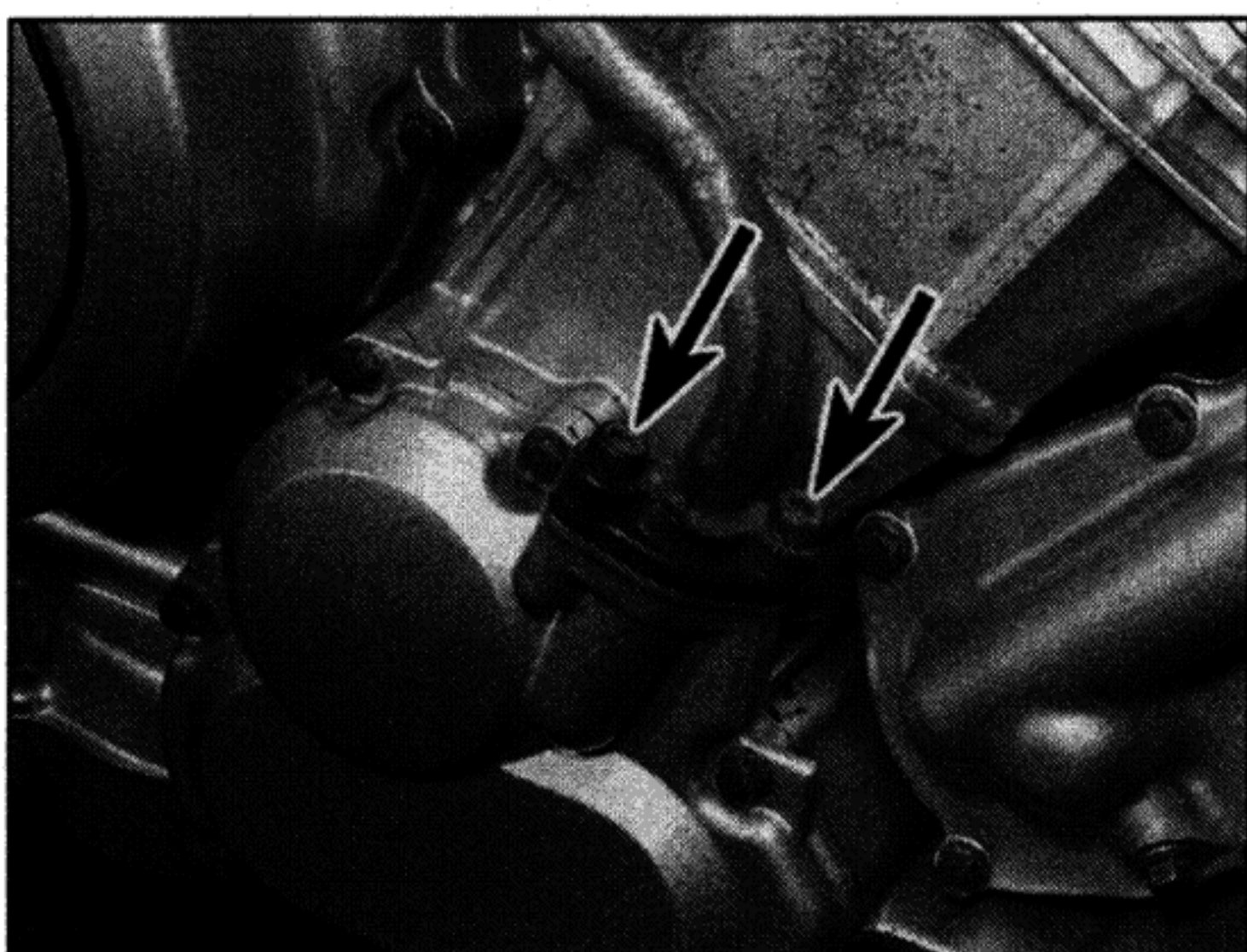
21 On TDM models, unscrew the bolts securing the engine bracket to the frame and the engine on each side and remove the brackets (**see illustrations**). Note which bolt fits where as they are of different lengths. Make sure the engine is properly supported on the jack, and have an assistant support it



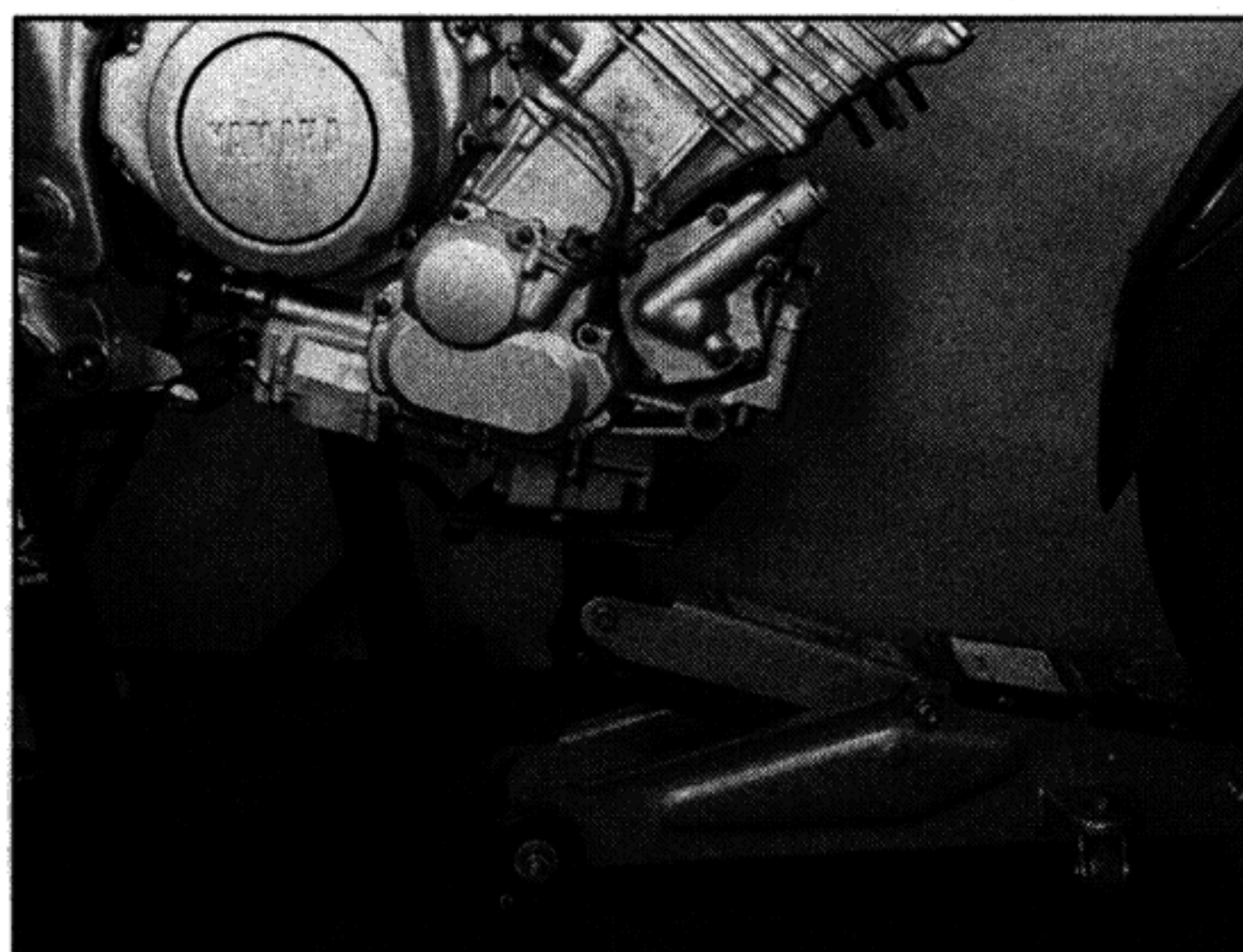
5.19a Release the clamp and detach the breather hose (arrowed)



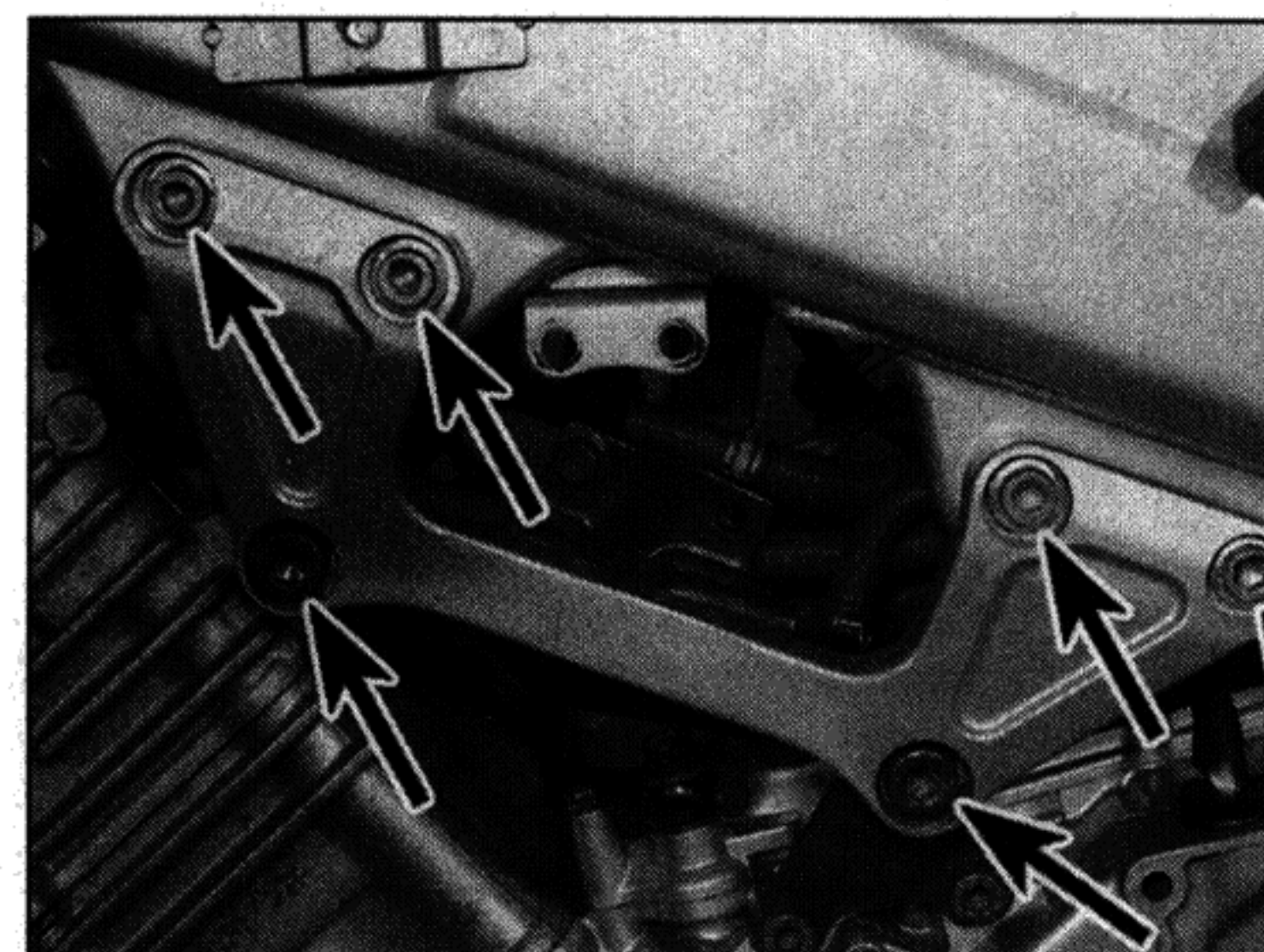
5.19b Slacken the clamp screw (arrowed) and detach the hose



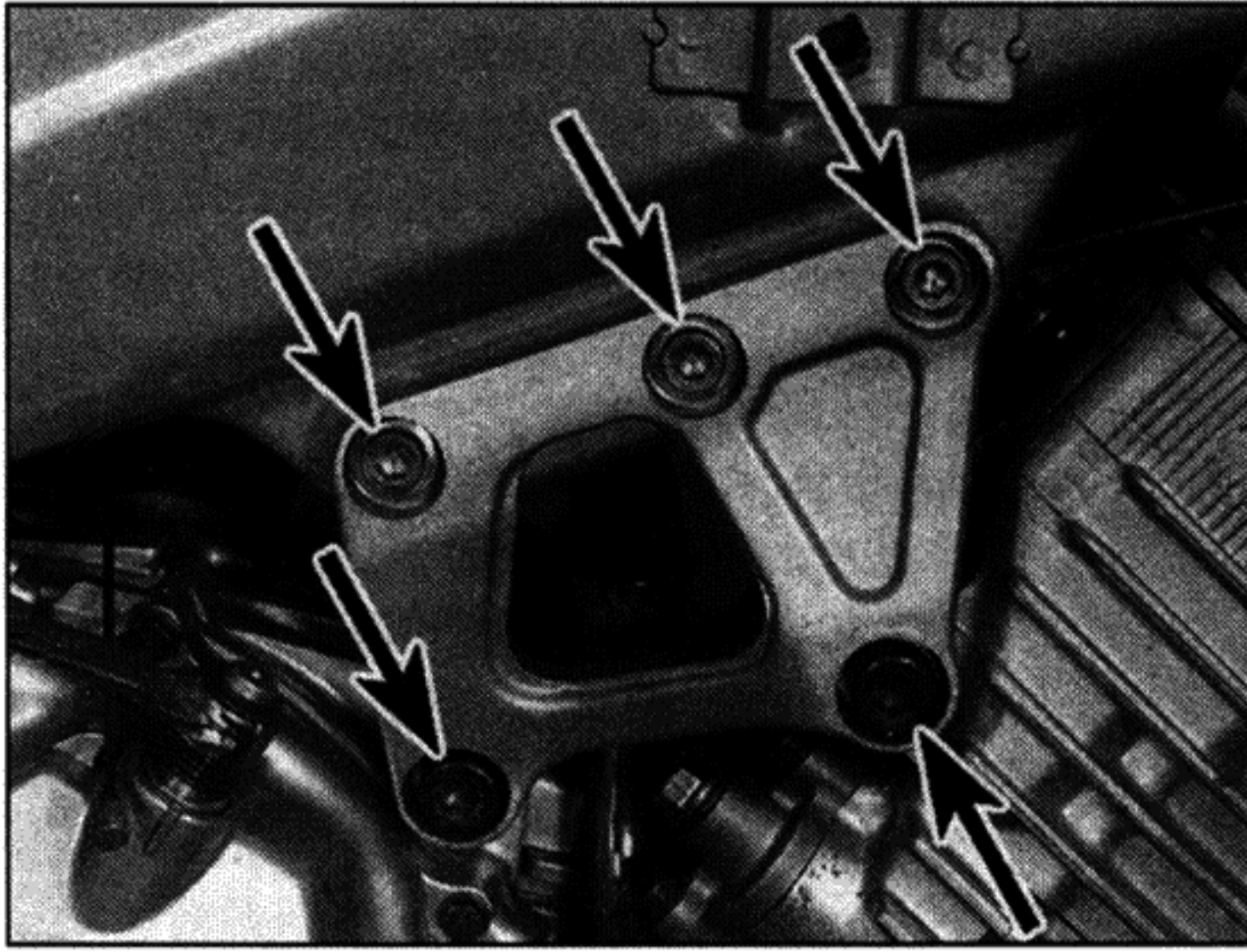
5.19c Unscrew the bolts (arrowed) and detach the pipe



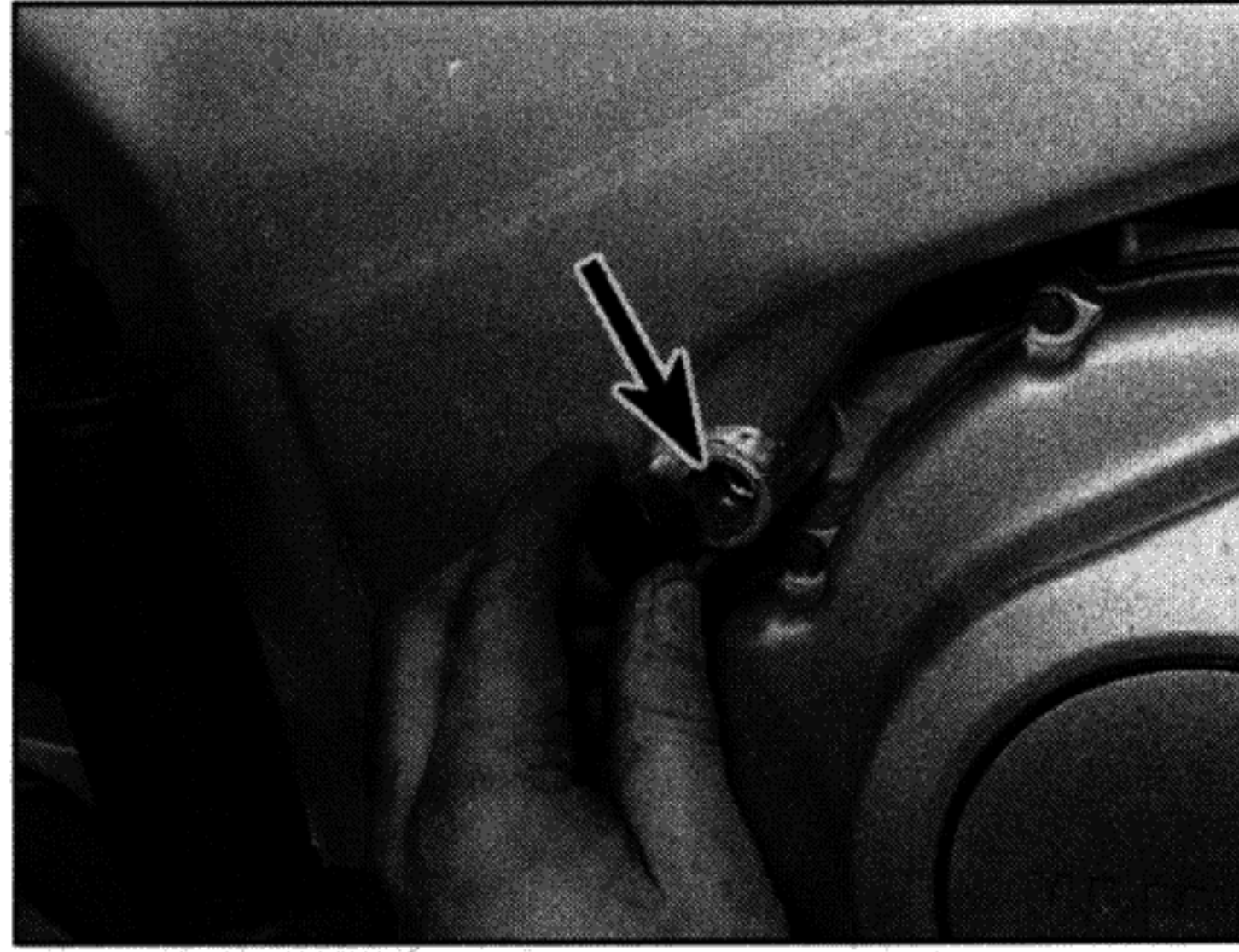
5.20 Position a jack under the engine



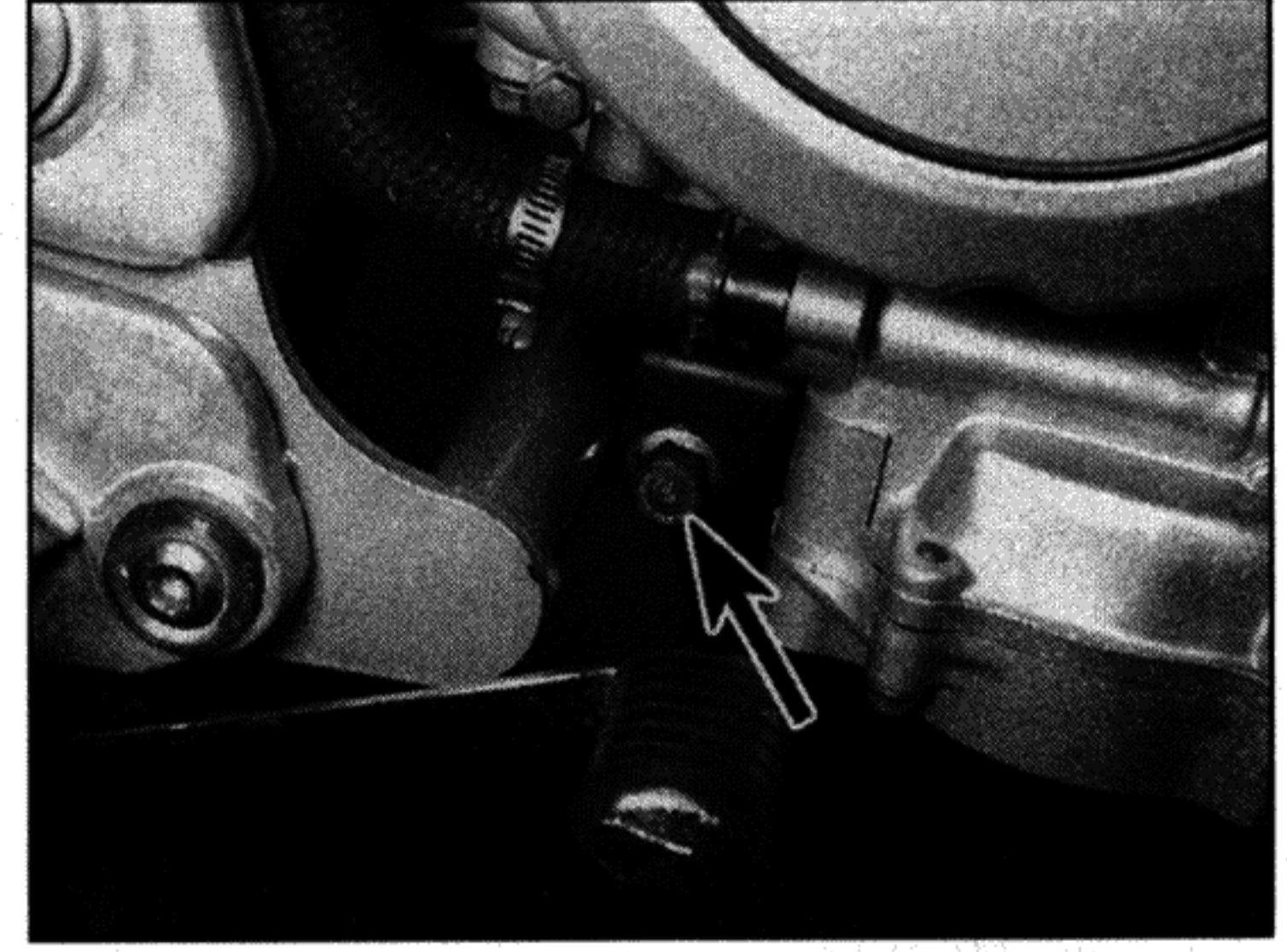
5.21a Unscrew the bolts (arrowed) and remove the left-hand . . .



5.21b ... and right-hand engine brackets



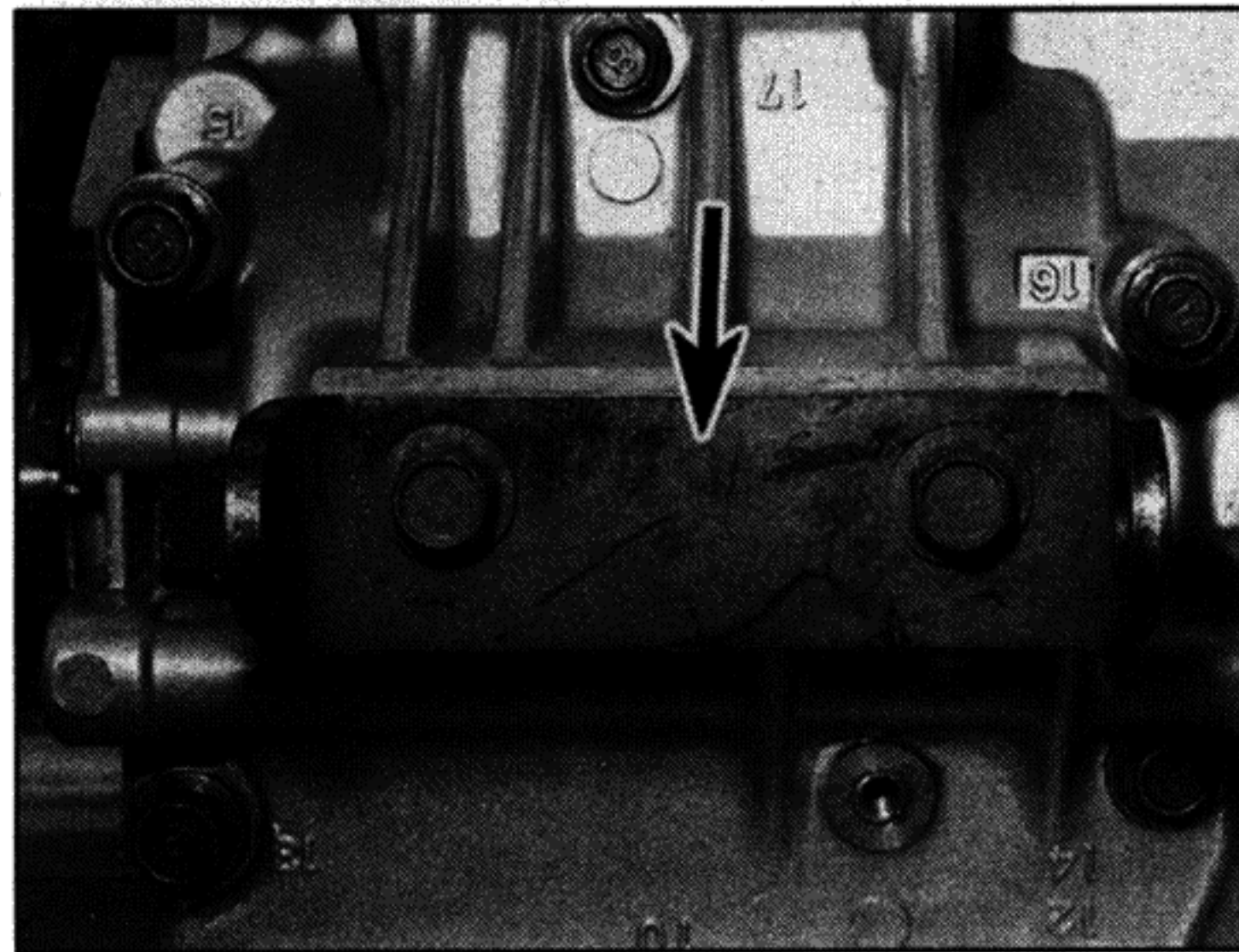
5.21c Upper rear engine mounting bolt (arrowed)



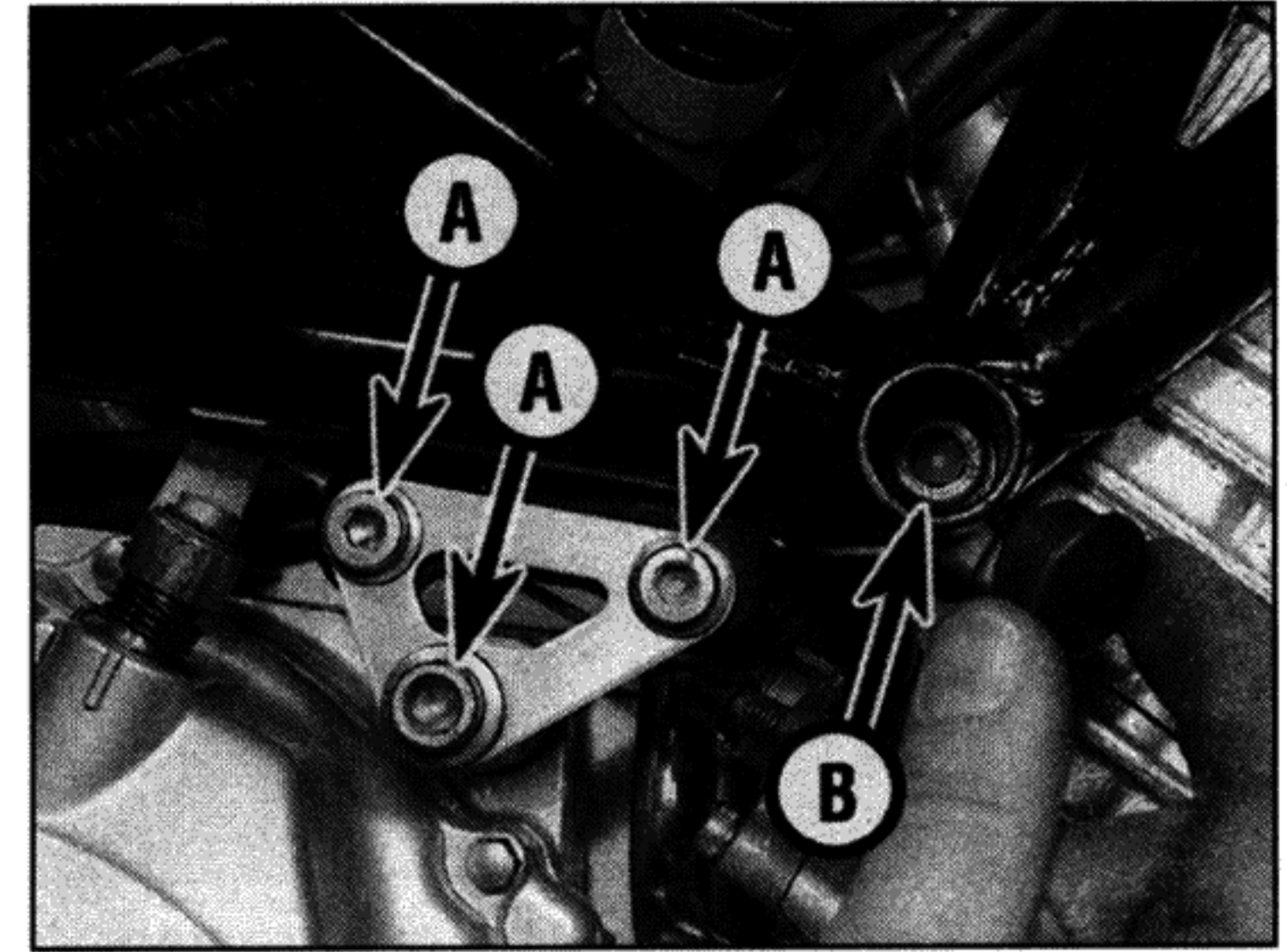
5.21d Lower rear engine mounting bolt (arrowed)



5.21e Remove the triangular bracket (arrowed) ...



5.21f ... and the bottom bracket (arrowed)



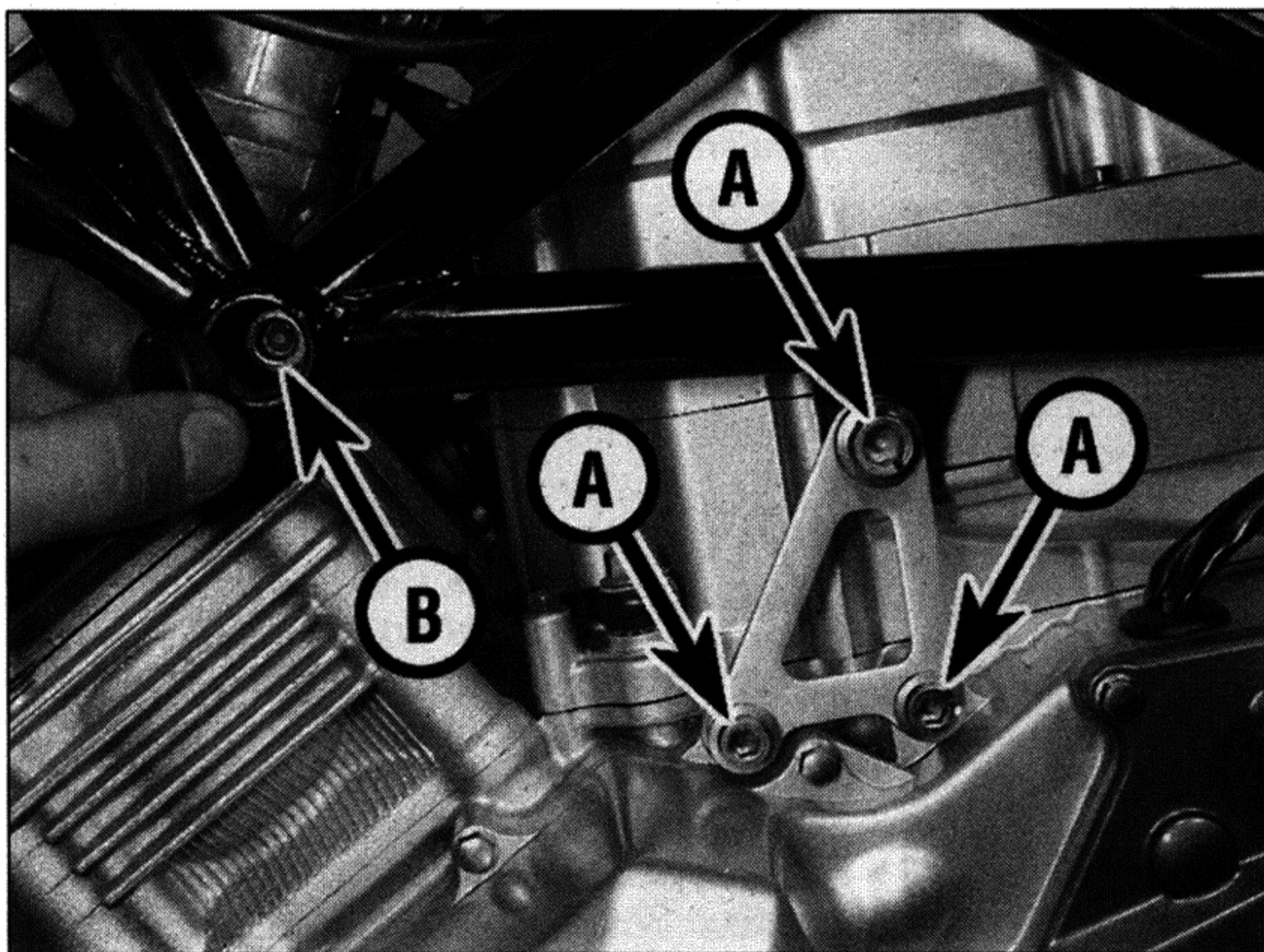
5.22a Engine bracket bolts (A) and upper front mounting bolt (B) – right-hand side

as well. Remove the cap from each end of the upper rear mounting bolt, then unscrew the nut and withdraw the bolt (**see illustration**). Finally unscrew and remove the lower rear mounting bolt (**see illustration**). If required, after the engine has been removed, unscrew the bolts securing the small triangular mounting bracket to the left-hand side of the engine and the bolts securing the bracket to

the underside of the engine at the back and remove the brackets (**see illustrations**).

22 On TRX models, unscrew the bolts securing the engine bracket to the frame and the engine on each side and remove the brackets, along with the collar fitted with the right-hand bracket (**see illustrations**). Note which bolt fits where as they are of different lengths. Remove the caps from the upper

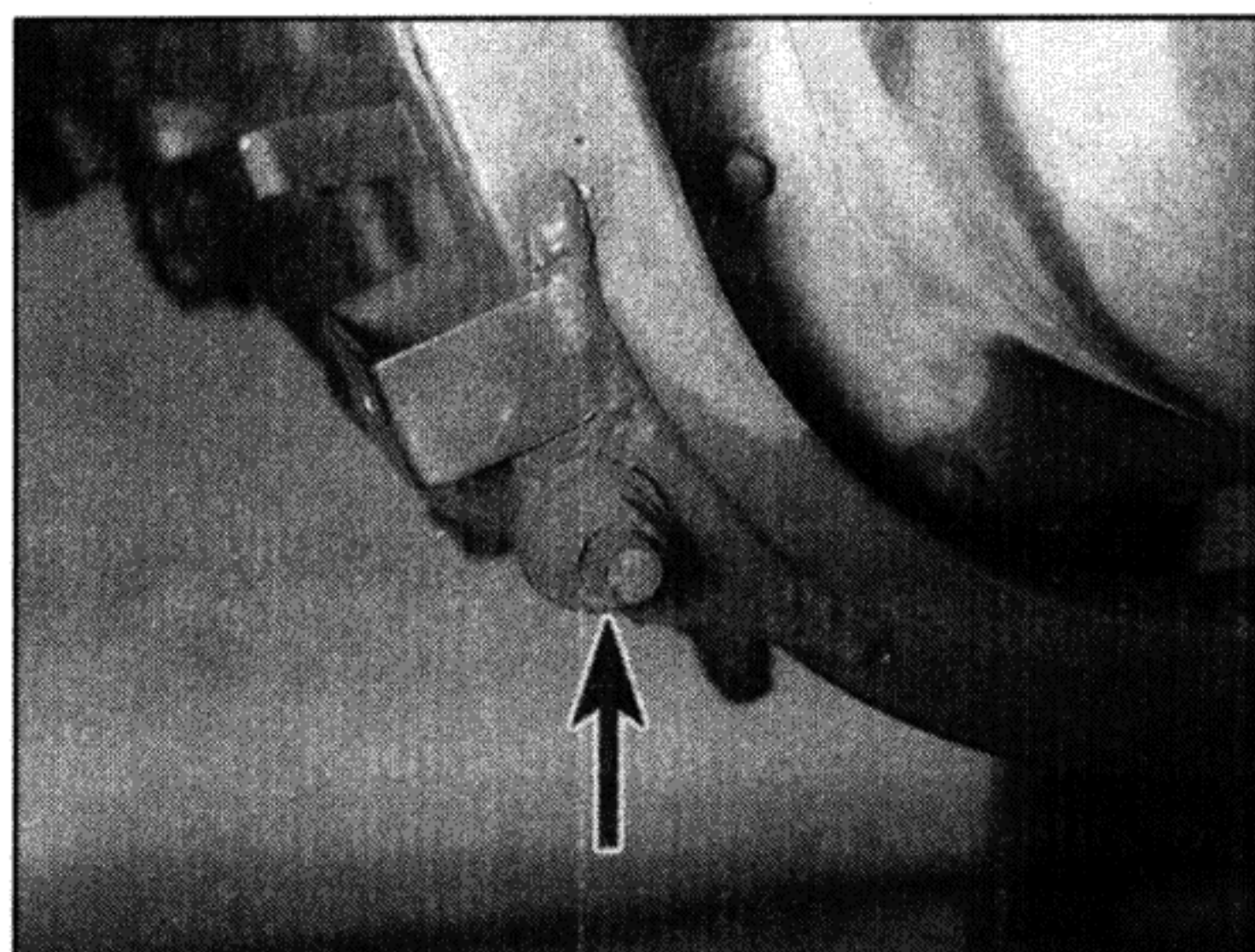
front mounting bolts, then unscrew the bolts. Make sure the engine is properly supported on the jack, and have an assistant support it as well. Unscrew the nut from the upper rear mounting bolt and withdraw the bolt (**see illustration**). Finally unscrew the nut on the lower rear mounting bolt and remove the bolt. **23** On XTZ models, unscrew the nut from the lower front mounting bolt and remove the bolt



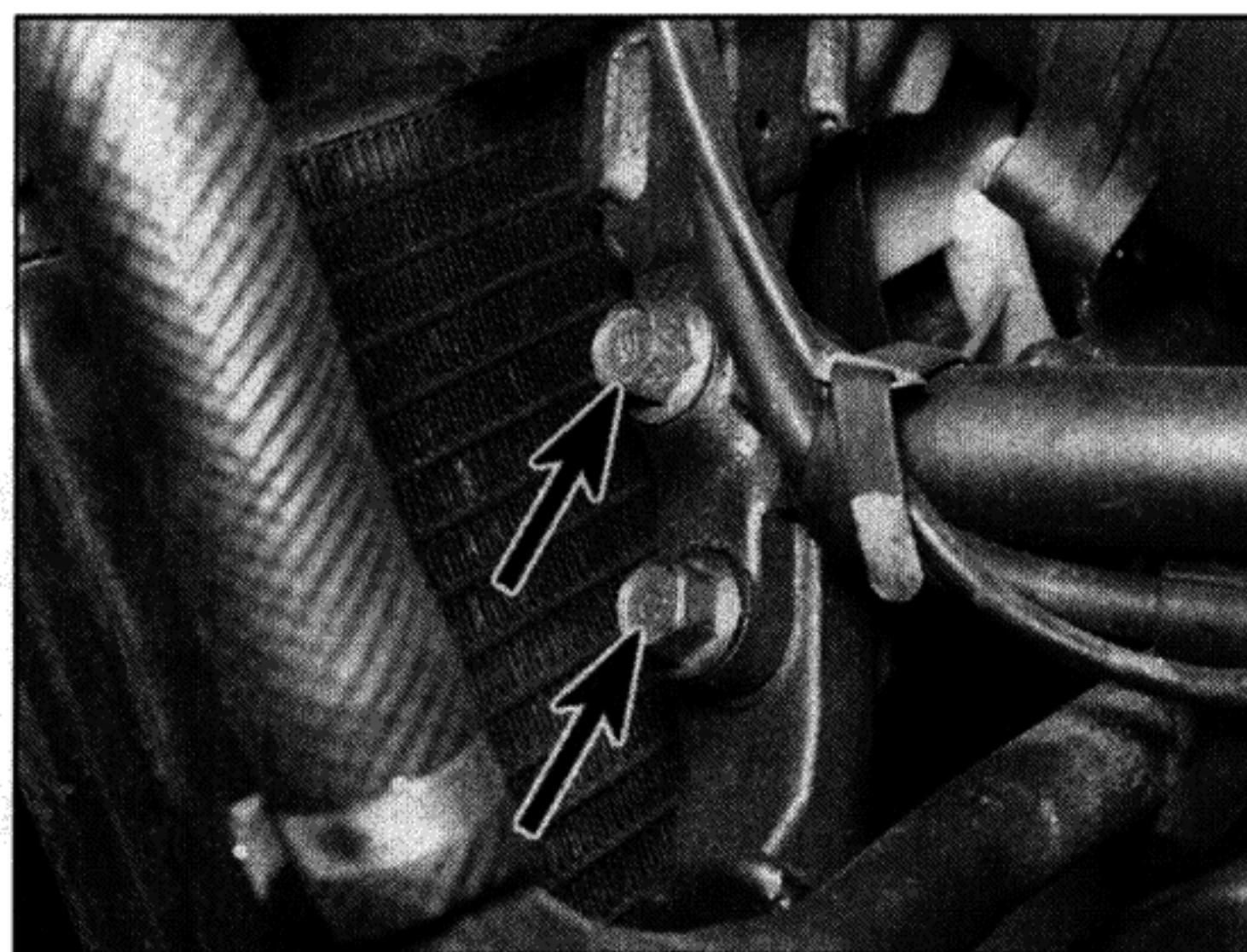
5.22b Engine bracket bolts (A) and upper front mounting bolt (B) – left-hand side



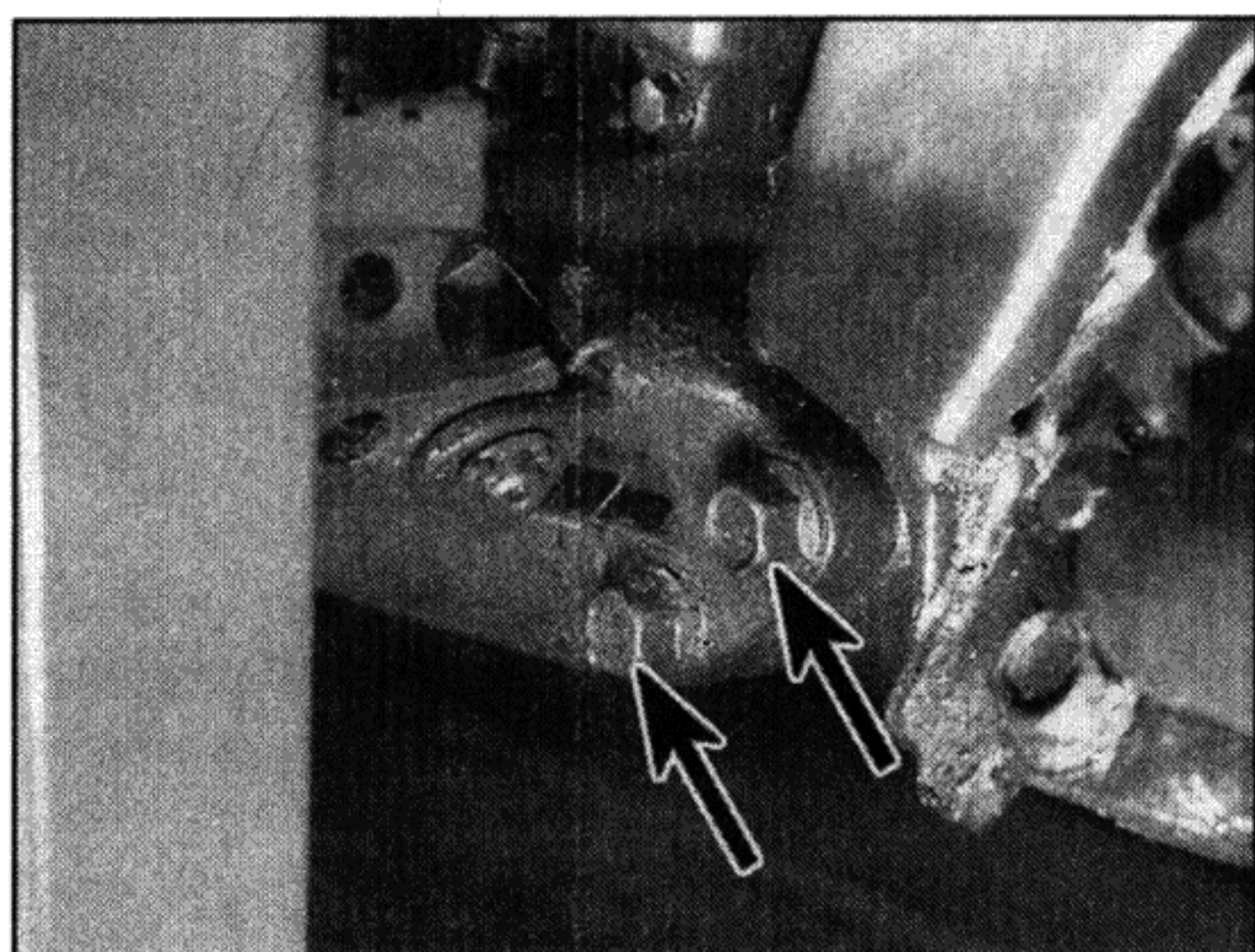
5.22c Upper and lower rear mounting bolts (arrowed)



5.23a Lower front mounting bolt (arrowed)



5.23b Downtube upper bolts (arrowed)



5.23c Downtube lower bolts (arrowed)



5.23d Upper and lower rear mounting bolts (arrowed)

(see illustration). Unscrew the four bolts securing each of the frame downtubes and remove the downtubes (see illustrations). Remove the cap from each end of the upper rear mounting bolt, then unscrew the nut and withdraw the bolt (see illustration). Unscrew the nut on the lower rear mounting bolt and remove the bolt. Remove the cap from each end of the swingarm pivot bolt, then unscrew the nut on its right-hand end. The swingarm pivot bolt also acts as the middle rear engine mounting bolt, so it must be removed. To prevent the swingarm/rear wheel assembly from becoming unstable, partially withdraw the pivot bolt from the left-hand side and slide into its place from the right-hand side a suitable bolt that will support the swingarm, making sure that it does not go into the engine mount. Withdraw the pivot bolt further until the engine is free, but leave it partially inserted so that it still supports the left-hand side of the swingarm.

24 The engine can now be removed from the frame. Check that all wiring, cables and hoses are well clear, then carefully lower the engine and manoeuvre it forward and out of the side of the frame (see **Caution** above).

Installation

25 Installation is the reverse of removal, noting the following points:

- Make sure no wires, cables or hoses become trapped between the engine and the frame when installing the engine.
- Many of the engine mounting bolts are of different size and length. Make sure the

correct bolt is installed in its correct location, with its washer if fitted. Install all of the bolts and nuts finger-tight until they are all located, then tighten them in the order given in the relevant Step below to their torque settings as specified at the beginning of the Chapter.

- On TDM models, if removed, and before the engine is mounted, fit the small triangular mounting bracket onto the left-hand side of the engine and the bracket to the underside of the engine at the back and tighten their bolts to the specified torque setting (see illustration 5.21e and f). Locate all the mounting bolts, not forgetting the washers with the engine bracket-to-engine mounting bolts, and tighten them finger-tight. Now tighten the lower rear mounting bolt first, then the upper rear mounting bolt nut, then the engine bracket-to-engine bolts, and finally the engine bracket-to-frame bolts, tightening them all to their specified torque. Fit the caps into each end of the upper rear bolt.
- On TRX models, locate all the mounting bolts, not forgetting the washers with the upper and lower rear bolts (they locate under the bolt head, not the nut), and the collar between the right-hand engine bracket and the engine, and tighten them finger-tight. Now tighten the lower rear mounting bolt nut first, then the upper rear mounting bolt nut, then the upper front mounting bolts (left-hand side first), then the engine bracket-to-engine and

frame bolts (left-hand side), and finally the engine bracket-to-engine and frame bolts (right-hand side), tightening them all to their specified torque. Fit the caps into the upper front bolts.

- On XTZ models, locate the swingarm pivot bolt first, followed by the lower and upper and rear mounting bolts, then fit the frame downtubes, and finally locate the lower front bolt, not forgetting the washers with the swingarm bolt nut and the lower rear bolt nut, and tighten them finger-tight. Now tighten them in the same order to the specified torque settings. Fit the caps into each end of the swingarm pivot and the upper rear bolt.
- On 1991 to 1995 TDM models and all XTZ models, use a new O-ring on the oil pipe to oil pump cover union and tighten the bolts to the specified torque setting.
- Use new gaskets on the exhaust pipe connections.
- Make sure all wires, cables and hoses are correctly routed and connected, and secured by any clips or ties.
- Refill the engine with oil and coolant (see Chapter 1).
- Adjust the throttle and clutch cable freeplay and engine idle speed (see Chapter 1).
- Adjust the drive chain slack (see Chapter 1).
- Start the engine and check that there are no oil or coolant leaks before installing the body panels.

6 Engine disassembly and reassembly – general information

Disassembly

1 Before disassembling the engine, the external surfaces of the unit should be thoroughly cleaned and degreased. This will prevent contamination of the engine internals, and will also make working a lot easier and cleaner. A high flash-point solvent, such as paraffin (kerosene) can be used, or better still, a proprietary engine degreaser. Use old paintbrushes and toothbrushes to work the solvent into the various recesses of the engine casings. Take care to exclude solvent or water from the electrical components and inlet 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, arrange the unit on the workbench, leaving suitable clear area for working. Gather a selection of small containers and plastic bags so that parts can be grouped together in an easily identifiable manner. Some paper and a pen should be on hand so that notes can be made and labels attached where necessary. A supply of clean rag is also required.

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

4 An engine support stand made from short lengths of 2 x 4 inch wood bolted together into a rectangle will help support the engine (**see illustration**). The perimeter of the mount should be just big enough to accommodate the sump within it so that the engine rests on its crankcase.

5 When disassembling the engine, keep 'mated' parts together (including gears, cylinders, pistons, connecting rods, valves, etc. that have been in contact with each other during engine operation). These 'mated' parts must be reused or renewed as an assembly.

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

Remove the valve cover

Remove the camshafts

Remove the cylinder head

Remove the cylinder block

Remove the pistons

Remove the clutch

Remove the alternator/pick-up coil assembly (see Chapter 9)

Remove the starter motor (see Chapter 9)

Remove the gearchange mechanism external components

Remove the oil pumps

Remove the oil sump

Separate the crankcase halves

Remove the crankshaft

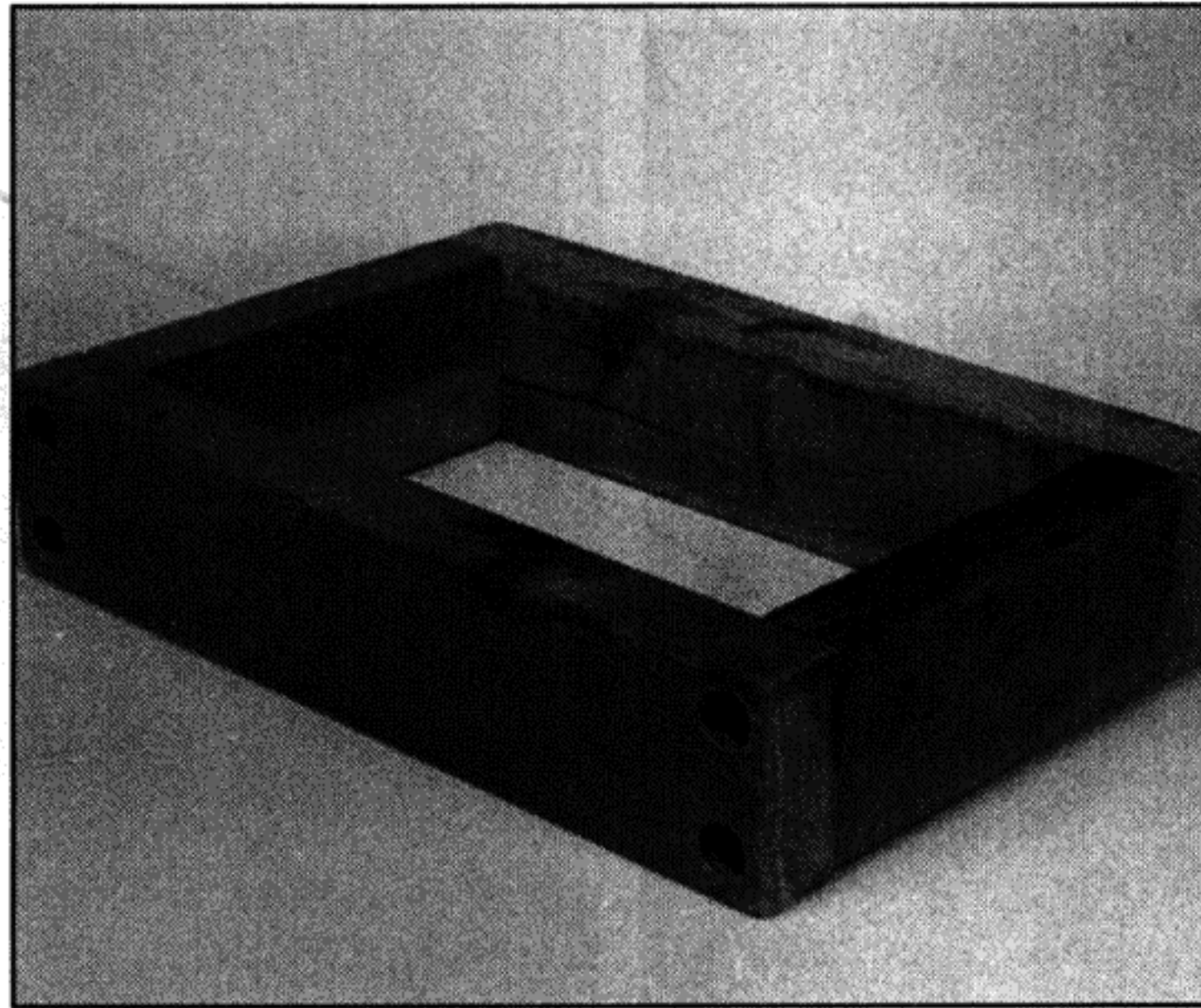
Remove the transmission shafts

Remove the selector drum and forks

Remove the balancer shafts

Reassembly

7 Reassembly is accomplished by reversing the general disassembly sequence.



6.4 An engine support made from pieces of 2 x 4 inch wood

7 Valve cover – 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.

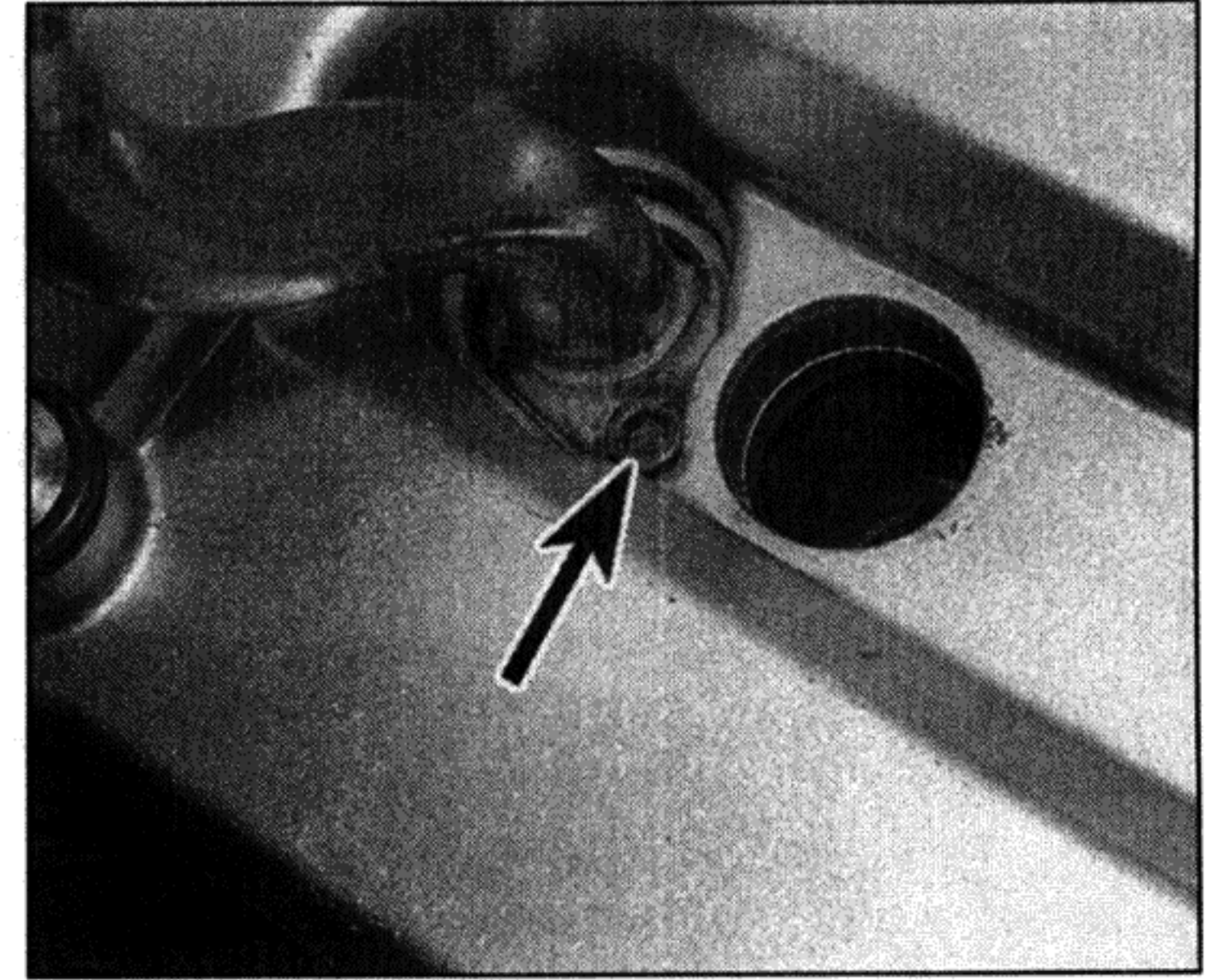
Removal

1 Remove the fuel tank, the air filter housing and the carburettors (see Chapter 4). Drain the coolant (see Chapter 1).

2 On TDM and TRX models, remove the thermostat housing (see Chapter 3). When removing the housing, remove it along with the pipe that bolts onto the valve cover, rather than separating the hose from the pipe. The pipe is secured by a bolt – make sure the pipe O-ring does not fall into the engine when easing out the pipe (**see illustration**). Discard the O-ring as a new one must be used.

3 On XTZ models, unscrew the bolt securing the coolant pipe to the valve cover and ease the pipe out, making sure the O-ring does not fall into the engine (**see illustration 7.2**). Discard the O-ring as a new one must be used.

4 If required, release the clamp securing the breather hose to the valve cover and detach the hose (**see illustration**).



7.2 Unscrew the bolt (arrowed) and detach the pipe from the cover

5 Pull the spark plug caps off the plugs and secure them clear of the engine, noting which fits where.

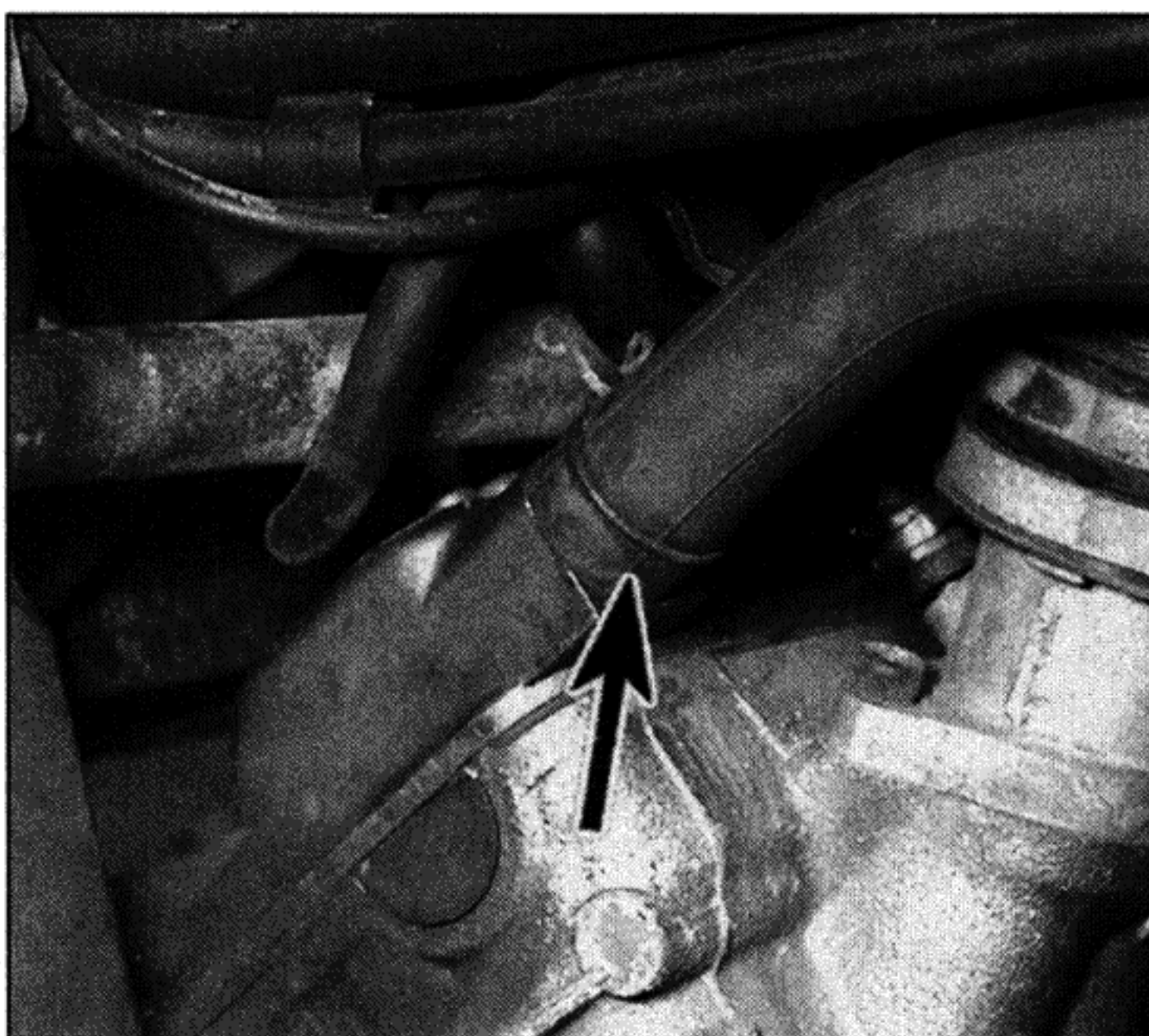
6 Unscrew the bolts securing the valve cover then lift the cover off the cylinder head (**see illustration**). On 1996-on TDM models and all TRX models, note which bolt fits where as some are of different length. If the cover is stuck, do not try to lever it off with a screwdriver. Tap it gently around the sides with a rubber hammer or block of wood to dislodge it. Also remove the gasket. Note the rubber spark plug hole gaskets fitted inside the cover and remove them if they are loose.

Installation

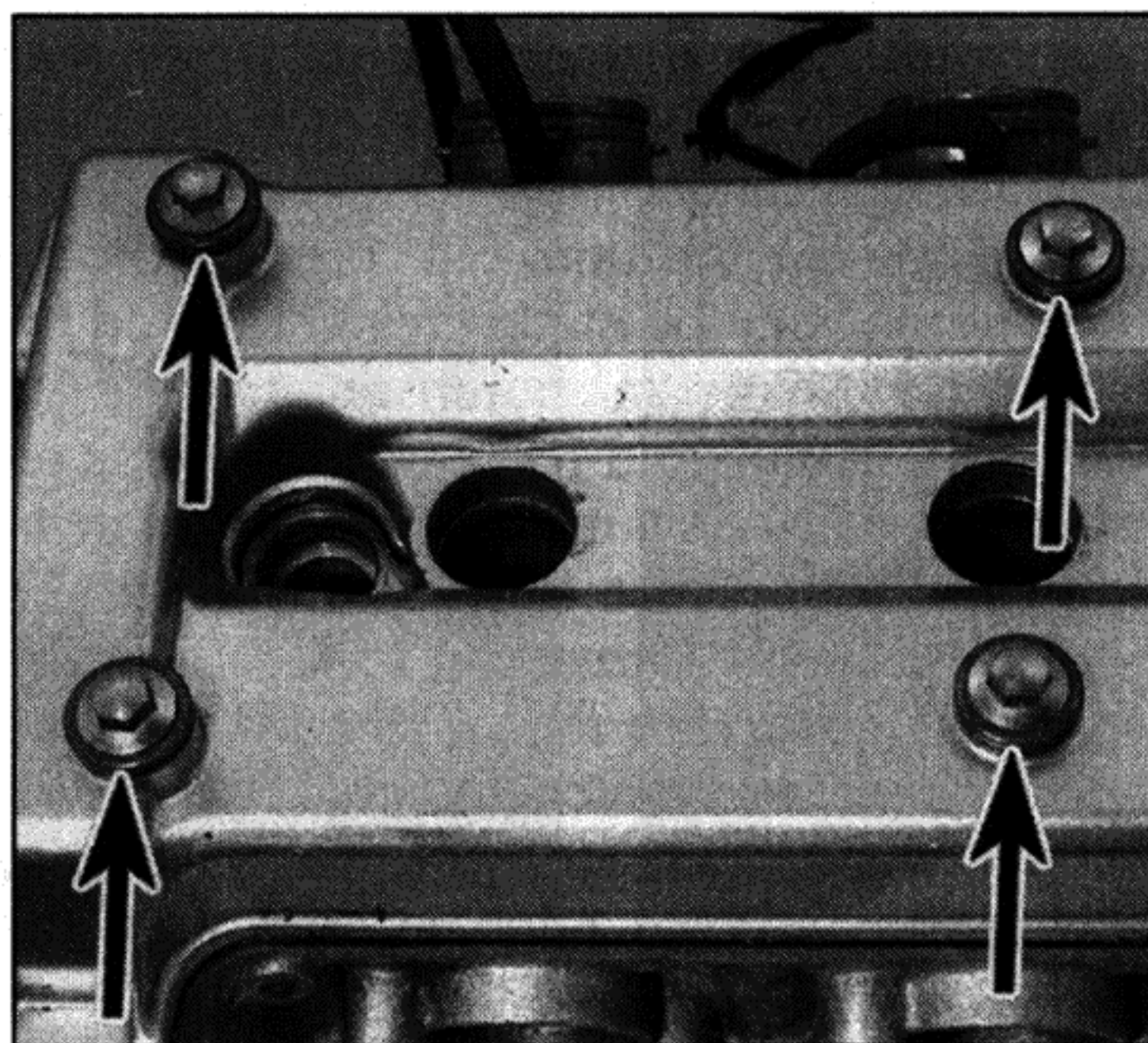
7 Examine the valve cover gasket and the spark plug hole gaskets for signs of damage or deterioration and renew them if necessary. Similarly check the rubber grommets on the cover bolts (**see illustration 7.10b**).

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

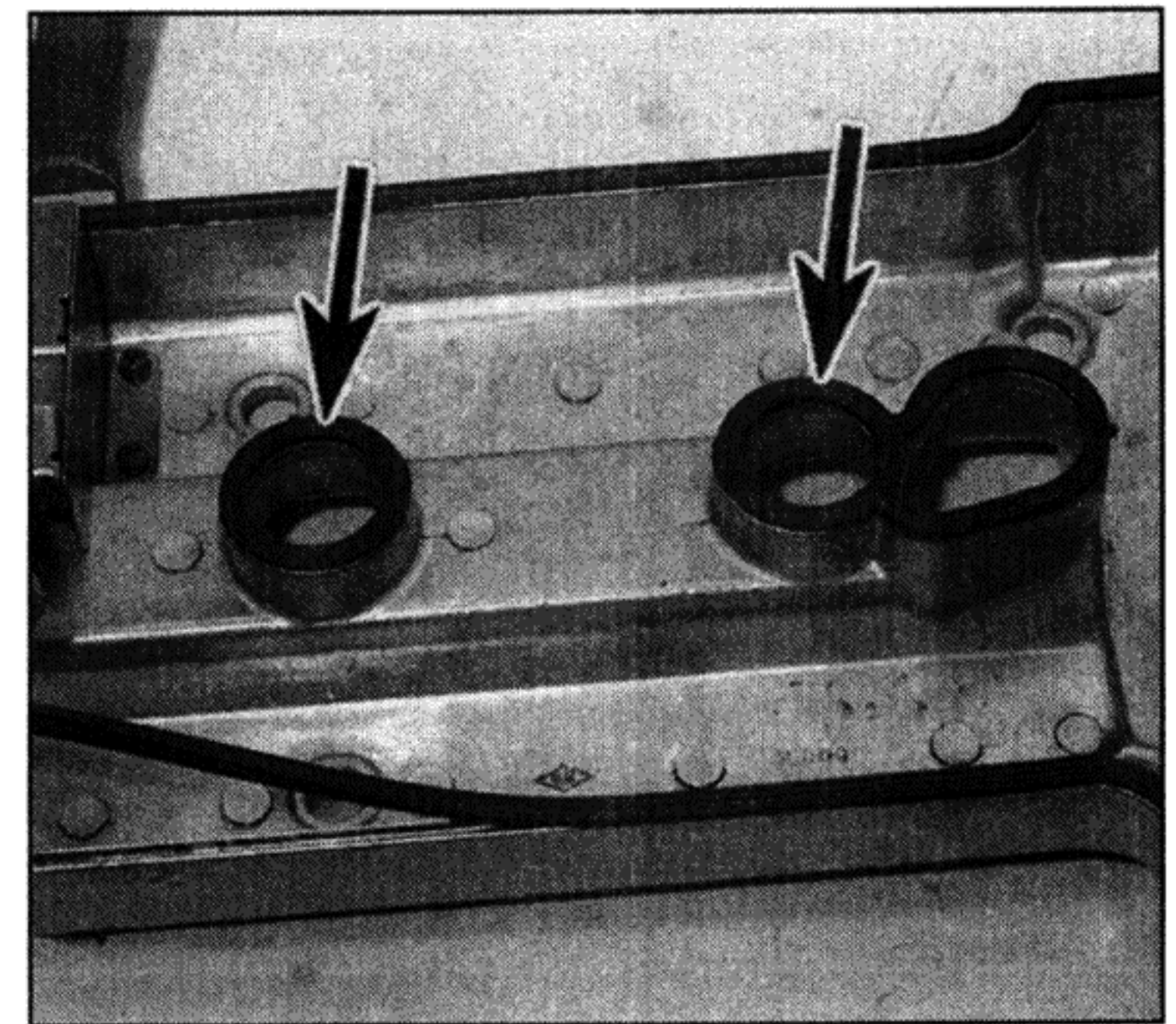
9 Install the gasket onto the valve cover, making sure it fits correctly into the groove (**see illustration**). Also fit the spark plug hole gaskets. Use a few dabs of grease to keep the gaskets in place while the cover is fitted.



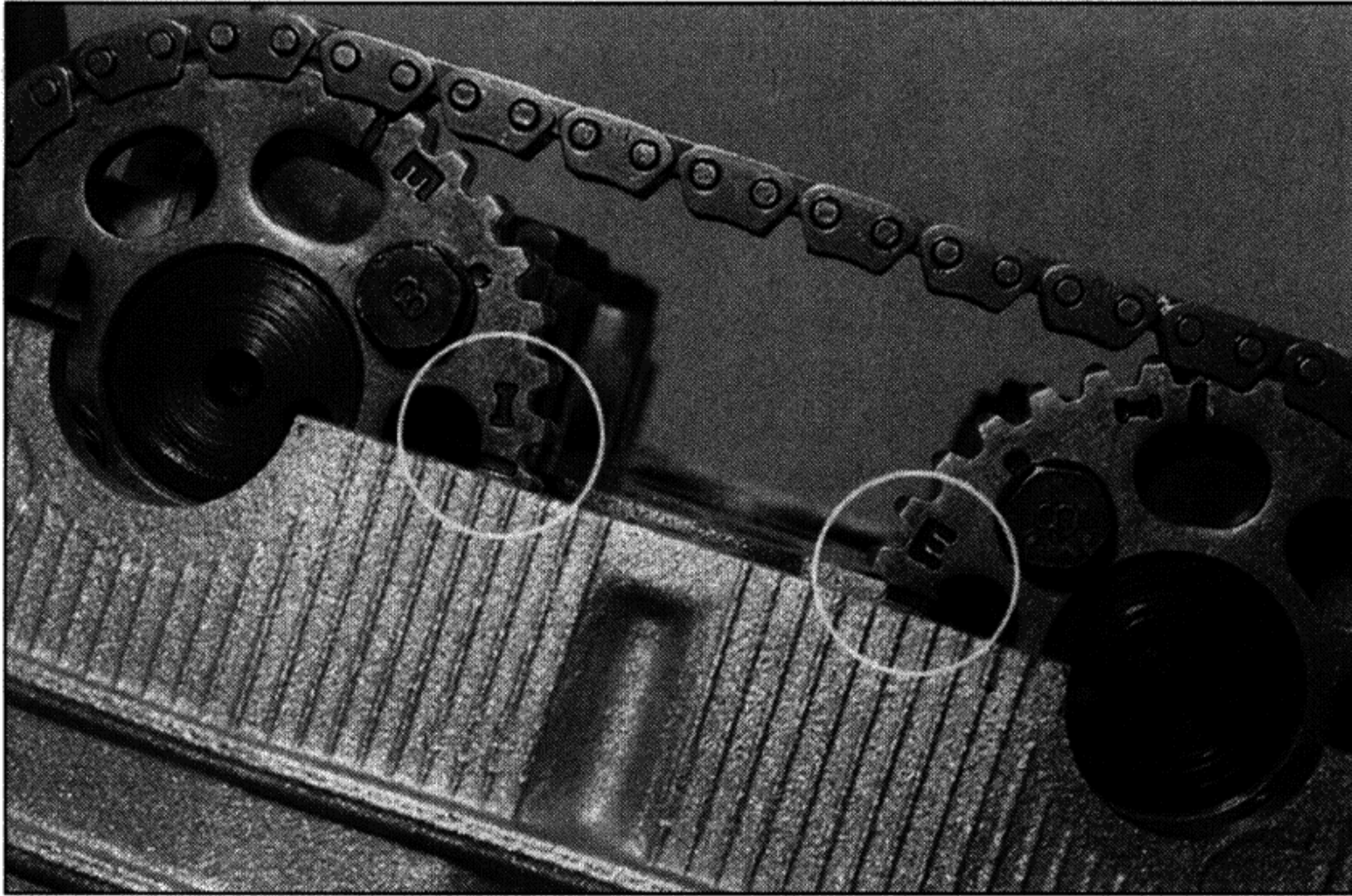
7.4 Release the clamp and detach the breather hose (arrowed)



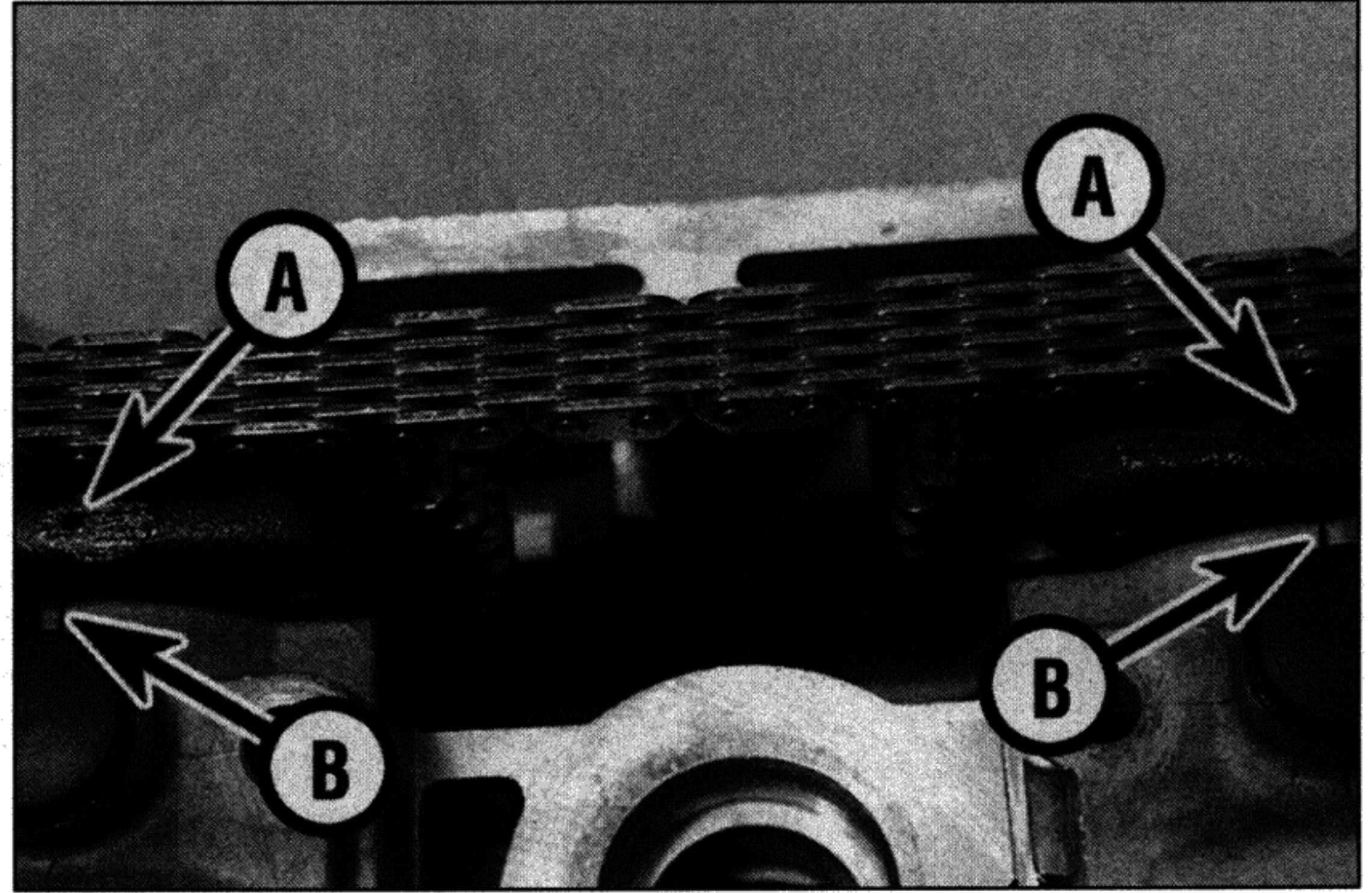
7.6 Unscrew the valve cover bolts (arrowed) and remove the cover – early TDM and XTZ type cover shown



7.9 Fit the main gasket and the spark plug hole gaskets (arrowed) into their grooves



8.3b Note the alignment of the timing mark letters on the sprockets with the cylinder head . . .



8.3c . . . and of the punch marks (A) on the ends of the camshafts with the lines (B) on the camshaft holders

surface and faces back, while the 'I' mark on the inlet camshaft sprocket is parallel with the cylinder head top surface and faces forward (see illustration). Also the punch mark on each camshaft sprocket holder faces up and aligns with the mark on the top of the camshaft holder (see illustration). If you are in any doubt as to the alignment of the markings, or if they are not visible, make your own alignment marks between all components, and also between a tooth on each sprocket and its corresponding link on the chain, before disturbing them. These markings ensure that the valve timing can be correctly set up on assembly without difficulty. As it is easy to be a tooth out on installation, marking between a tooth on each sprocket and its link in the chain is especially useful.

4 Unscrew the bolts securing the cam chain top guide and remove the guide, noting how it fits (see illustration).

5 Slacken, but do not remove, the camshaft sprocket bolts (see illustration). If the sprockets turn, counter-hold them by

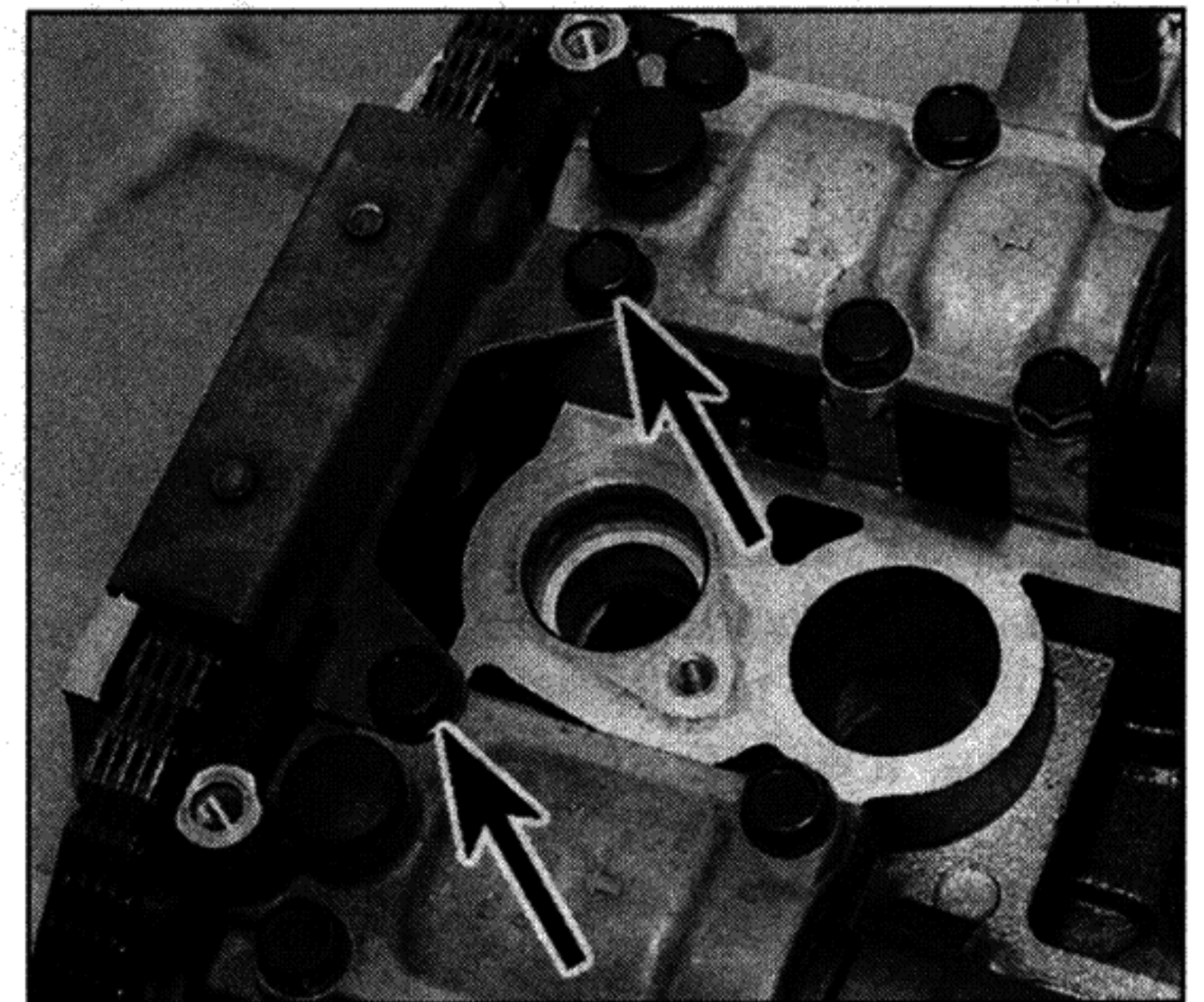
inserting a screwdriver or bar through the hole in the centre of the camshaft (see illustration 8.29a), or by counter-holding the alternator rotor.

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

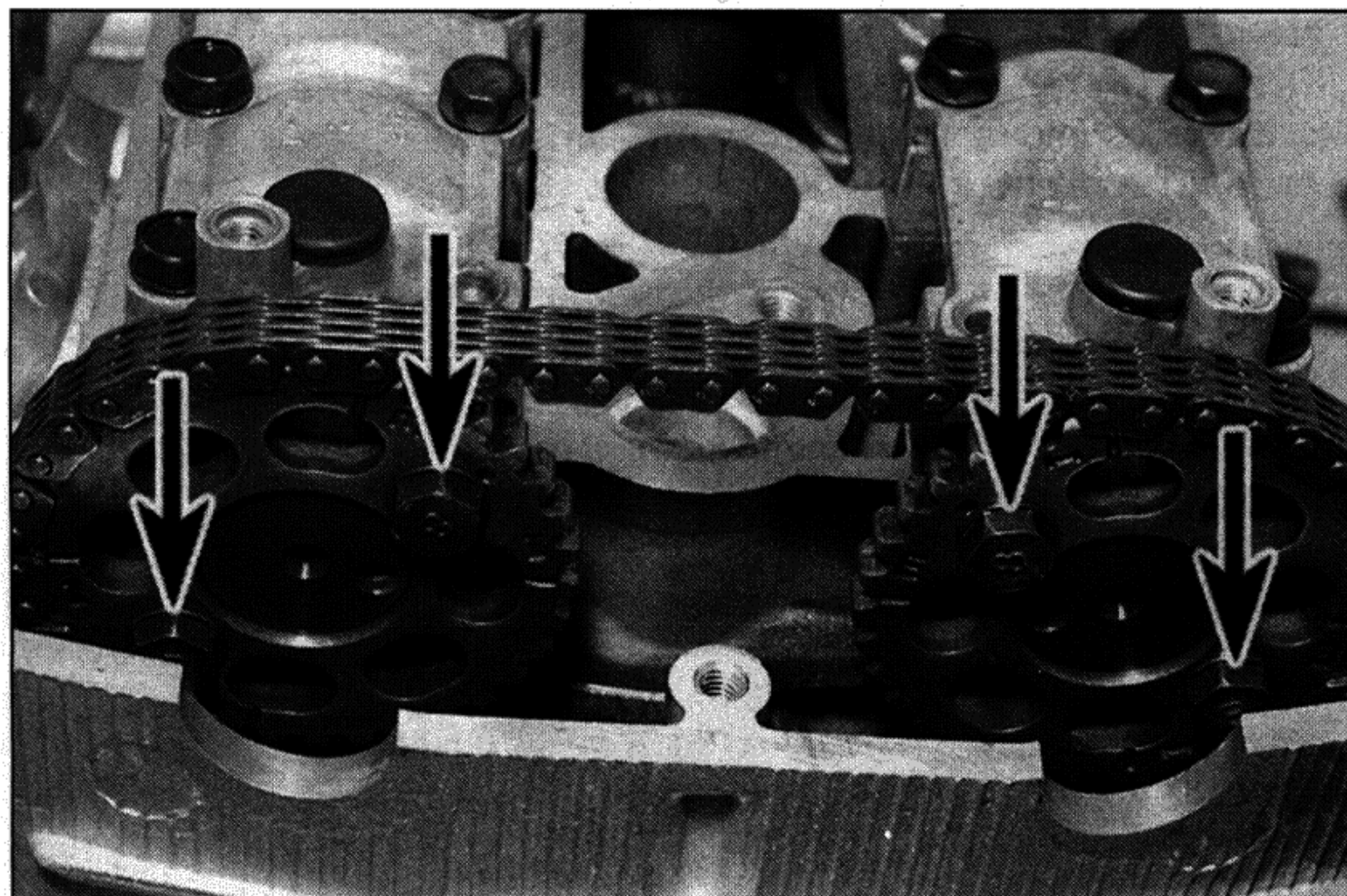
7 Make a mark on each sprocket to denote whether it fits with the exhaust or inlet camshaft (the appropriate existing letter can be highlighted). Remove the sprocket bolts, then draw each sprocket off the end of its camshaft and slip it out of the chain (see illustration). If required, also lift the cam chain front guide out of the front of the cam chain tunnel, noting how and which way round it fits (see Section 24). While the camshaft sprockets are off, don't allow the cam chain to go slack and do not rotate the crankshaft – the chain may drop down and bind between the crankshaft and case, which could damage these components. Wire the chain to another component or secure it using a rod of some sort to prevent it from dropping.

8 Before removing the camshaft holders, make a note of which fits where. All the

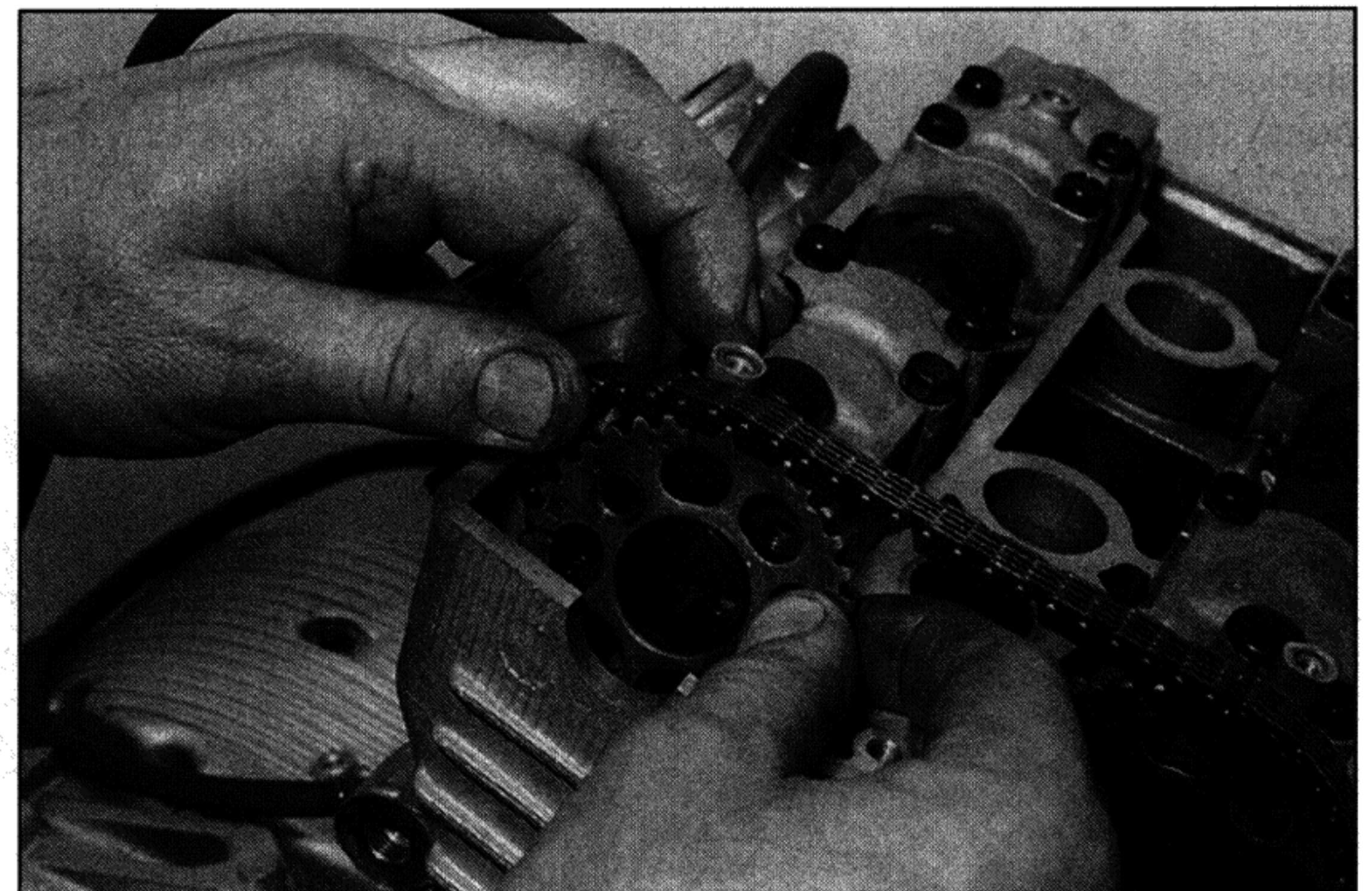
holders are marked with a letter and number to denote their location – I 1 is the inlet camshaft holder on the No. 1 cylinder (left-hand) side, E 1 is the exhaust camshaft holder on the No. 1 cylinder, and so on. Also each holder is marked with an arrow which points towards the cam chain. Otherwise their



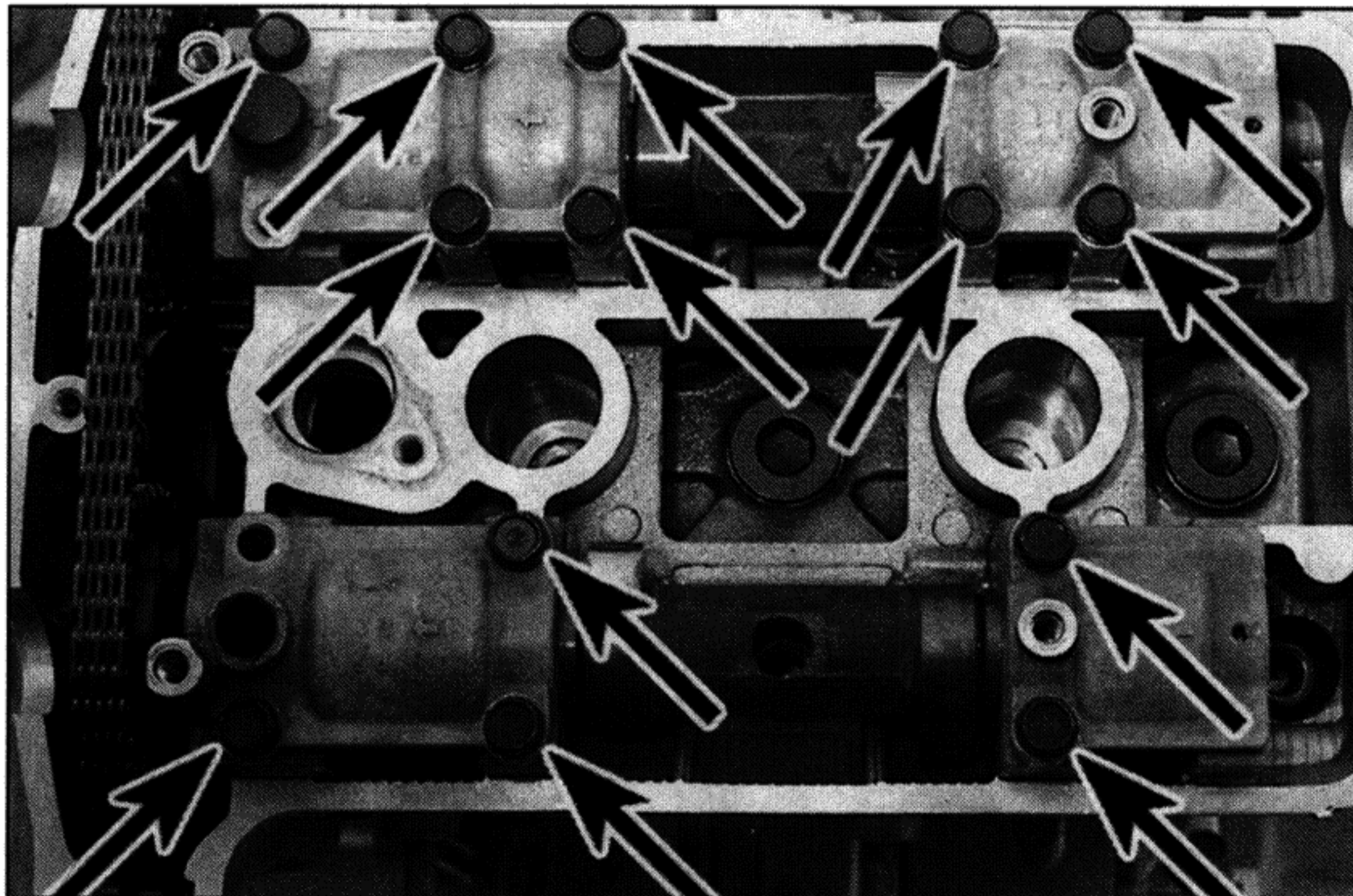
8.4 Unscrew the bolts (arrowed) and remove the guide



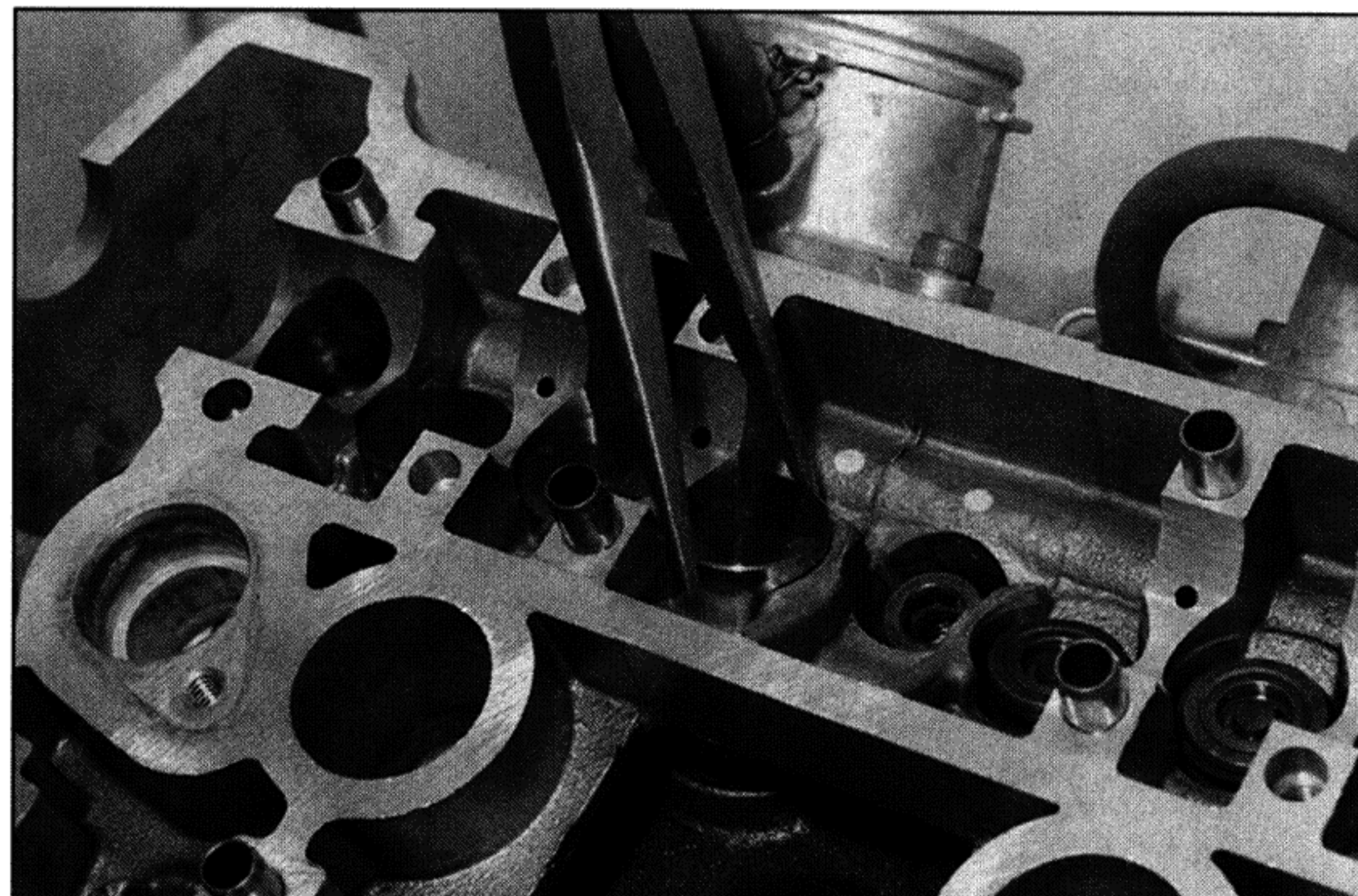
8.5 Slacken the camshaft sprocket bolts (arrowed)



8.7 Slide the sprockets off the camshafts and out of the chain



8.9 Unscrew and remove the camshaft holder bolts (arrowed)



8.10a Lift out the follower . . .



8.10b . . . and remove the shim either from inside the follower . . .



8.10c . . . or from the top of the valve

locations are readily identifiable by the differing number or location of bolts which secures each one.

9 Before slackening the camshaft holder bolts, check whether any of the cam lobes are directly depressing the valves and if so, rotate the camshaft slightly to release the pressure; this will prevent distortion or undue strain on the holders as the bolts are slackened. Unscrew the camshaft holder bolts for the camshaft being worked on, evenly and a little at a time in a criss-cross

pattern, until they are all loose (**see illustration**).

Caution: *If the bolts aren't loosened evenly, the camshaft may bind.*

Remove the bolts, then lift off the camshaft holders, noting how they fit, and remove the camshafts (**see illustrations 8.26a and 8.25**). Retrieve the dowels from either the holder or the cylinder head if they are loose. Keep all mated parts together.

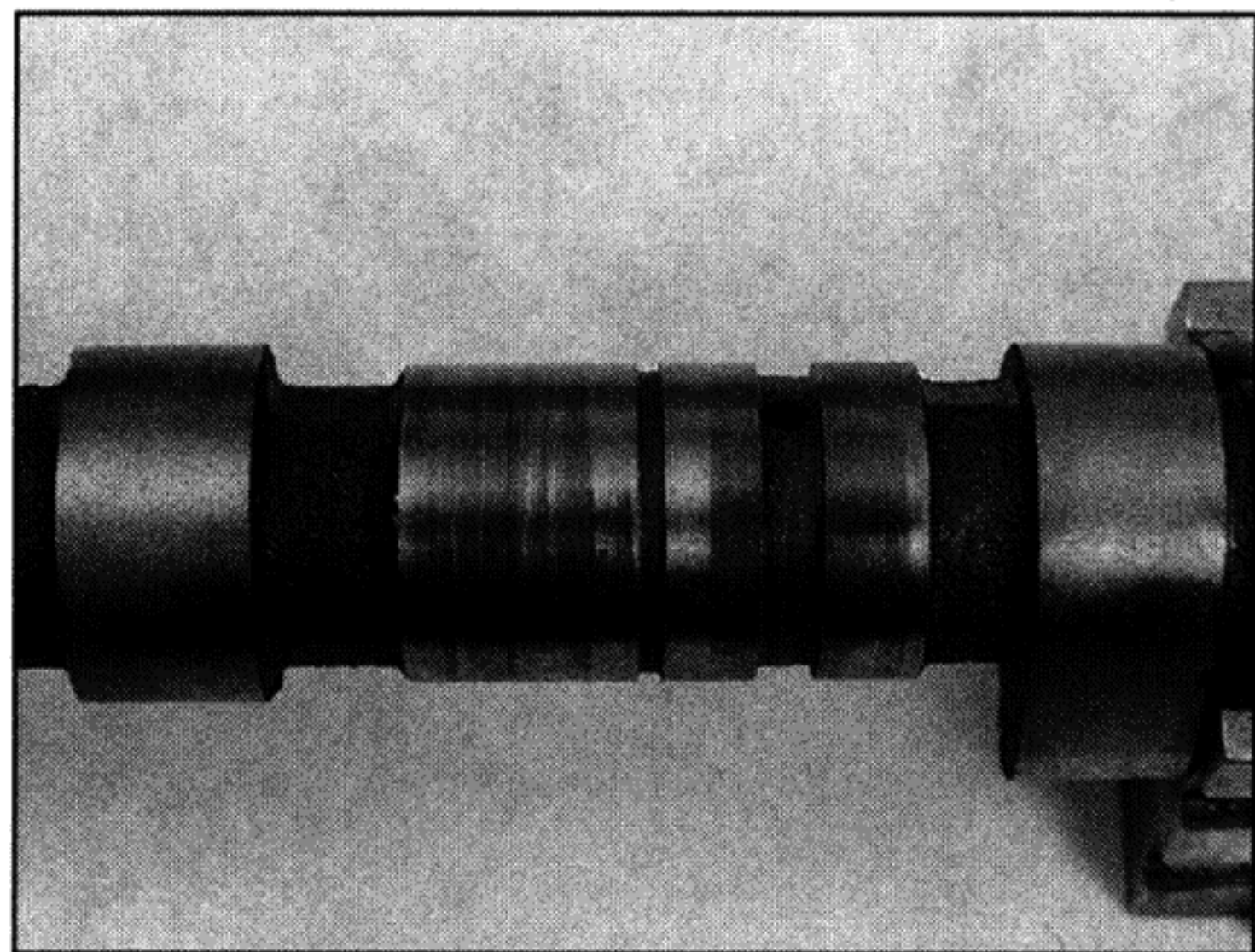
10 Obtain a container which is divided into ten compartments, and label each compartment

with the location of its corresponding valve in the cylinder head and whether it belongs with an inlet or an exhaust valve. If a container is not available, use labelled plastic bags. Using a pair of pliers or a magnet if necessary, lift each follower out of the cylinder head and store it in its corresponding compartment in the container (**see illustration**). The shim is likely to stick to the inside of the follower so take great care not to lose it when removing the follower (**see illustration**). Retrieve the shim from either the inside of the follower or pick it out of the top of the valve using a magnet, a small screwdriver with a dab of grease on it (the shim will stick to the grease), or a screwdriver and a pair of pliers (**see illustration**). Do not allow the shim to fall into the engine.

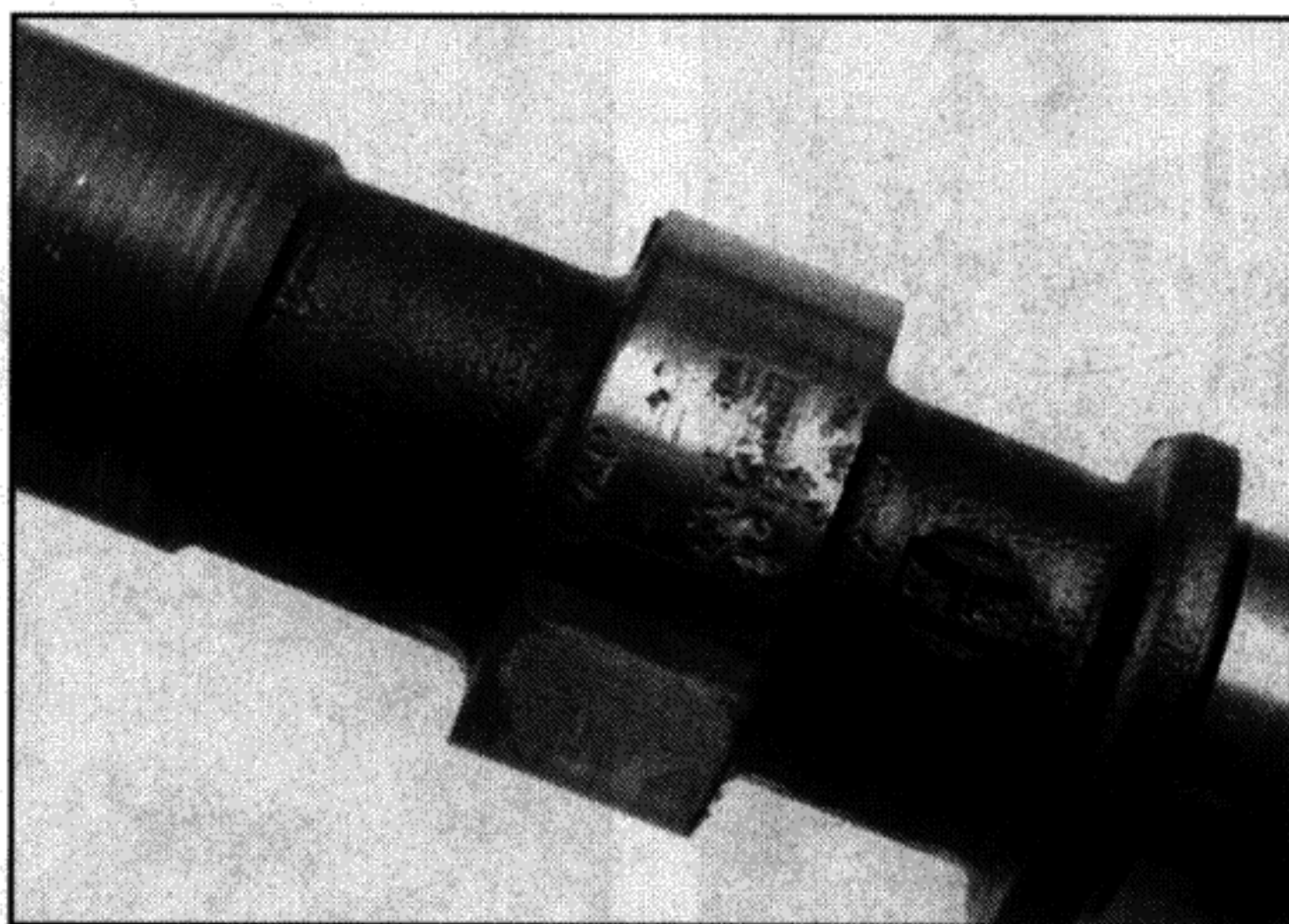
Inspection

11 Inspect the bearing surfaces of the camshaft holders and the corresponding journals on the camshaft. Look for score marks, deep scratches and evidence of spalling (a pitted appearance) (**see illustration**).

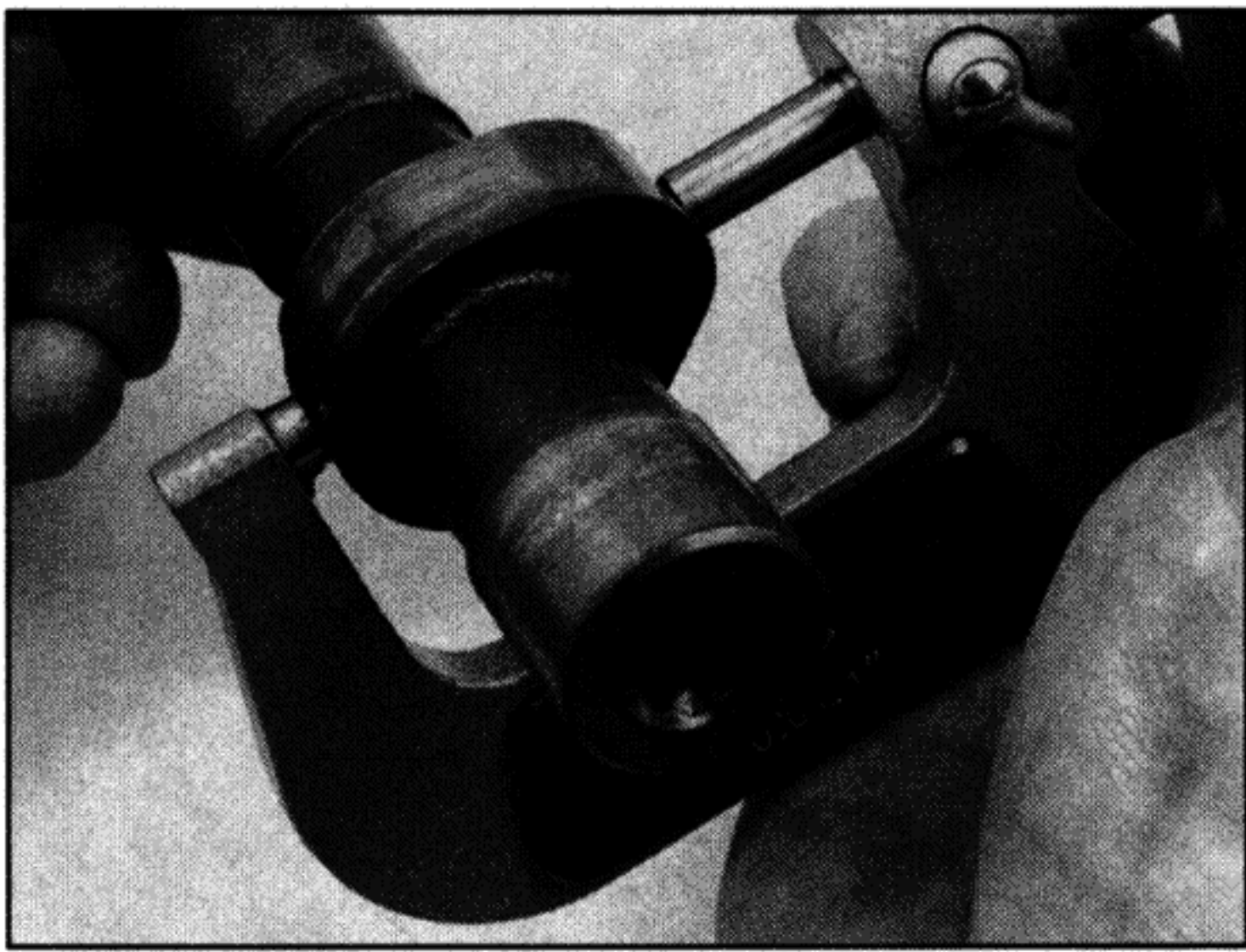
12 Check the camshaft lobes for heat discoloration (blue appearance), score marks, chipped areas, flat spots and spalling (**see illustration**). Measure the height of each lobe



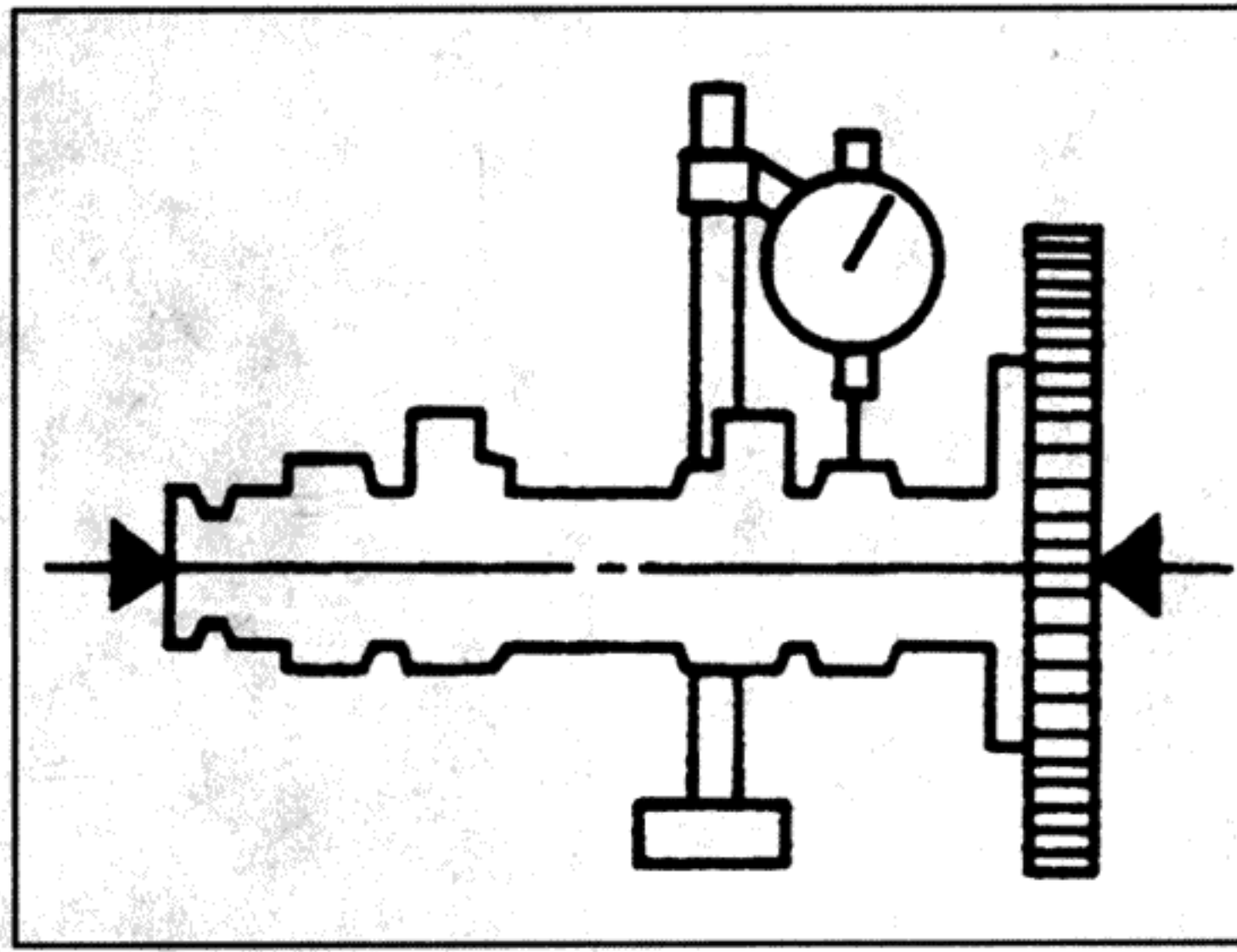
8.11 Check the journal surfaces of the camshaft for scratches or wear



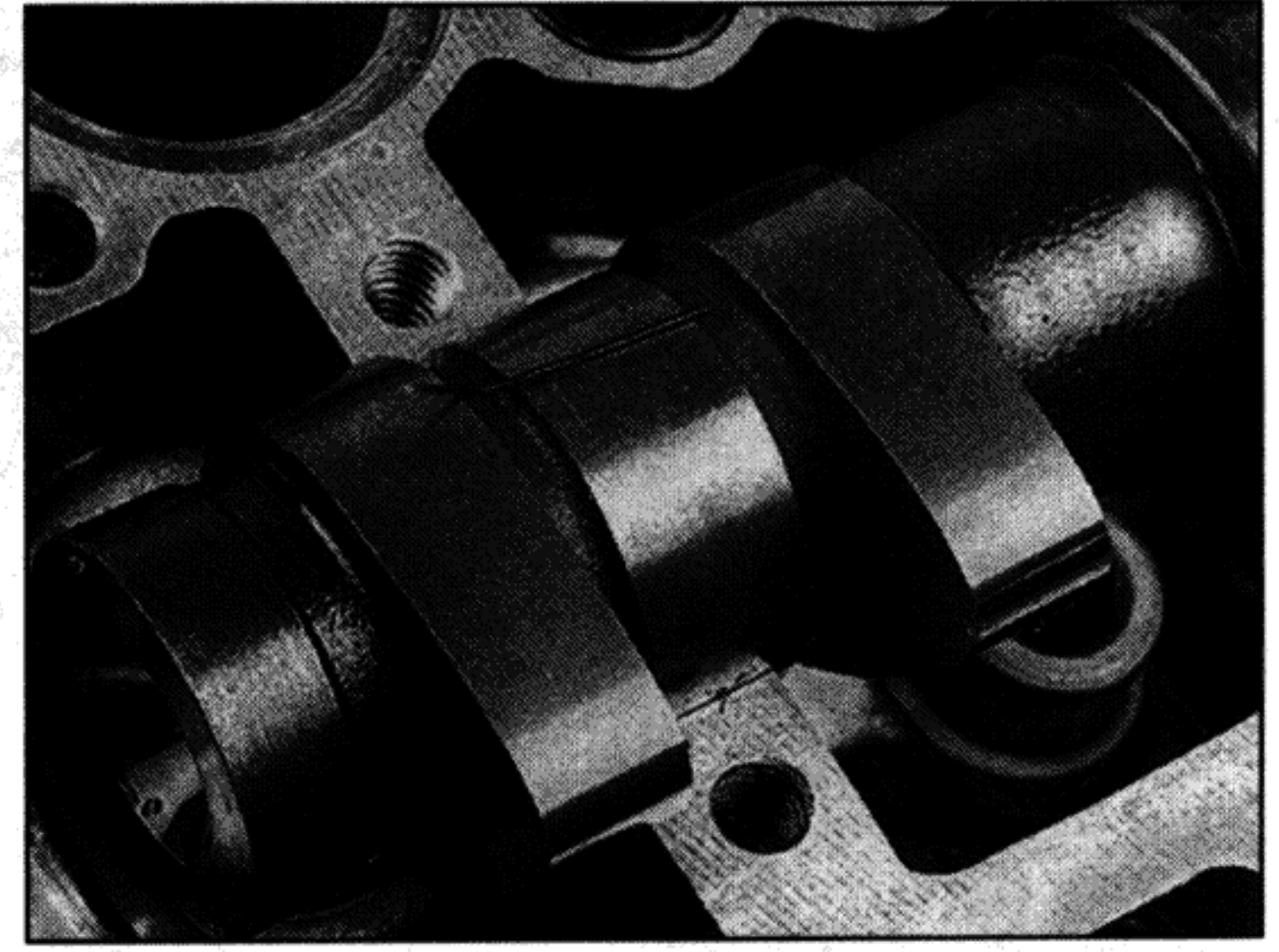
8.12a Check the lobes of the camshaft for wear – here's an example of damage requiring camshaft repair or renewal



8.12b Measure the height of the camshaft lobes with a micrometer



8.13 Measuring camshaft runout



8.15 Lay a strip of Plastigauge across each bearing journal, parallel with the camshaft centreline

with a micrometer (see illustration) and compare the results to the minimum lobe height listed in this Chapter's Specifications. If damage is noted or wear is excessive, the camshaft must be renewed. Also, be sure to check the condition of the followers.

13 Check the amount of camshaft runout by supporting each end of the camshaft on V-blocks, and measuring any runout using a dial gauge (see illustration). If the runout exceeds the specified limit the camshaft must be renewed.



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

14 Next, check the camshaft bearing oil clearances. Check each camshaft in turn rather than at the same time. Clean the camshaft, the bearing surfaces in the cylinder head and camshaft holders with a clean lint-free cloth, then lay the camshaft in place in the cylinder head.

15 Cut some strips of Plastigauge and lay one piece on each bearing journal, parallel with the camshaft centreline (see

illustration). Make sure the camshaft holder dowels are installed. Lay the holders in their correct place in the cylinder head (see Step 8) (see illustration 8.26a). Make sure the arrow on each camshaft holder points towards the cam chain. Tighten the bolts evenly and a little at a time in a criss-cross pattern, working from the centre of the camshaft outwards, to the torque setting specified at the beginning of the Chapter (see illustration 8.26b). Whilst tightening the bolts, make sure the holders are being pulled squarely down and are not binding on the dowels. While doing this, don't let the camshafts rotate.

16 Now unscrew the bolts a evenly and a little at a time in a criss-cross pattern, and carefully lift off the camshaft holders.

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



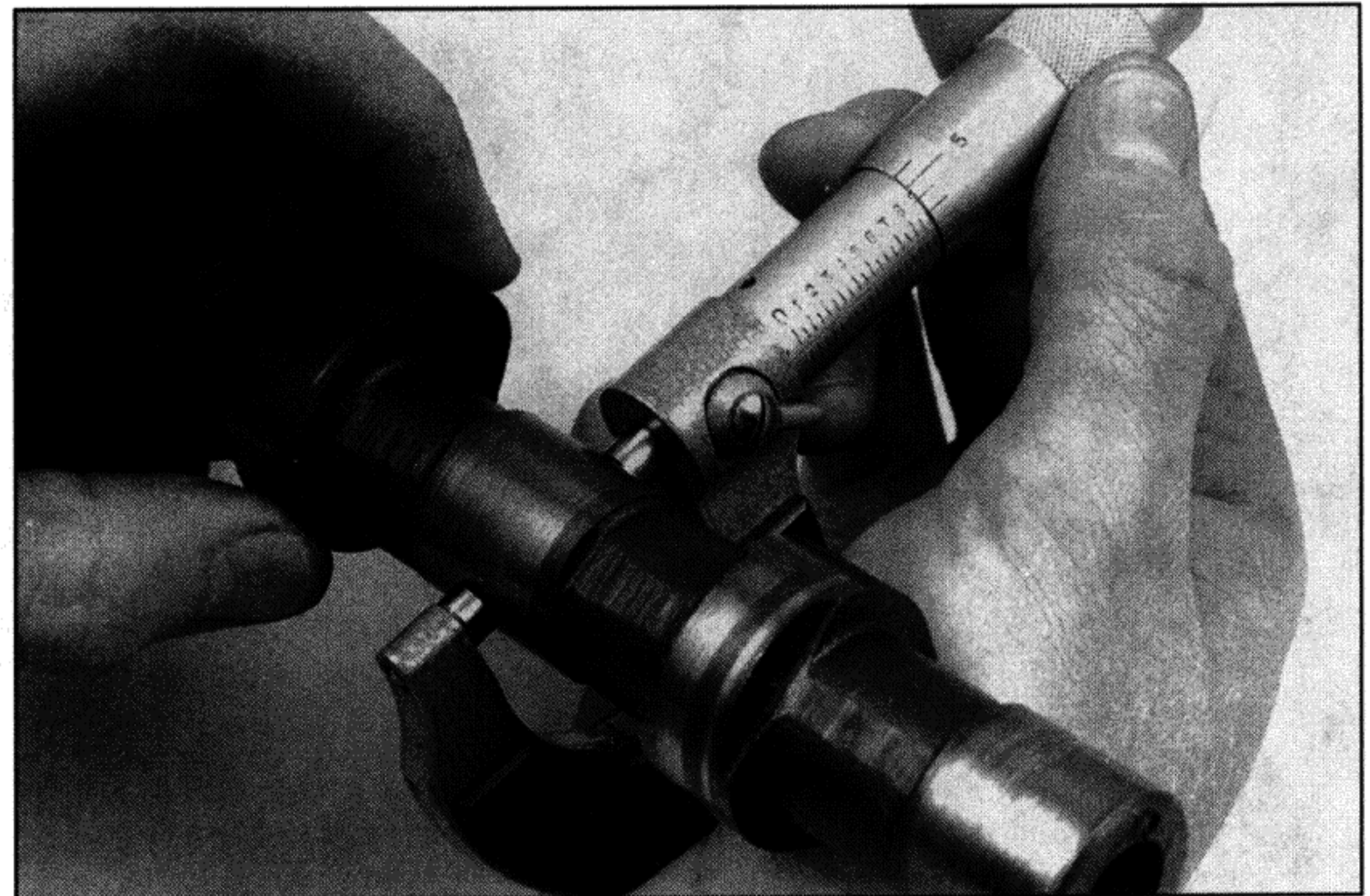
Before renewing camshafts or the holders because of damage, check with local machine shops specialising in motorcycle engine work. In the case of the camshafts, it may be possible for cam lobes to be welded, reground and hardened, at a cost far lower than that of a new camshaft. If the bearing surfaces in the 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!

18 Except in cases of oil starvation, the cam chain wears very little. If the chain has stretched excessively, which makes it difficult to maintain proper tension, or if it is stiff or the links are binding or kinking, renew it. Refer to Section 24 for the procedure.

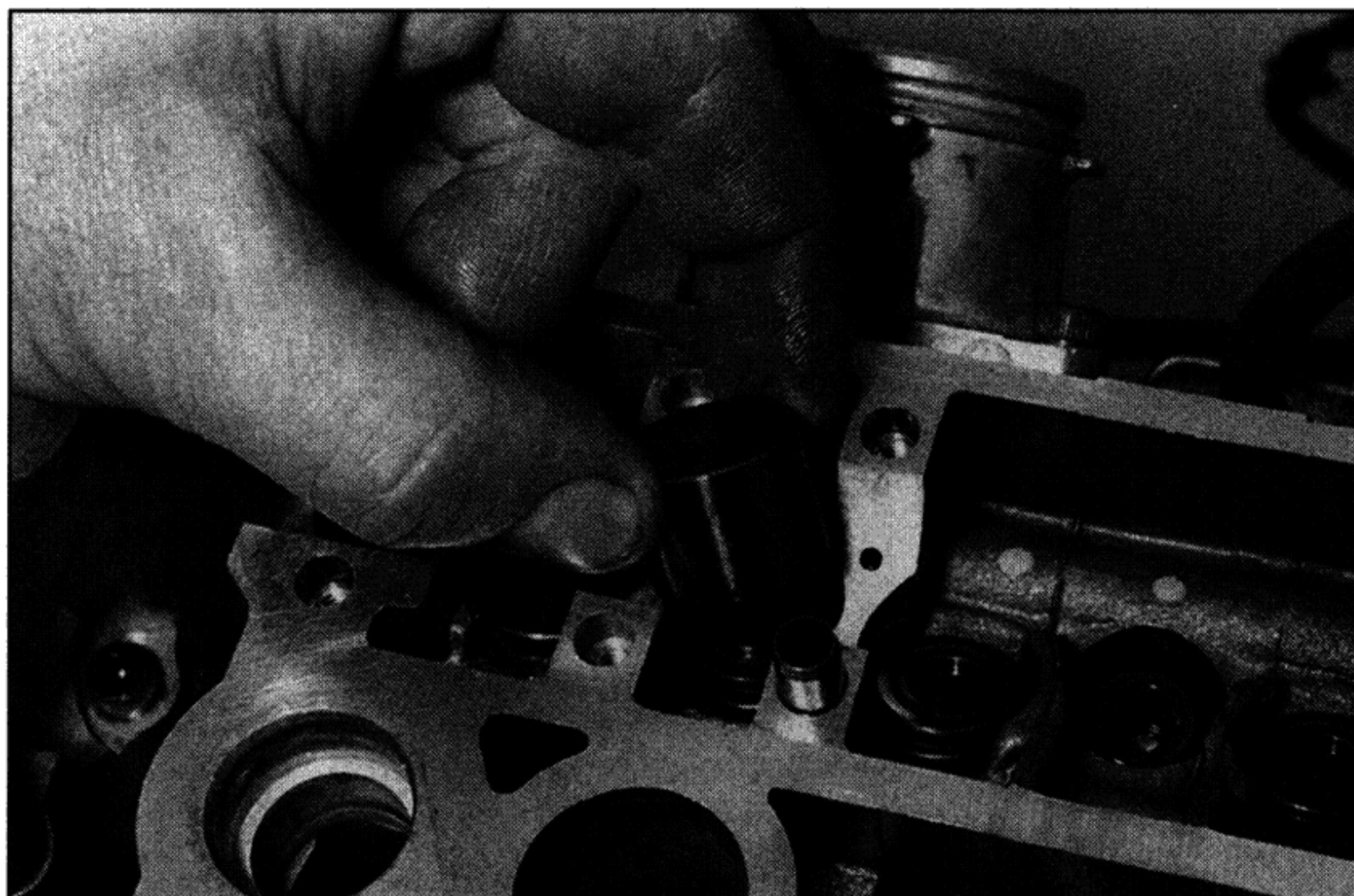
19 Check the sprockets for wear, cracks and other damage. If the sprockets are worn, the cam chain is also worn, and so is the sprocket on the crankshaft. If severe wear is apparent, the entire engine should be disassembled for inspection.



8.17a Compare the width of the crushed Plastigauge to the scale printed on the Plastigauge container



8.17b Measure the cam bearing journals with a micrometer



8.22 Fit the followers onto the valves

20 Inspect the cam chain guide blade (see Section 24).

21 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.

Installation

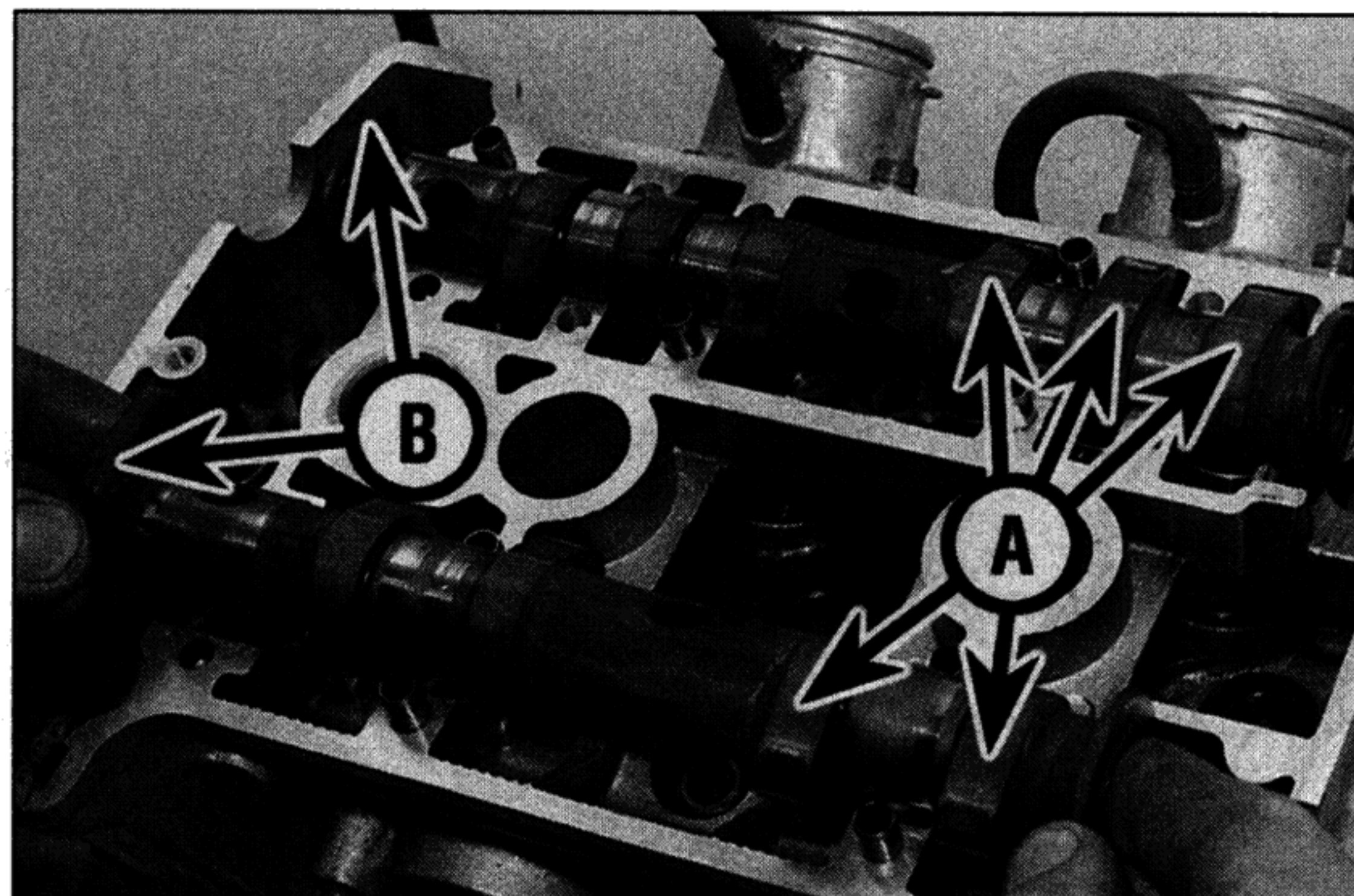
22 Lubricate each shim and its follower with molybdenum disulphide oil (a 50/50 mixture of molybdenum disulphide grease and engine oil) and fit each shim into its recess in the top of the valve, with the size marking on each shim facing up (see illustration 8.10c). Make sure each shim is correctly seated in the top of the valve assembly, then install each follower, making sure it fits squarely in its bore (see illustration). **Note:** It is most important that the shims and followers are returned to

their original valves otherwise the valve clearances will be inaccurate.

23 If removed, fit the cam chain front guide into the front of the cam chain tunnel, making sure it is the correct way round with the lugs properly located in the cutouts in the top of the cylinder head (see Section 24).

24 Make sure the bearing surfaces on the camshafts and in the holders are clean, then apply molybdenum disulphide oil (a 50/50 mixture of molybdenum disulphide grease and engine oil) to each of them. Also apply it to the camshaft lobes.

25 Verify that the 'I' mark on the timing rotor is still aligned with the notch (see Step 3) (see illustration 8.3a). Lay the inlet camshaft (with six lobes) onto the back of the head, making sure the No. 1 (left-hand) cylinder lobes are facing backwards and the punch mark on the sprocket holder is facing up. Now lay the exhaust camshaft (with four lobes) onto the front of the head, making sure the No. 1 cylinder lobes are facing forward and the punch mark on the sprocket holder is facing up (see illustration).

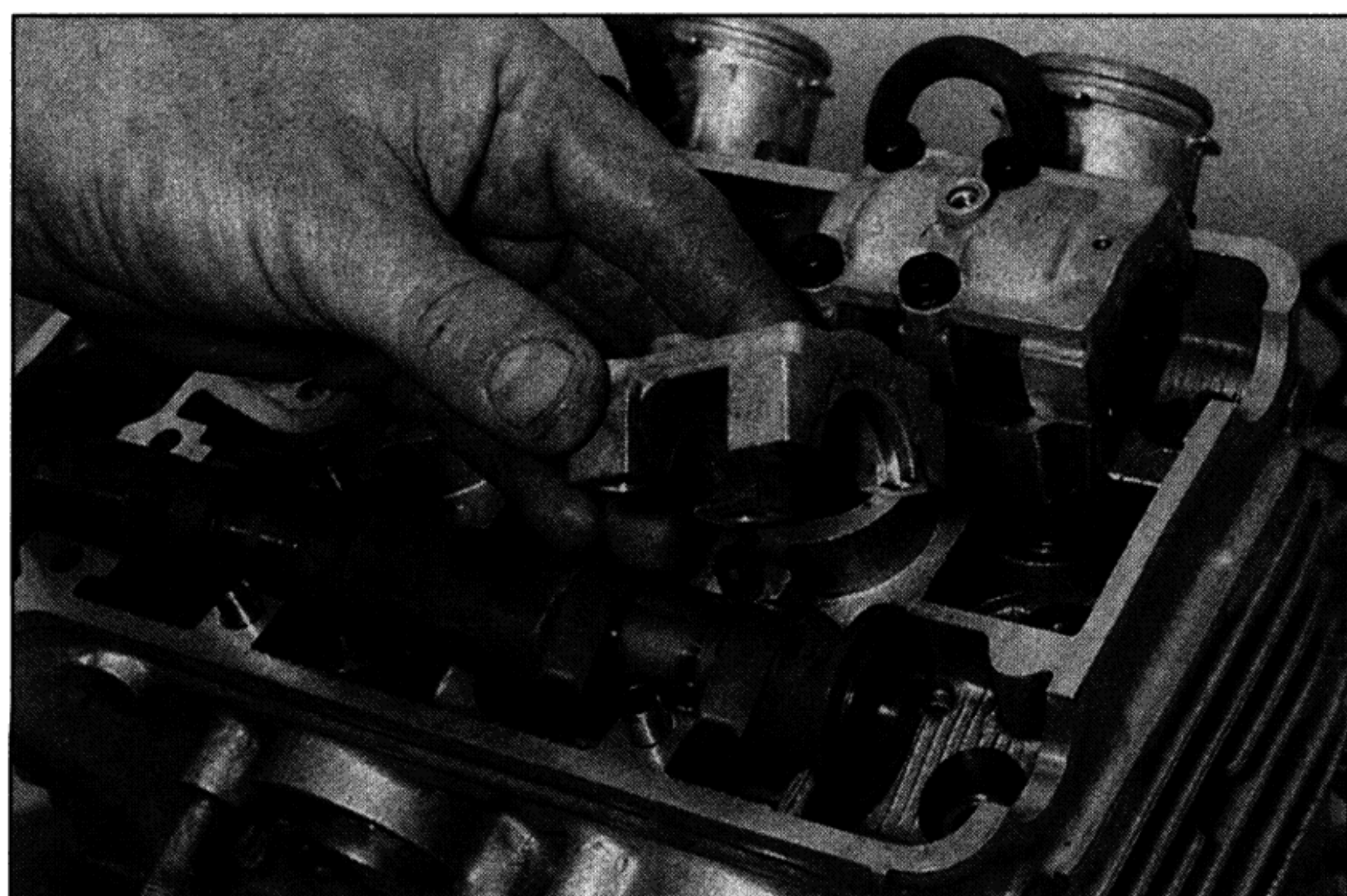


8.25 Install the camshafts as shown, with the No. 1 cylinder lobes (A) facing away from each other and the punch mark (B) on each sprocket holder facing up

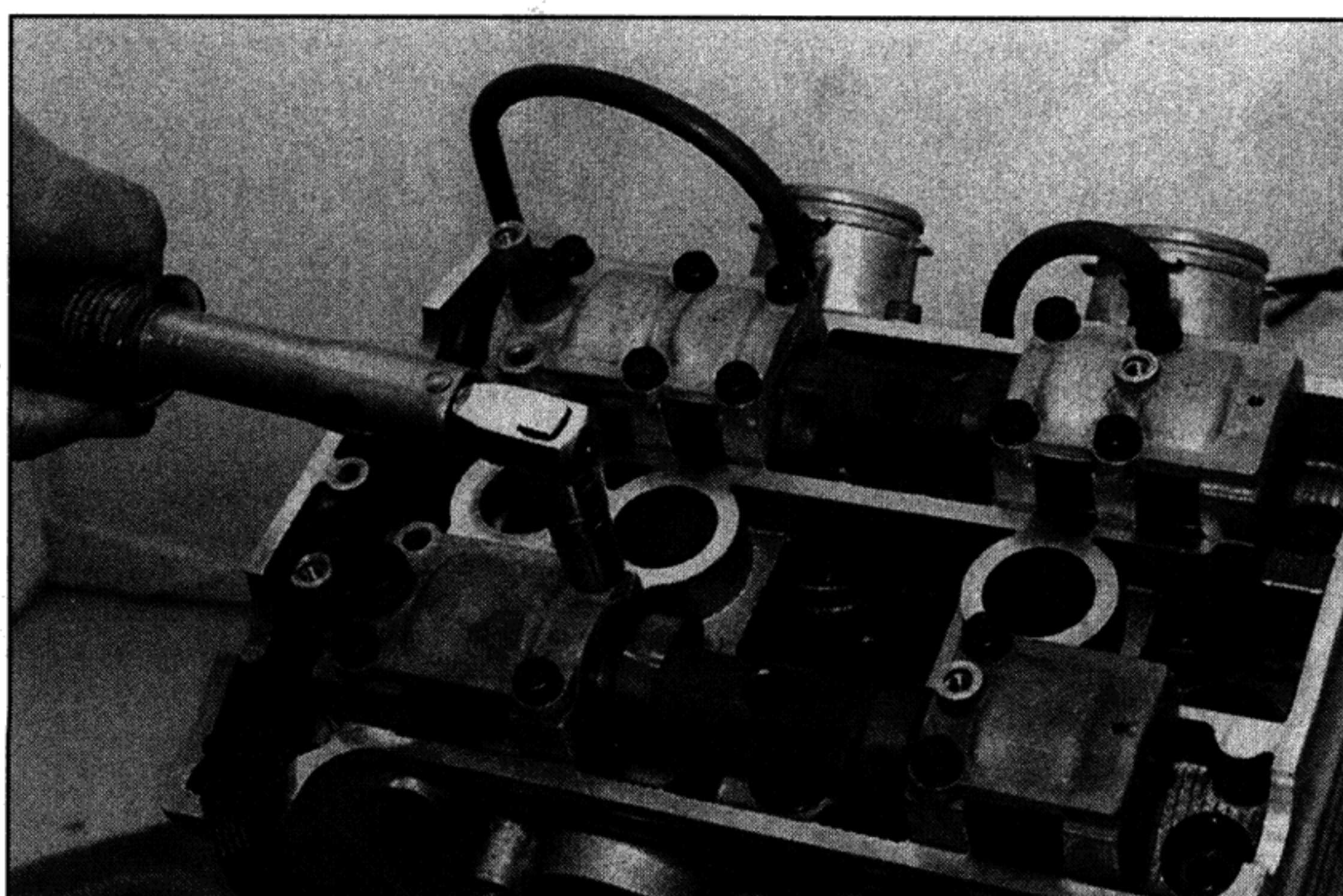
26 Make sure the camshaft holder dowels are installed. Lay the holders in their correct place in the cylinder head (see Step 8) (see illustration). Make sure the arrow on each camshaft holder points towards the cam chain. Tighten the bolts evenly and a little at a time in a criss-cross pattern, working from the centre of the camshaft outwards, to the torque setting specified at the beginning of the Chapter (see illustration). Whilst tightening the bolts, make sure the holders are being pulled squarely down and are not binding on the dowels.

Caution: The holders are likely to break if they are not tightened down evenly and squarely.

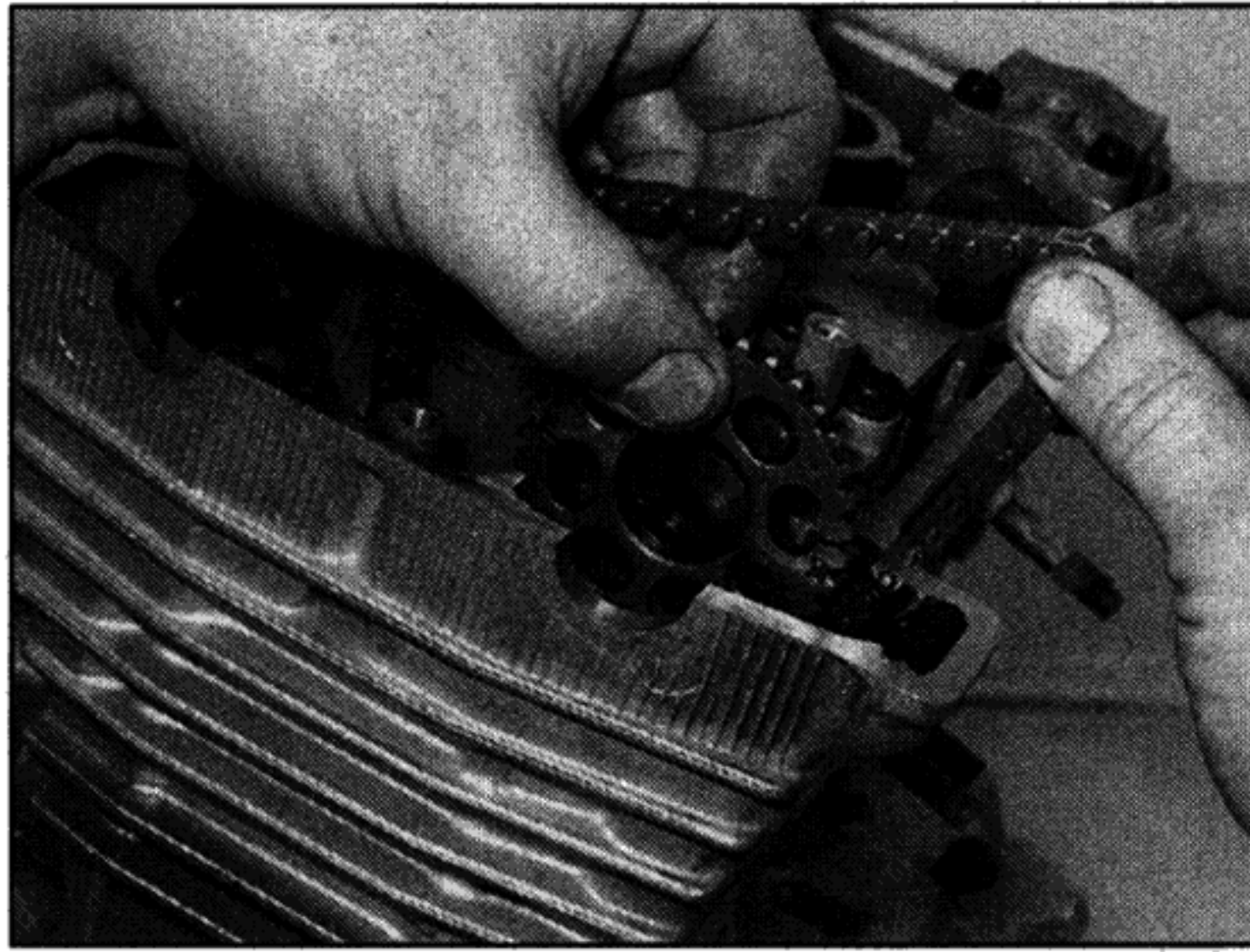
27 When installing the camshaft sprockets, align the 'E' marks (for the exhaust camshaft) and the 'I' marks (for the inlet camshaft) on the camshaft sprockets exactly with the cylinder head surface, with the letters that are the correct way up facing each other (see illustration 8.3b). Check that the punch mark on each sprocket holder is aligned with the mark on the camshaft holders (see illustration 8.3c). If the camshafts need to be



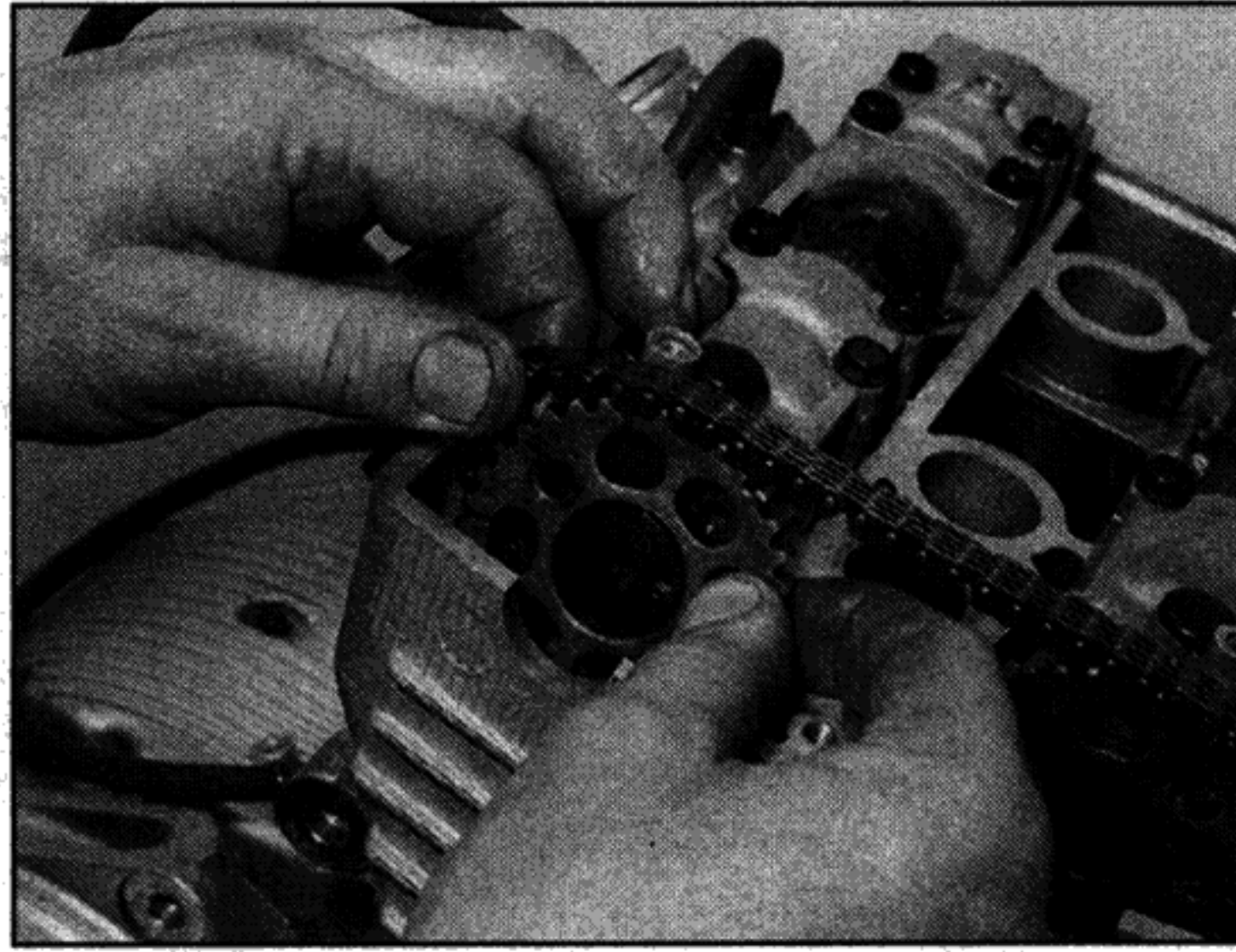
8.26a Fit the holders onto the dowels . . .



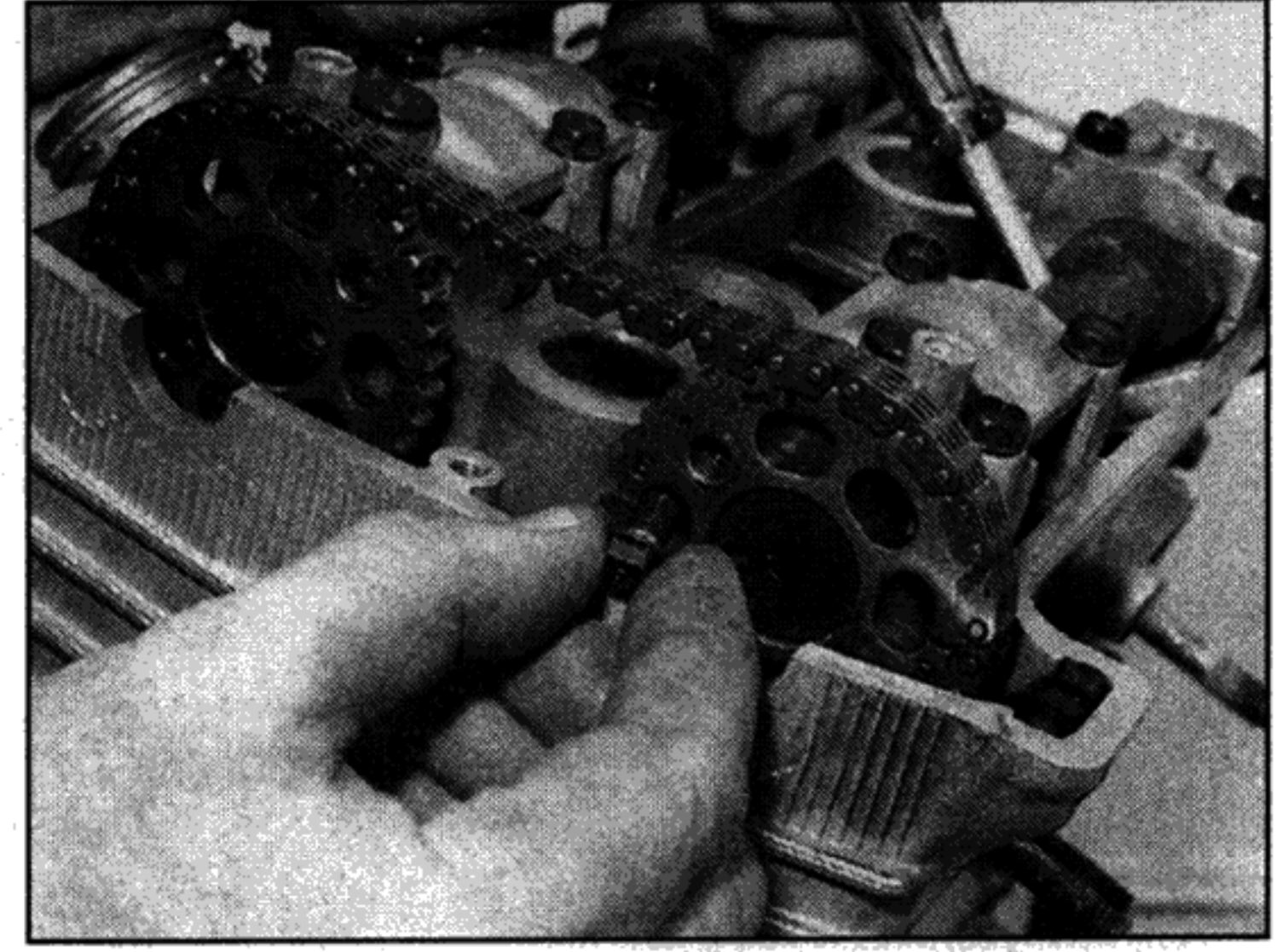
8.26b . . . and tighten the bolts as described to the specified torque setting



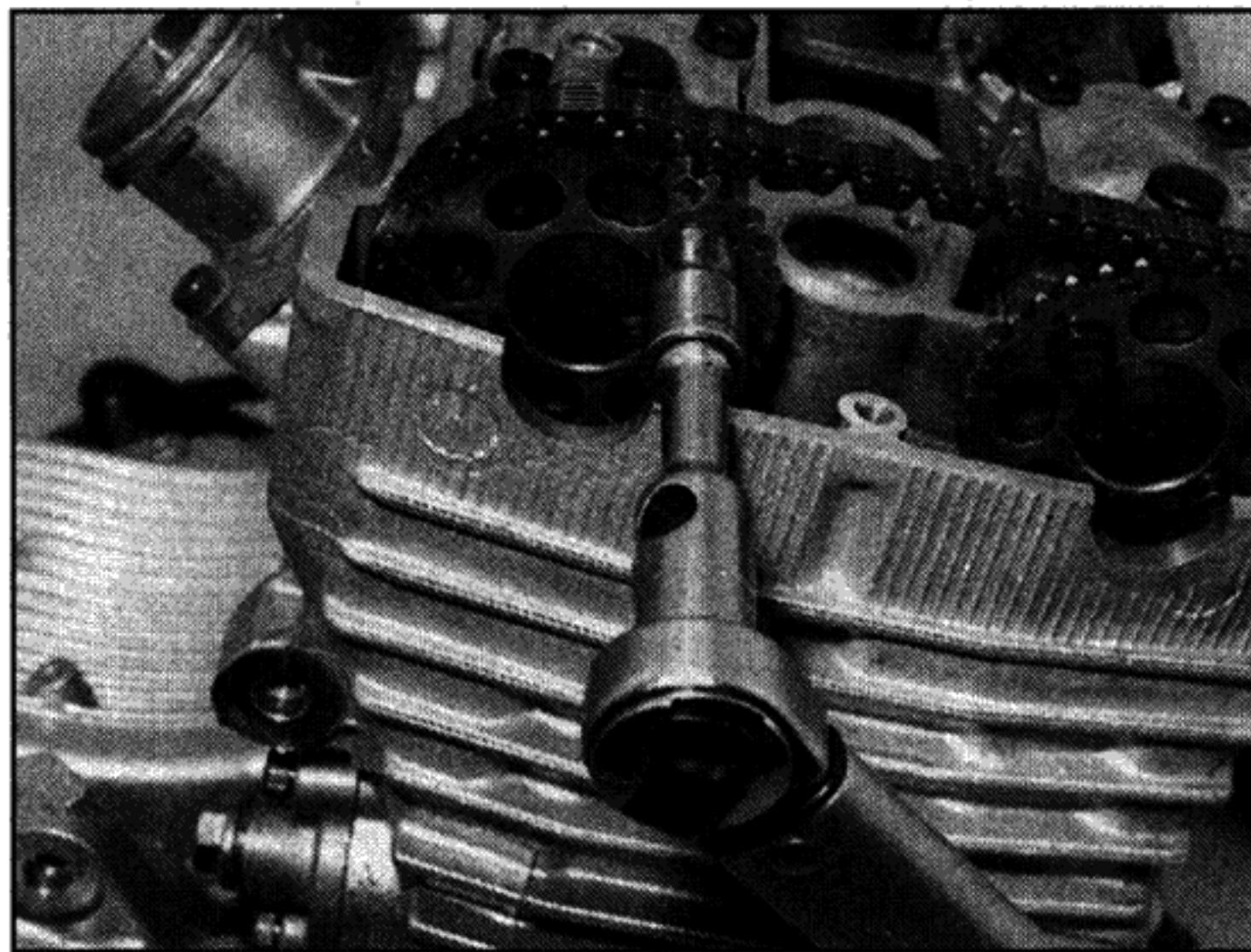
8.28a Fit the exhaust sprocket into the chain and onto the camshaft . . .



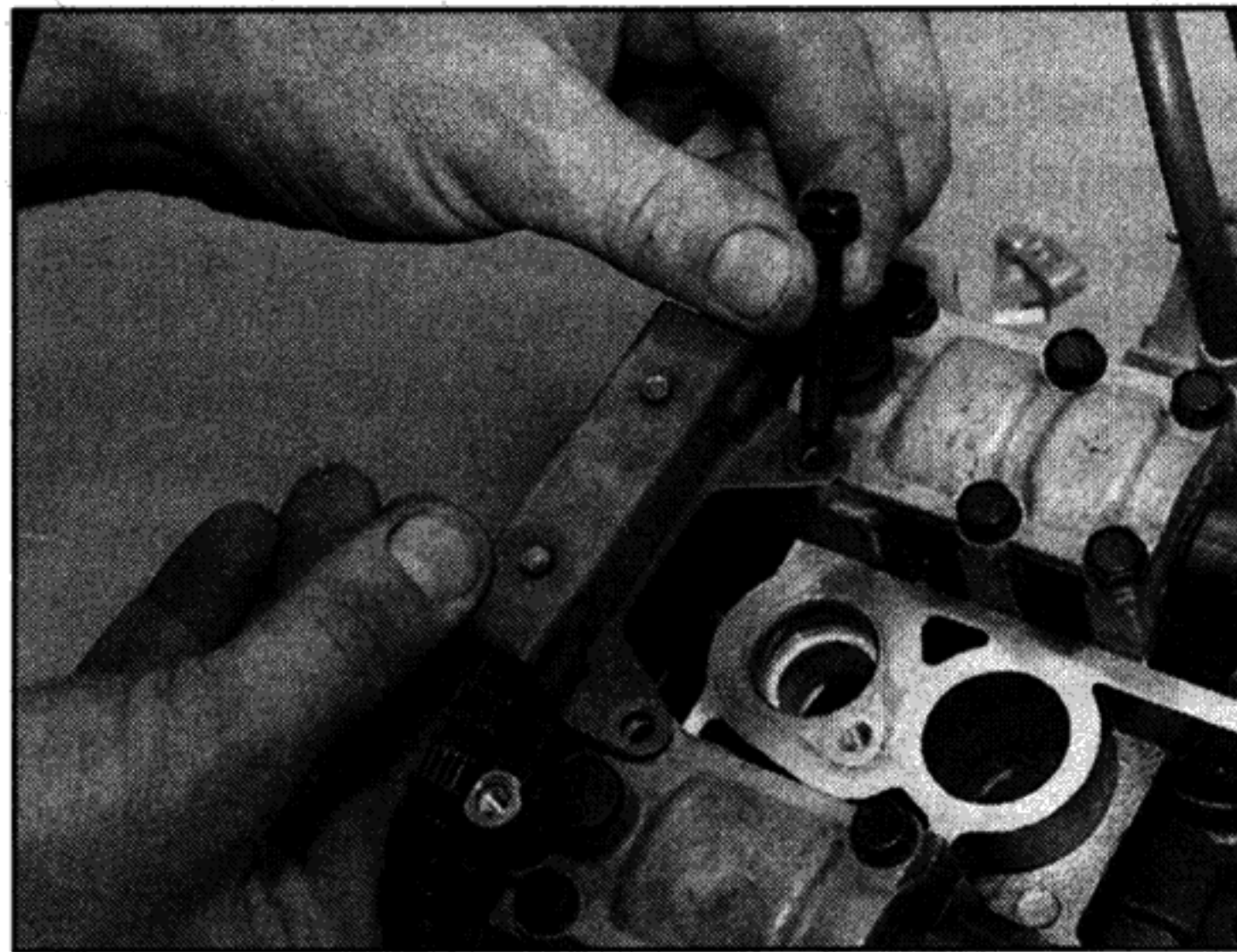
8.28b . . . then fit the inlet sprocket



8.29a Install the sprocket bolts and counter-hold the camshafts as shown . . .



8.29b . . . then tighten the bolts to the specified torque



8.30 Install the cam chain top guide



8.33 Use new O-rings on the plugs

turned slightly, use a screwdriver or bar through the hole in the middle of the camshaft to turn them.

28 Fit the cam chain around the exhaust sprocket, aligning the marks between sprocket tooth and link if made. When fitting the chain, pull up on the front run to remove all slack from it (**see illustration**). Now fit the sprocket onto the end of the camshaft, aligning the bolt holes. Next fit the inlet sprocket into the chain and onto the inlet camshaft, making sure there is no slack in the chain between the camshafts, and aligning the bolt holes (**see illustration**). At this point check that all the timing marks are still in **exact** alignment as described in Step 3. Note that it is easy to be slightly out (one tooth on the sprocket) without the marks appearing drastically out of alignment. If all marks align correctly, install the sprocket bolts and tighten them finger-tight. If the marks are out, verify which sprocket is misaligned and slide it off the camshaft, then disengage it from the chain and move it round as required, then fit it back into the chain and onto the sprocket, and check the marks again.

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.

29 With everything correctly aligned, tighten the sprocket bolts to the torque setting specified at the beginning of the Chapter,

using a screwdriver or bar inserted through the hole in each camshaft to prevent them turning, or by counter-holding the alternator rotor (**see illustrations**).

30 Install the cam chain top guide and tighten the bolts to the same torque setting as the other camshaft holder bolts (**see illustration**).

31 Install the cam chain tensioner (**see Section 9**). Turn the engine anti-clockwise through two full turns and check again that all the timing marks still align (**see Step 3**).

32 Check the valve clearances and adjust them if necessary (**see Chapter 1**). **Note:** A valve clearance check is essential if you have installed any new valve components or a new camshaft.

33 Use new O-rings on the timing inspection plug and centre plug and tighten the plugs securely (**see illustration**).

34 Install the valve cover (**see Section 7**).

9 Cam chain tensioner – removal, inspection and installation

Note: This procedure can be performed with the engine in the frame.

Caution: Once you start to remove the tensioner bolts, you must remove the tensioner all the way and reset it before tightening the bolts. The tensioner extends

itself and locks in place, so if you loosen the bolts partway and then retighten them, the tensioner or cam chain will be damaged.

Removal

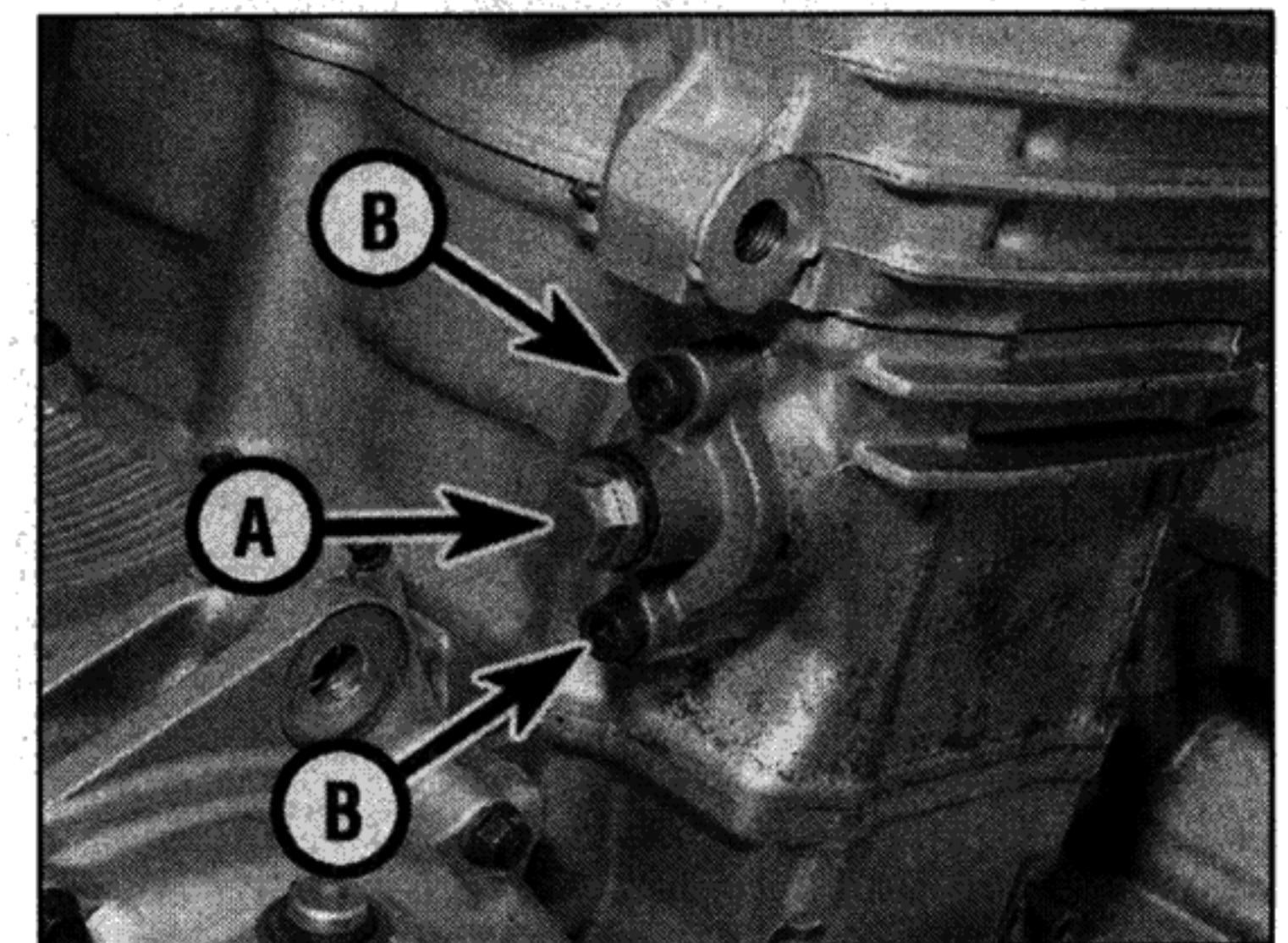
1 Unscrew the tensioner spring cap bolt and withdraw the springs from the tensioner body (**see illustration**).

2 Unscrew the two tensioner mounting bolts and withdraw the tensioner from the back of the cylinder block, noting which way up it fits (**see illustration 9.1**).

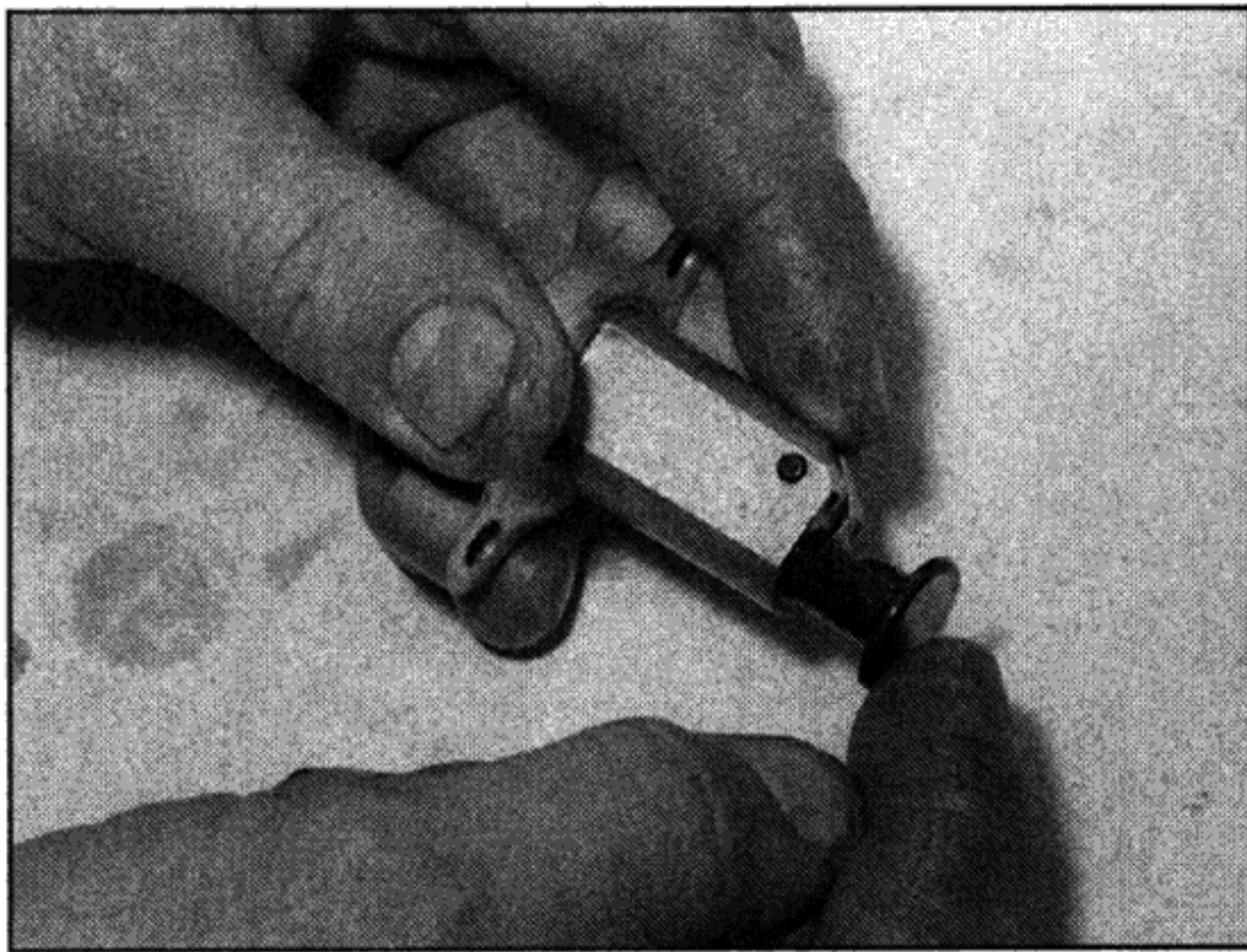
3 Discard the tensioner body gasket as a new one must be used.

Inspection

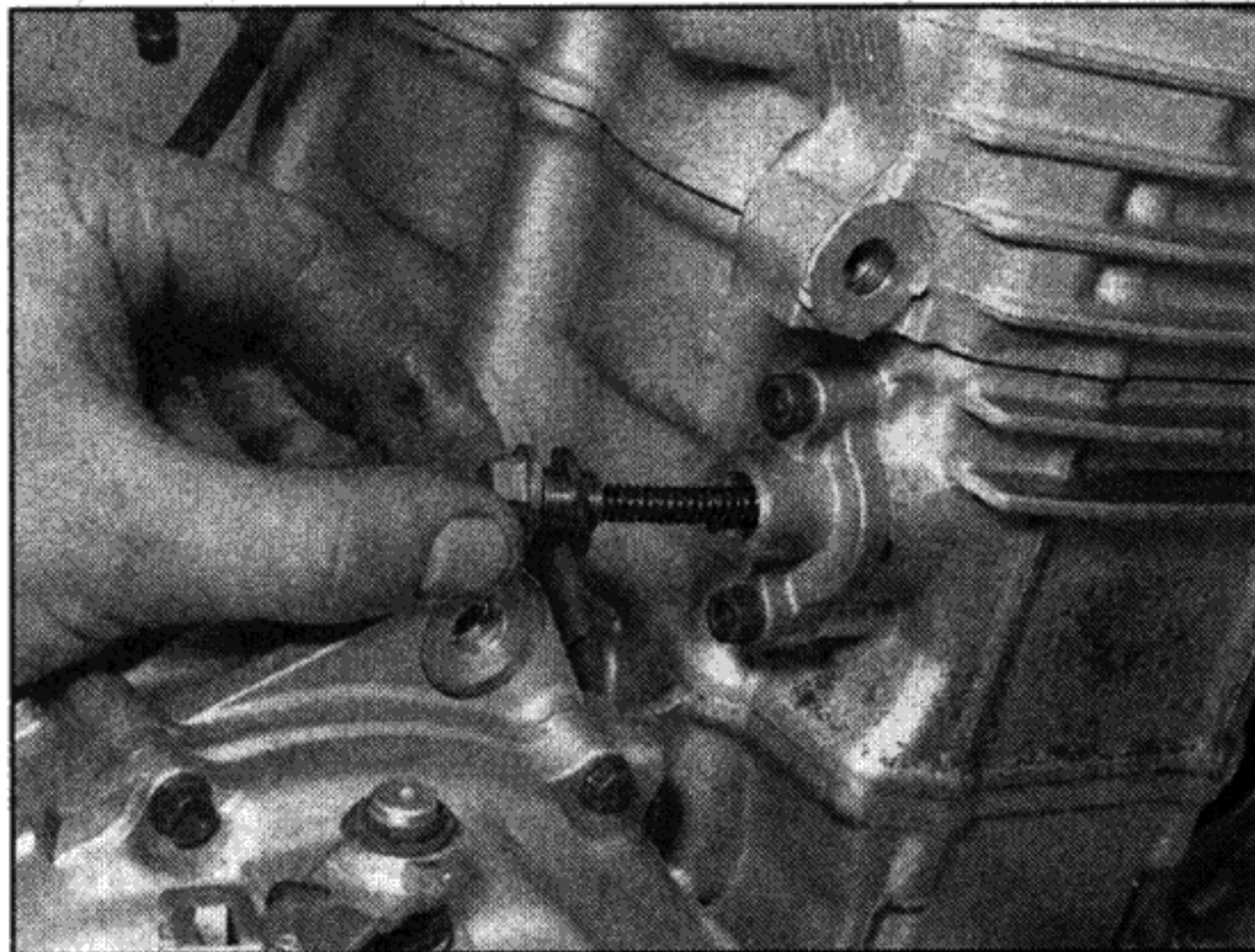
4 Examine the tensioner components for signs of wear or damage.



9.1 Tensioner cap bolt (A), tensioner mounting bolts (B)



9.5 Release the ratchet and press the plunger in



9.9 Install the springs and cap bolt

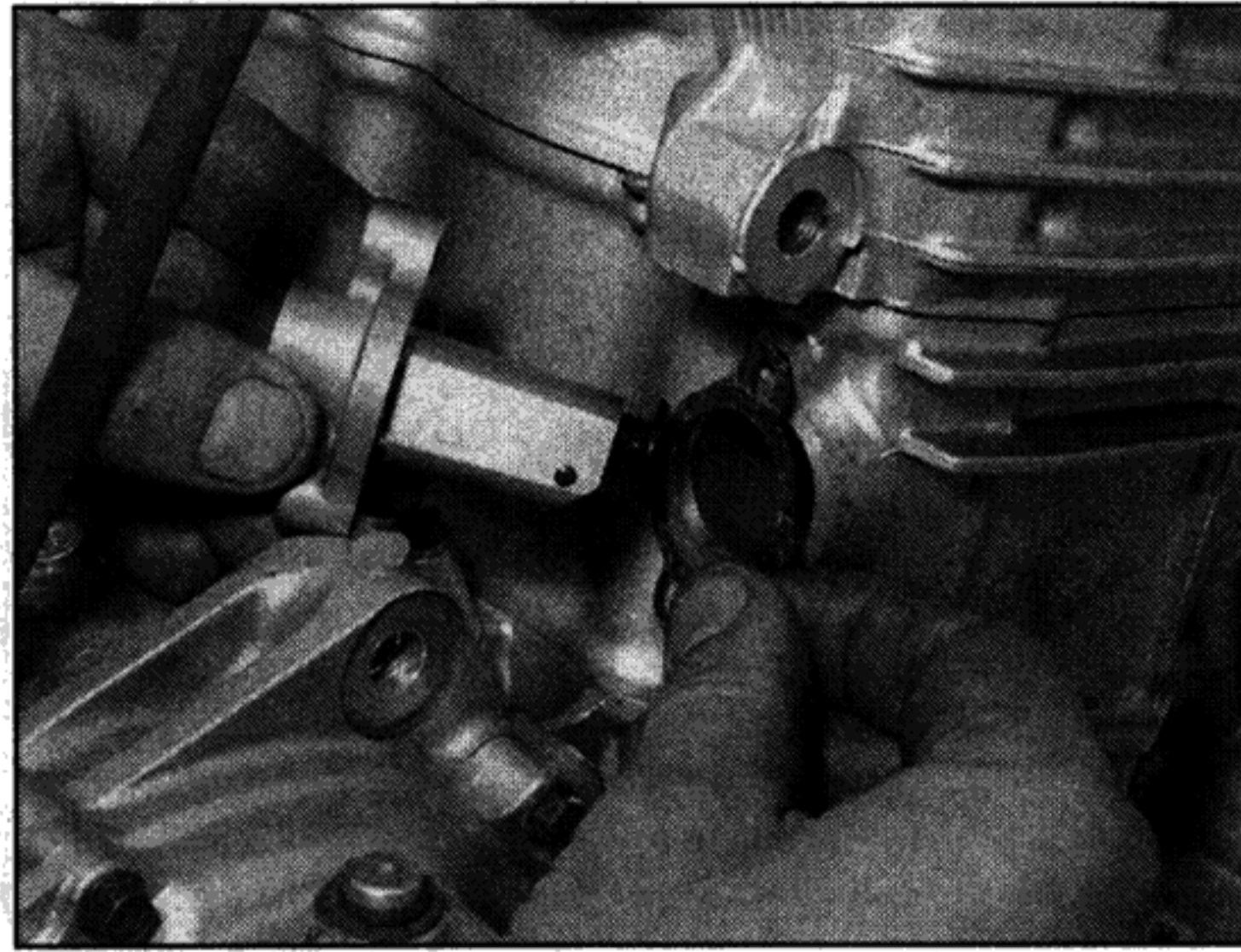
5 Release the ratchet mechanism from the tensioner plunger and check that the plunger moves freely in and out of the tensioner body (see illustration).

6 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 renewed – individual components are not available.

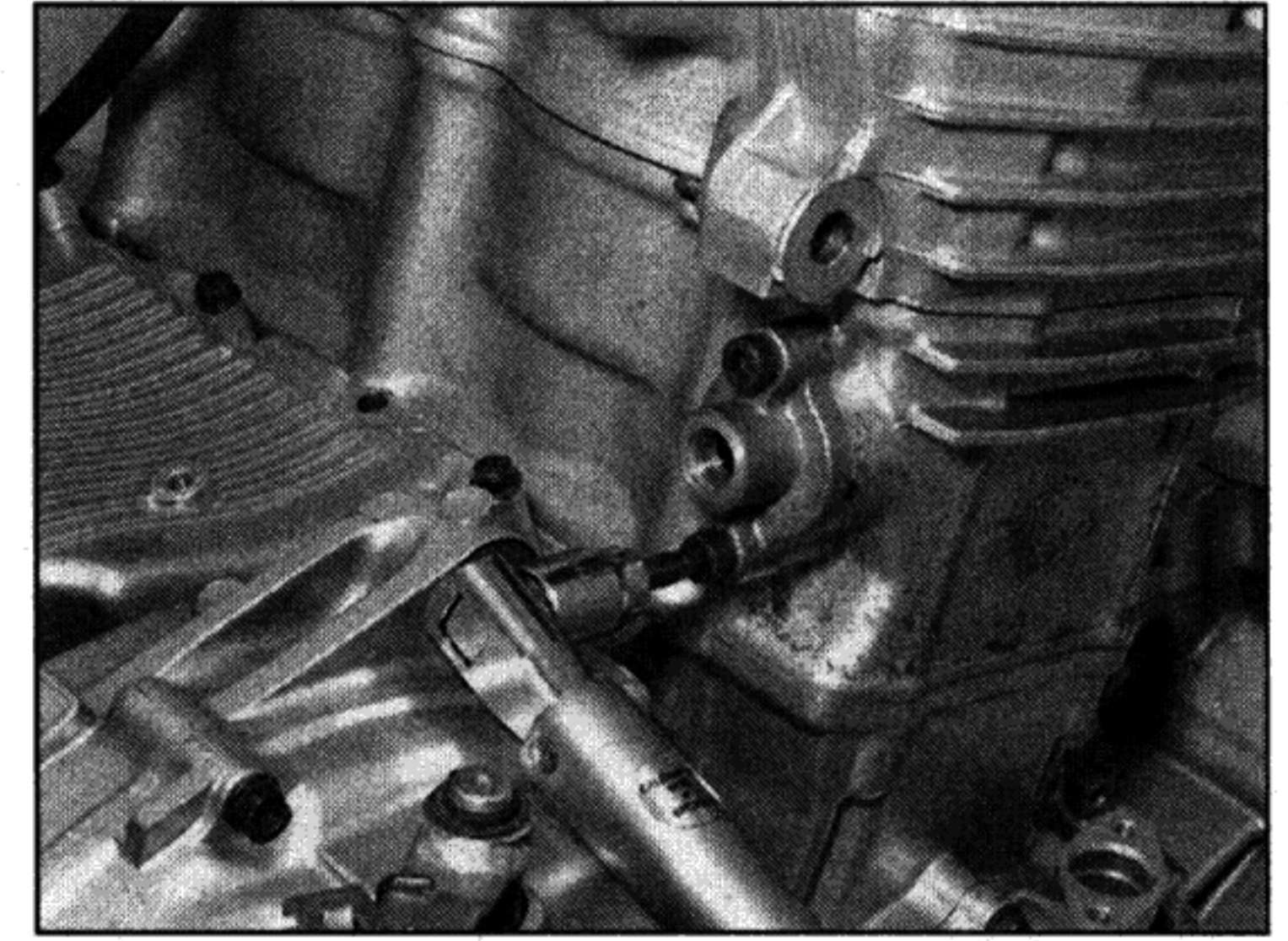
Installation

7 Release the ratchet mechanism and press the tensioner plunger all the way into the tensioner body (see illustration 9.5).

8 Fit a new gasket onto the tensioner body, then install the tensioner in the engine and tighten the bolts to the torque setting



9.8a Install the tensioner using a new gasket ...



9.8b ... and tighten the mounting bolts to the specified torque

specified at the beginning of the Chapter (see illustrations).

9 Install the springs and cap bolt, with its washer, and tighten the bolt to the specified torque setting (see illustration).

10 Remove the alternator cover centre plug and turn the crankshaft anti-clockwise through two full turns using a socket on the rotor bolt (see illustrations 8.2a and b). This will allow the tensioner to set itself properly. Use a new O-ring on the centre plug.

11 It is advisable to remove the valve cover (see Section 7) and check that the cam chain is tensioned and all the timing marks are in alignment (see Section 8). If the 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 8), then install the valve cover (see Section 7).

10 Cylinder head – removal and installation



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

Note 1: The cylinder head can be removed with the engine in the frame. If the engine has been removed, ignore the steps which don't apply.

Note 2: If no work is being carried out on the valves, the cylinder head can be removed with the camshafts in place. Holes in the camshafts and in the right-hand camshaft holders allow access to the cylinder head nuts. The camshaft sprockets must be removed.

Removal

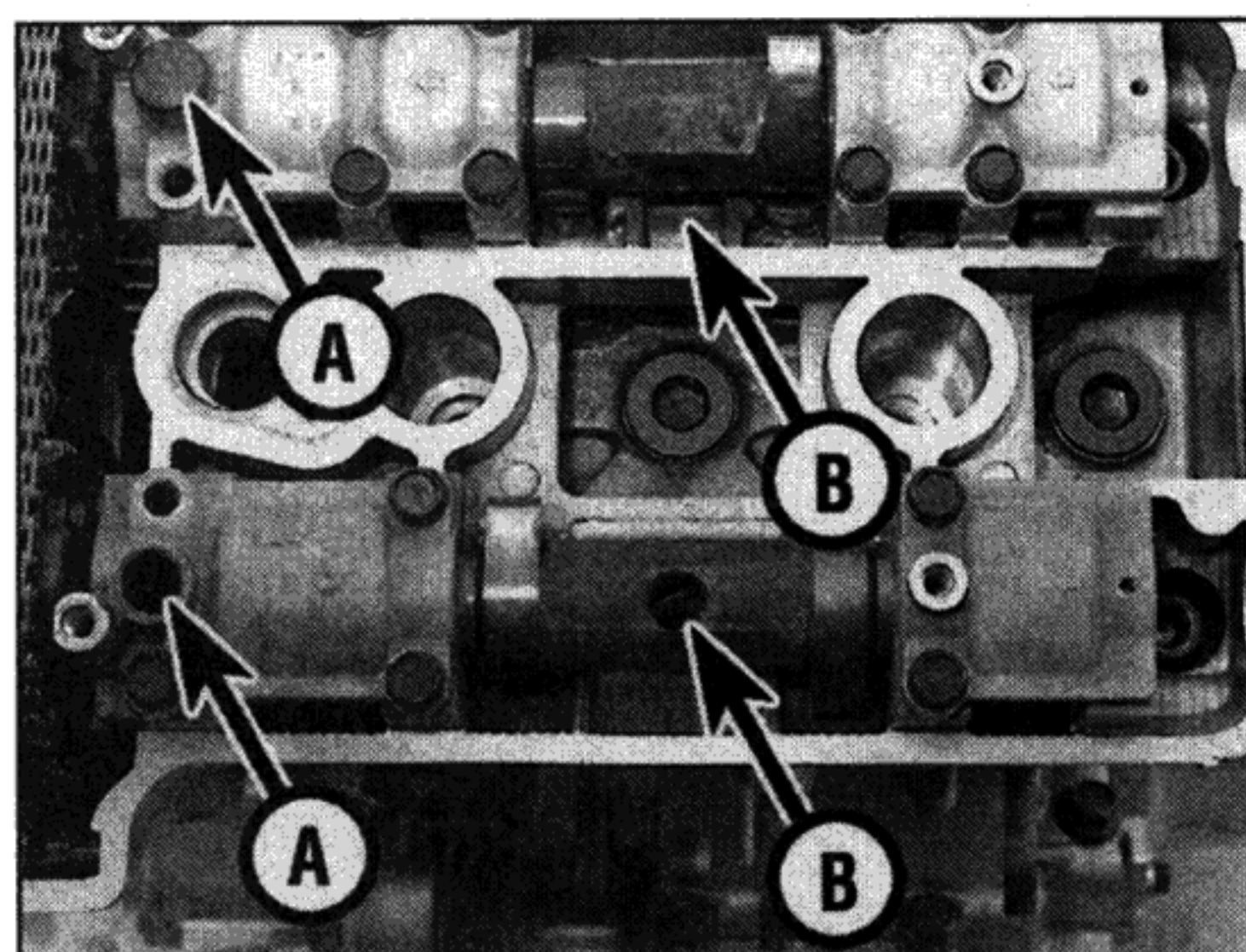
1 Remove the valve cover (see Section 7), the camshaft sprockets (see Section 8), and if required the camshafts (see Note 2 above). If the camshafts are being left in place, remove the blanking cap from the top of each right-hand camshaft holder, then turn the camshafts using a screwdriver or rod through the hole in the middle of the camshaft until the access holes in the shafts align with the cylinder head nuts (see illustration). If the camshafts are left in place, the nuts and washers cannot be removed after they have been loosened as the camshafts will be in the way.

2 Remove the exhaust system (see Chapter 4).

3 If not already done, remove the cam chain front guide (see Section 24).

4 If required, release the clamp(s) securing the vacuum hose(s) to the inlet manifold(s) and detach the hose(s).

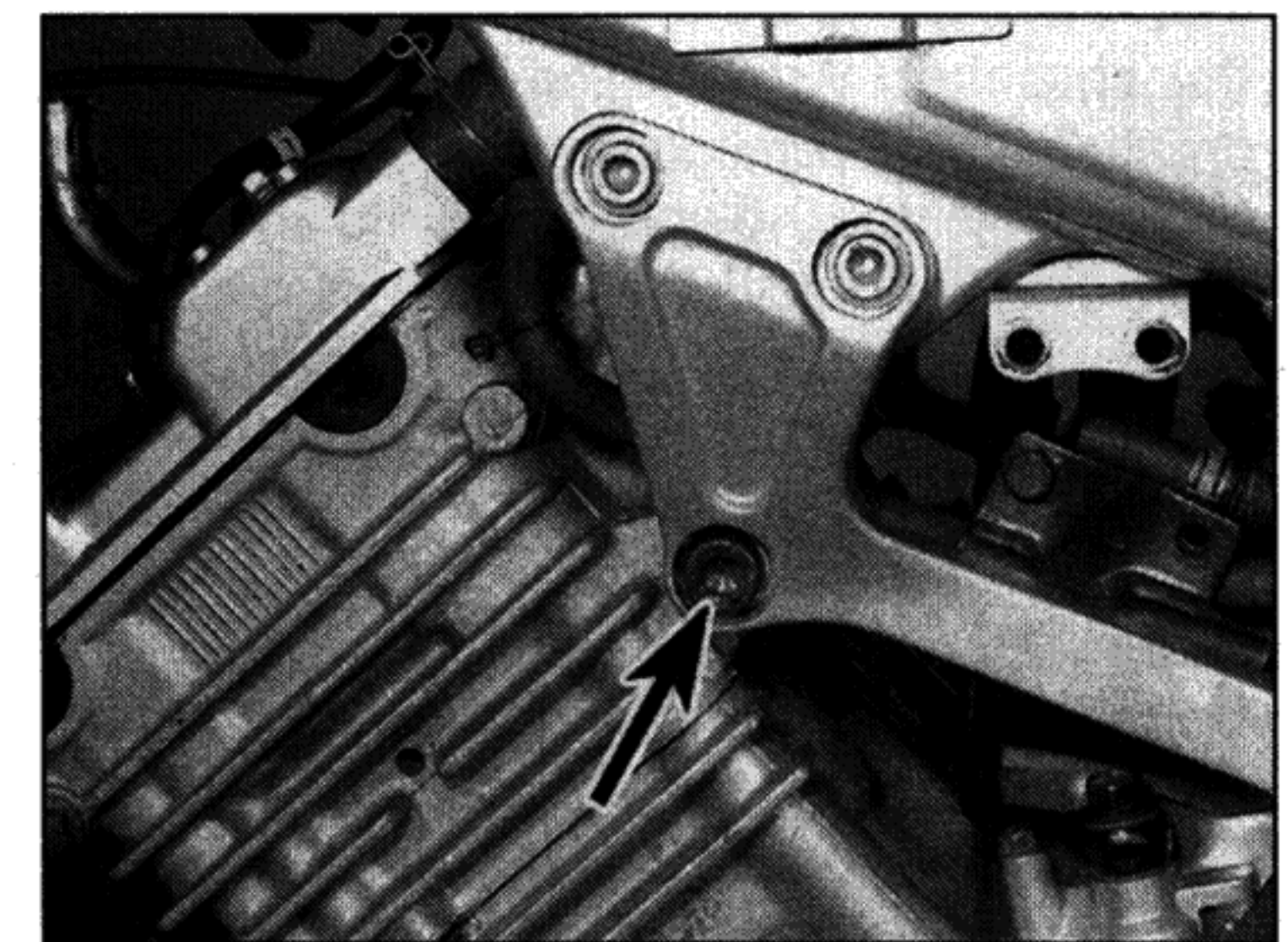
5 Unscrew the oil pipe banjo bolt from the cylinder head and detach the pipe from the cylinder head (see illustration). Discard the banjo bolt sealing washers as new ones must be used.



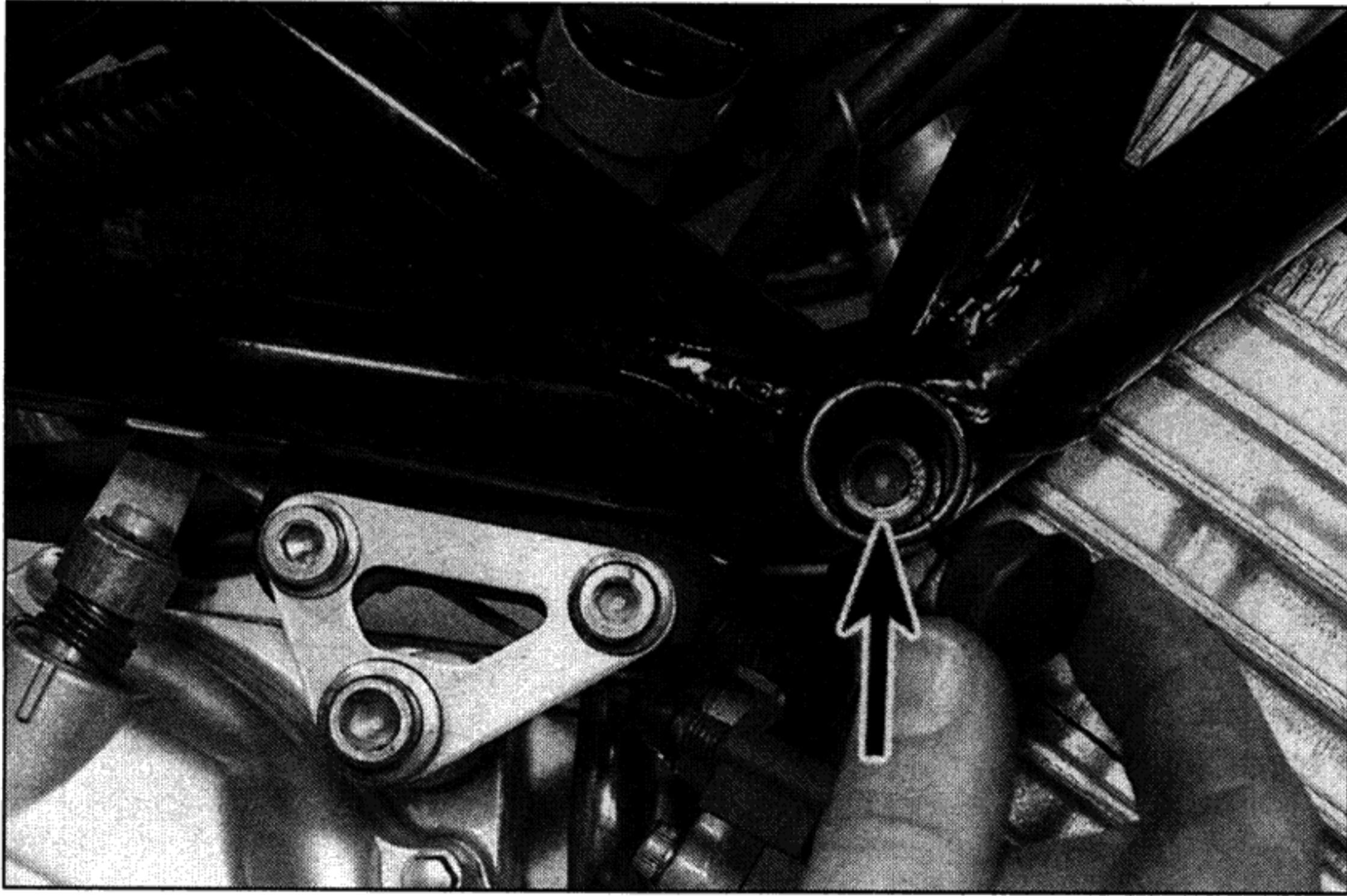
10.1 Remove the blanking caps (A) from the holes in the holders. Turn the shafts using the centre holes (B) until the access holes in each camshaft align with the nuts



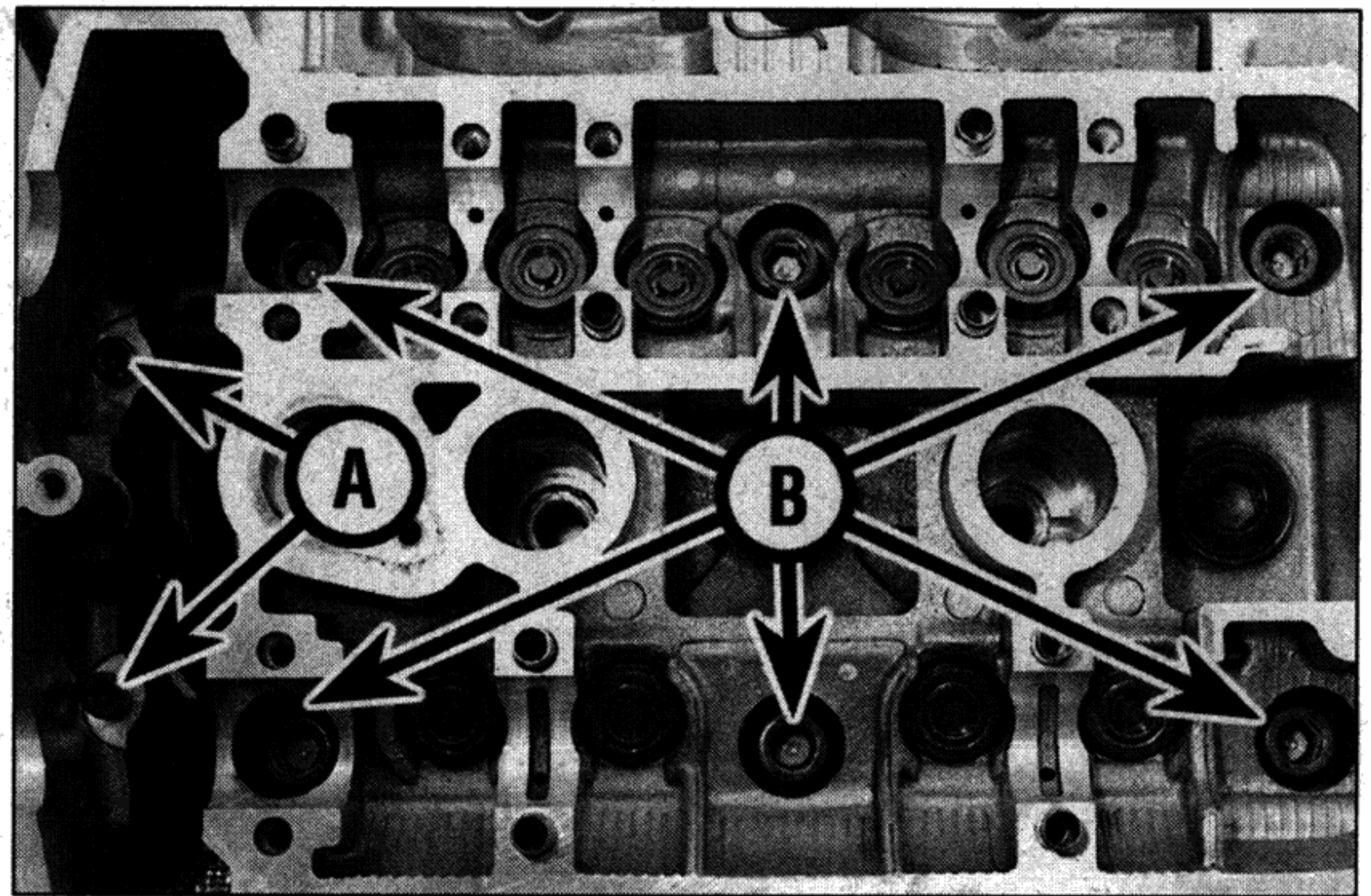
10.5 Unscrew the banjo bolt (arrowed) and detach the oil pipe



10.6a On TDM models, remove the cylinder head-to-bracket bolt (arrowed) on each side



10.6b On TRX models, remove the blanking cap, then remove the frame-to-cylinder head bolt (arrowed) on each side



10.7 Cylinder head bolts (A) and nuts (B)

6 On TDM and TRX models, unscrew the engine mounting bolts which thread into the cylinder head on each side (**see illustrations**). On TRX models, first remove the caps.

7 Each cylinder head is secured by two bolts, located in the cam chain tunnel, and six nuts (**see illustration**). First unscrew and remove the bolts (**see illustration 10.16**). Now slacken the nuts evenly and a little at a time in a criss-cross pattern until they are all slack, then remove the nuts and their washers (**see illustration 10.15**).

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

9 If they are loose, remove the dowels from the cylinder block. If they appear to be missing they are probably stuck in the underside of the cylinder head.

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

Installation

11 Clean all traces of old gasket material from the cylinder head and block. 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 bores or the oil passages.



Refer to Tools and Workshop Tips in the Reference section for details of gasket removal methods.

12 If removed, install the dowels into the cylinder block (**see illustration 10.13**). Lubricate the cylinder bores with engine oil.

13 Ensure both cylinder head and block mating surfaces are clean, then lay the new head gasket in place on the cylinder block, making sure all the holes are correctly aligned (**see illustration**). Never re-use the old gasket.

14 Carefully fit the cylinder head onto the block, making sure it locates correctly onto the dowels (**see illustration 10.8**).

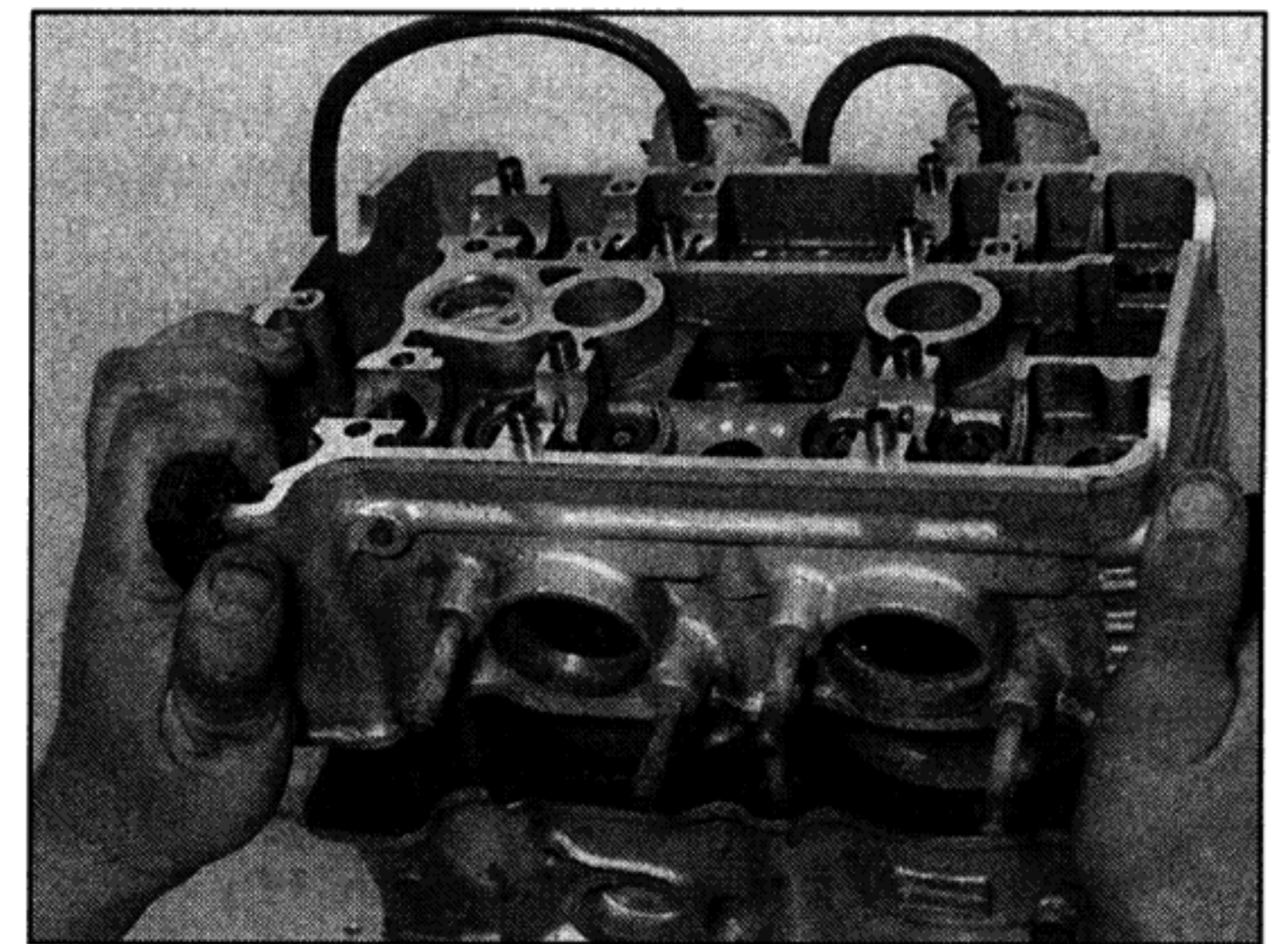
15 Lubricate the threads of the cylinder head nuts with clean engine oil (if the camshafts are in place, one or two drops of oil can be squirted around the nuts into the stud holes). Install the nuts with their washers and tighten

them finger-tight (**see illustration**). Now tighten the nuts evenly and a little at a time in a criss-cross pattern to the torque setting specified at the beginning of the Chapter.

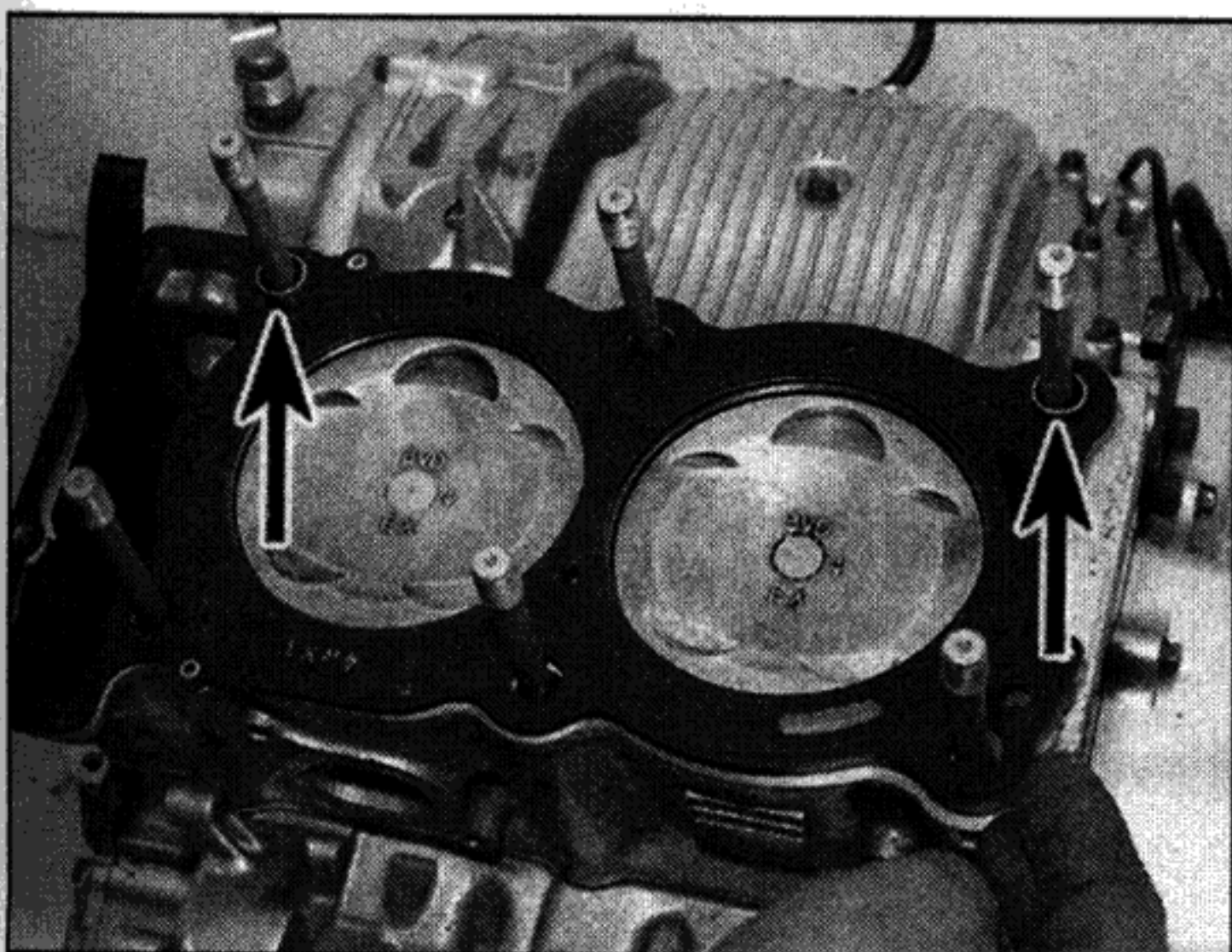
16 Install the two cylinder head bolts and tighten them to the specified torque setting (**see illustration**).

17 On TDM and TRX models, install the engine mounting bolts and tighten them to the specified torque setting (**see illustrations 10.6a and b**). On TRX models, fit the caps into the bolt heads.

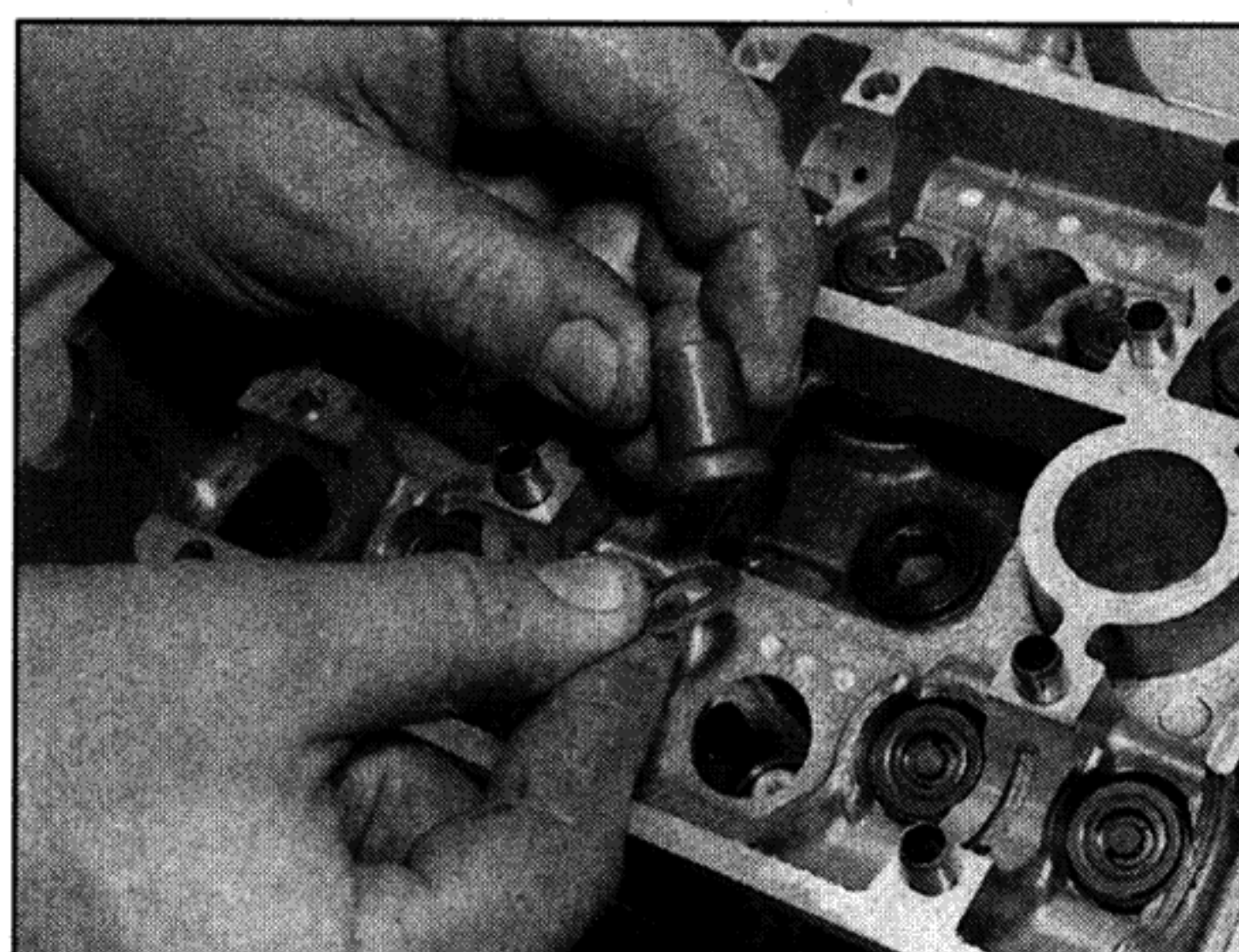
18 Install the oil pipe onto the cylinder head, using new sealing washers on each side of



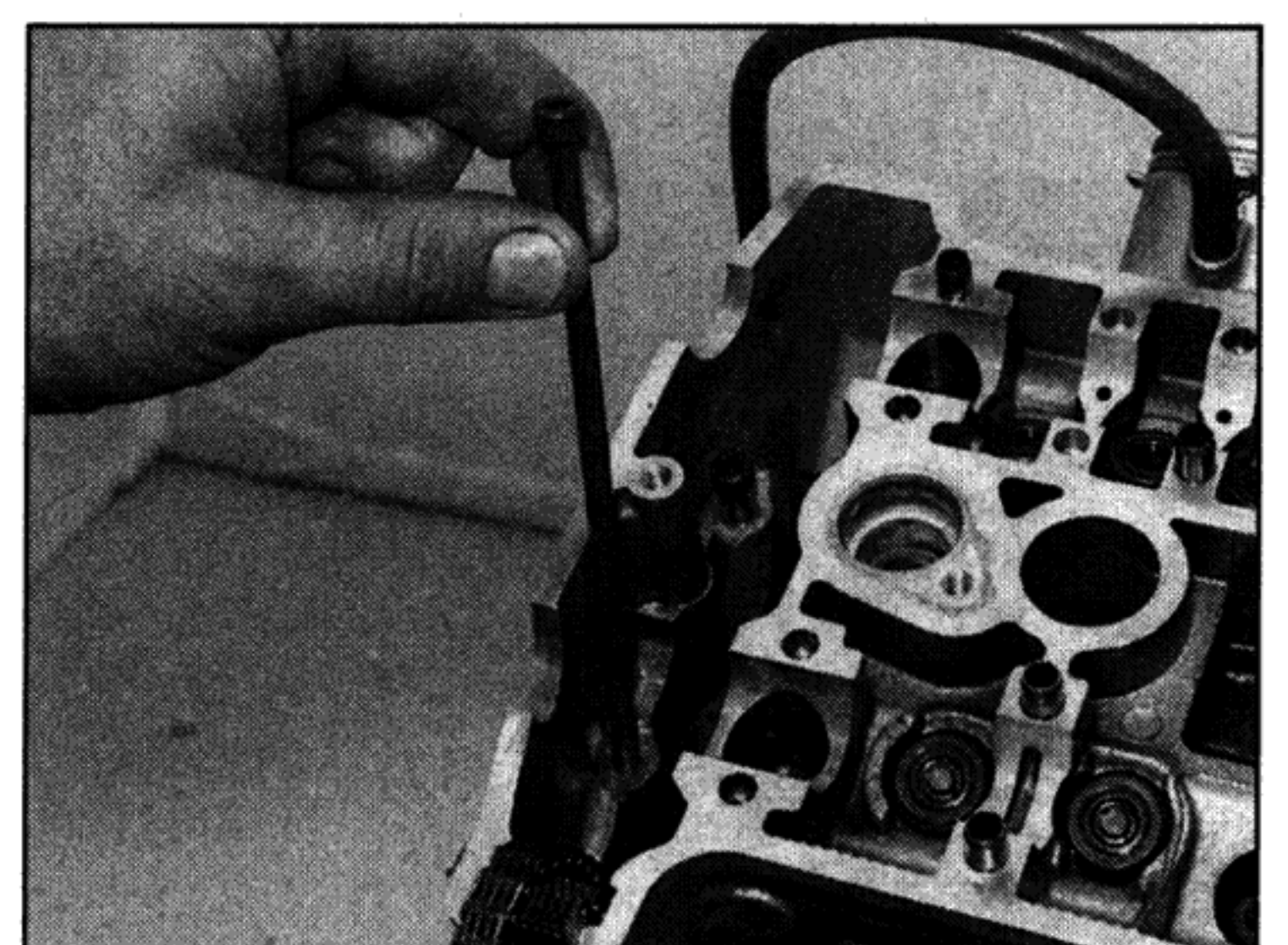
10.8 Carefully lift the head up off the block



10.13 Lay a new head gasket over the dowels (arrowed) and onto the head



10.15 Install the nuts with their washers and tighten them as described to the specified torque



10.16 Install the bolts and tighten them to the specified torque



10.18a Use new sealing washers on each side of the union . . .

the union, and tighten the banjo bolt to the specified torque (**see illustrations**).

19 If removed, fit the vacuum hose(s) onto the inlet manifold(s) and fit the clamp(s).

20 Install the remaining components in a reverse of their removal sequence, referring to the relevant Sections or Chapters (see Steps 1, 2 and 3).

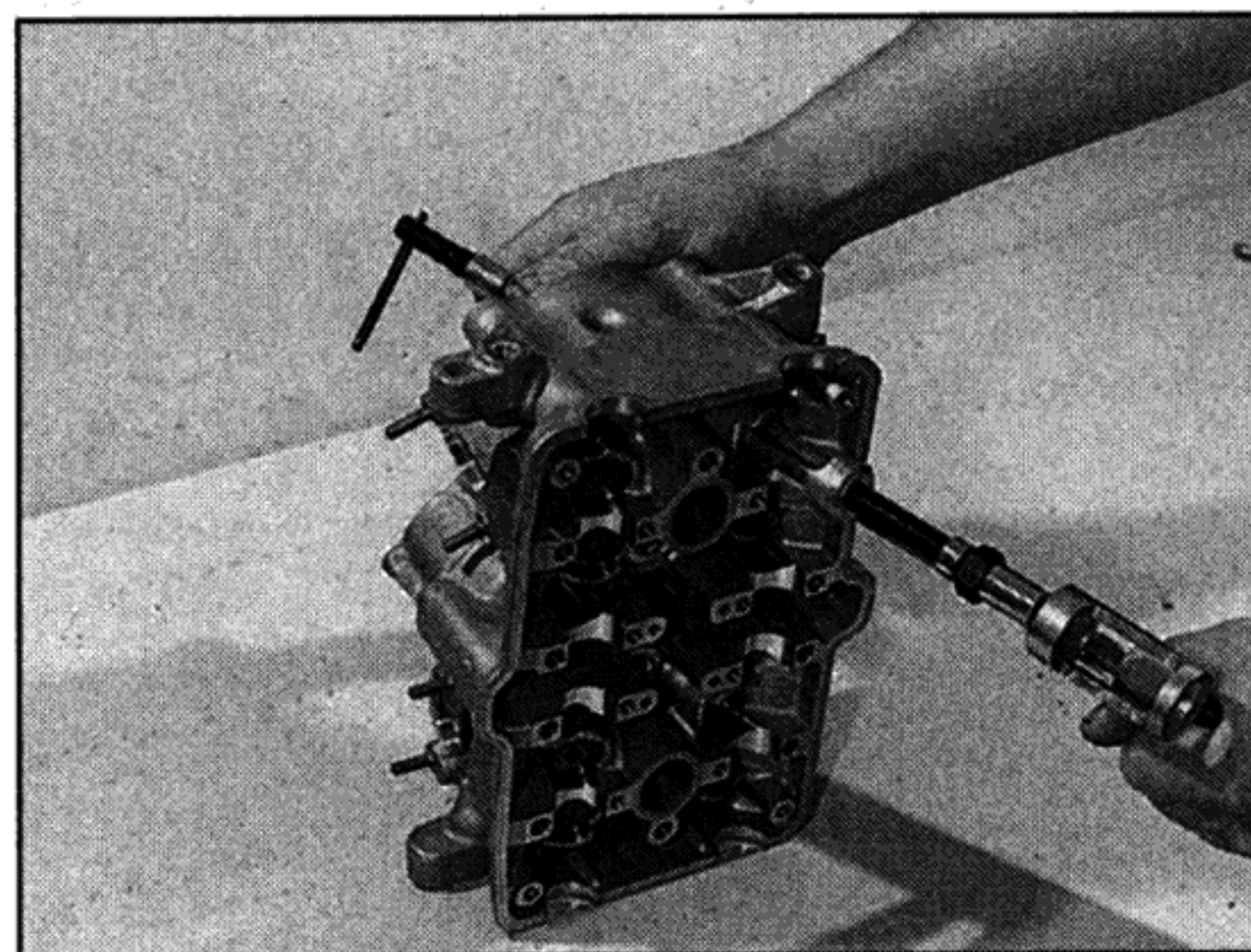
11 Valves/valve seats/valve guides – overhaul

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.

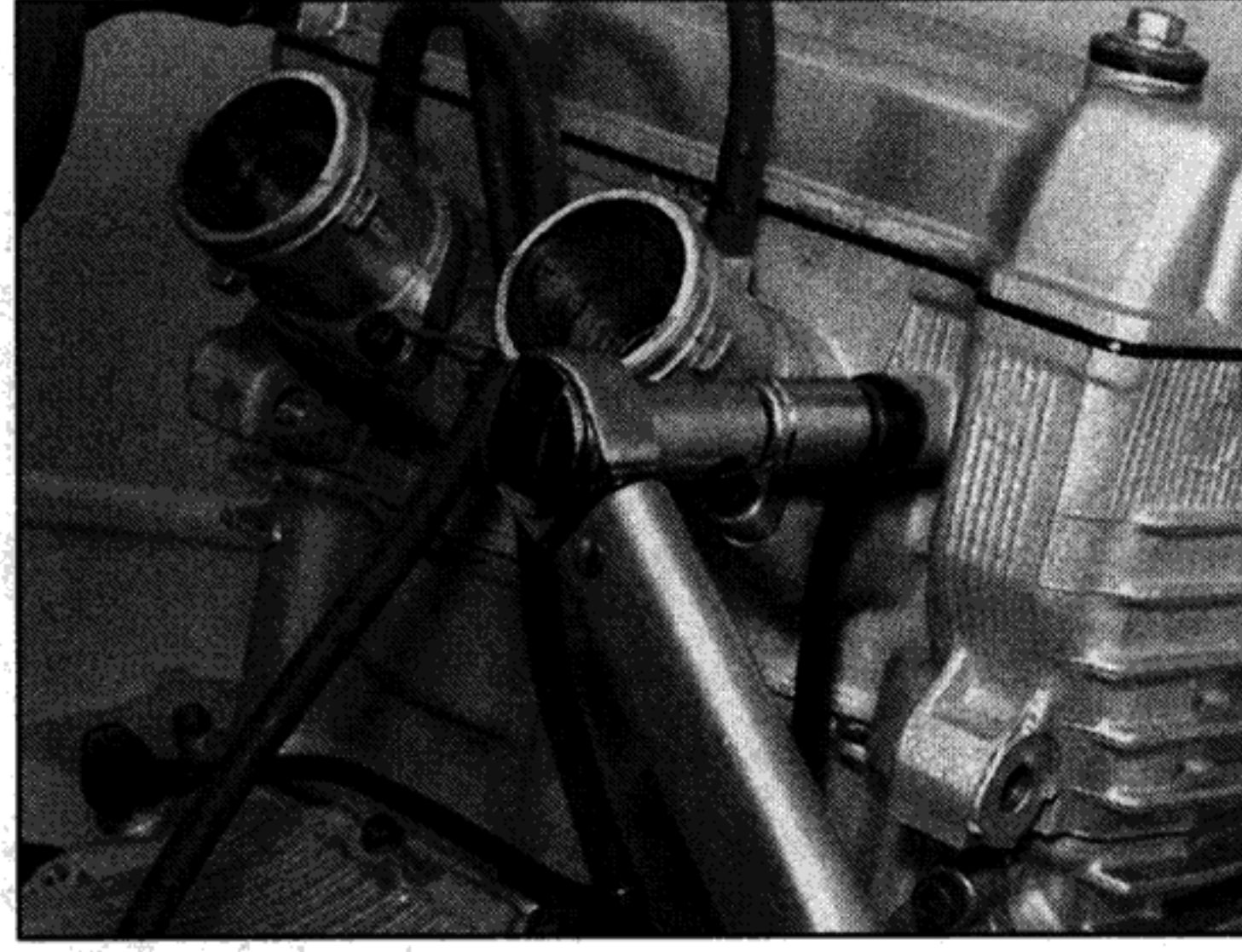
2 The home mechanic can, however, remove the valves from the cylinder head, clean and check the components for wear and assess the extent of the work needed, and, unless a valve overhaul is required, grind in the valves (**see Section 12**).

3 The engineer will renew the valves, guides and springs, recut the valve seats, clean and polish the valve ports and reassemble the valve components.

4 After the valve overhaul has been performed, the head will be in like-new condition. When the head is returned, be sure to clean it again 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.



12.5a Compressing the valve springs using a valve spring compressor



10.18b . . . and tighten the banjo bolt to the specified torque

Use compressed air, if available, to blow out all the holes and passages.

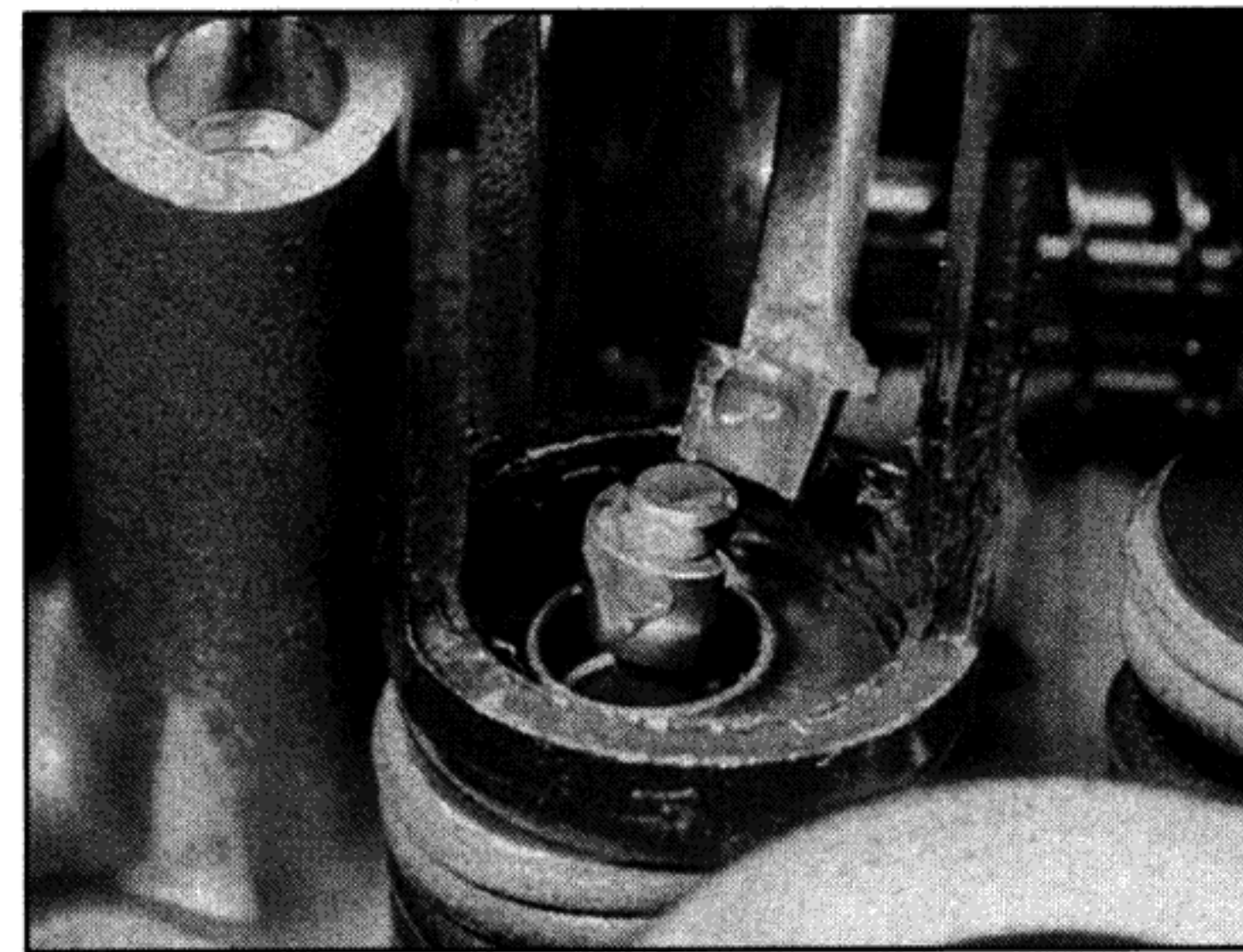
12 Cylinder head and valves – disassembly, inspection and reassembly

1 As mentioned in the previous section, valve overhaul should be left to an engineer. However, disassembly, cleaning and inspection of the valves and related components can be done (if the necessary special tools are available) by the home mechanic. This way no expense is incurred if the inspection reveals that overhaul is not required at this time.

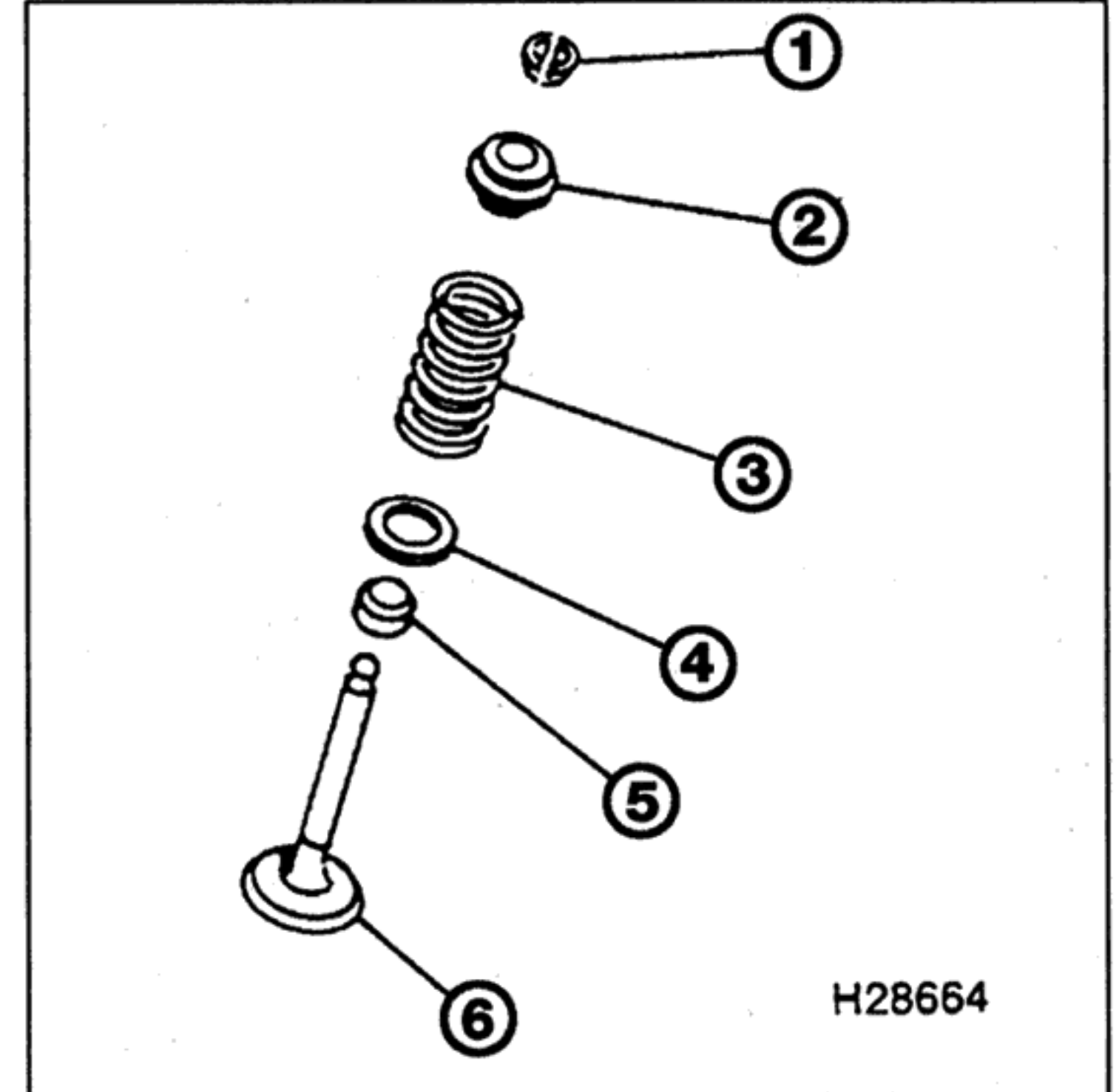
2 To disassemble the valve components without the risk of damaging them, a valve spring compressor is absolutely essential. Make sure that it is suitable for motorcycle work.

Disassembly

3 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 container as the shims are stored in (see Section 8), or to obtain a separate container which is divided into ten compartments, and to label each compartment with the identity of the valve which will be stored in it (ie number of cylinder, inlet or exhaust side, inner, middle or outer valve). Alternatively, labelled plastic bags will do just as well.



12.5b Remove the collets with needle-nose pliers, tweezers, a magnet or a screwdriver with a dab of grease on it



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12.3 Valve components

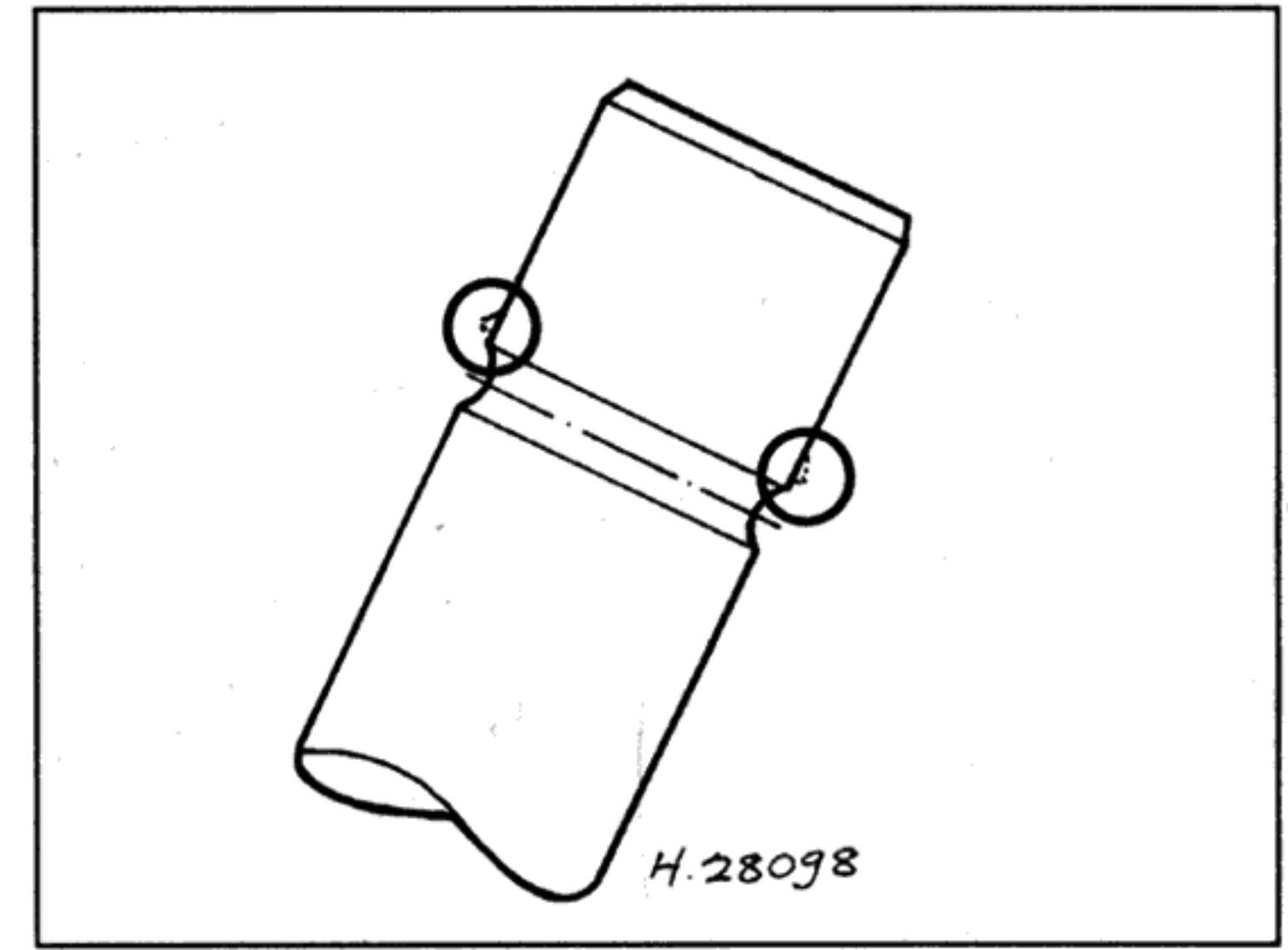
- | | |
|-------------------|-----------------------|
| 1 Collets | 5 Valve stem oil seal |
| 2 Spring retainer | 6 Valve |
| 3 Valve spring | |
| 4 Spring seat | |

4 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.



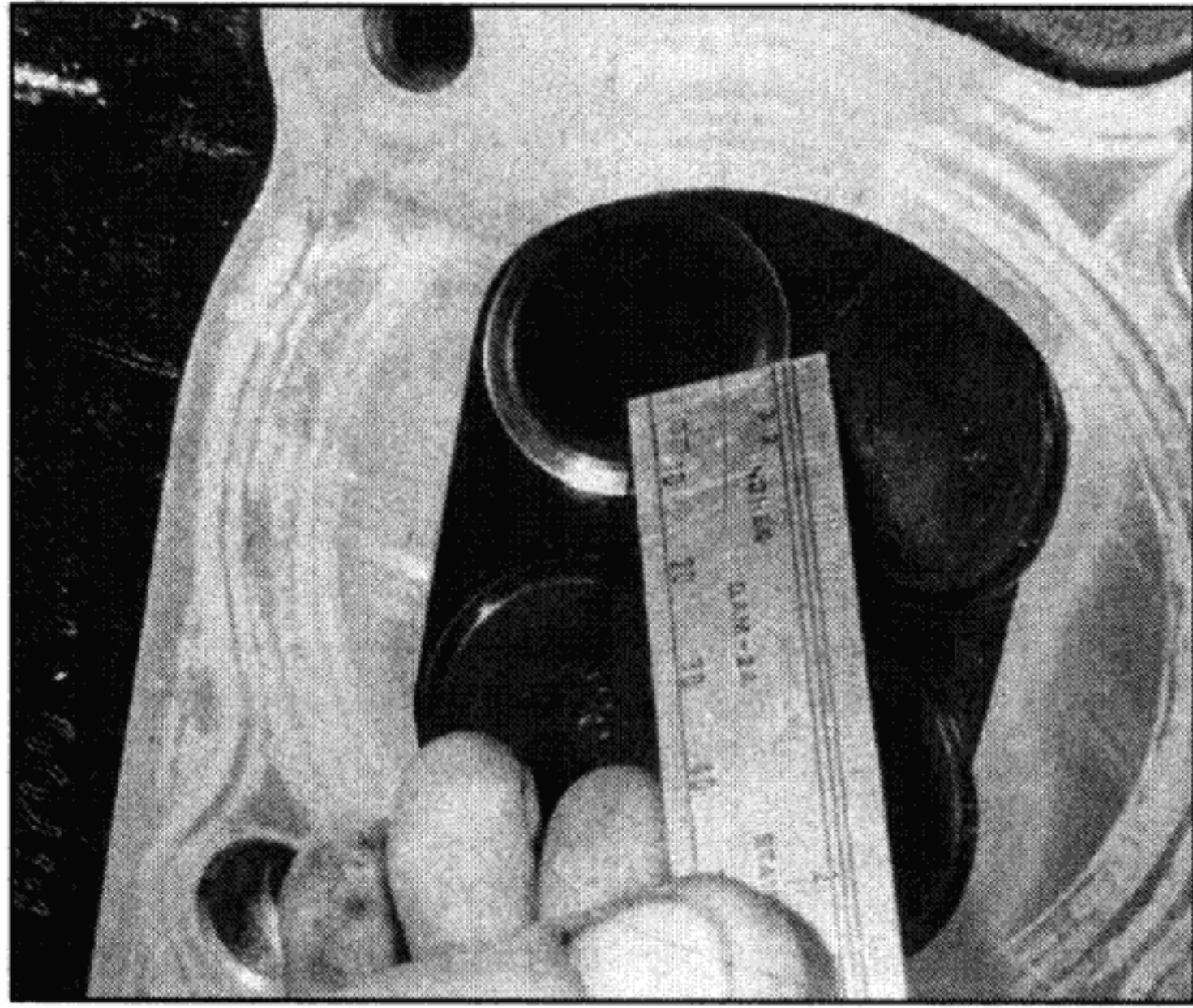
Refer to Tools and Workshop Tips in the Reference section for details of gasket removal methods.

5 Compress the valve spring on the first valve with the spring compressor, making sure it is correctly located onto each end of the valve assembly (**see illustration**). Do not compress the spring any more than is absolutely necessary. Remove the collets, using either needle-nose pliers, tweezers, a magnet or a screwdriver with a dab of grease on it (**see illustration**). Carefully release the valve spring compressor and remove the spring retainer, noting which way up it fits, the spring, the spring seat, and the valve, from the head (**see illustration 12.3**). 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**).

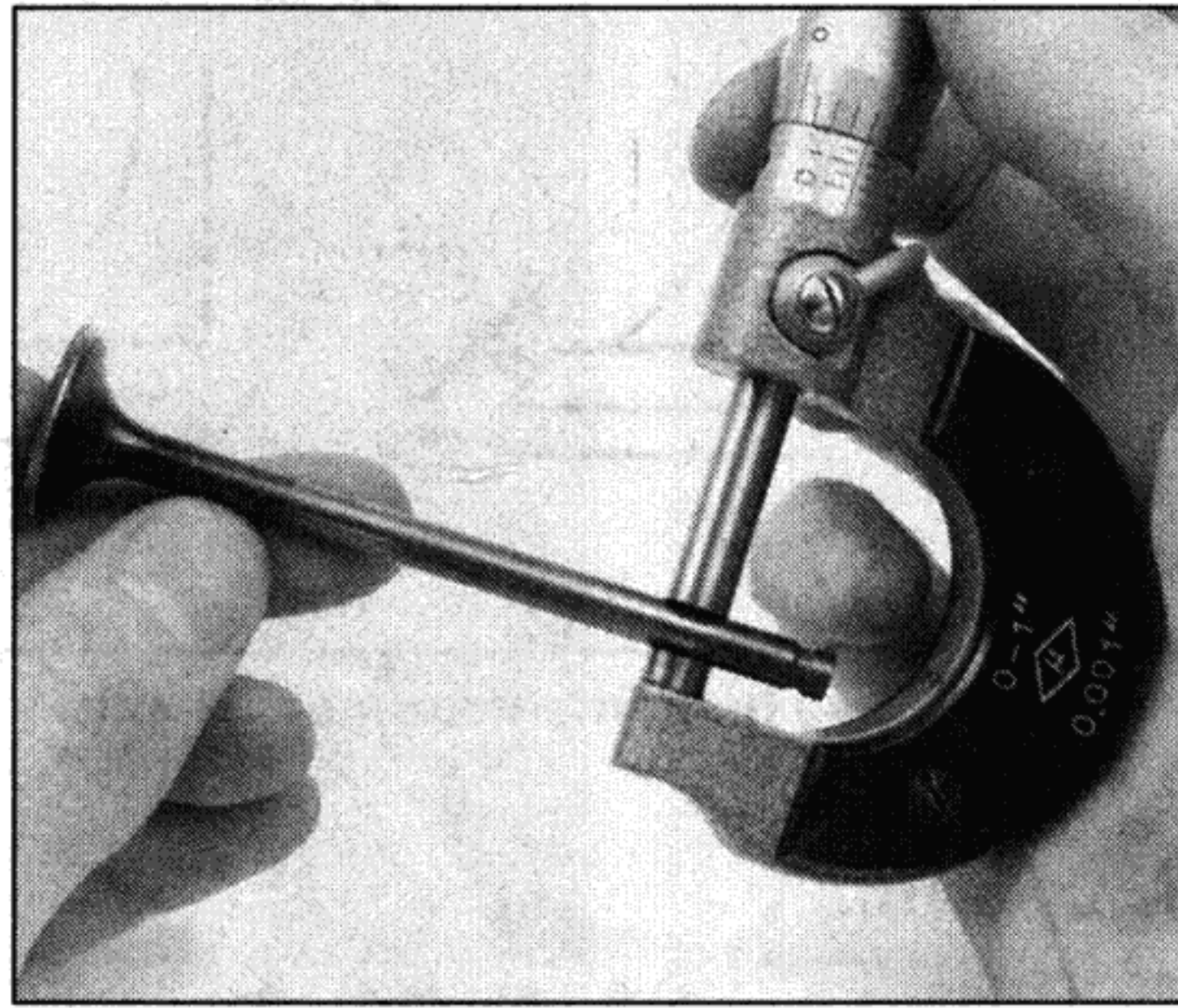


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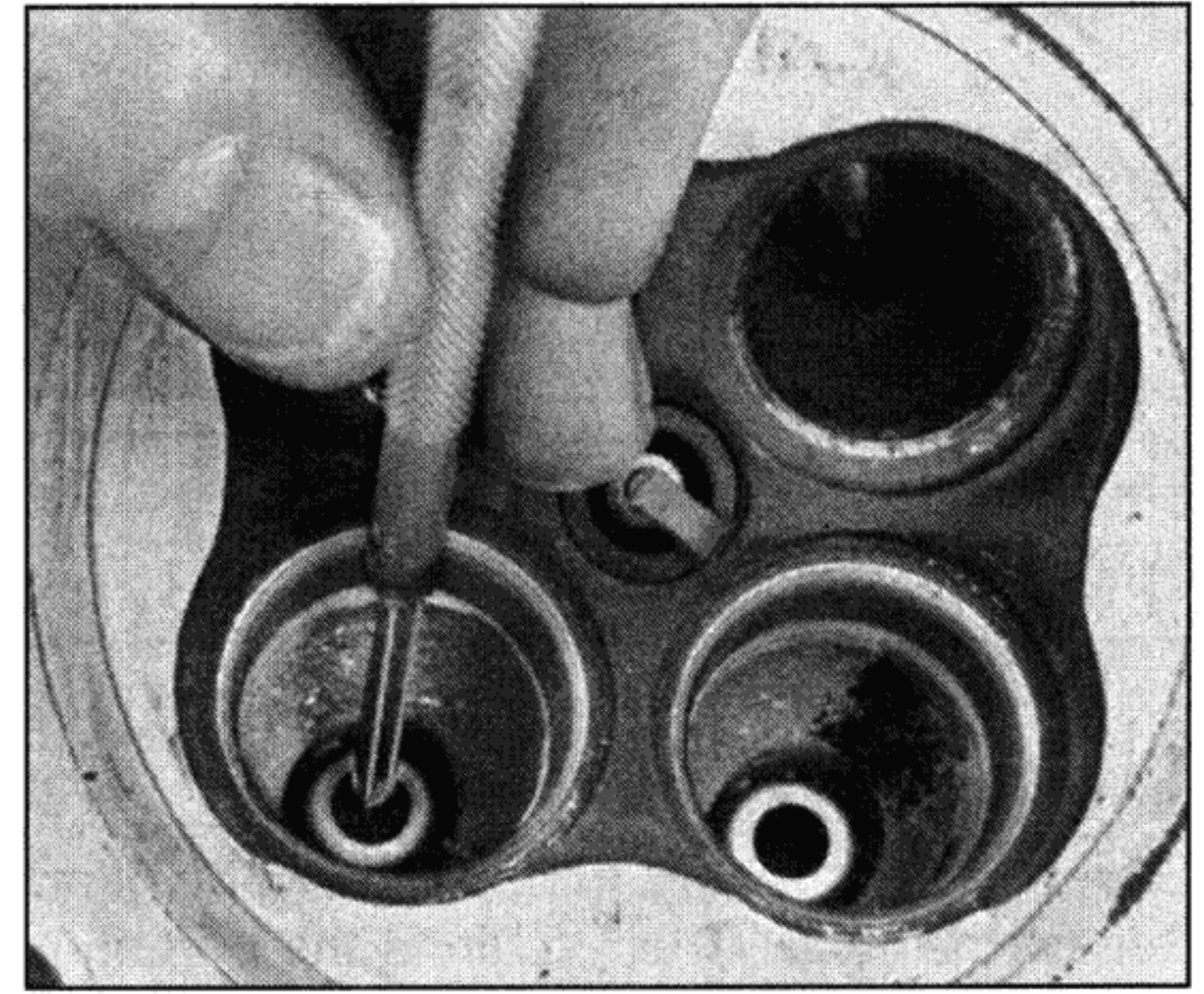
12.5c If the valve stem won't pull through the guide, deburr the area above the collet groove



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



12.14a Measure the valve stem diameter with a micrometer



12.14b Insert a small-hole gauge into the valve guide and expand it so there's a slight drag when it's pulled out

6 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.

7 Once the valves have been removed and labelled, pull the valve stem seals off the top of the valve guides with pliers and discard them (the old seals should never be reused).

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

9 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 that no mixing of parts between valves occurs.

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

Inspection

11 Inspect the head very carefully for cracks and other damage. If cracks are found, a new head will be required. Check the cam bearing surfaces for wear and evidence of seizure. Check the camshafts for wear as well (see Section 8).

12 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.

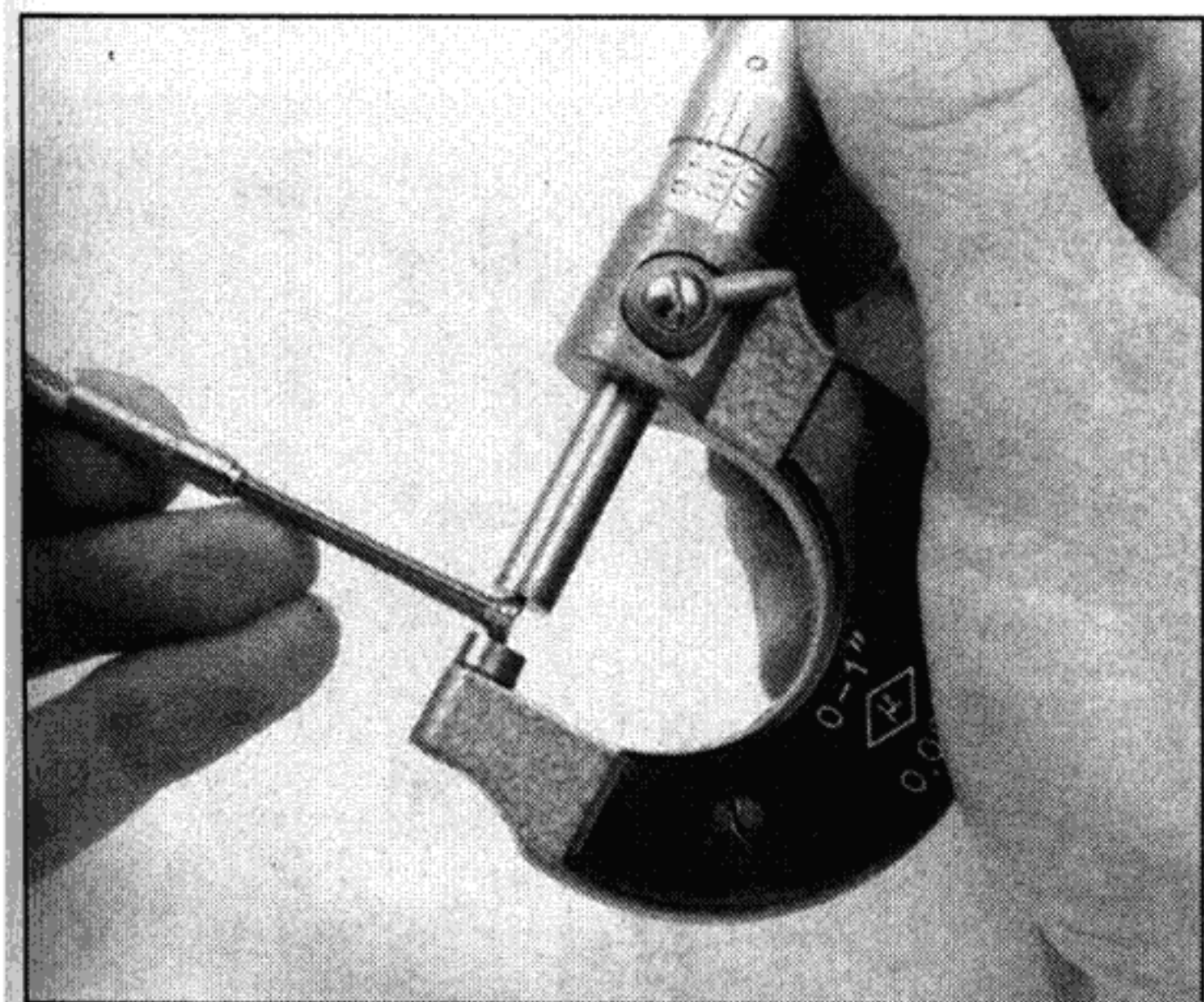
13 Examine the valve seats in the combustion chamber. If they are pitted, cracked or burned, the head will require work beyond the scope of the home mechanic. Measure the valve seat width and compare it to this Chapter's Specifications (**see illustration**). If it exceeds the service limit, or if it varies around its circumference, valve overhaul is required. If available, use Prussian blue to determine the extent of valve seat wear. Uniformly coat the seat with the Prussian blue, then install the valve and rotate it back and forth using a lapping tool. Remove the valve and check whether the ring of blue on the valve is uniform and continuous around the valve, and of the correct width as specified.

14 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**

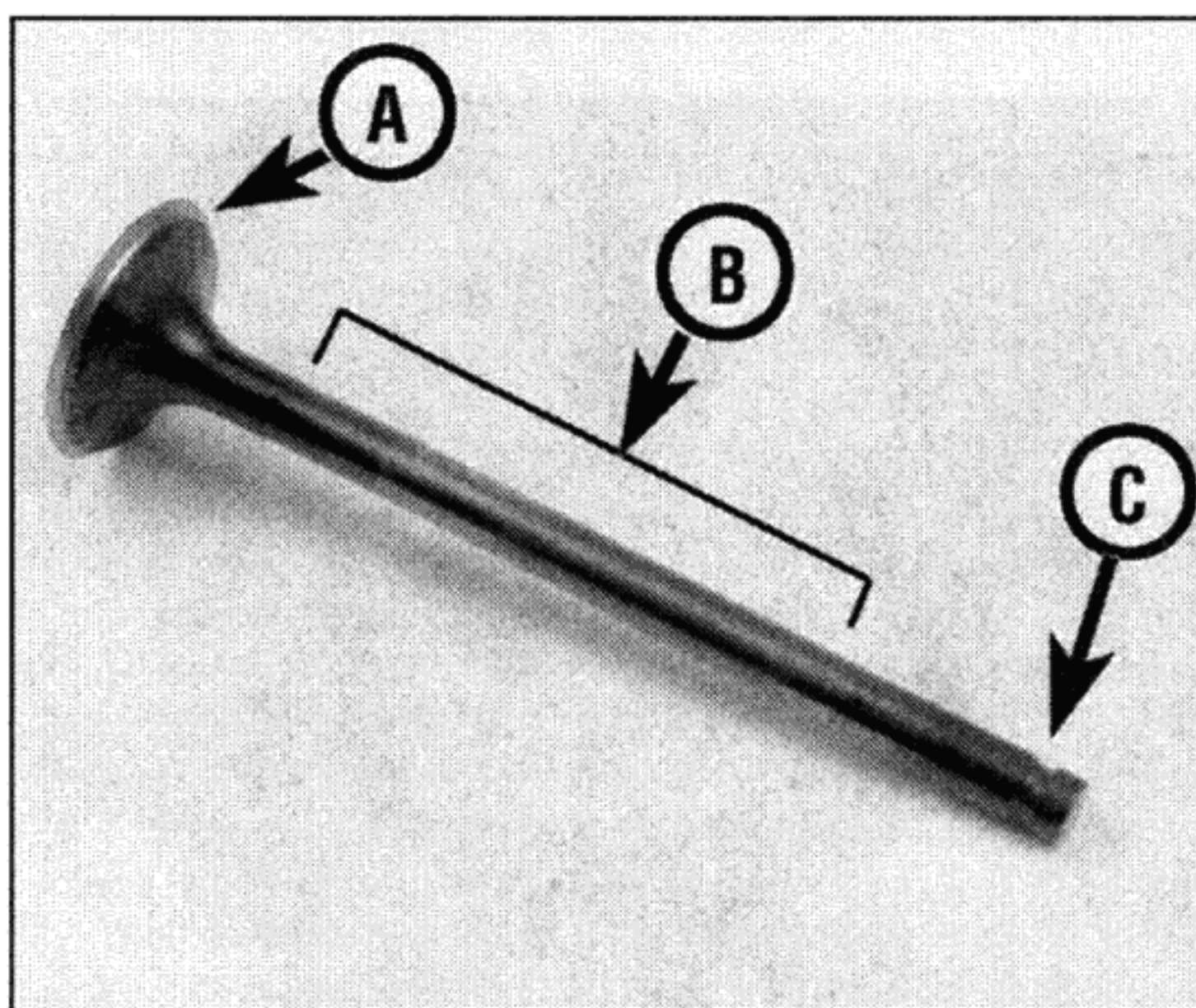
illustrations). The guides are measured at the ends and at the centre to determine if they are worn in a bell-mouth pattern (more wear at the ends). Subtract the stem diameter from the valve guide diameter to obtain the valve stem-to-guide clearance. If the stem-to-guide clearance is greater than listed in this Chapter's Specifications, the guides and valves will have to be renewed. If the valve stem or guide is worn beyond its limit, or if the guide is worn unevenly, it must be renewed.

15 Carefully inspect each valve face for cracks, pits and burned spots. Check the valve stem and the collet groove area for cracks (**see illustration**). 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 renewed. 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 sufficient.

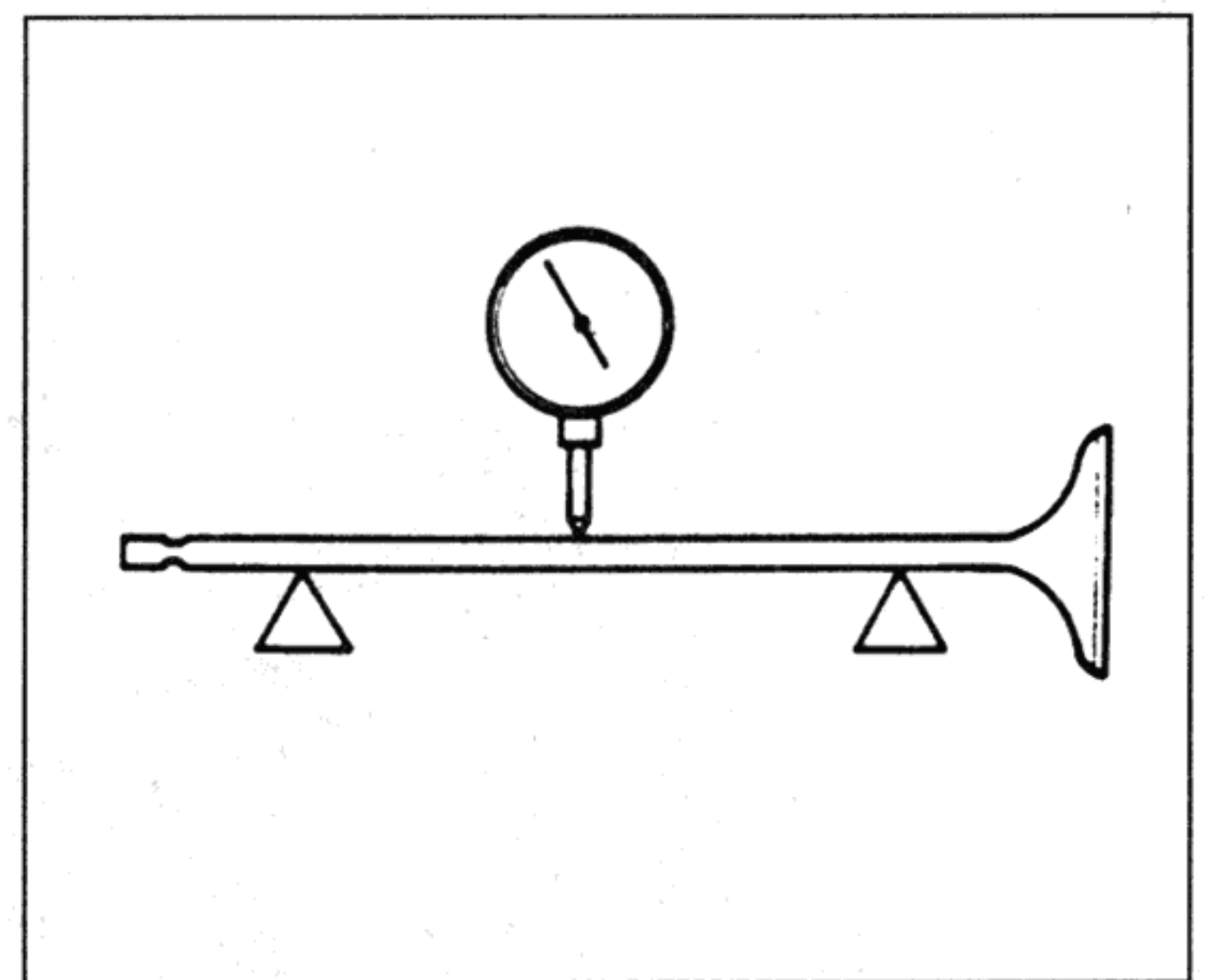
16 Measure the valve margin thickness and compare it to the specifications (**see**



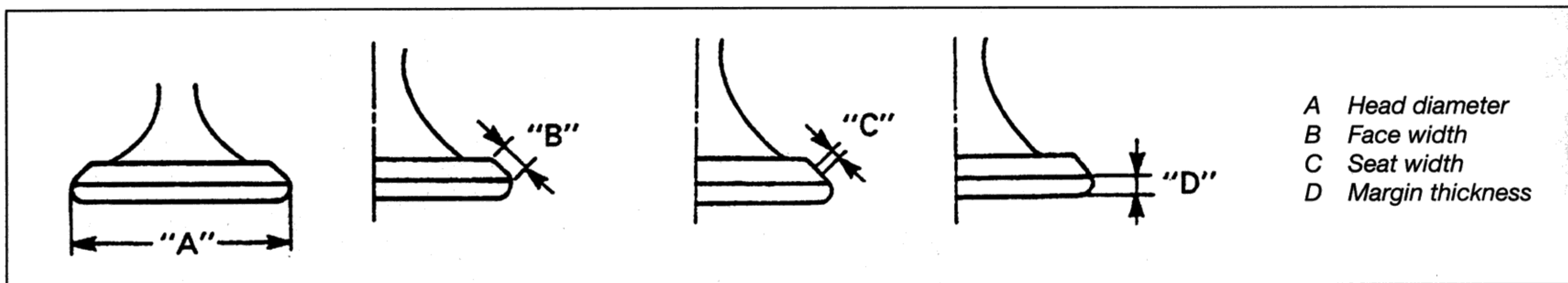
12.14c Measure the small-hole gauge with a micrometer



12.15a Check the valve face (A), stem (B) and collet groove (C) for signs of wear and damage



12.15b Check the valve stem for runout using V-blocks and a dial gauge



12.16 Valve head measurement points

illustration). If it is thinner than specified, renew the valve. The margin is the portion of the valve head which is below the valve seat.

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

18 Check the spring 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.

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

Reassembly

20 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. 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.

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

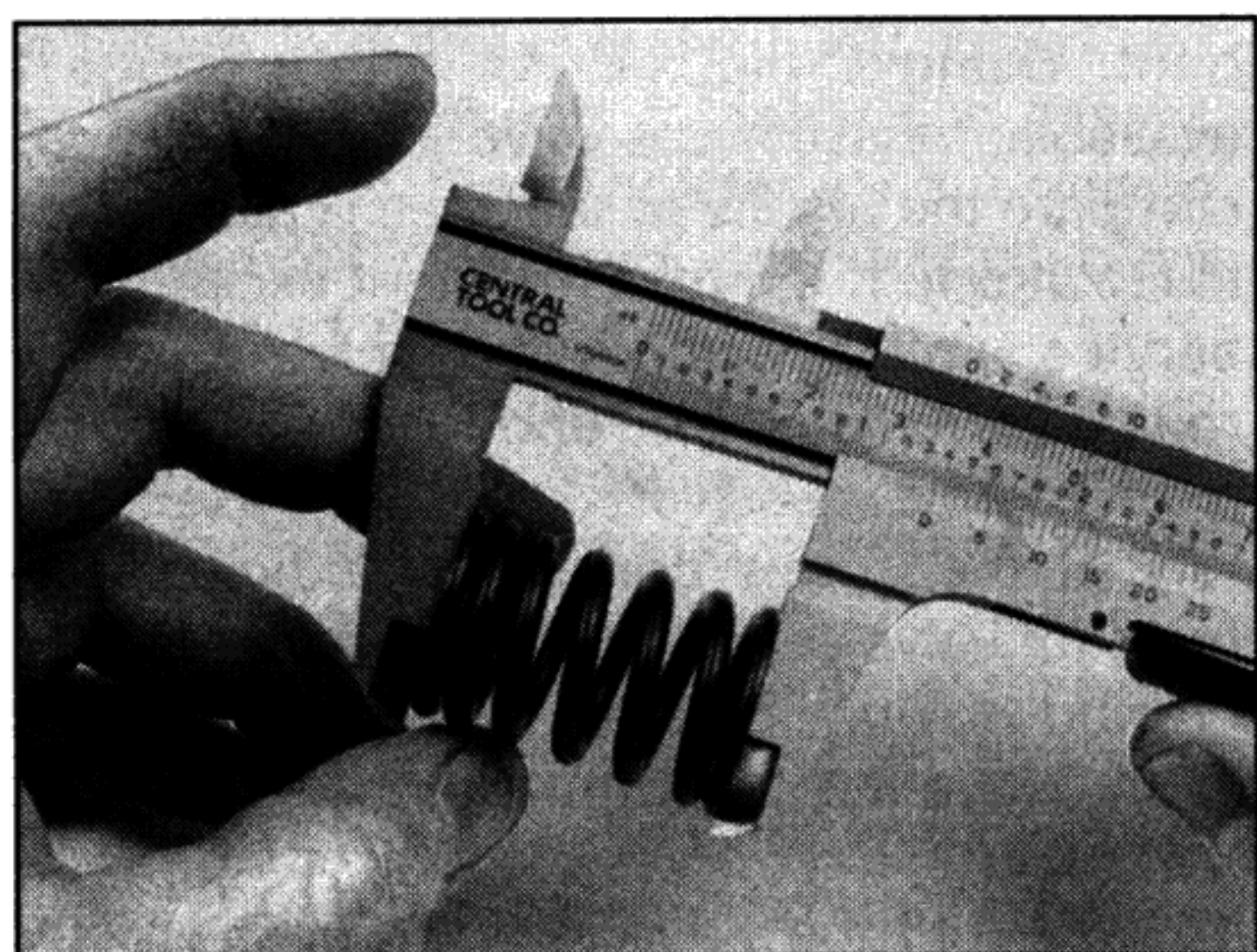
22 Attach the grinding tool (or hose) to the valve and rotate the tool between the palms of

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

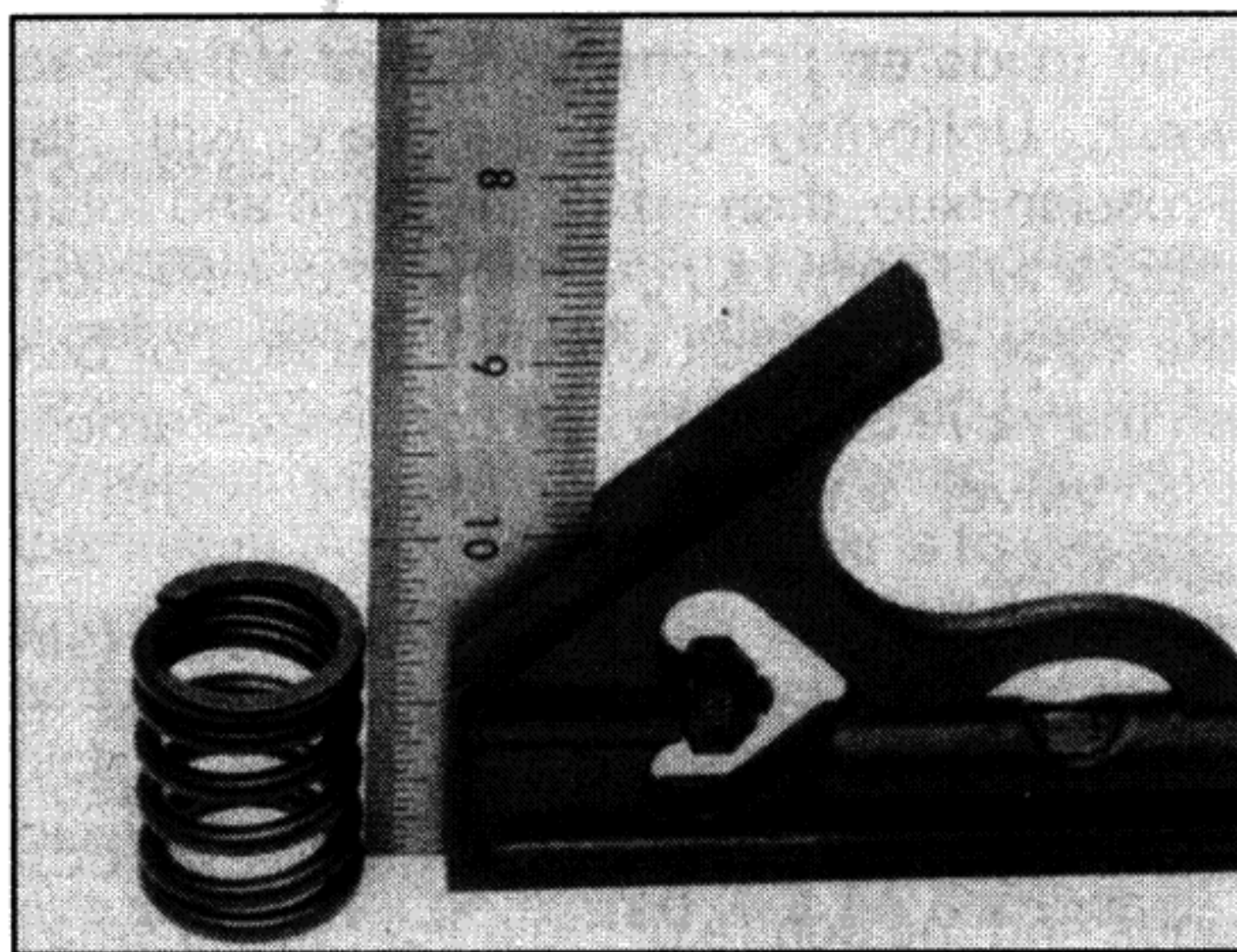
23 Carefully remove the valve from the guide and wipe off all traces of grinding compound. Use solvent to clean the valve and wipe the seat area thoroughly with a solvent soaked cloth.

24 Repeat the procedure with fine valve grinding compound, then repeat the entire procedure for the remaining valves.

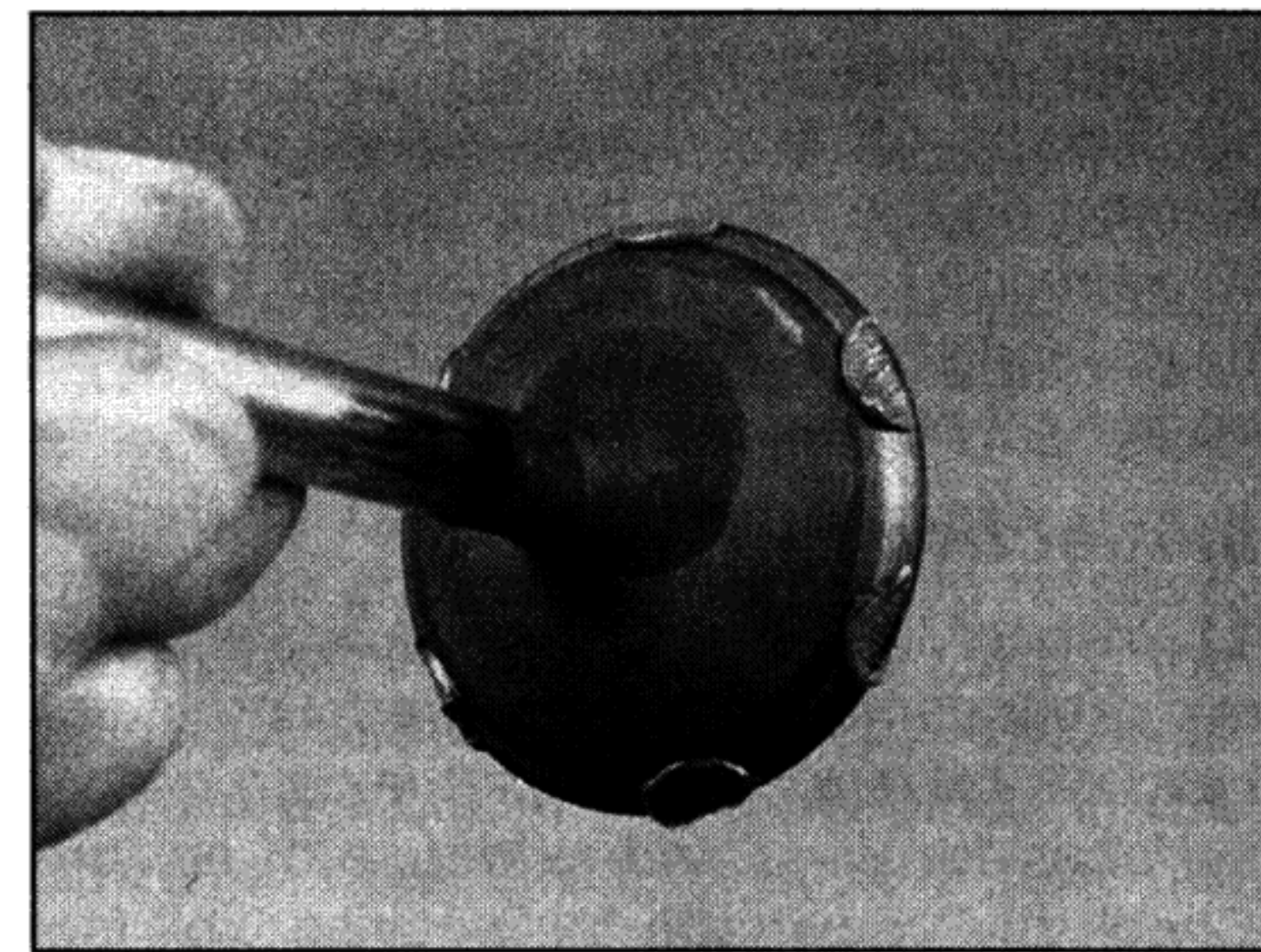
25 Lay the spring seat for each valve in place



12.17a Measure the free length of the valve springs



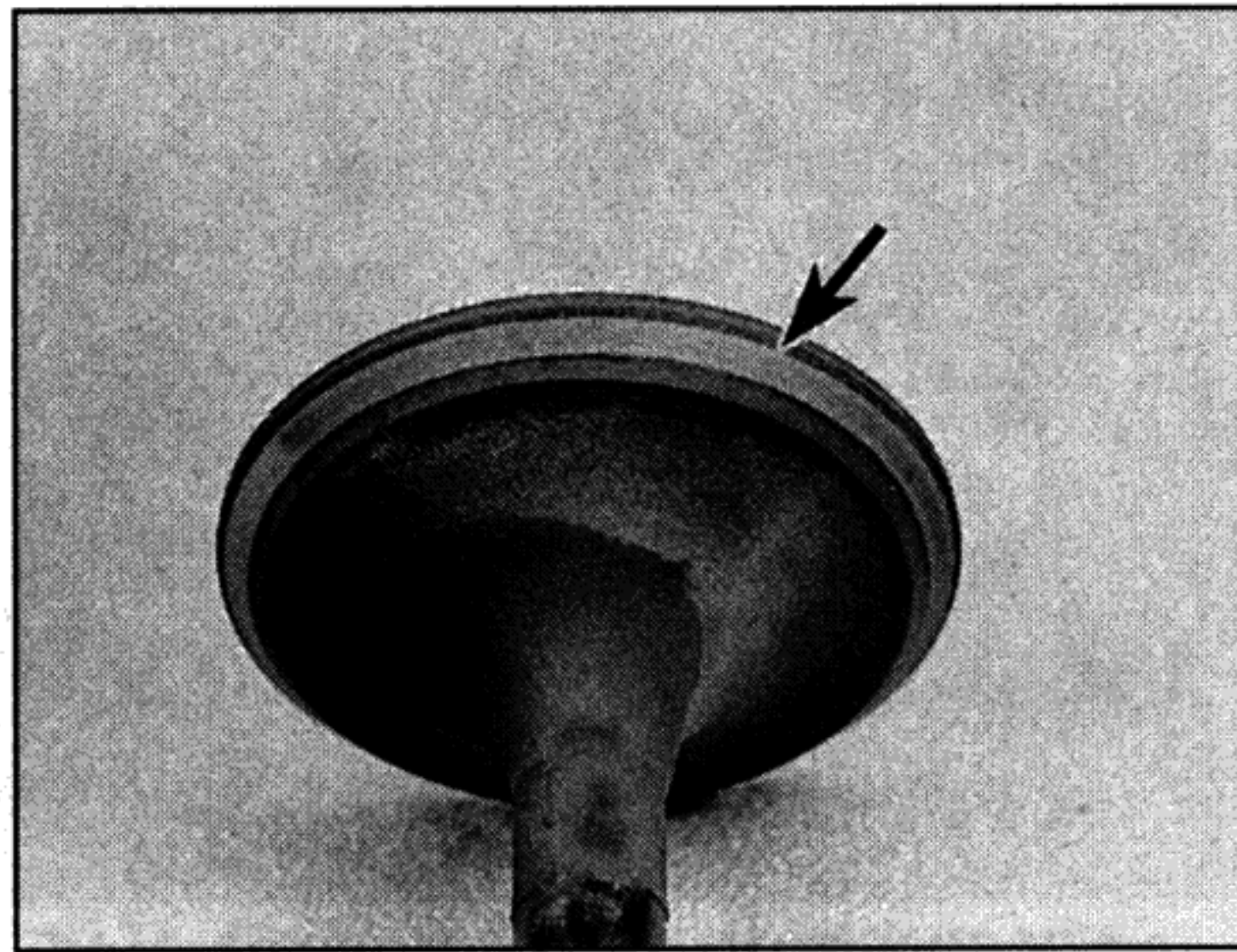
12.17b Check the valve springs for squareness



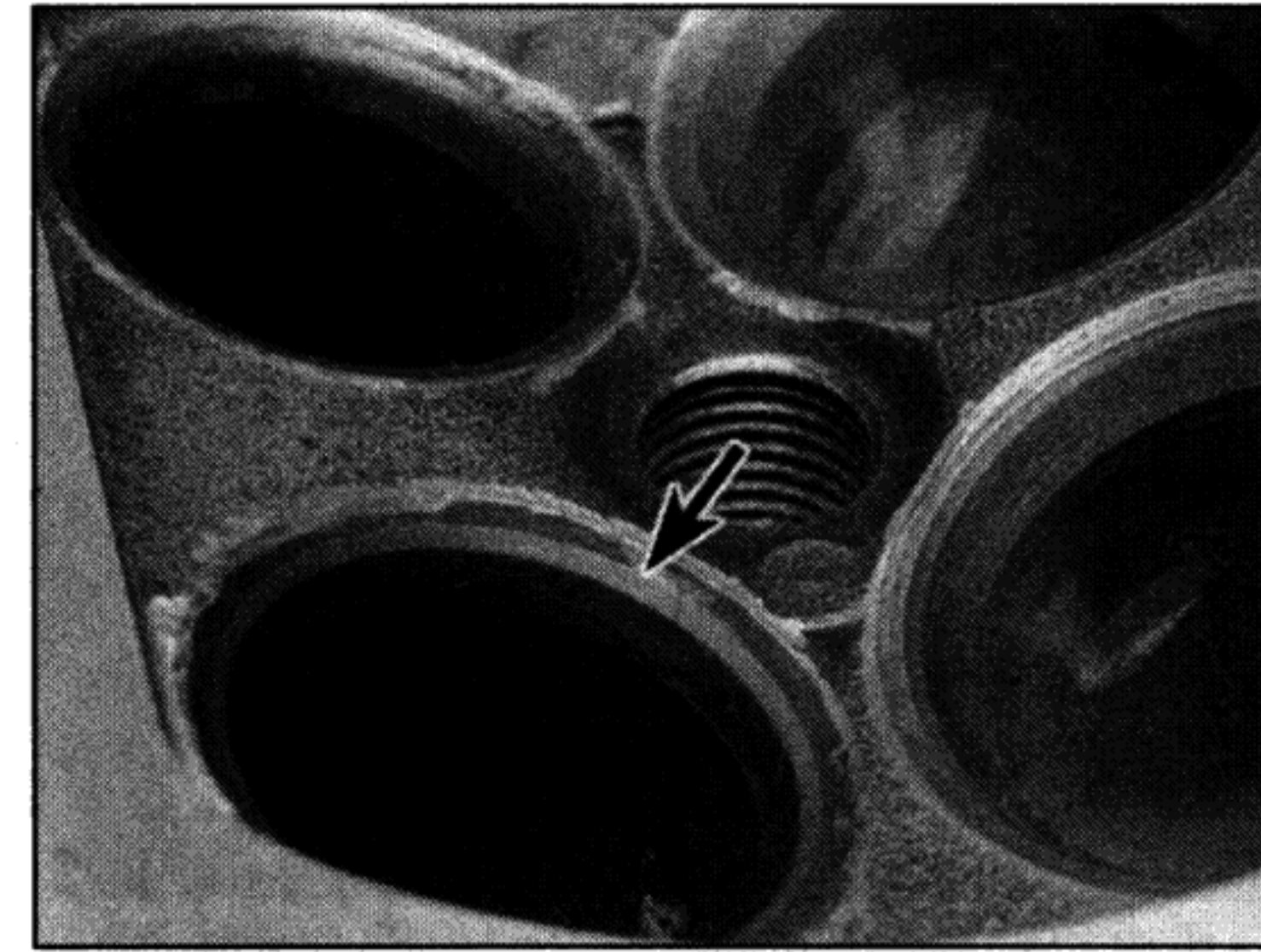
12.21 Apply the lapping compound very sparingly, in small dabs, to the valve face only



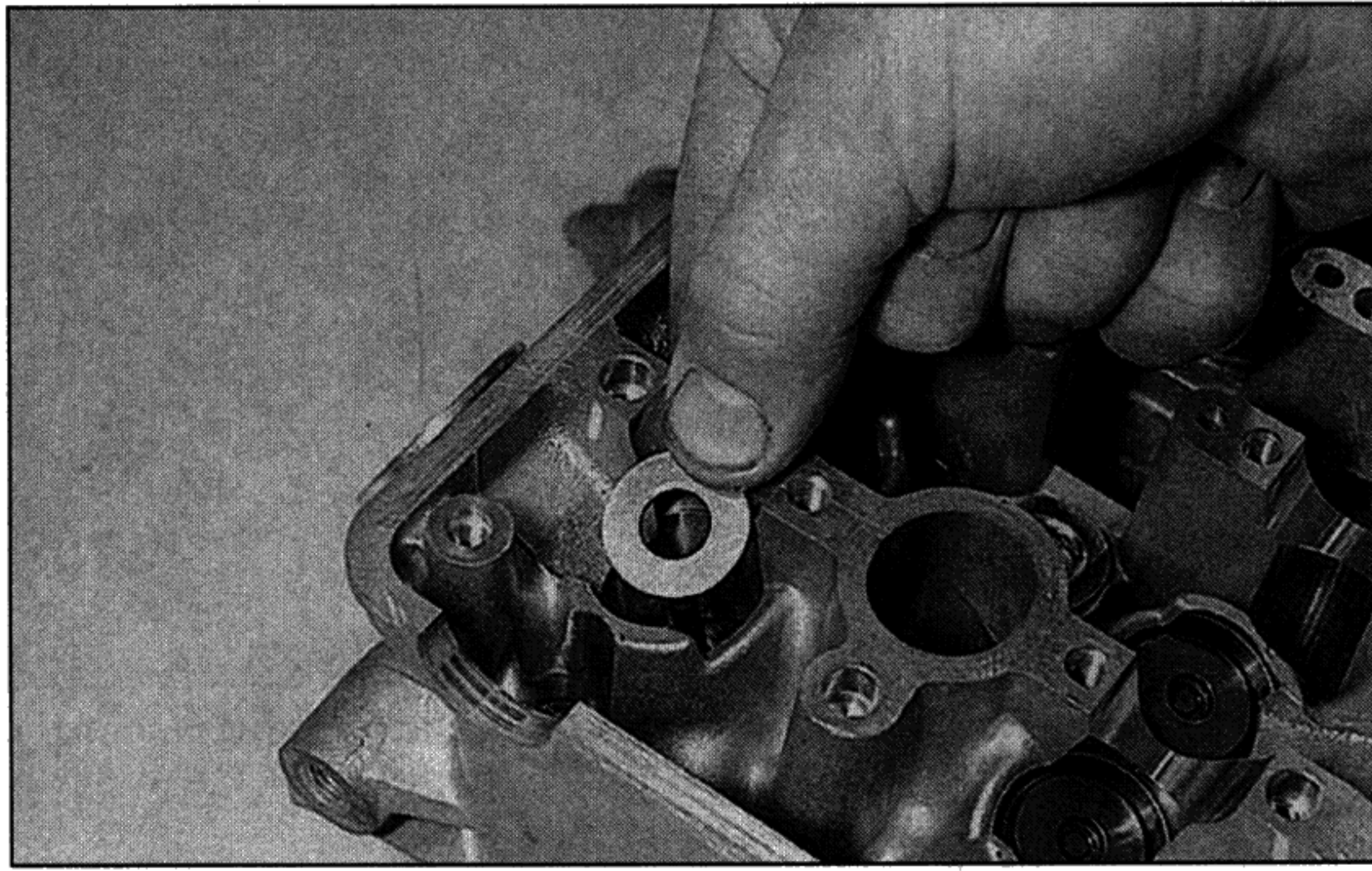
12.22a Rotate the valve grinding tool back and forth between the palms of your hands



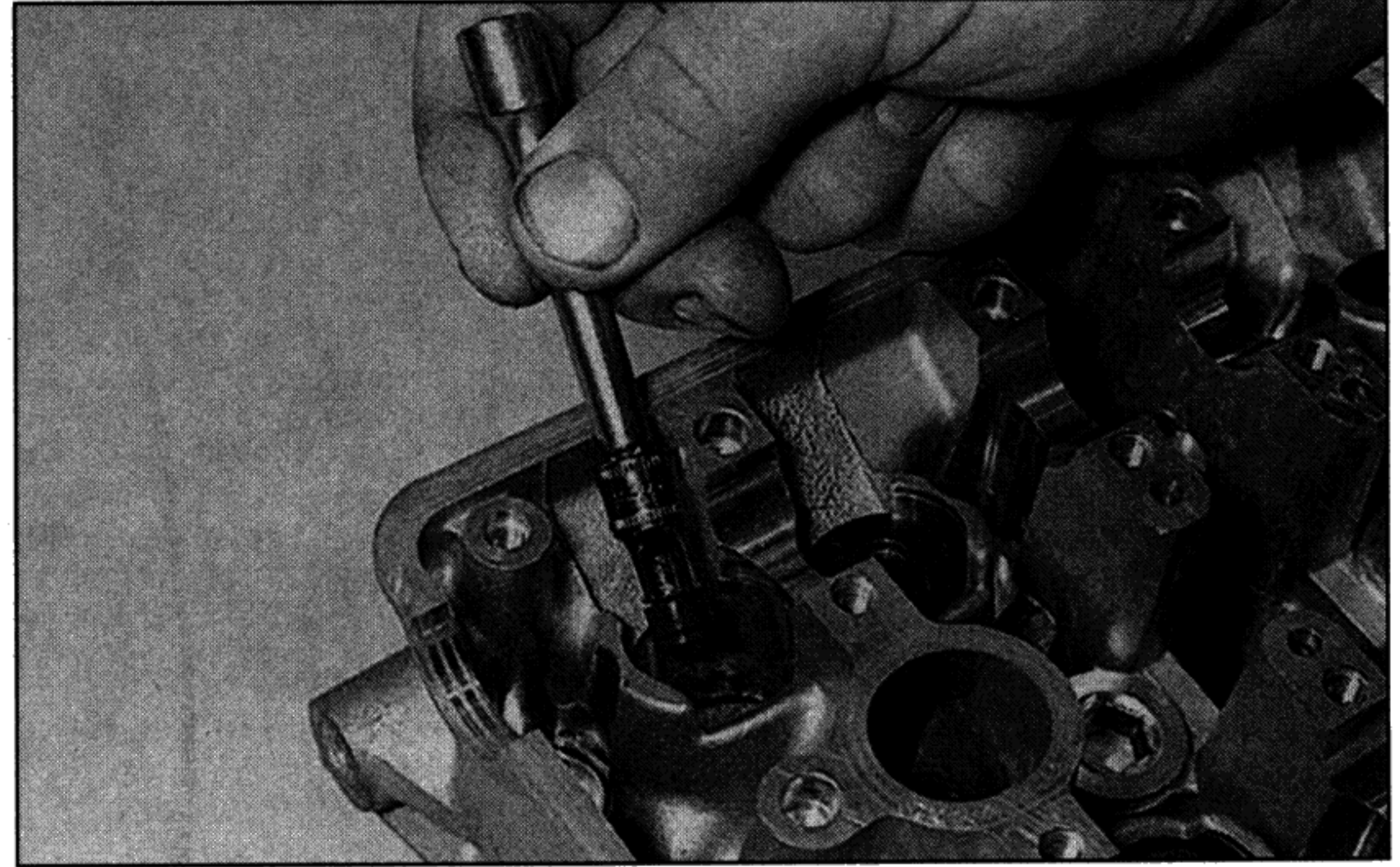
12.22b The valve face and seat should show a uniform unbroken ring . . .



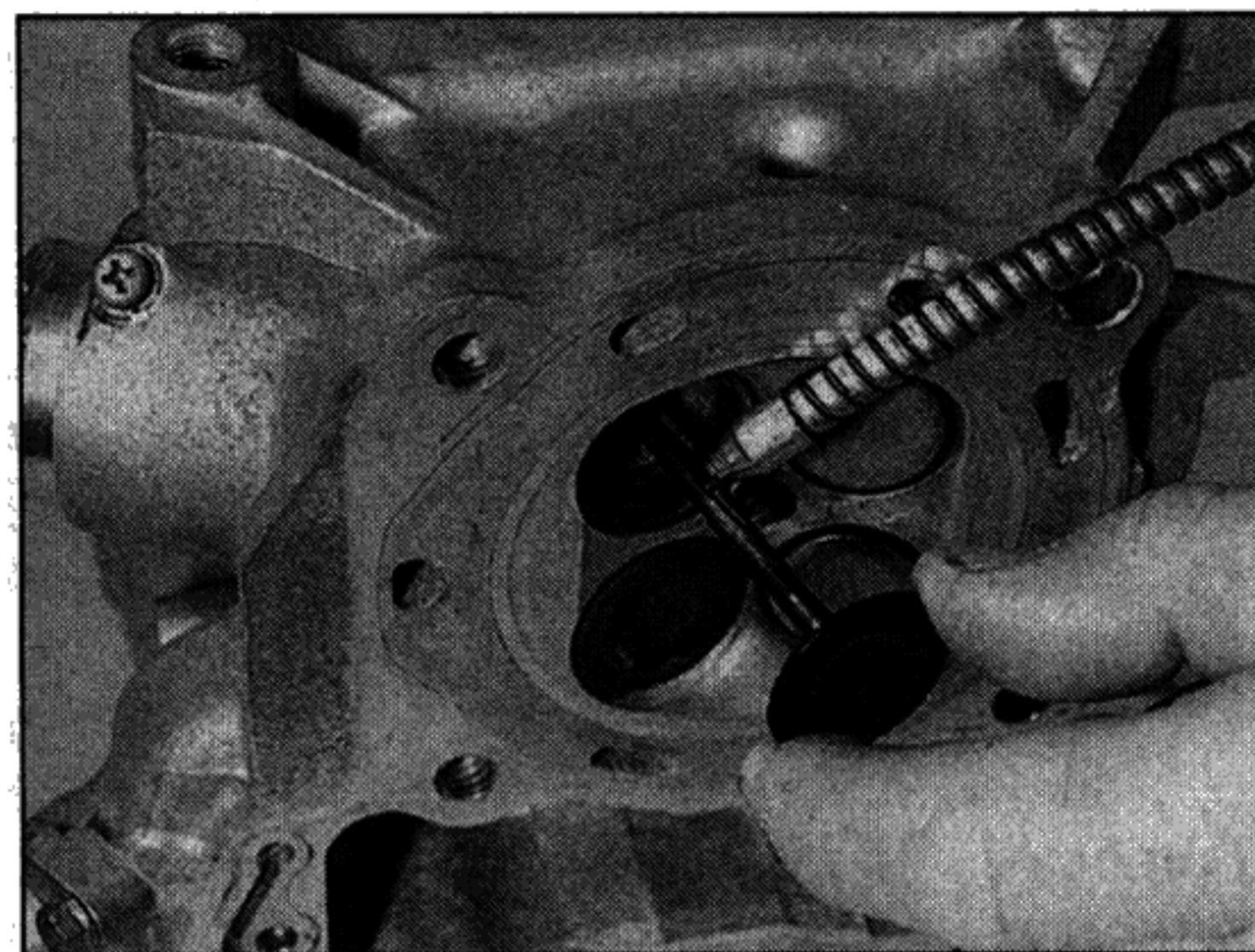
12.22c . . . and the seat (arrowed) should be the specified width all the way round



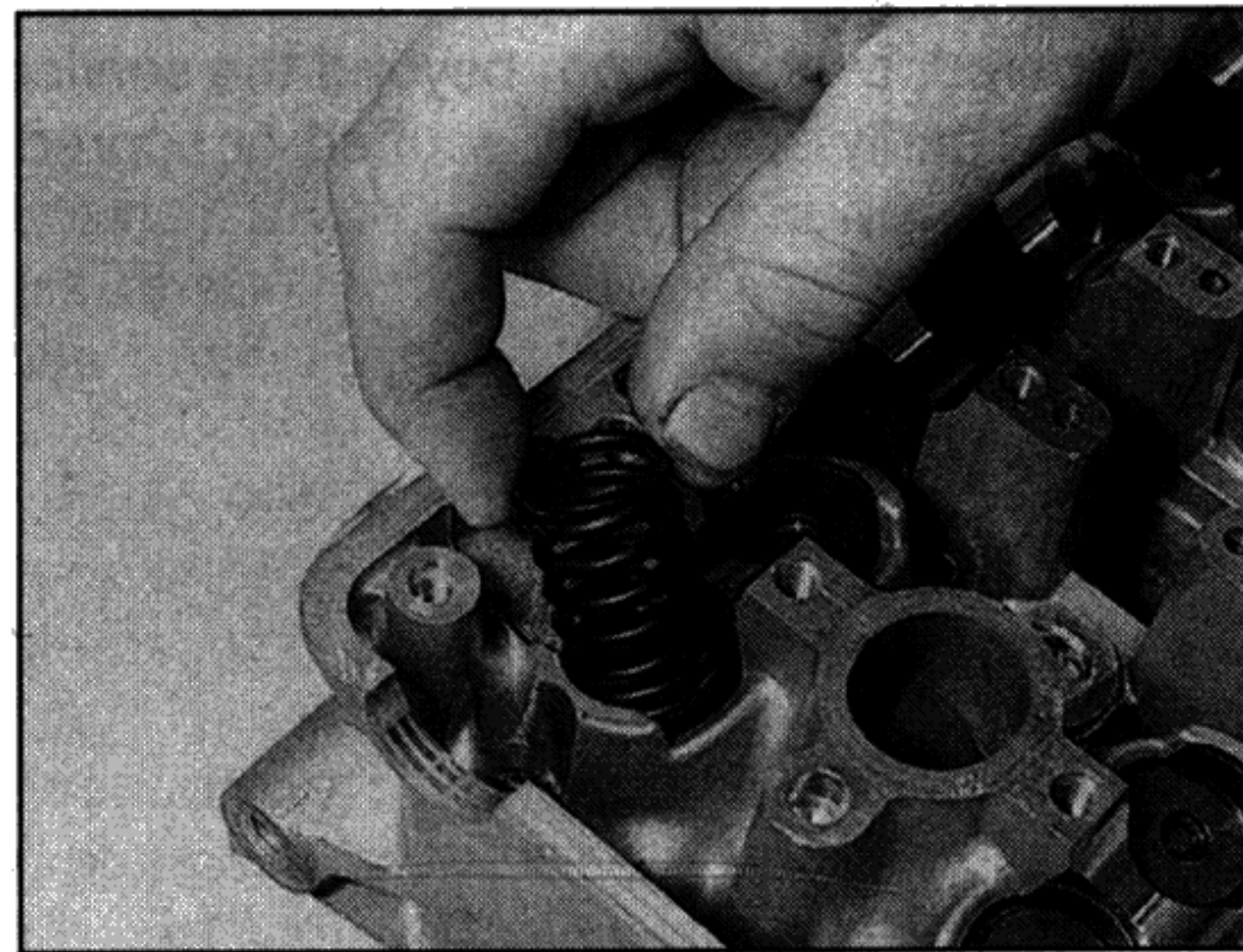
12.25a Fit the spring seat . . .



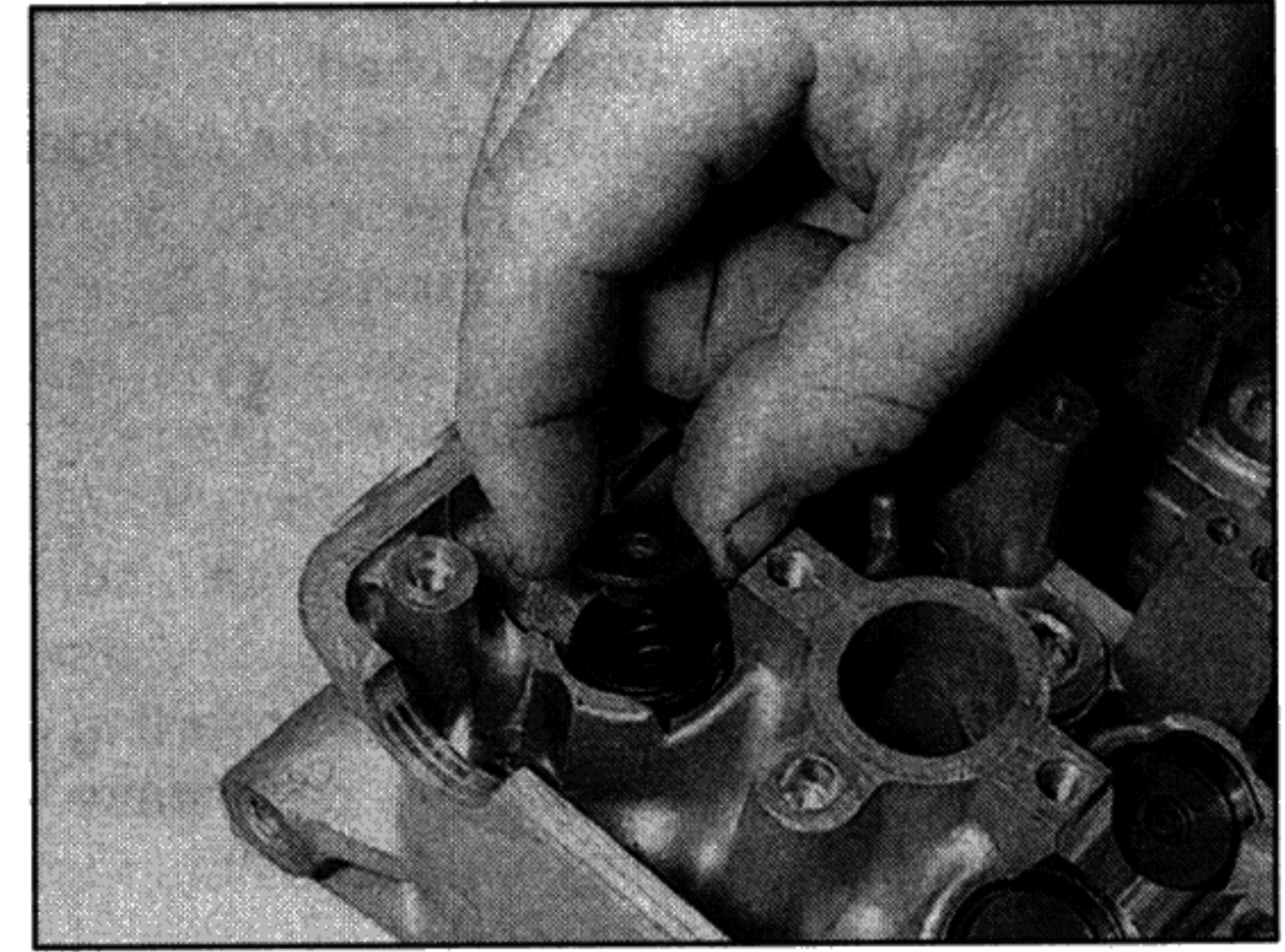
12.25b . . . then press the valve stem seal into position using a suitable deep socket



12.26a Lubricate the stem and slide the valve into its correct location



12.26b Fit the valve spring with its closer-wound coils facing down. . .



14.26c . . . then fit the spring retainer

in the cylinder head, with its shouldered side up so that the spring fits into it, then install new valve stem seals on each of the guides (**see illustrations**). Use an appropriate size deep socket to push the seals over the end of the valve guide until they are felt to clip into place. Don't twist or cock them, or they will not seal properly against the valve stems. Also, don't remove them again or they will be damaged.

26 Coat the valve stems with molybdenum disulphide grease, then install one of them 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. Next, install the spring, with its closer-wound coils facing down into the cylinder head, followed by the spring retainer, with its shouldered side facing down so that it fits into the top of the spring (**see illustrations**).

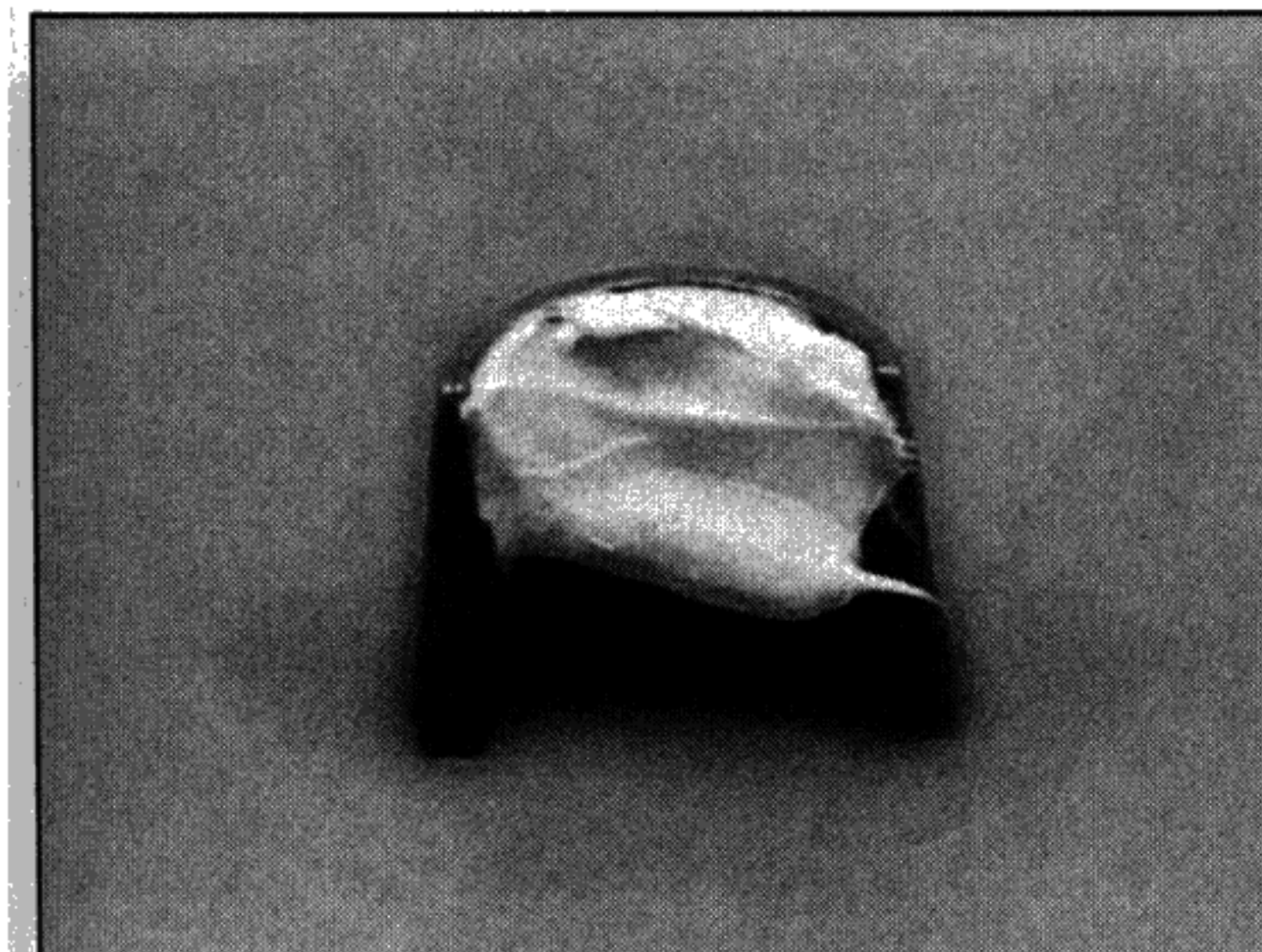
27 Apply a small amount of grease to the collets to help hold them in place as the pressure is released from the springs (**see illustration**). Compress the springs with the valve spring compressor and install the collets (**see illustration**). When compressing the spring, depress them only as far as is

absolutely necessary to slip the collets into place. Make certain that the collets are securely locked in their retaining grooves.

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

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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.



12.27a A small dab of grease will help to keep the collets in place on the valve while the spring is released



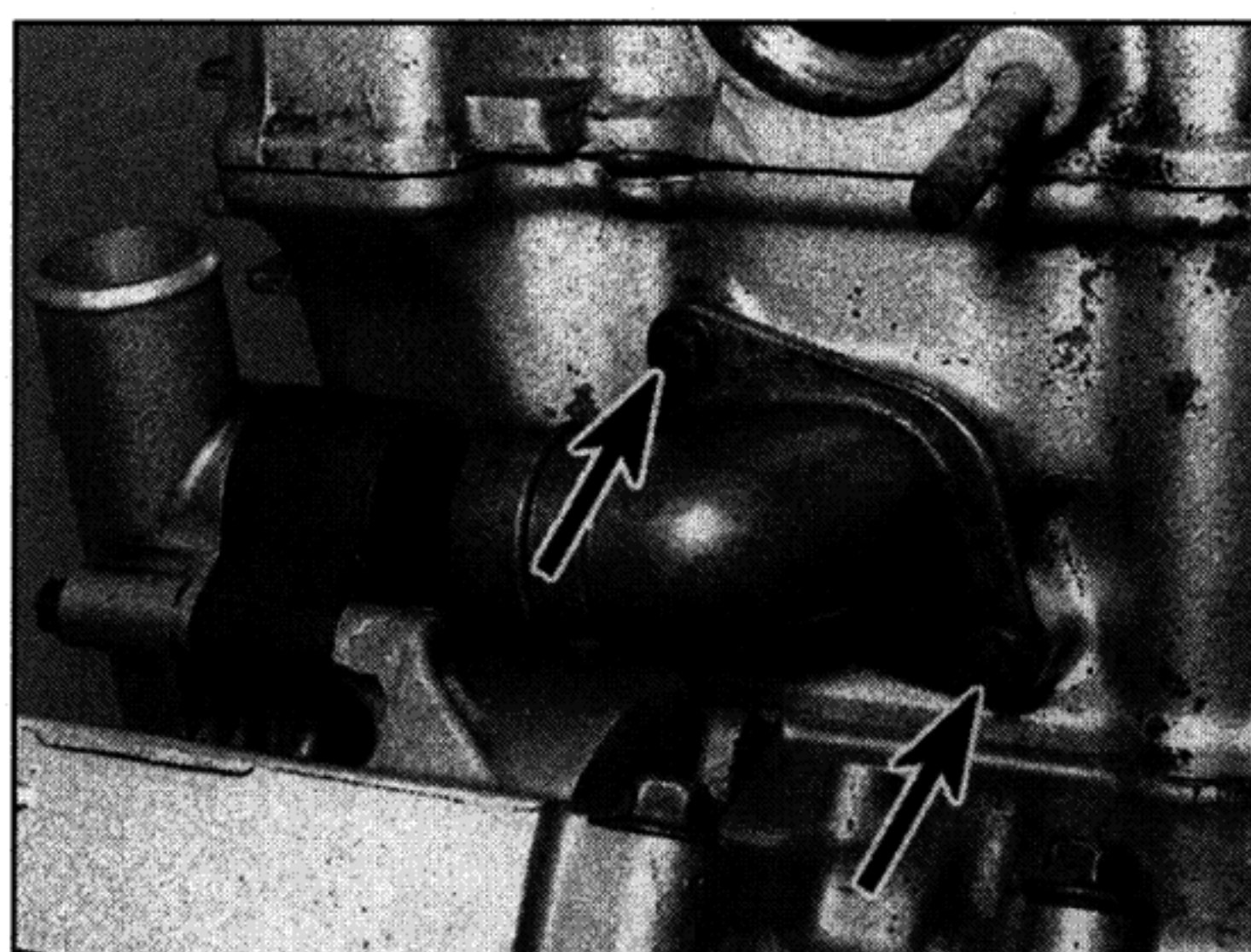
12.27b Compress the spring and install the collets, making sure they locate in the groove

13 Cylinder block – removal, inspection and installation

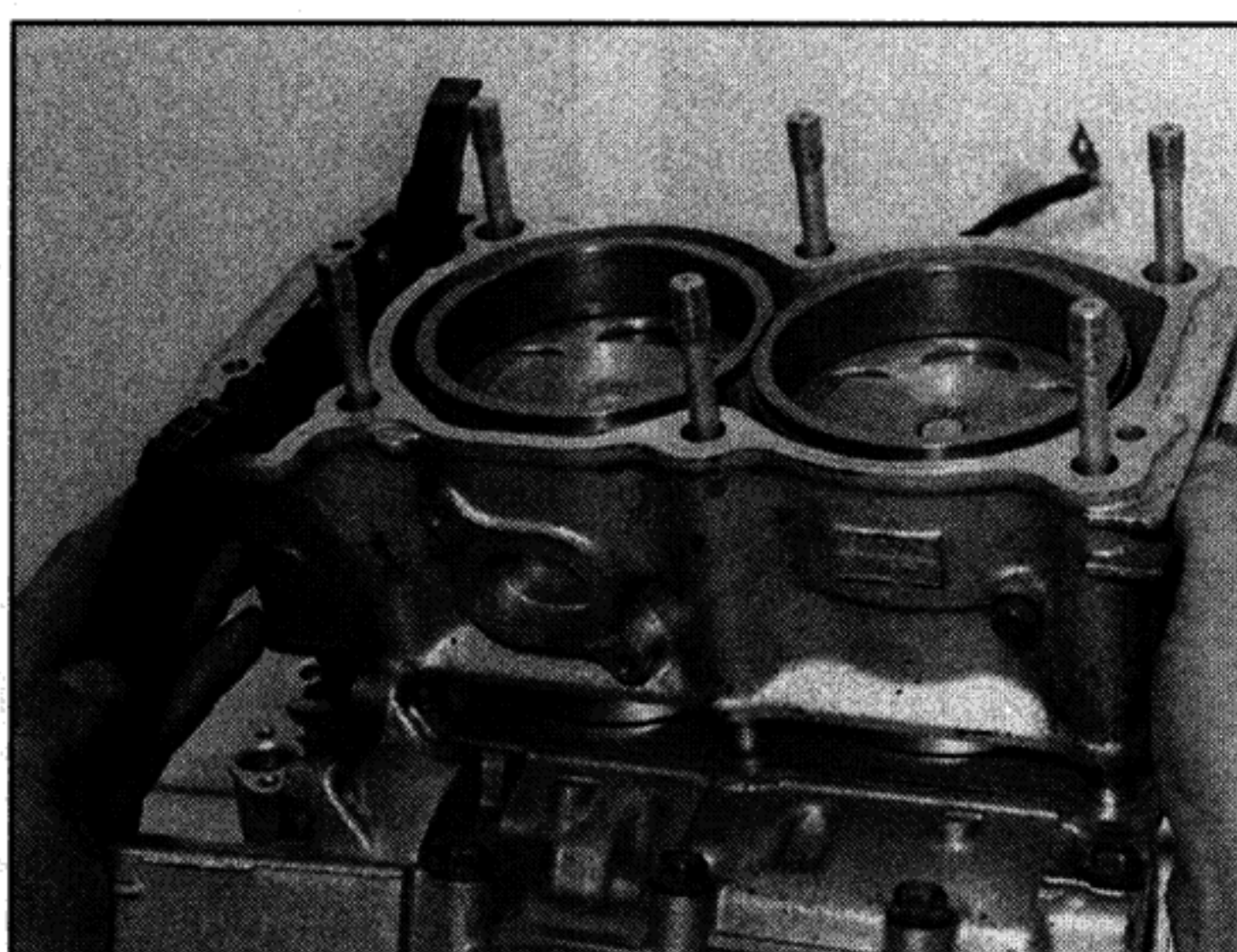
Note: The cylinder block can be removed with the engine in the frame.

Removal

- 1 Remove the cylinder head (see Section 10).
- 2 Unscrew the bolts securing the coolant hose union to the front of the block and



13.2 Unscrew the two bolts (arrowed) and remove the union



13.3 Lift the block up off the crankcase



13.4 Pick out the O-rings and discard them

remove the union (**see illustration**). The joint pipe between the union and the water pump housing may come with the union, otherwise leave it in place in the housing. Discard the O-rings as new ones must be used.

3 Hold the cam chain up and lift the cylinder block up, then pass the cam chain down through the tunnel (**see illustration**). Do not let the chain fall into the crankcase – secure it with a piece of wire or metal bar to prevent it from doing so. If the block is stuck, tap around the joint faces of the block with a soft-faced mallet to free it from the crankcase. Don't attempt to free the block by inserting a screwdriver between it and the crankcase – you'll damage the sealing surfaces. When the block is removed, stuff clean rags around the pistons to prevent anything falling into the crankcase. Remove the dowels from the mating surface of the crankcase or the underside of the block if they are loose. Be careful not to drop them into the engine.

4 Remove the O-ring from around each cylinder liner and discard them as new ones must be used (**see illustration**).

5 Remove the gasket and clean all traces of old gasket material from the cylinder block and crankcase mating surfaces. 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 or the oil passages.

Inspection

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

6 Check the cylinder walls carefully for scratches and score marks. A rebore will be necessary to remove any deep scores.

7 Using telescoping gauges and a micrometer (**see Tools and Workshop Tips** in the Reference section), 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 – about 10 mm below the top of the cylinder), centre and bottom (but above the level of the oil ring at BDC – about 20 mm above the bottom of the cylinder) of the bore both parallel to and across the crankshaft axis (**see illustration**). Calculate any differences

between the measurements taken to determine any taper and ovality in the bore. Compare the results to the specifications at the beginning of the Chapter. If the cylinders are tapered, oval, or worn beyond the service limits, or badly scratched, scuffed or scored, have them rebored and honed by a Yamaha dealer or engineer. If the cylinders are rebored, they will require oversize pistons and rings.

8 If the precision measuring tools are not available, take the block and pistons to a Yamaha dealer or engineer for assessment and advice.

9 If the block and cylinders are in good condition and the piston-to-bore clearance is within specifications (**see Section 14**), the cylinders should be honed (de-glazed). To perform this operation you will need the proper size flexible hone with fine stones (**see Tools and Workshop Tips** in the Reference section), or a bottle-brush type hone, plenty of light oil or honing oil, some clean rags and an electric drill motor.

10 Hold the block sideways (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, compress the stones and insert the hone into the cylinder. Thoroughly lubricate the cylinder, then 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 cylinder. Remember, do not take too much material from the cylinder wall.

11 Wash the cylinders thoroughly with warm soapy water to remove all traces of the abrasive grit produced during the honing operation. Be sure to run a brush through the bolt holes and flush them with running water. After rinsing, dry the cylinders thoroughly and apply a thin coat of light, rust-preventative oil to all machined surfaces.

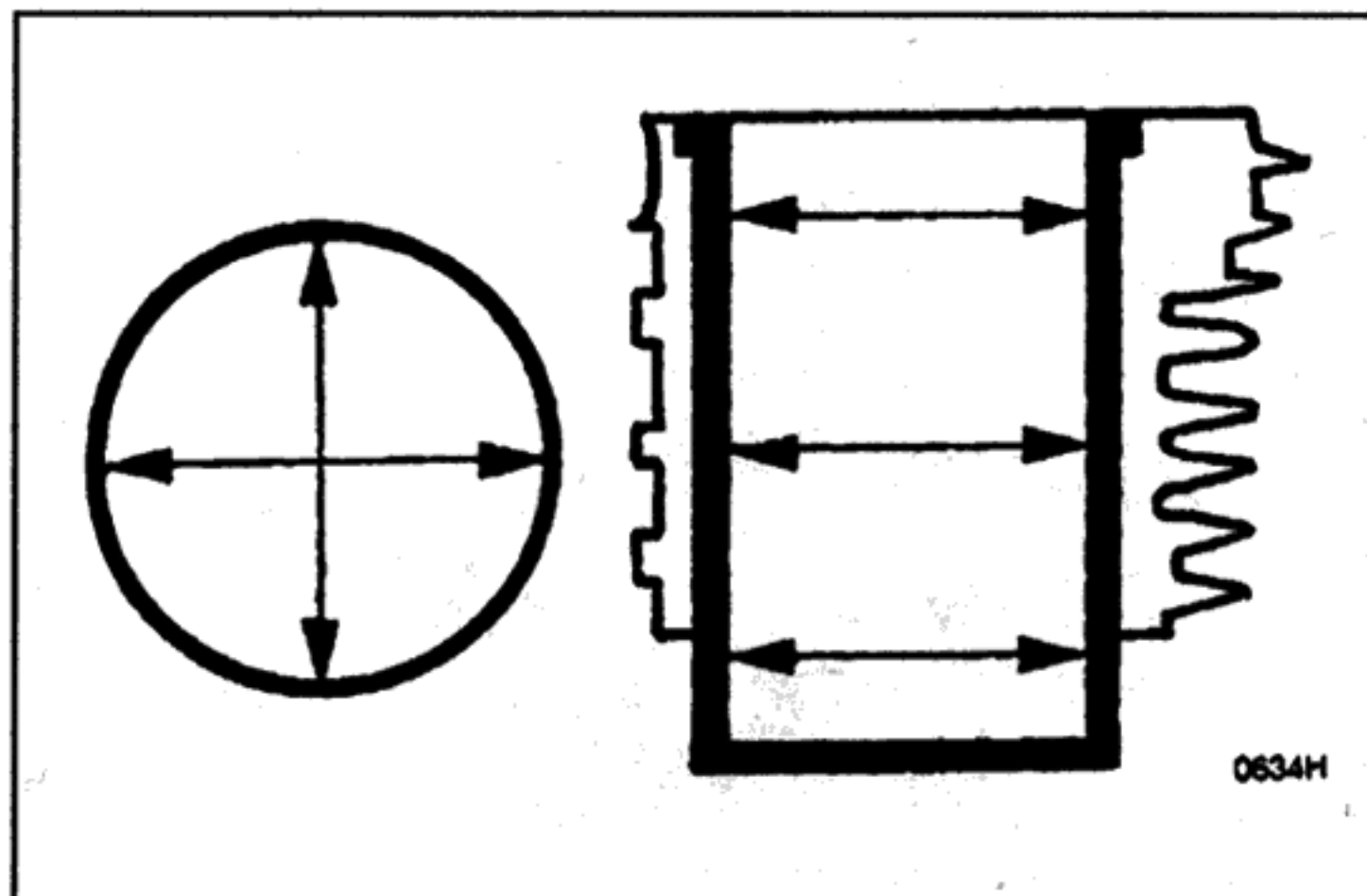
12 If you do not have the equipment or desire to perform the honing operation, take the block to a Yamaha dealer or engineer.

Installation

13 Check that the mating surfaces of the cylinder block and crankcase are free from oil or pieces of old gasket. If removed, fit the dowels into the crankcase (**see illustration 13.15**).

14 Fit a new O-ring into the groove around the base of each cylinder liner and press it into the groove between the liner and the cylinder block, taking care not to damage it (**see illustration**).

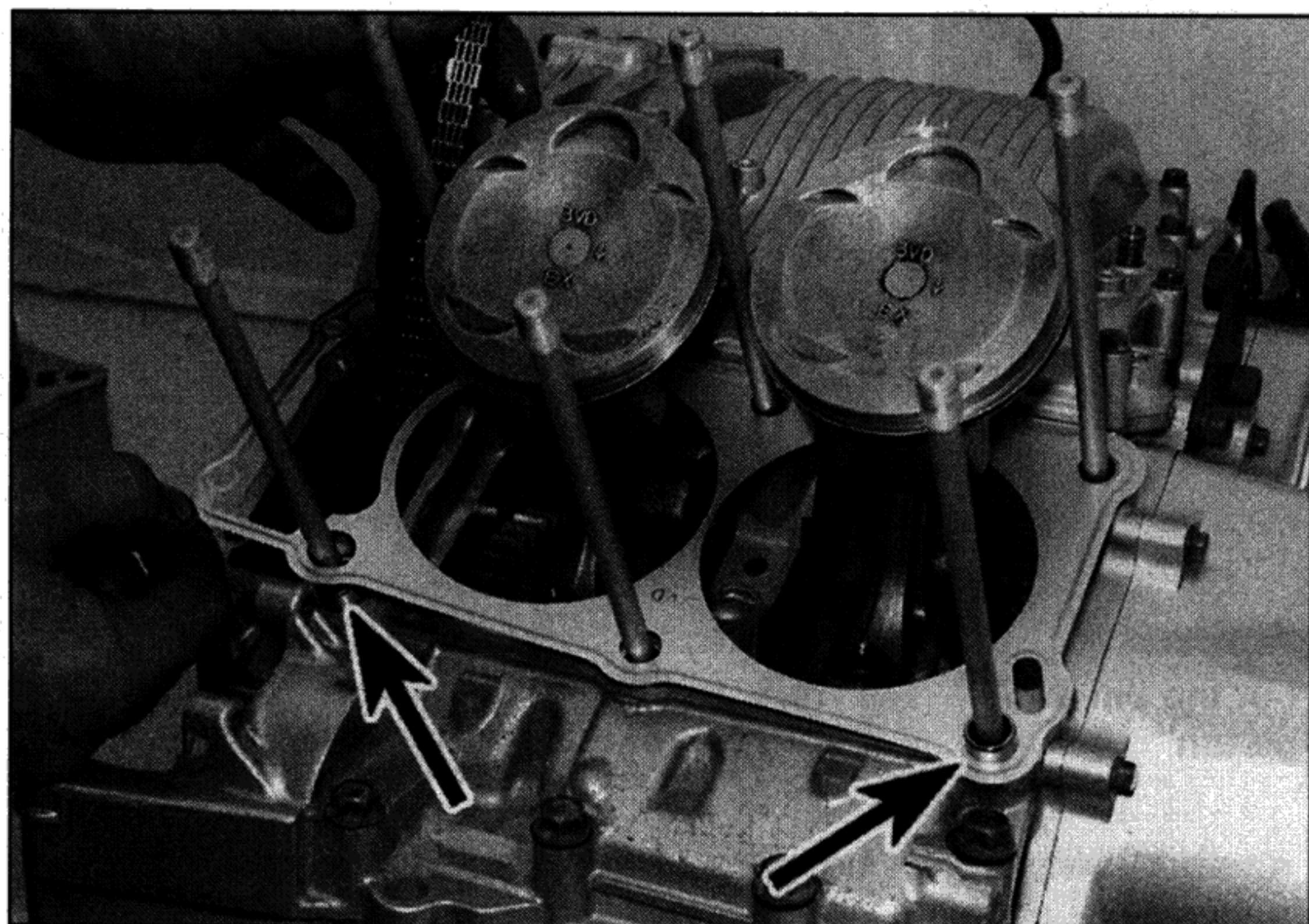
15 Remove the rags from around the pistons.



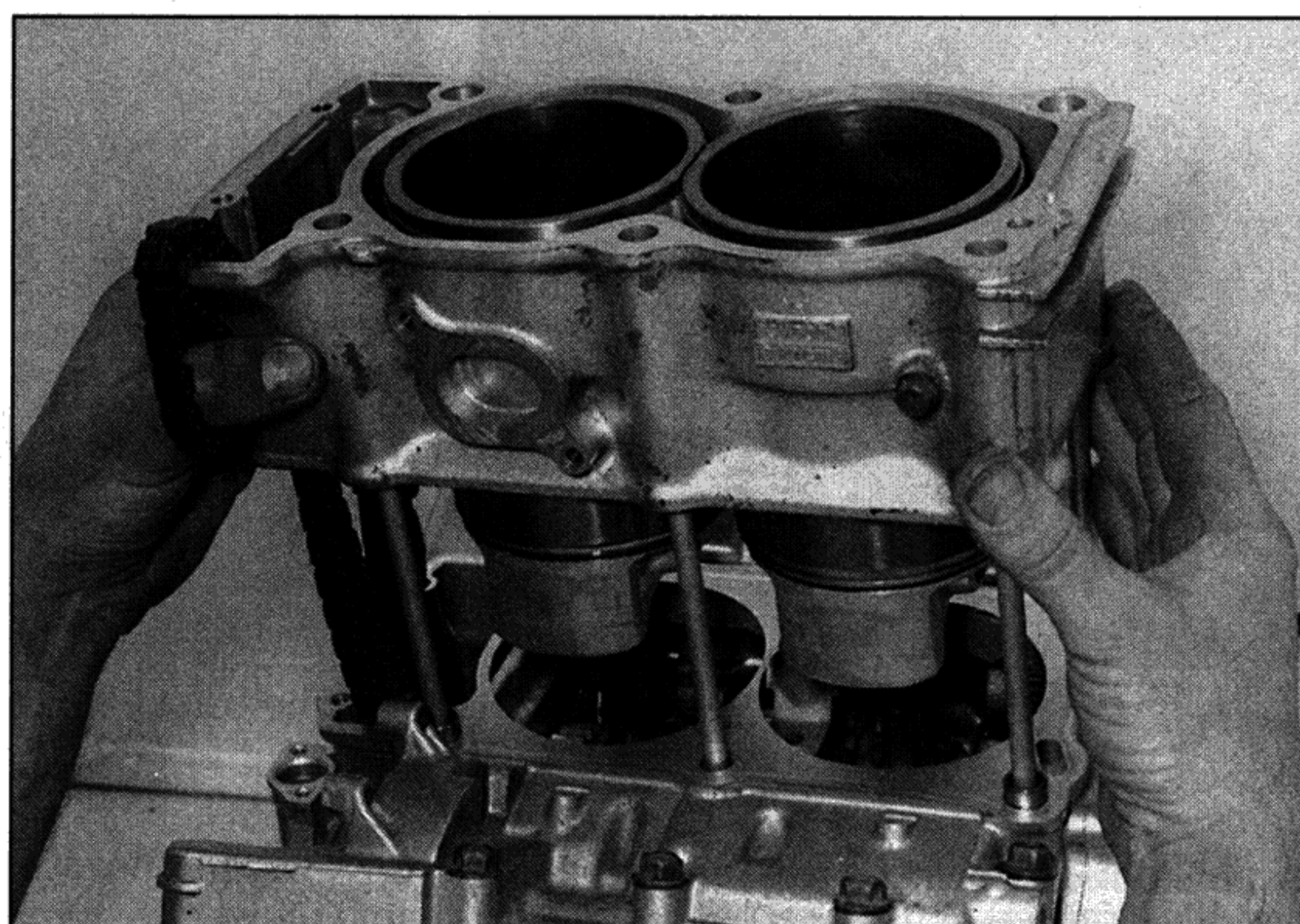
13.7 Measure the cylinder bore in the directions shown with a telescoping gauge, then measure the gauge with a micrometer



13.14 Fit a new O-ring into the groove around the liner base



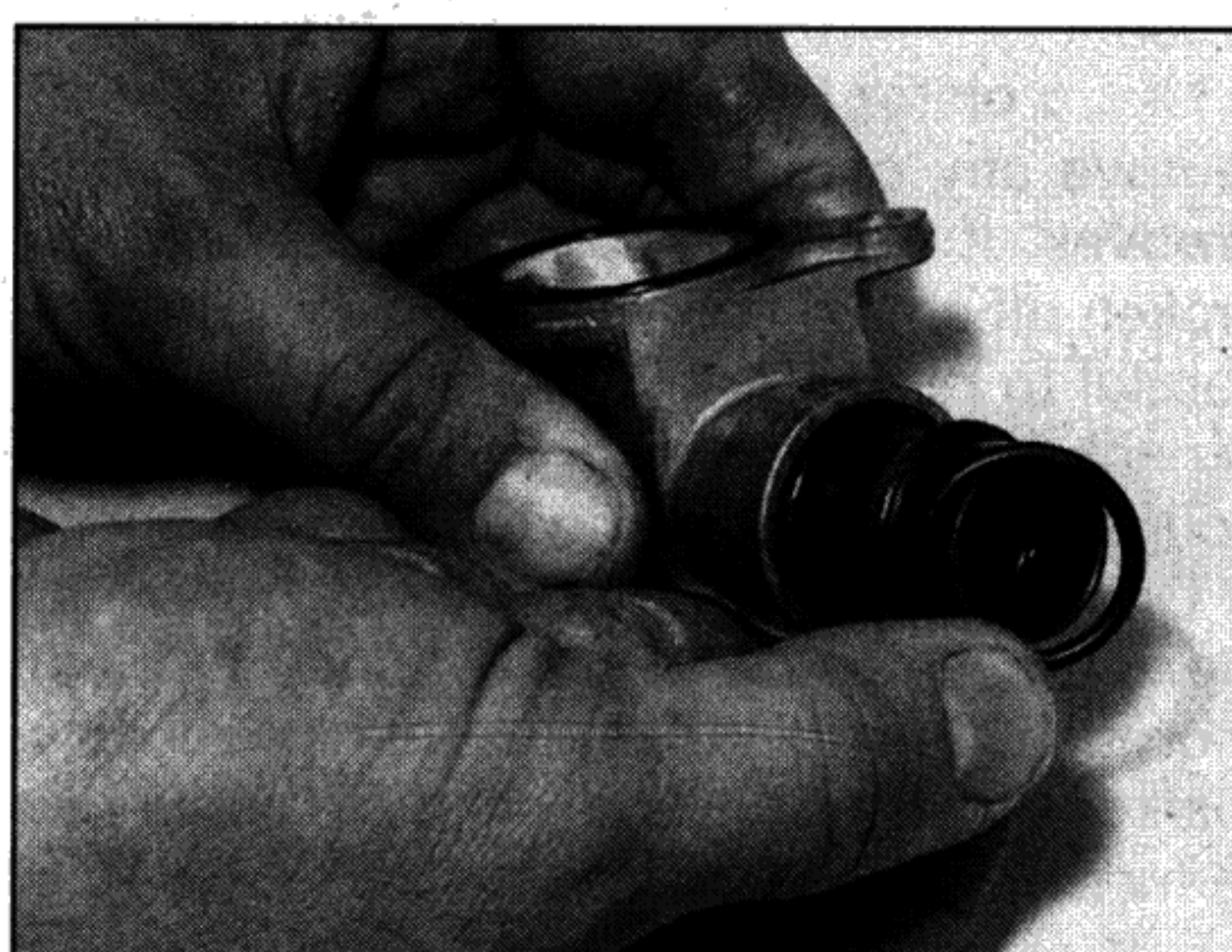
13.15 Lay the new gasket over the dowels (arrowed) and onto the crankcase



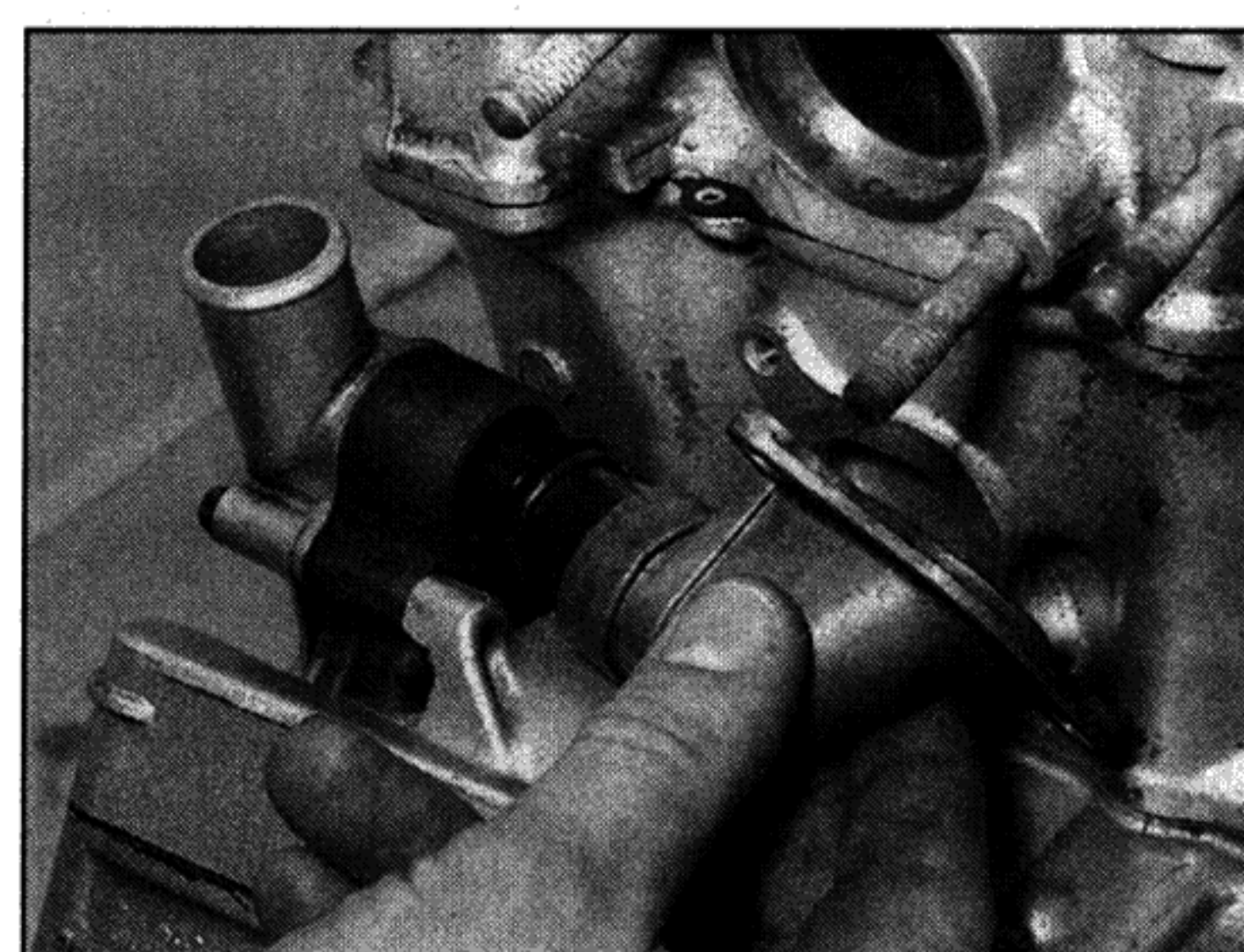
13.17 Carefully lower the block onto the pistons



13.20a Fit a new O-ring onto the union . . .



13.20b . . . and the joint pipe . . .



13.20c . . . then install the union

Lay the new base gasket in place on the crankcase, making sure all the holes are correctly aligned (**see illustration**). Never re-use the old gasket.

16 If required, install piston ring clamps onto the pistons to ease their entry into the bores as the block is lowered. This is not essential as each cylinder has a good lead-in enabling the piston rings to be hand-fed into the bore. If possible, have an assistant to support the block while this is done.

17 Lubricate the cylinder bores, pistons and piston rings, and the connecting rod big- and small-ends, with clean engine oil, then install the block down over the studs until the piston crowns fit into the bores (**see illustration**). At this stage feed the cam chain up through the block and secure it in place with a piece of wire to prevent it from falling back down.

18 Gently push down on the cylinder block, making sure the pistons enter the bore squarely and do not get cocked sideways. If piston ring clamps are not being used, carefully compress and feed each ring into the bore as the block is lowered. If necessary, use a soft mallet to gently tap the block down, but do not use force if the block appears to be stuck as the pistons and/or rings will be

damaged. If clamps are used, remove them once the pistons are in the bore.

19 When the pistons are correctly installed in the cylinders, press the block down onto the base gasket, making sure it locates correctly onto the dowels.

20 Fit a new O-ring into the groove in the coolant union face and around the pipe joint (**see illustrations**). Fit the coolant hose union onto the front of the block and the joint pipe, or fit the joint pipe into the water pump housing if it came away with the union (**see illustration**). Tighten the bolts to the torque setting specified at the beginning of the Chapter.

21 Install the cylinder head (see Section 10).

14 Pistons – removal, inspection and installation

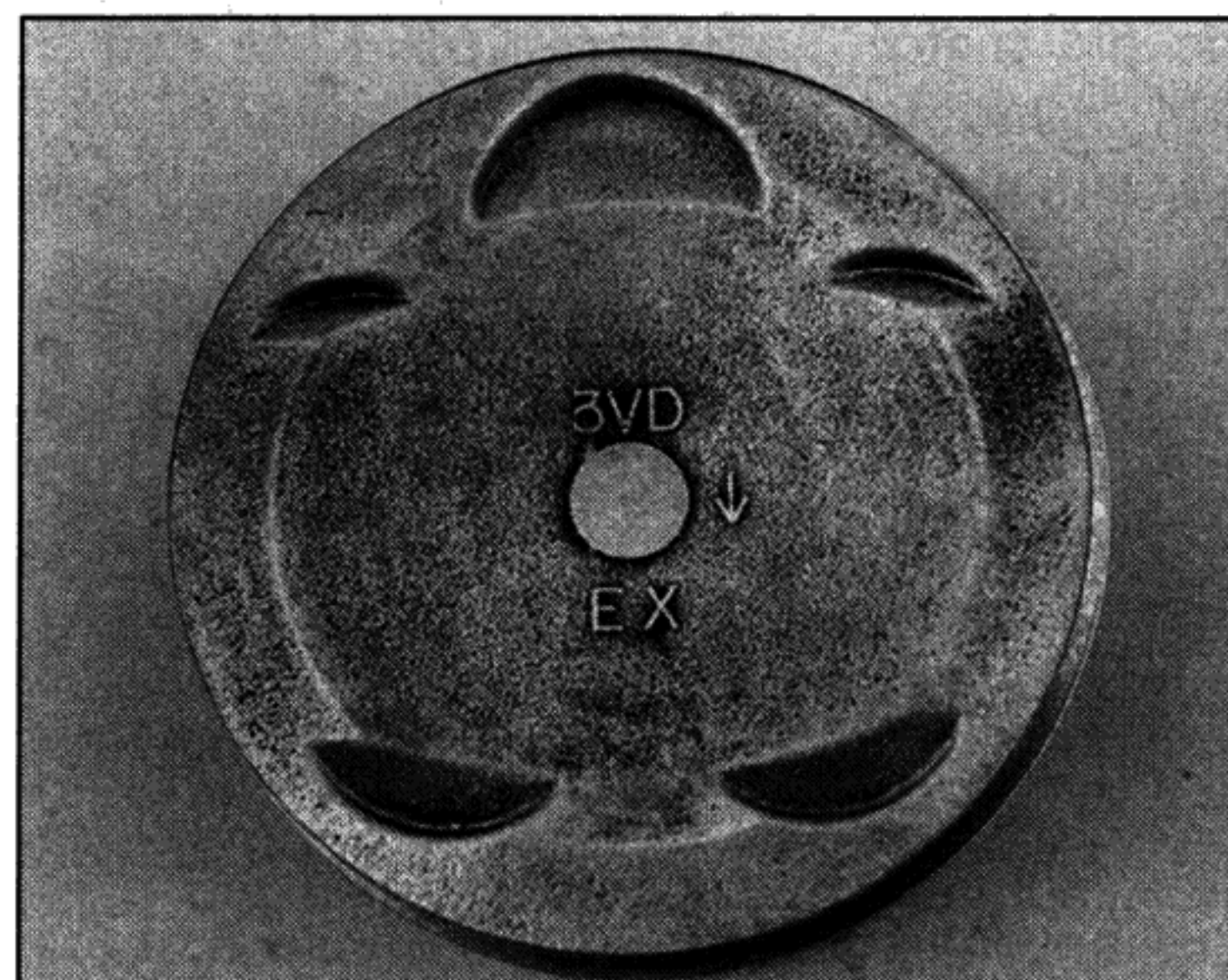
Note: The pistons can be removed with the engine in the frame.

Removal

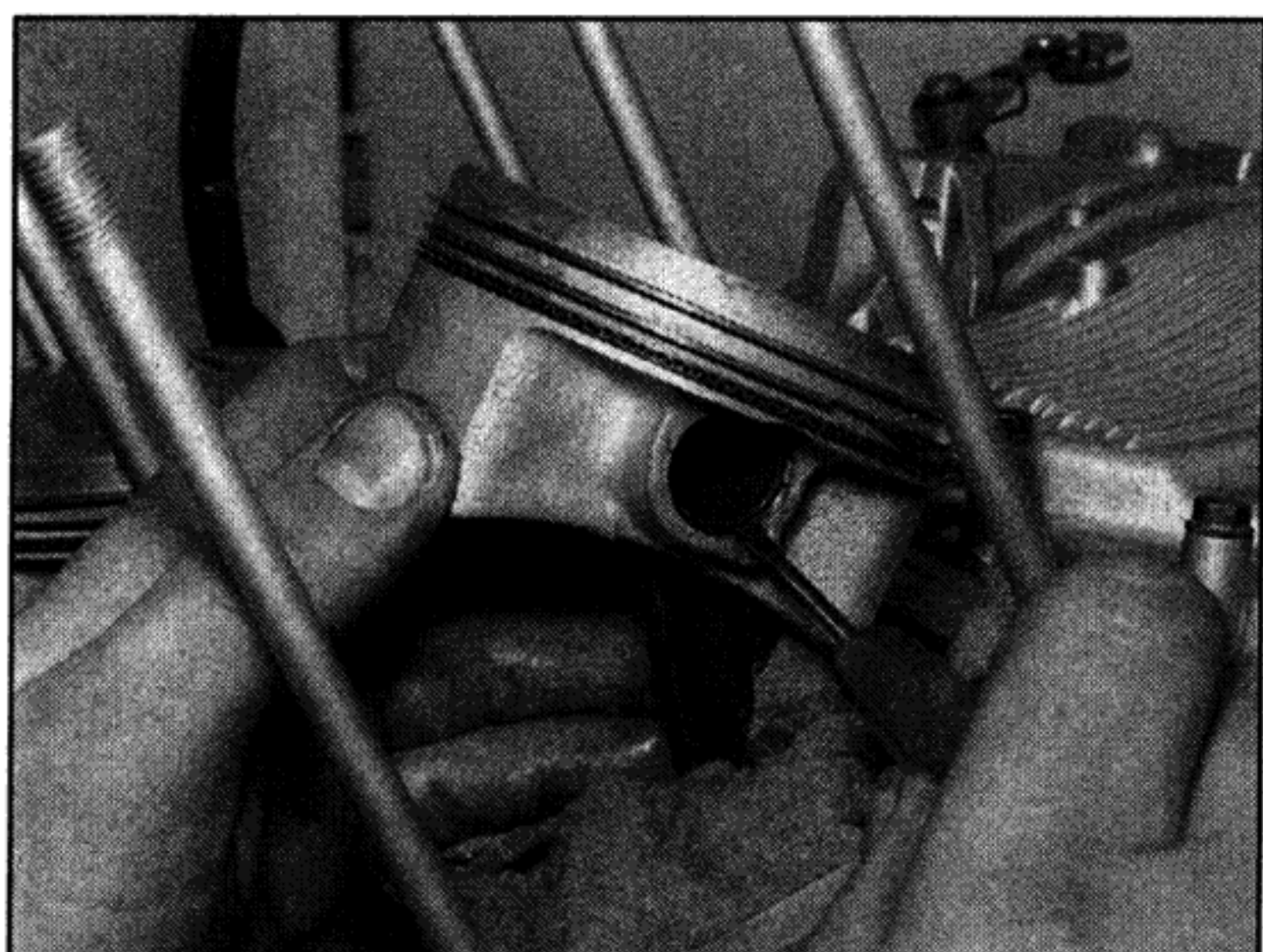
- 1** Remove the cylinder block (see Section 13).
- 2** Before removing the piston from the connecting rod, use a sharp scribe or felt

marker pen to write the cylinder identity on the crown of each piston (or on the inside of the skirt if the piston is dirty and going to be cleaned) as it must be installed in its original cylinder. Each piston should also have an arrow mark on its crown which should face the exhaust side of the bore (**see illustration**). If this is not visible, mark the piston accordingly so that it can be installed the correct way round.

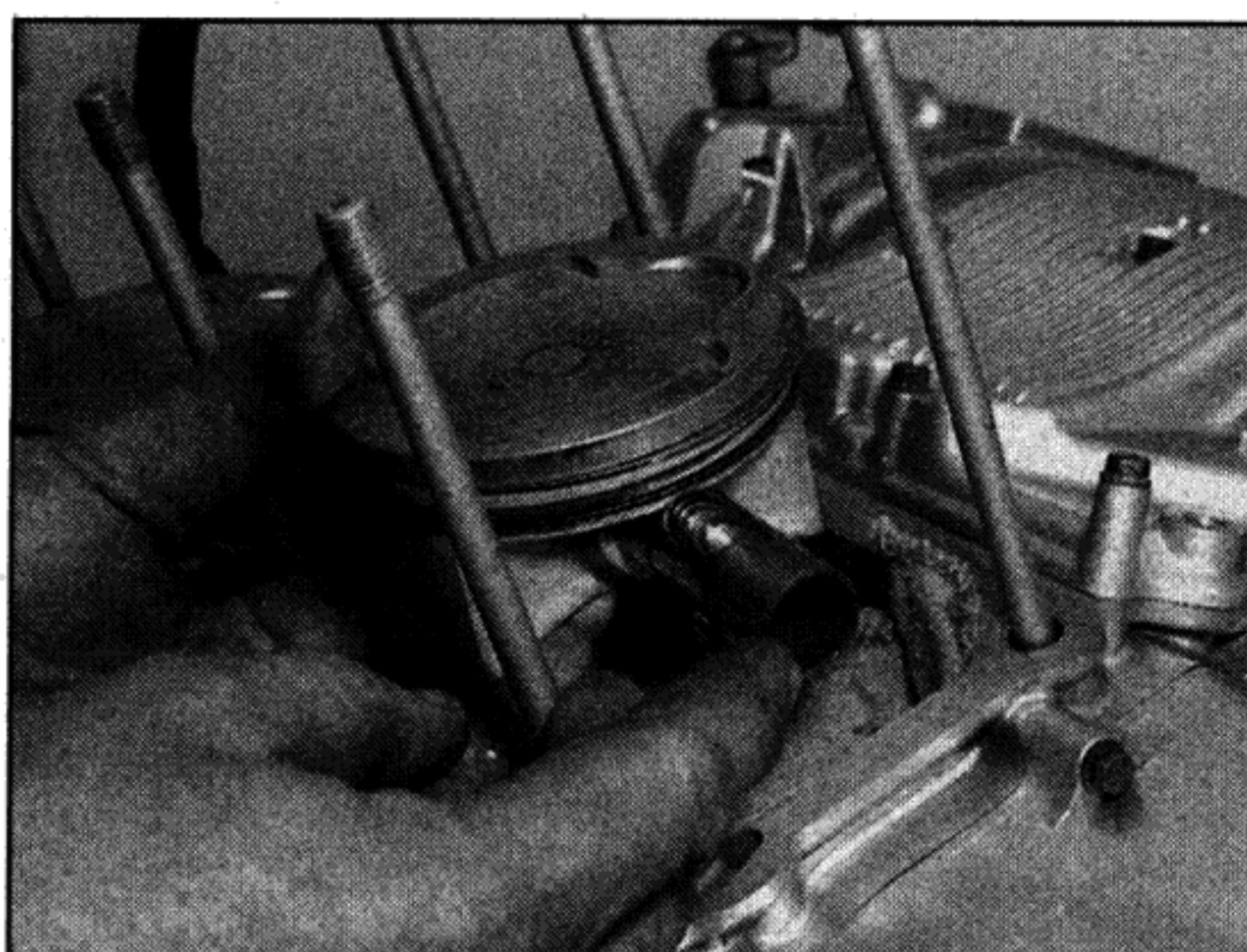
3 Carefully prise out the circlip on one side of the piston using needle-nose pliers or a small



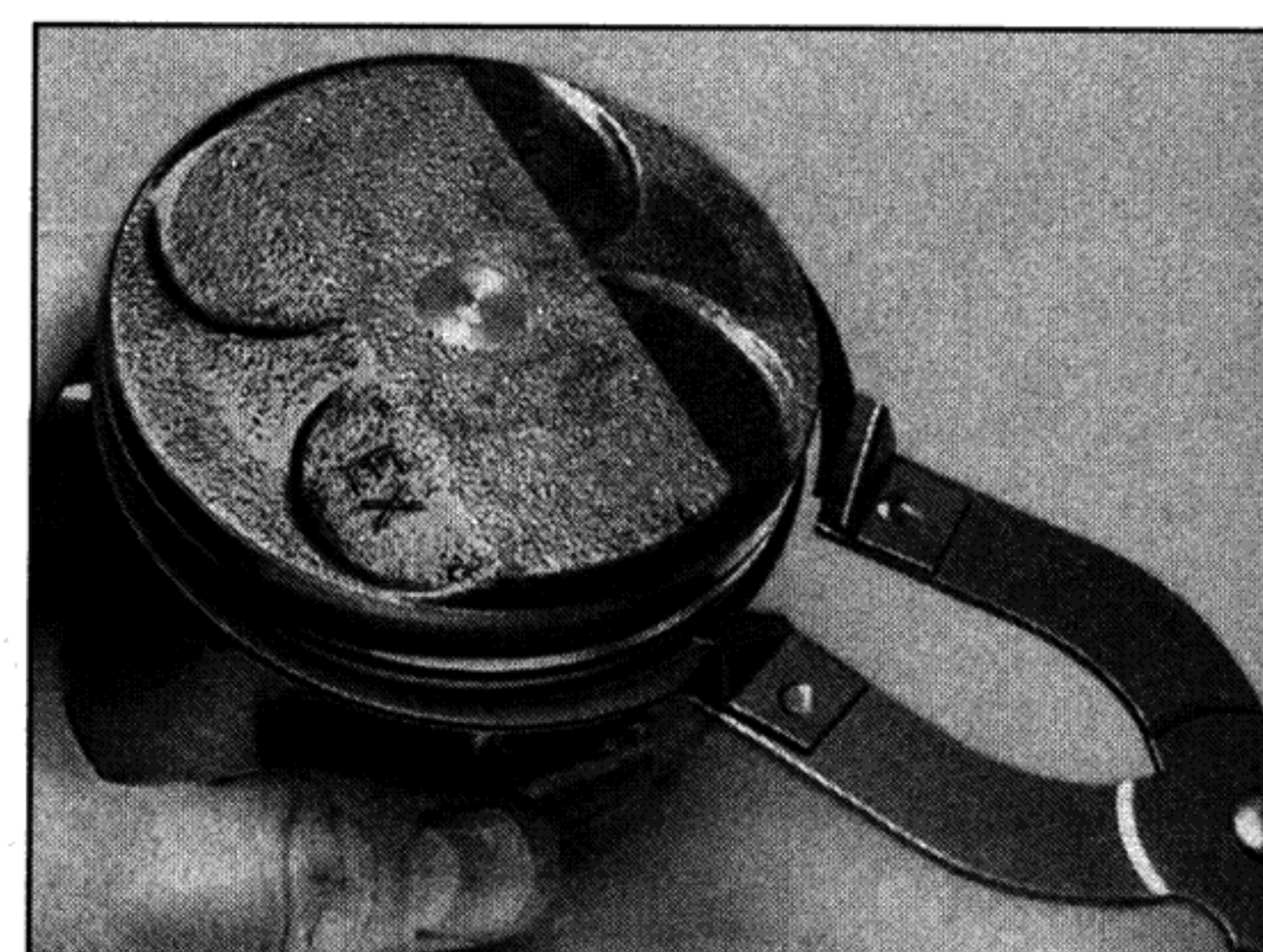
14.2 Note the arrow mark on the piston which must point forwards



14.3a Prise out the circlip . . .



14.3b . . . then push out the pin and remove the piston



14.5 Removing the piston rings using a ring removal and installation tool

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). If required, remove the other circlip. Discard the removed circlip(s) 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.



To prevent the circlip from pinging away, pass a rod or screwdriver, whose diameter is greater than the gap between the circlip ends, through the piston pin. This will trap the circlip if it springs out.



If a piston pin is a tight fit in the piston bosses, 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 Before the inspection process can be carried out, the pistons must be cleaned and the old piston rings removed. Note that if the cylinders are being rebored, piston inspection can be overlooked as new ones will be fitted.

5 Using your thumbs or a piston ring removal and installation tool, carefully remove the rings from the pistons (see illustration). 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 has a manufacturer's mark or letter at one end.

6 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.

7 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.

8 Once the deposits have been removed, clean the pistons with solvent and dry them thoroughly. If the identification previously marked 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 are clear.

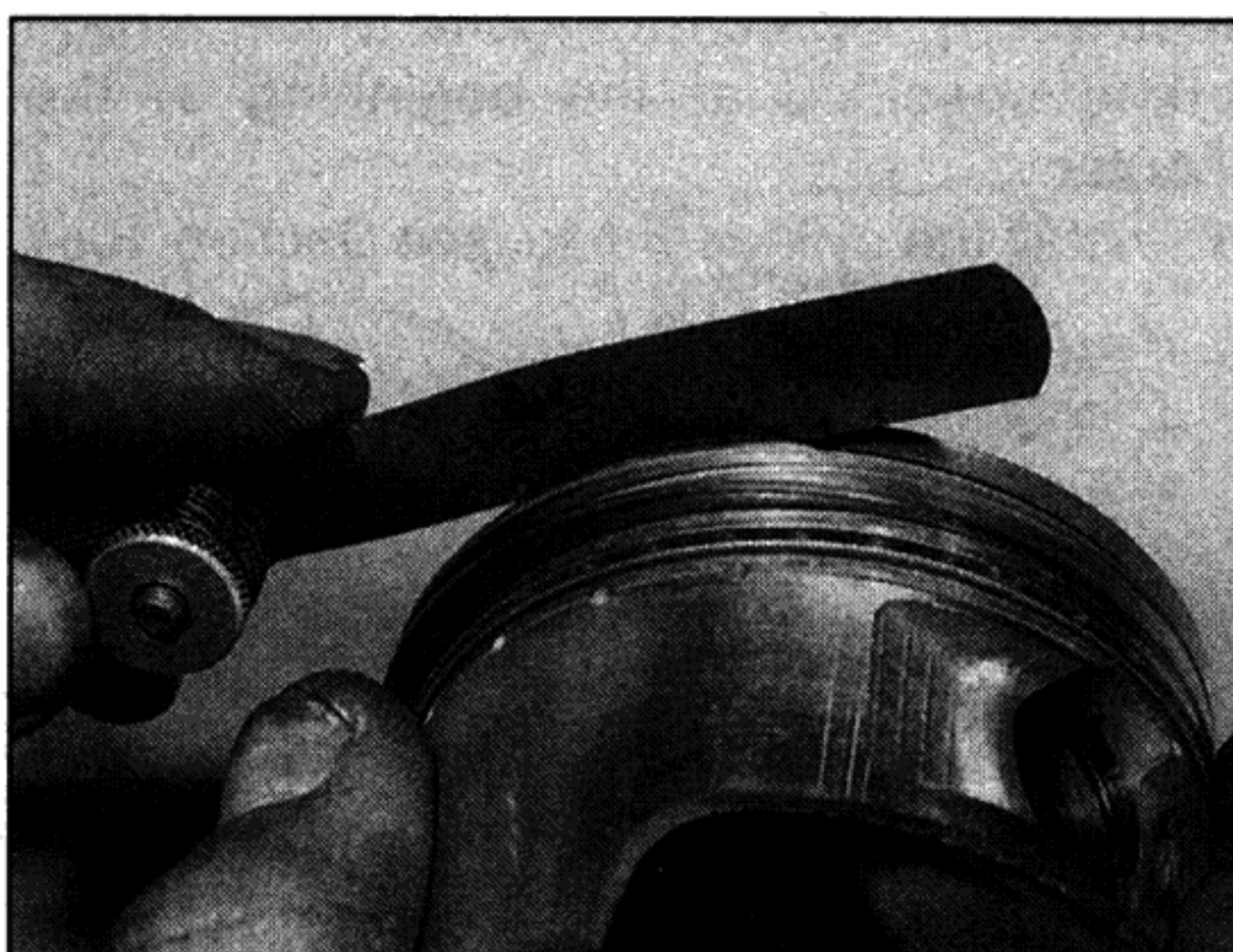
9 Carefully inspect each piston for cracks around the skirt, at the pin bosses and at the ring lands. Normal piston wear appears as even, vertical wear on the thrust surfaces of the piston and slight looseness of the top ring in its groove. If the skirt is scored or scuffed, the engine may have been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

10 A hole in the piston crown, an extreme to

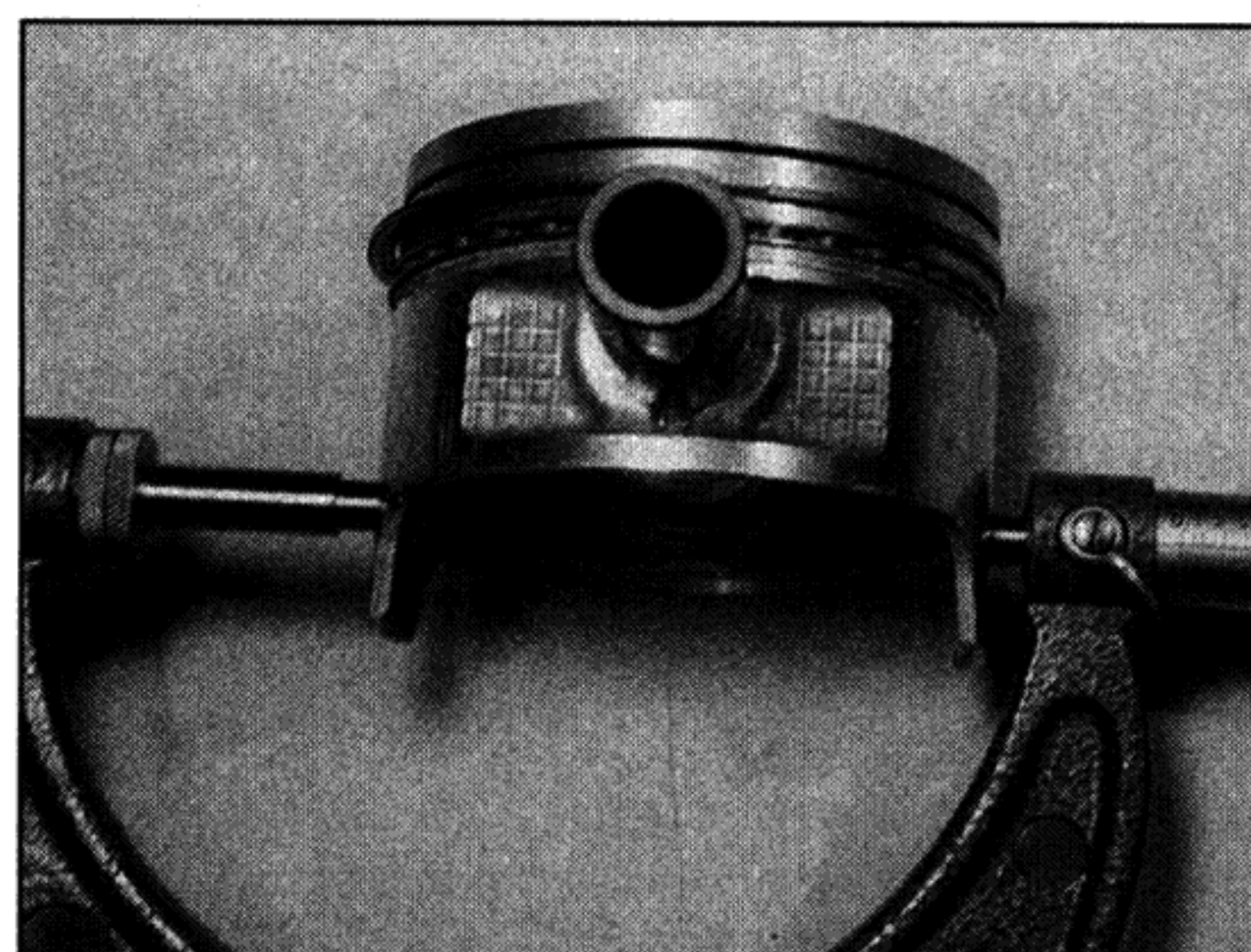
be sure, is an indication that abnormal combustion (pre-ignition) was occurring. Burned areas at the edge of the piston crown are usually evidence of spark knock (detonation). If any of the above problems exist, the causes must be corrected or the damage will occur again.

11 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 5). Check the clearance at three or four locations around the groove. If the clearance is greater than specified, renew both the piston and rings as a set. If new rings are being used, measure the clearance using the new rings. If the clearance is greater than that specified, the piston is worn and must be renewed.

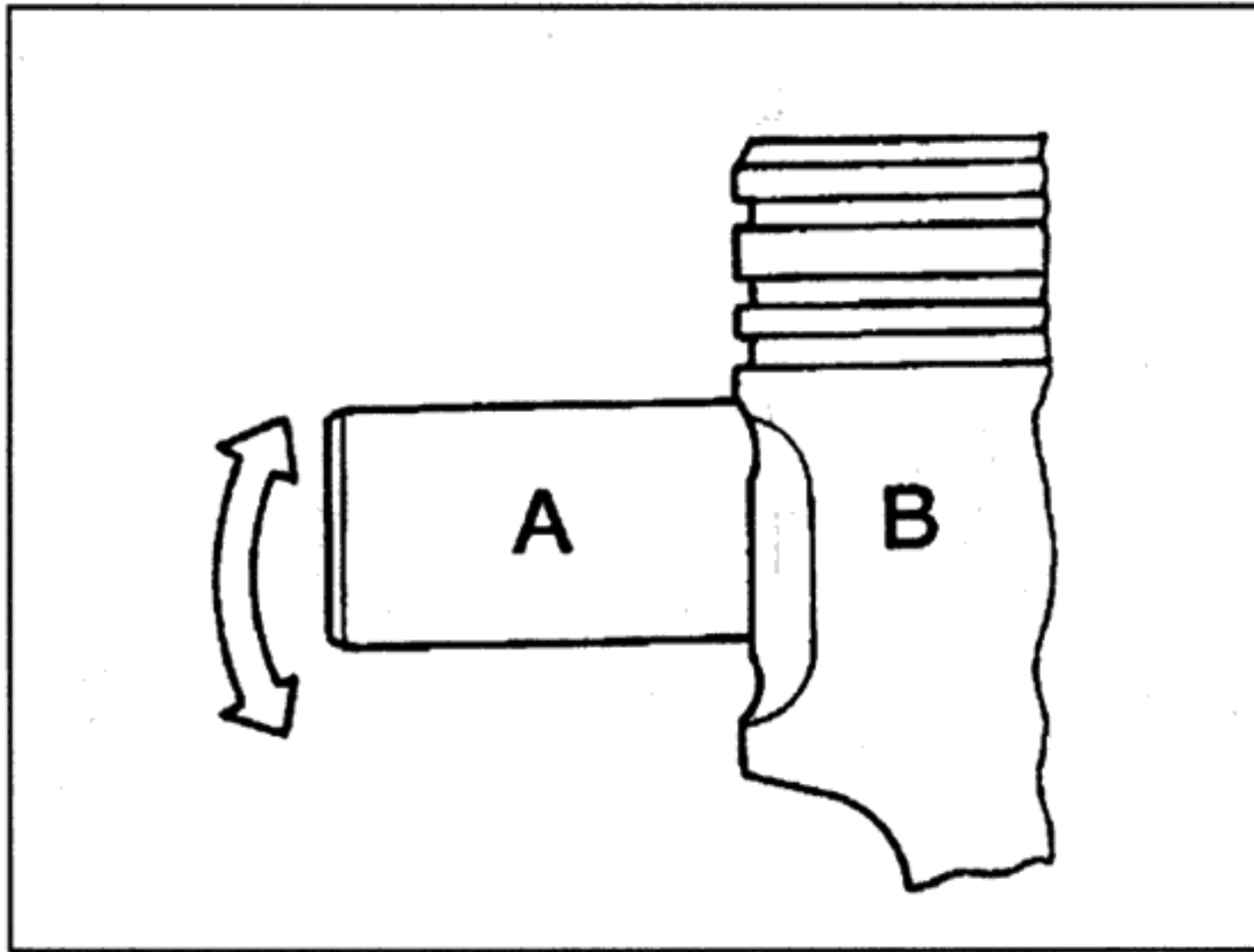
12 Check the piston-to-bore clearance by measuring the bore (see Section 13) and the piston diameter. Make sure each piston is matched to its correct cylinder. Measure the piston 4.5 mm (1991 to 1995 TDM models), 4.7 mm (XTZ models), or 5.5 mm (1996-on TDM and all TRX models) up from the bottom of the 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 renewed (assuming the bore itself is within limits, otherwise a rebore is necessary).



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



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



14.13a Slip the pin (A) into the piston (B) and try to rock it back and forth. If it's loose, renew the piston and pin



14.13b Measuring the internal diameter of the bore in the piston



14.16a Align the piston with the connecting rod small-end and insert the pin

13 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 28.6b**), and the pin bore in the piston (**see illustration**). 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, renew the components that are worn beyond their specified limits.

Installation

14 Inspect and install the piston rings (see Section 15).

15 Lubricate the piston pin, the piston pin bore and the connecting rod small-end bore with clean engine oil.

16 When installing the pistons onto the connecting rods, make sure that the arrow points towards the exhaust side of the engine (**see illustration 14.2**). If both circlips were removed, install a new circlip in one side of the piston (do not re-use old circlips). 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. When installing the circlips, compress them only just enough to fit them in the piston, and make sure they are properly seated in their grooves with the open end

away from the removal notch (**see illustration**).

17 Install the cylinder block (see Section 13).

15 Piston rings – inspection and installation

1 It is good practice to renew the piston rings when an engine is being overhauled. Before installing the new piston rings, the ring end gaps must be checked with the rings installed in the cylinder.

2 Lay out each piston with its new ring sets so the rings will be matched with the same piston and cylinder during the end gap measurement procedure and engine assembly.

3 To measure the installed ring end gap, insert the top ring into the top of the first cylinder and square it up with the cylinder walls by pushing it in with the top of the piston. The ring should be about 20 mm below the top edge of the cylinder. To measure the end gap, 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 rings before proceeding.

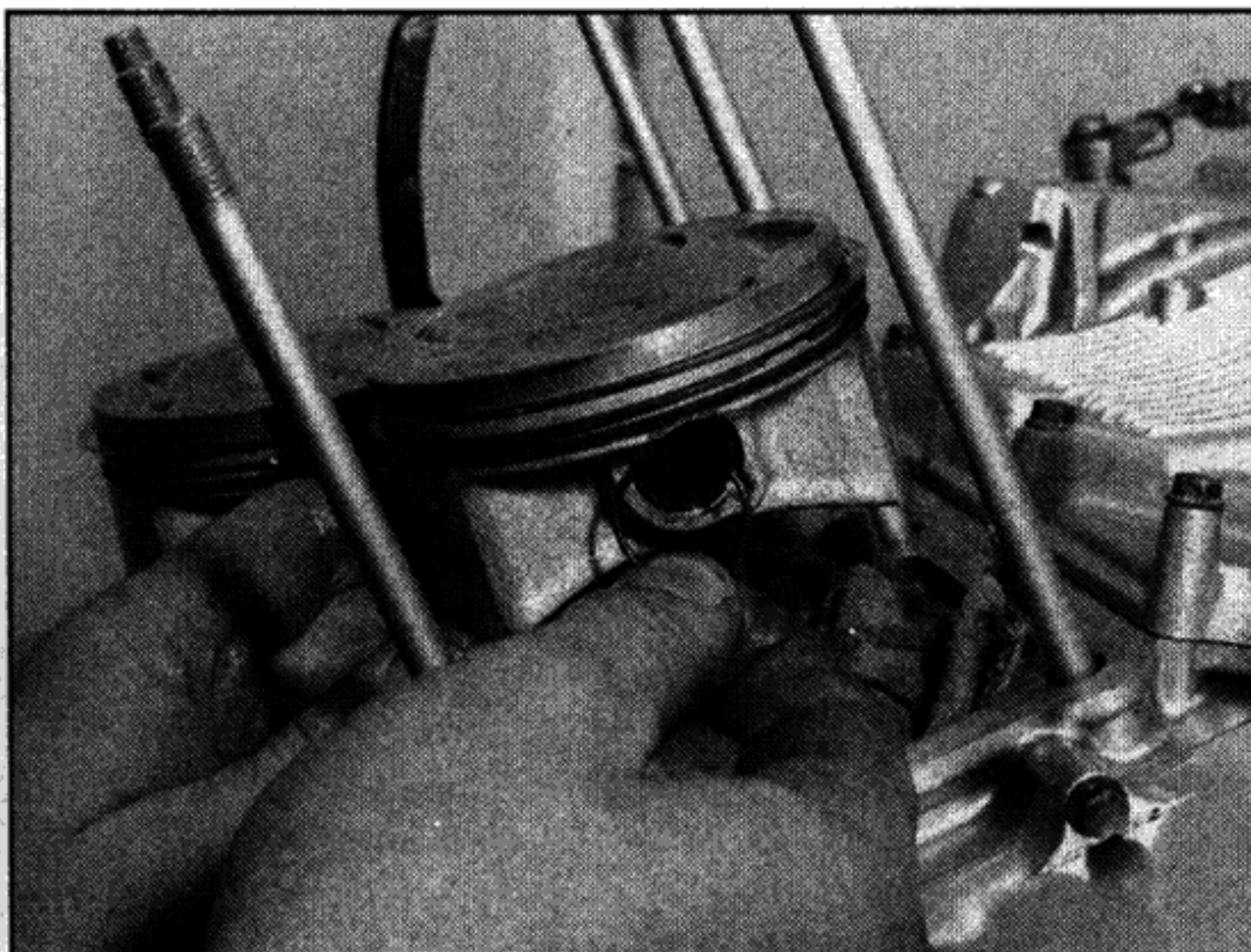
5 If the gap is too small, it must be enlarged or the ring ends may come in contact with each other during engine operation, which can cause serious damage. The end gap can be increased by filing the ring ends very carefully with a fine file. When performing this operation, file only from the outside in (**see illustration**).

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

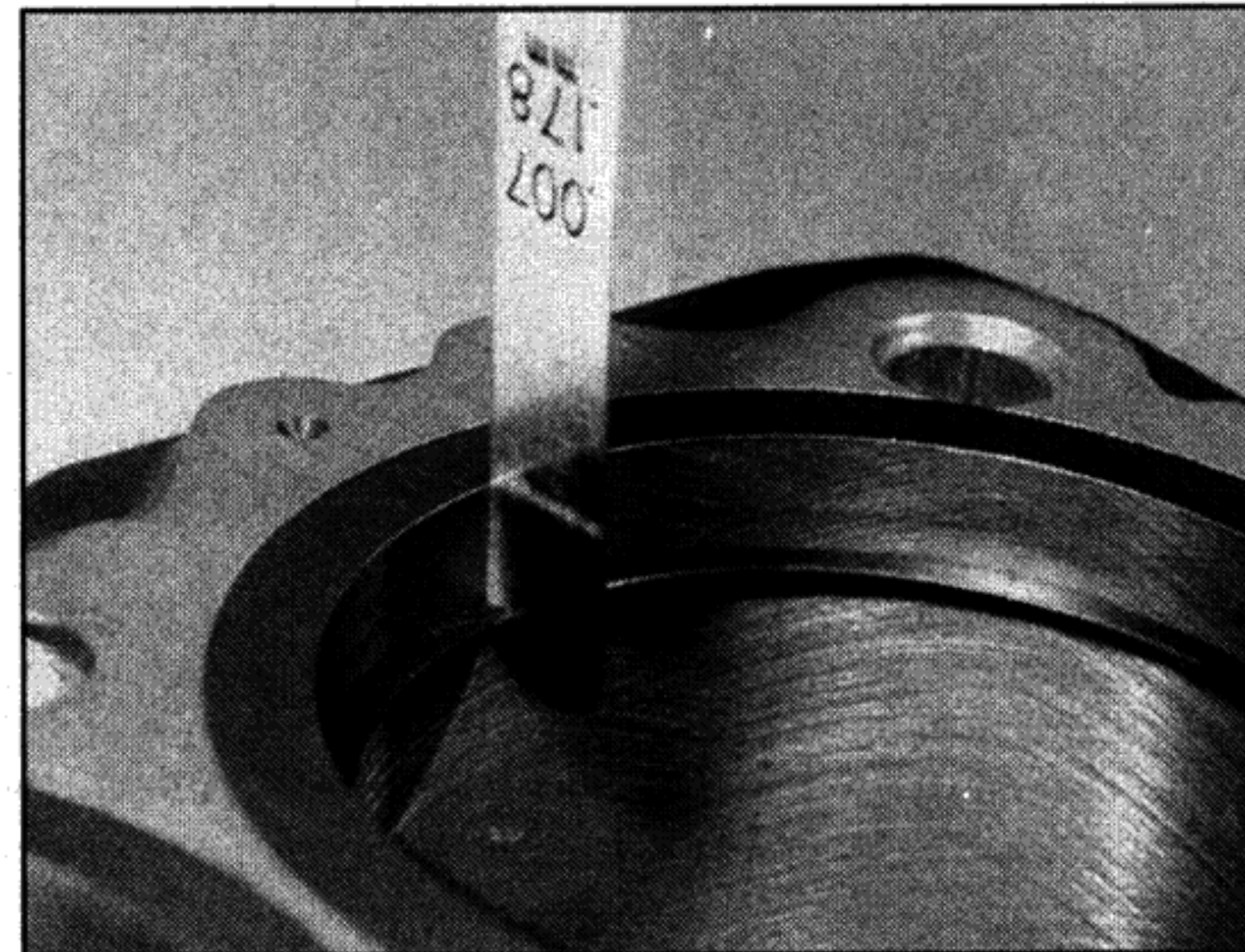
7 Repeat the procedure for each ring that will be installed in the cylinders. When checking the oil ring, only the side-rails can be checked as the ends of the expander ring should contact each other. Remember to keep the rings, pistons and cylinders matched up.

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

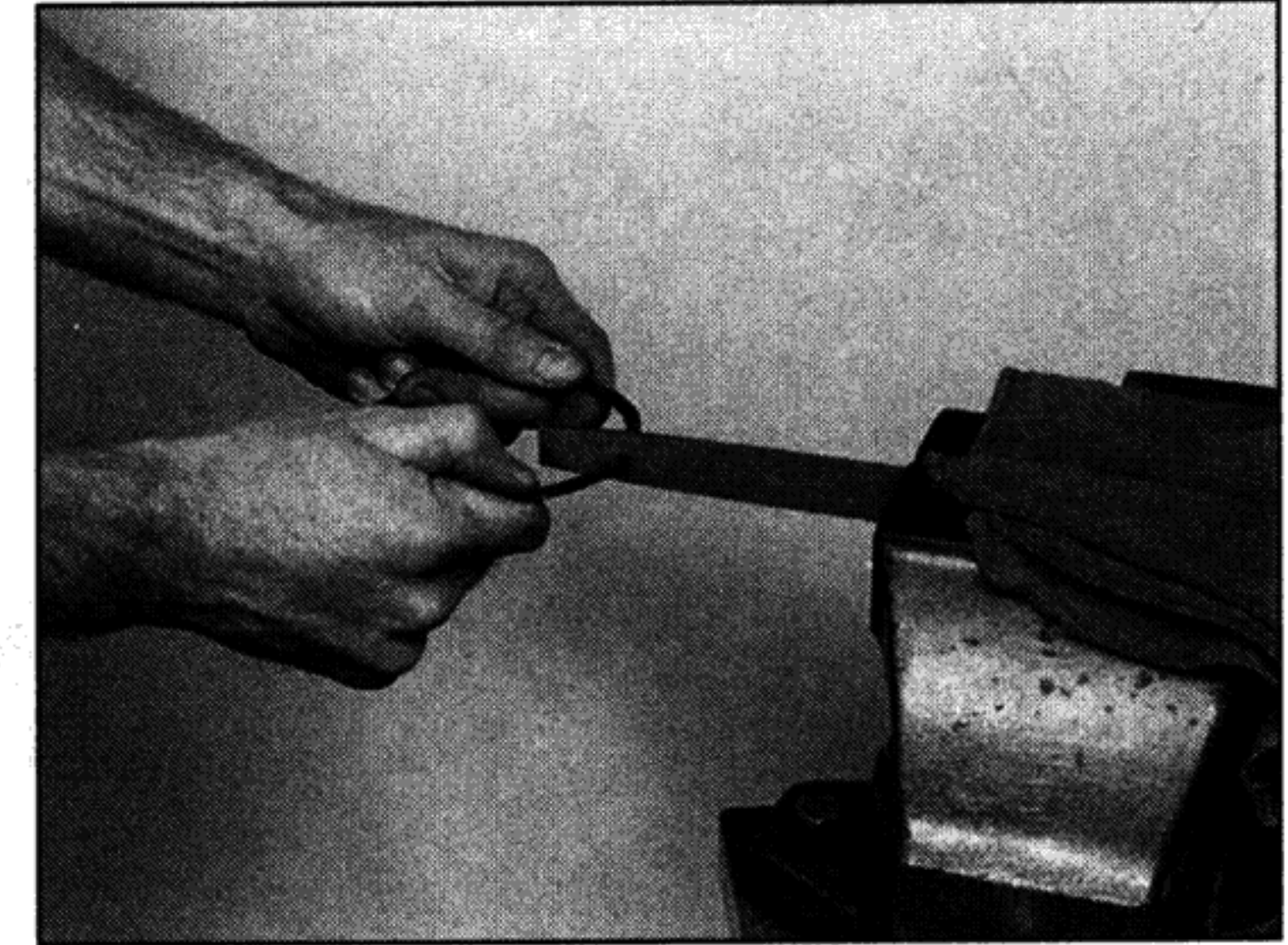
9 The oil control ring (lowest on the piston) is installed first. It is composed of three separate components, namely the expander and the upper and lower side rails. Slip the expander into the groove, then install the upper side rail. Do not use a piston ring installation tool on the oil ring side rails 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



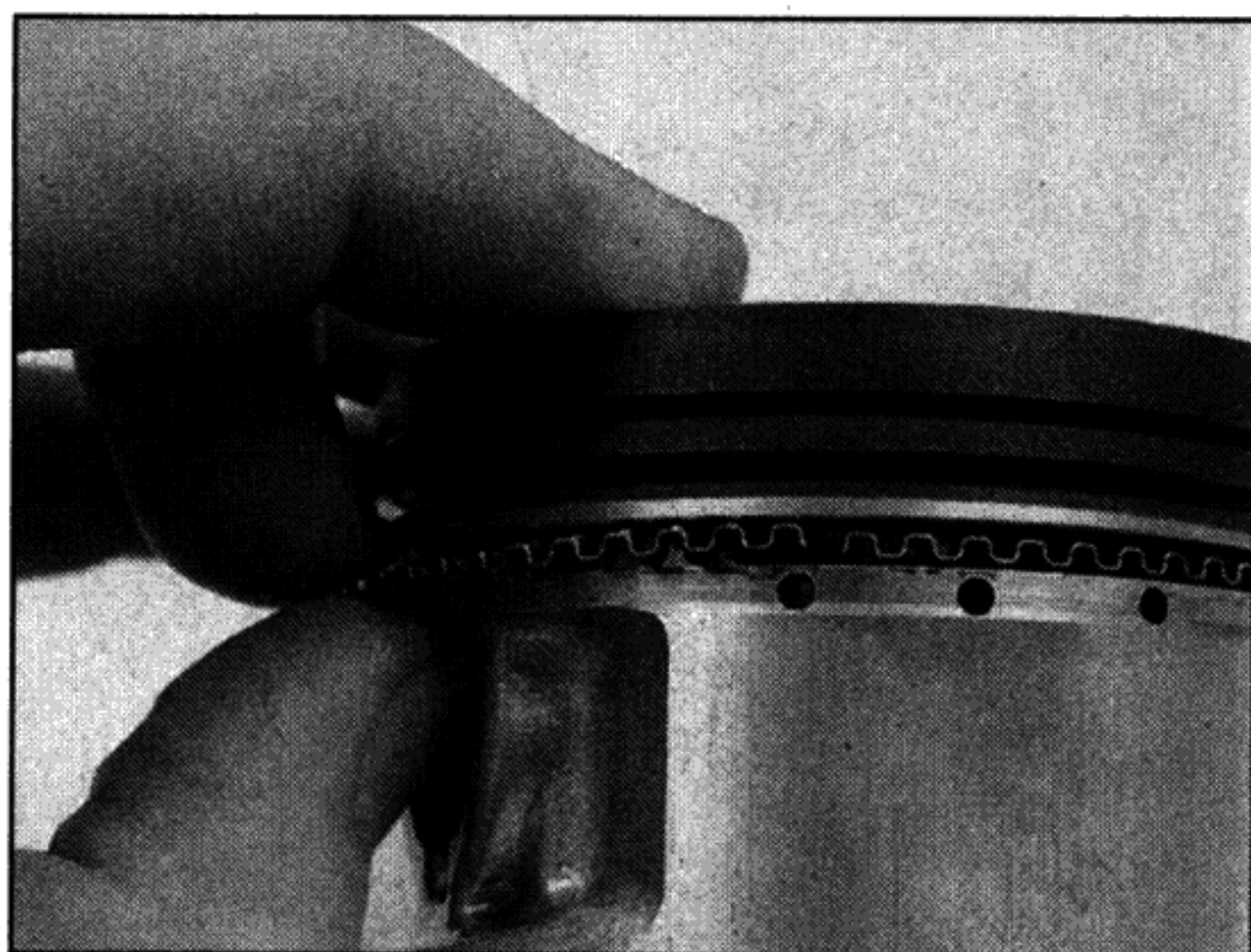
14.16b Do not over-compress the circlip when fitting it into the piston



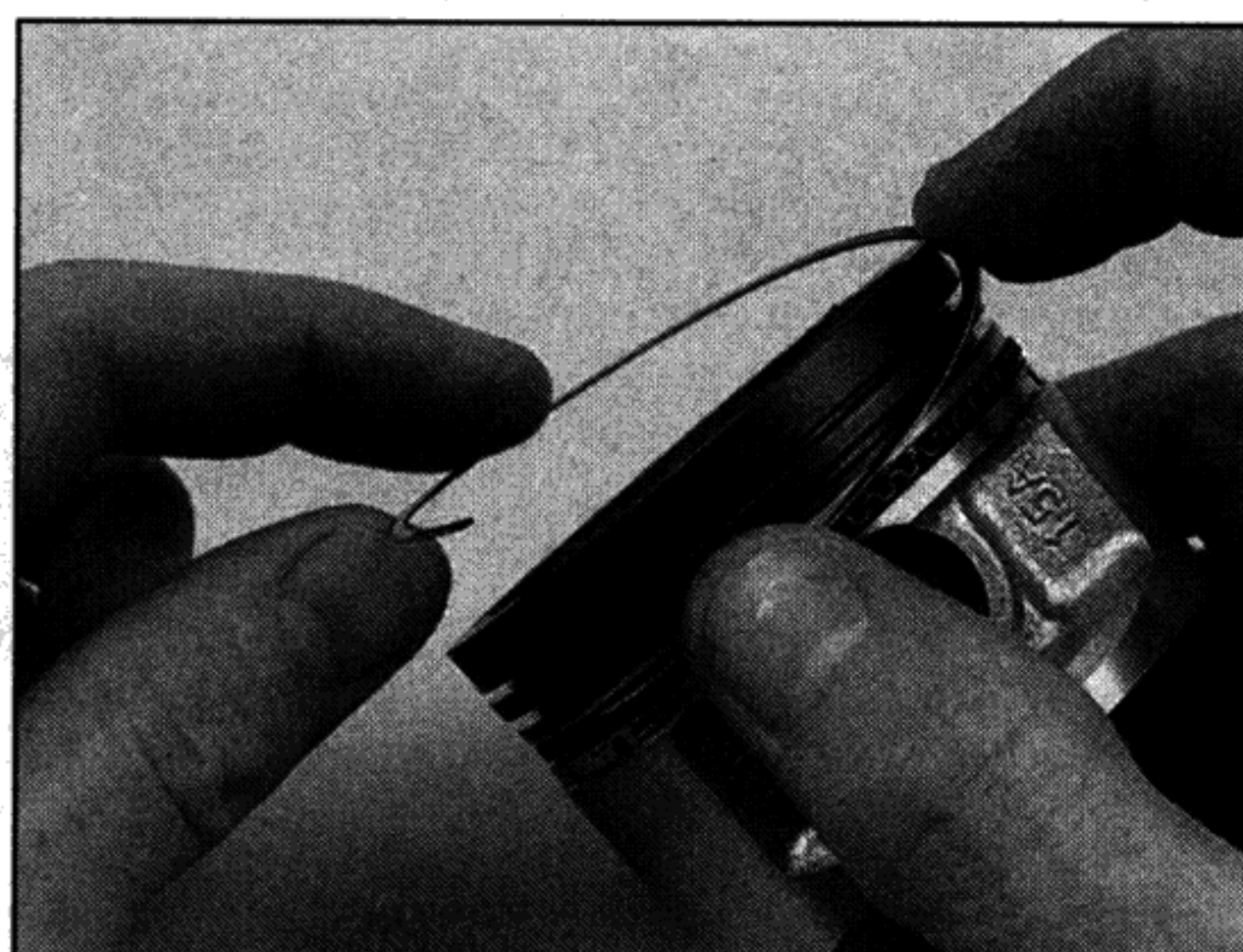
15.3 Measuring piston ring installed end gap



15.5 Ring end gap can be enlarged by clamping a file in a vice and filing the ring ends



15.9a Install the oil ring expander in its groove . . .



15.9b . . . and fit the side rails each side of it. The oil ring must be installed by hand

around the piston while pushing the rail into the groove. Next, install the lower side rail in the same manner (**see illustrations**). Make sure the ends of the expander do not overlap.

10 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.

11 The upper surface of each compression ring is marked with a mark or letter at one end (**see illustration**). Make sure that the identification mark or letter near the end gap is facing up when installed.

12 Fit the second ring into the middle groove in the piston. Make sure the identification letter near the end gap is facing up. Do not expand the ring any more than is necessary to slide it into place. To avoid breaking the ring, use a piston ring installation tool.

13 Finally, install the top ring in the same manner into the top groove in the piston. Make sure the identification letter near the end gap is facing up.

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

16 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

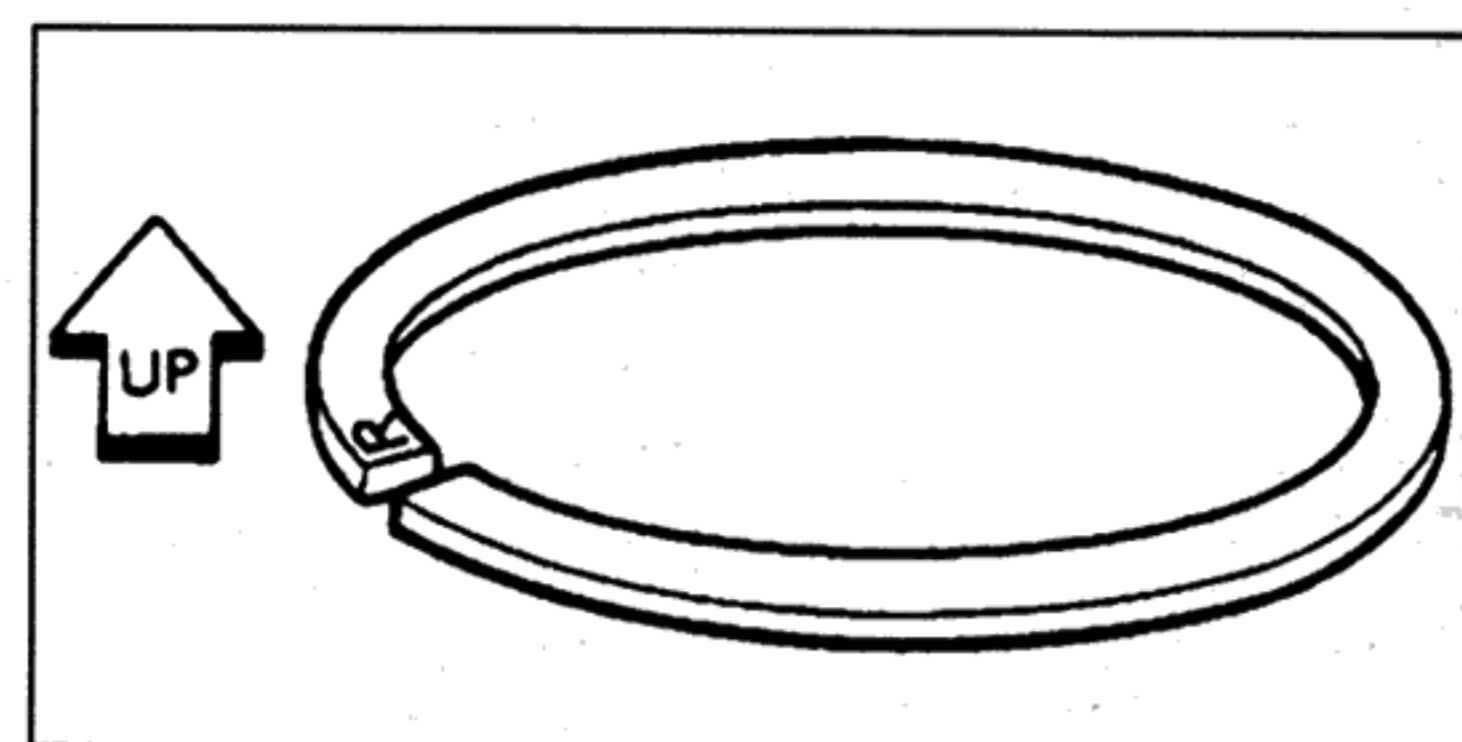
1 Drain the engine oil (see Chapter 1).

2 Detach the clutch cable from the operating lever on the clutch cover (see Section 17).

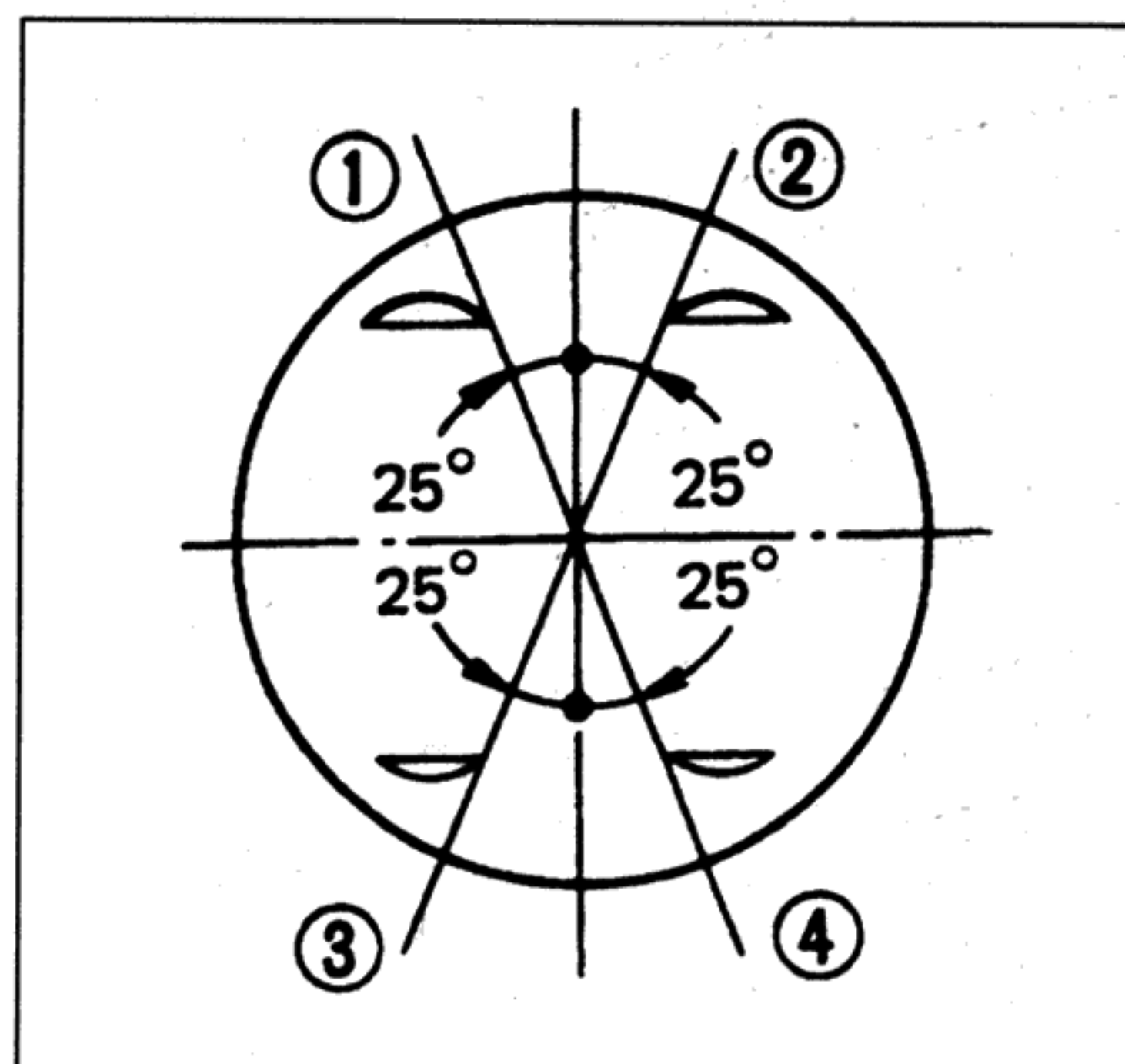
3 Working evenly in a criss-cross pattern, unscrew the clutch cover bolts (**see illustration**). Lift the cover away from the engine, being prepared to catch any residual oil which may be released as the cover is removed.

4 Remove the gasket and discard it. Note the positions of the two locating dowels fitted to the crankcase and remove them for safe-keeping if they are loose.

5 Working in a criss-cross pattern, gradually slacken the clutch pressure plate bolts



15.11 Compression ring top surface is marked by a letter

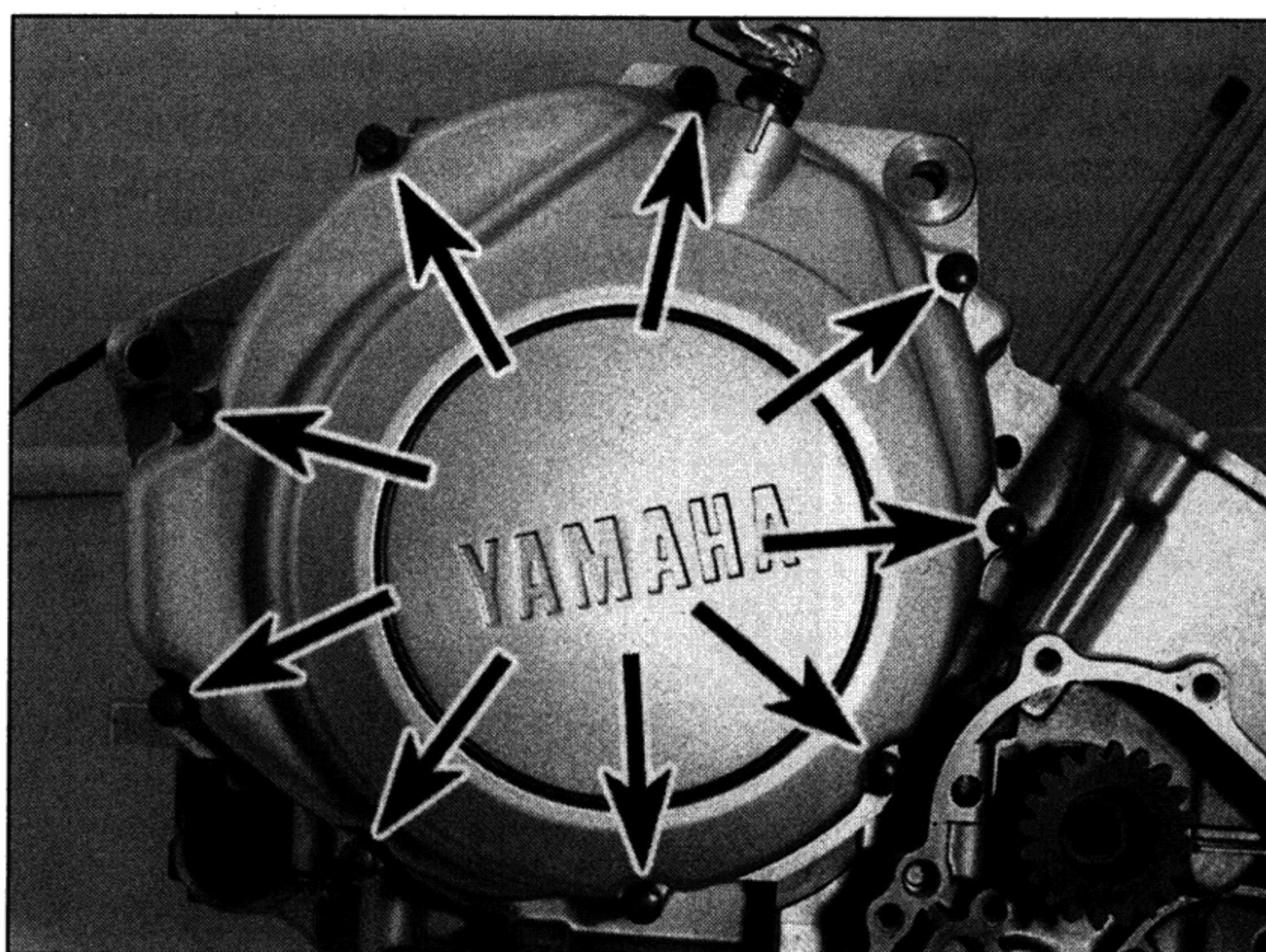


15.14 Stagger the ring end gaps as shown

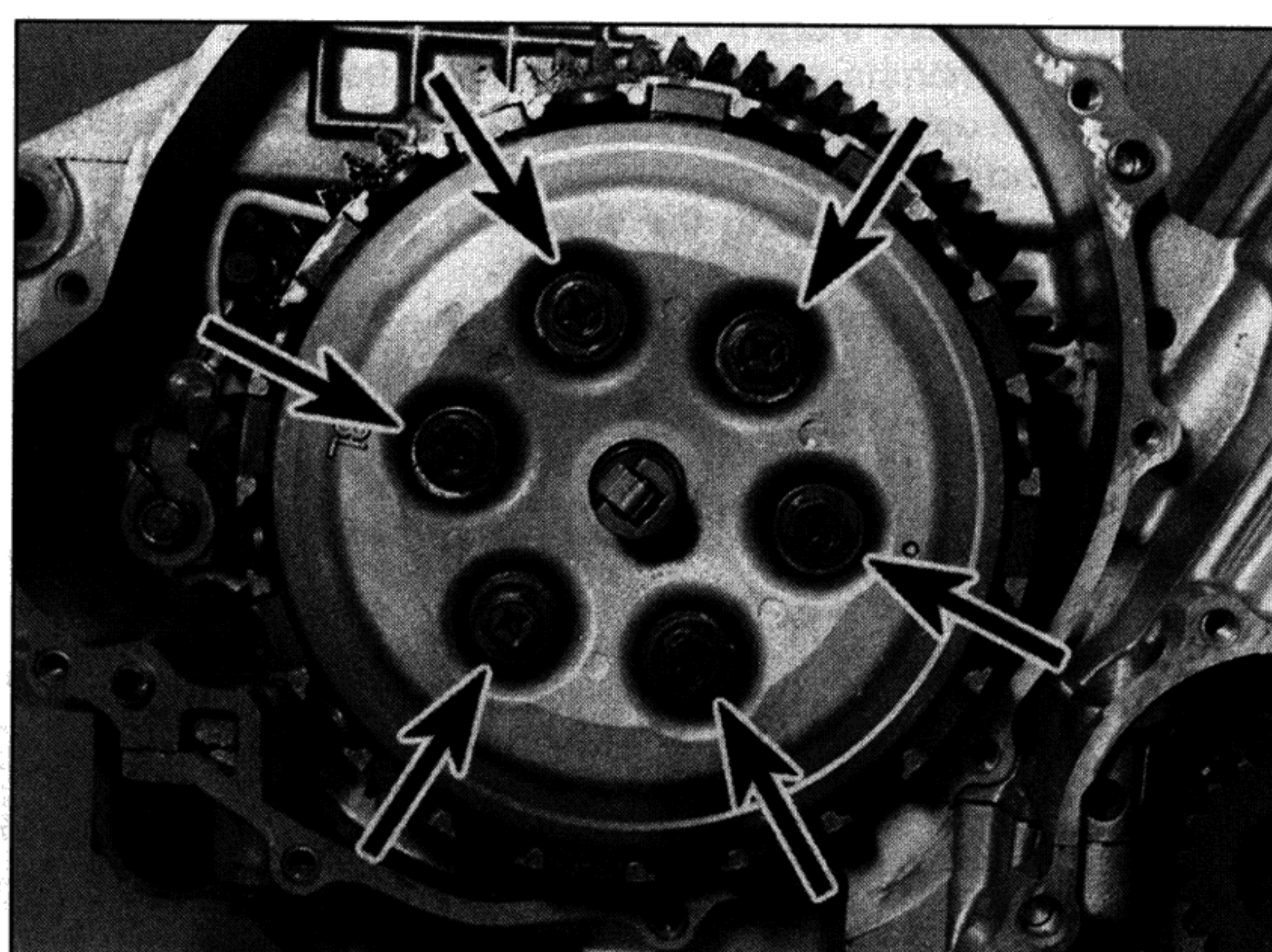
- 1 Top ring
- 2 Oil ring lower rail
- 3 Oil ring upper rail
- 4 Second (middle) ring

until spring pressure is released (**see illustration**). Counter-hold the clutch housing to prevent it turning. Remove the bolts and springs, then lift out the clutch pressure plate complete with its pull rod, thrust bearing and plate washer (**see illustrations 16.30b and a**).

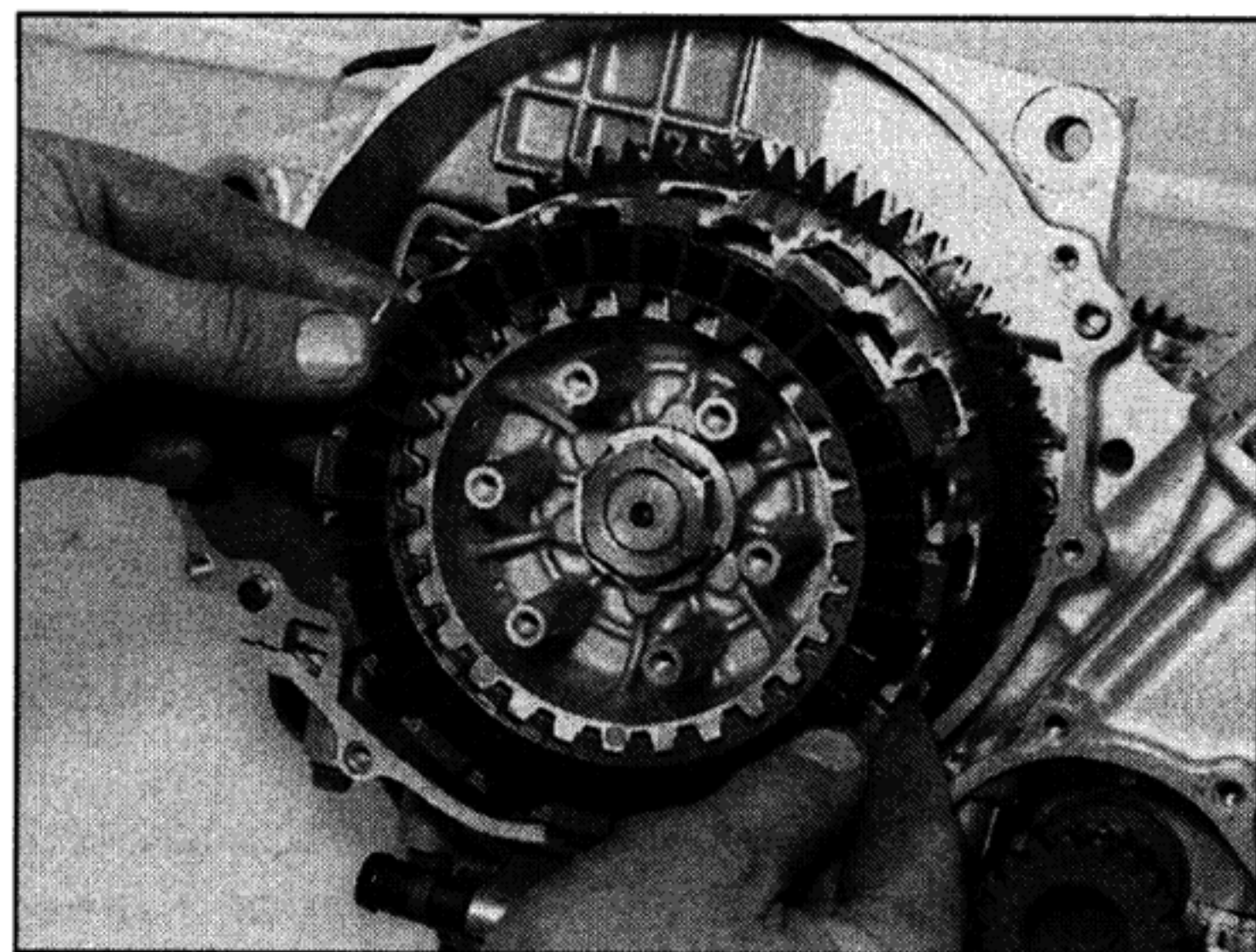
6 Grasp the complete set of clutch plates and



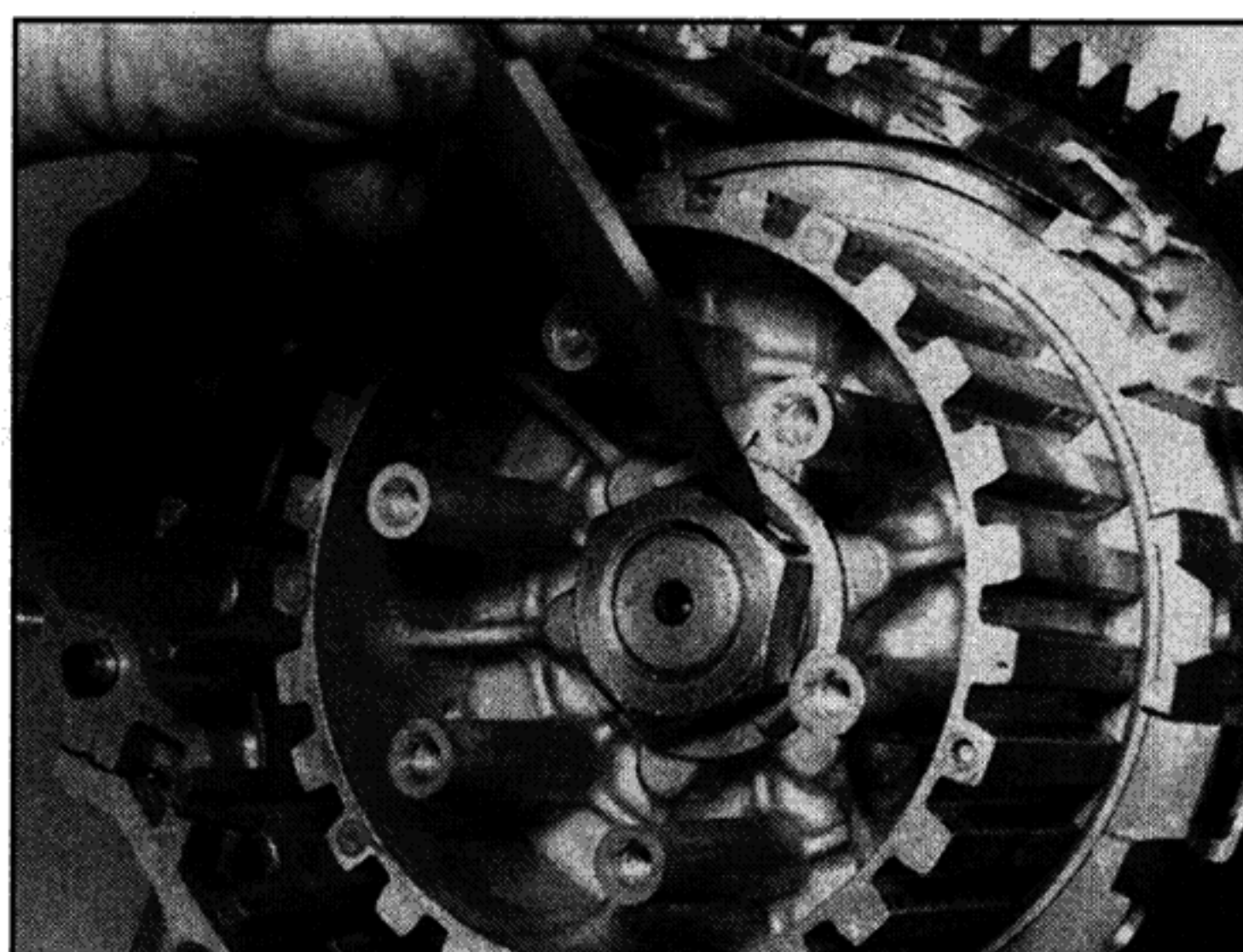
16.3 Unscrew the clutch cover bolts (arrowed) and remove the cover



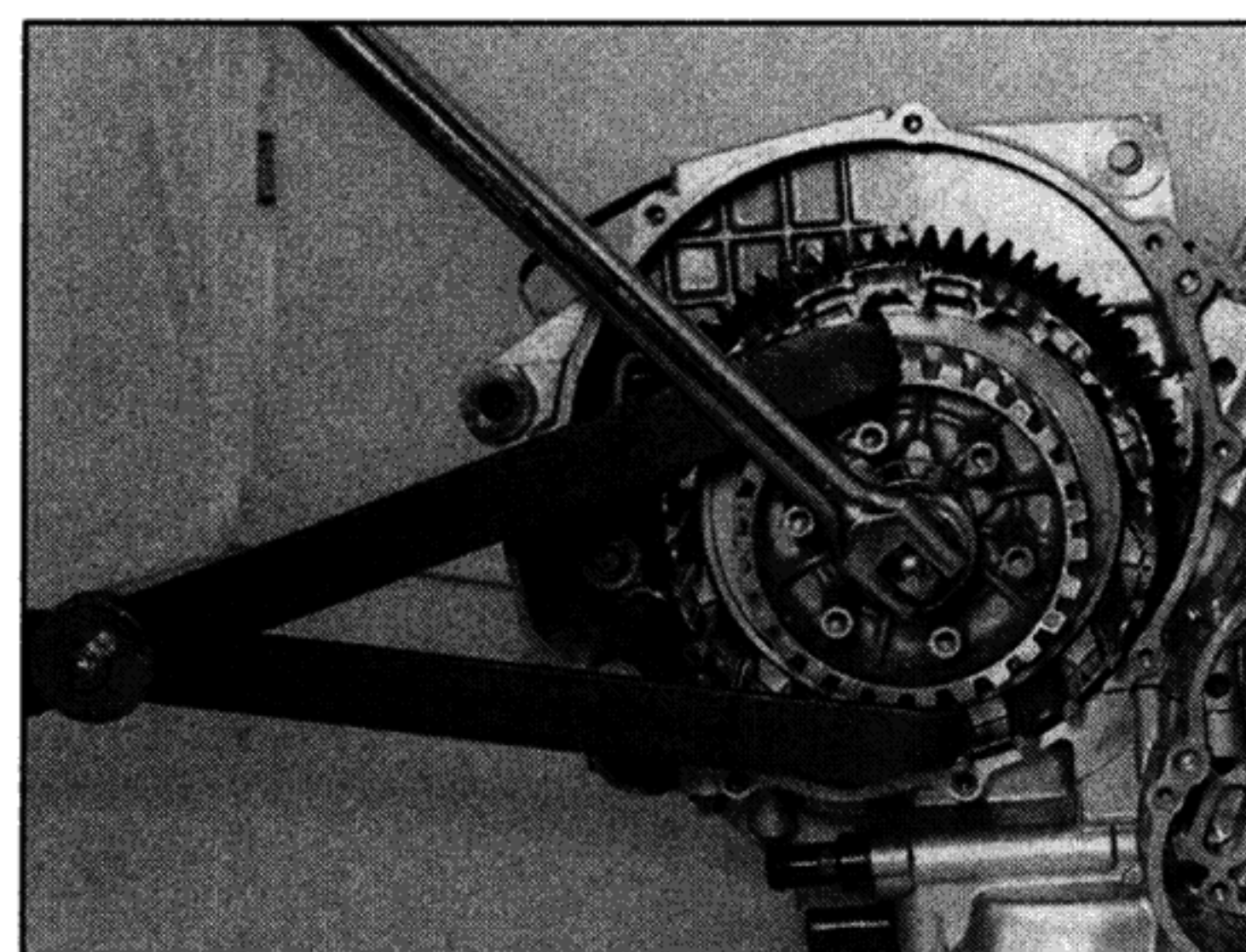
16.5 Clutch pressure plate bolts (arrowed)



16.6 Remove the clutch plates as a pack



16.7a Bend back the lockwasher tabs



16.7b Slackening the clutch nut using the holding tool described

remove them as a pack (**see illustration**). Unless the plates are being renewed, keep them in their original order. On 1991 to 1995 TDM models and 1990-on XTZ models, note the inner plate fitted in the clutch centre – if you remove it, keep it separate as it must be installed first (**see illustration 16.27**).

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 1st 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 home-made tool made from two strips of steel bent at the ends and bolted together in the middle (**see Tool tip**), can be used to hold the clutch centre whilst the nut is slackened (**see illustration**). Unscrew the nut and remove the

lockwasher from the mainshaft, noting how it fits. Discard the lockwasher as a new one must be used on installation.

8 Remove the clutch centre and the outer thrust plate from the shaft (**see illustrations 16.26a and 16.25**).

9 Support the clutch housing and remove the large sleeve from its centre (**see illustration**). To get a grip on the sleeve, grasp the housing and wiggle it out and in – it should draw the sleeve out far enough to grip it. If difficulty is experienced, screw a 6 mm bolt (a clutch cover bolt is the correct size) into one or both of the threaded holes and pull the sleeve from the housing.

10 Remove the caged needle roller bearing from the housing if it didn't come away with the sleeve, and then remove the housing from the engine (**see illustrations 16.24a and 16.23**).

11 Remove the inner thrust plate (**see illustration 16.22b**) and, with the

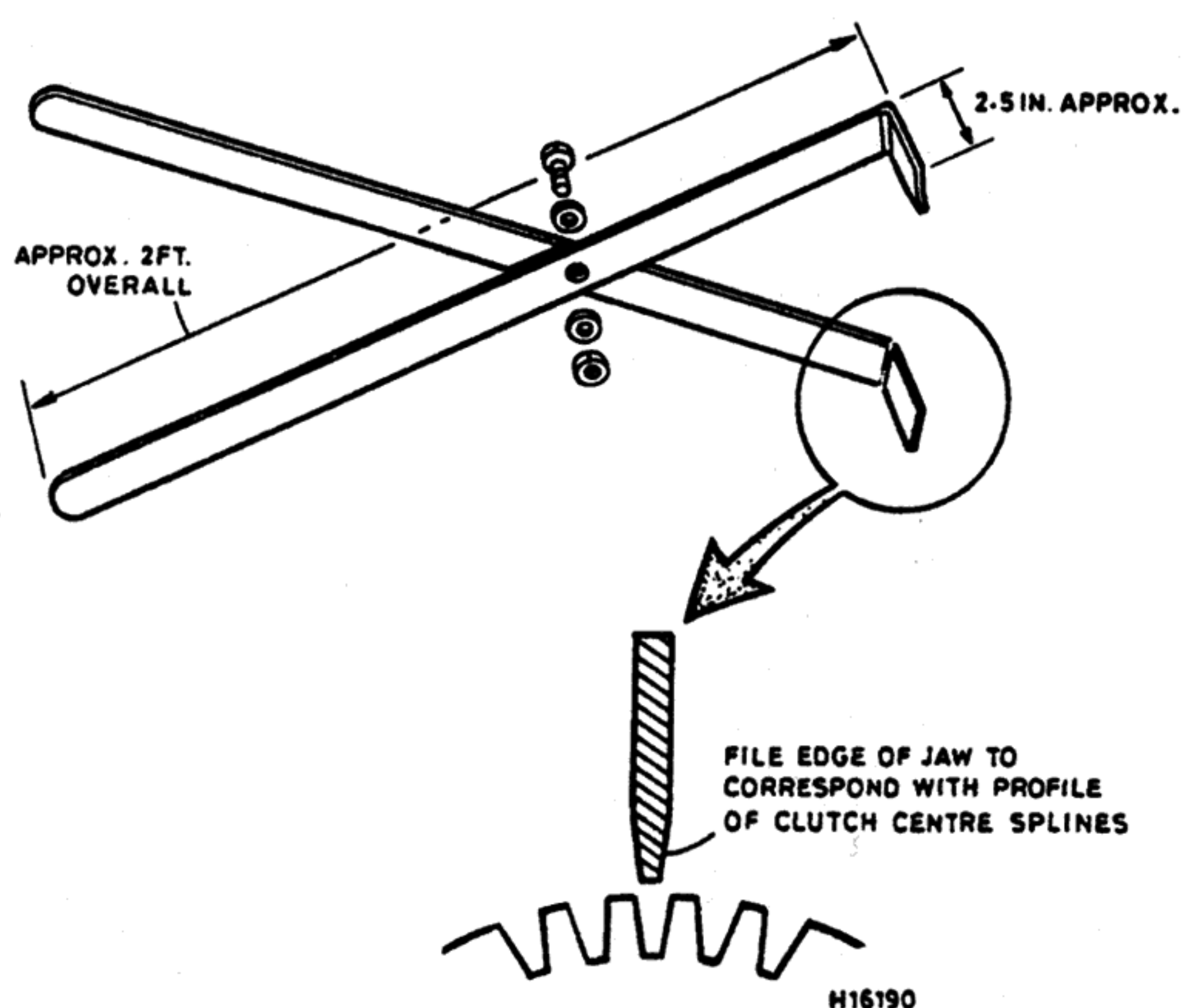
exception of 1989 to 1991 XTZ models, the thrust washer from the shaft (**see illustration 16.22a**).

12 On 1989 XTZ models, the clutch centre anti-judder assembly can be left intact unless the clutch has been chattering (juddering) excessively. If it is necessary to remove it, remove the wire retainer ring, plain plate, anti-judder spring and spring seat.

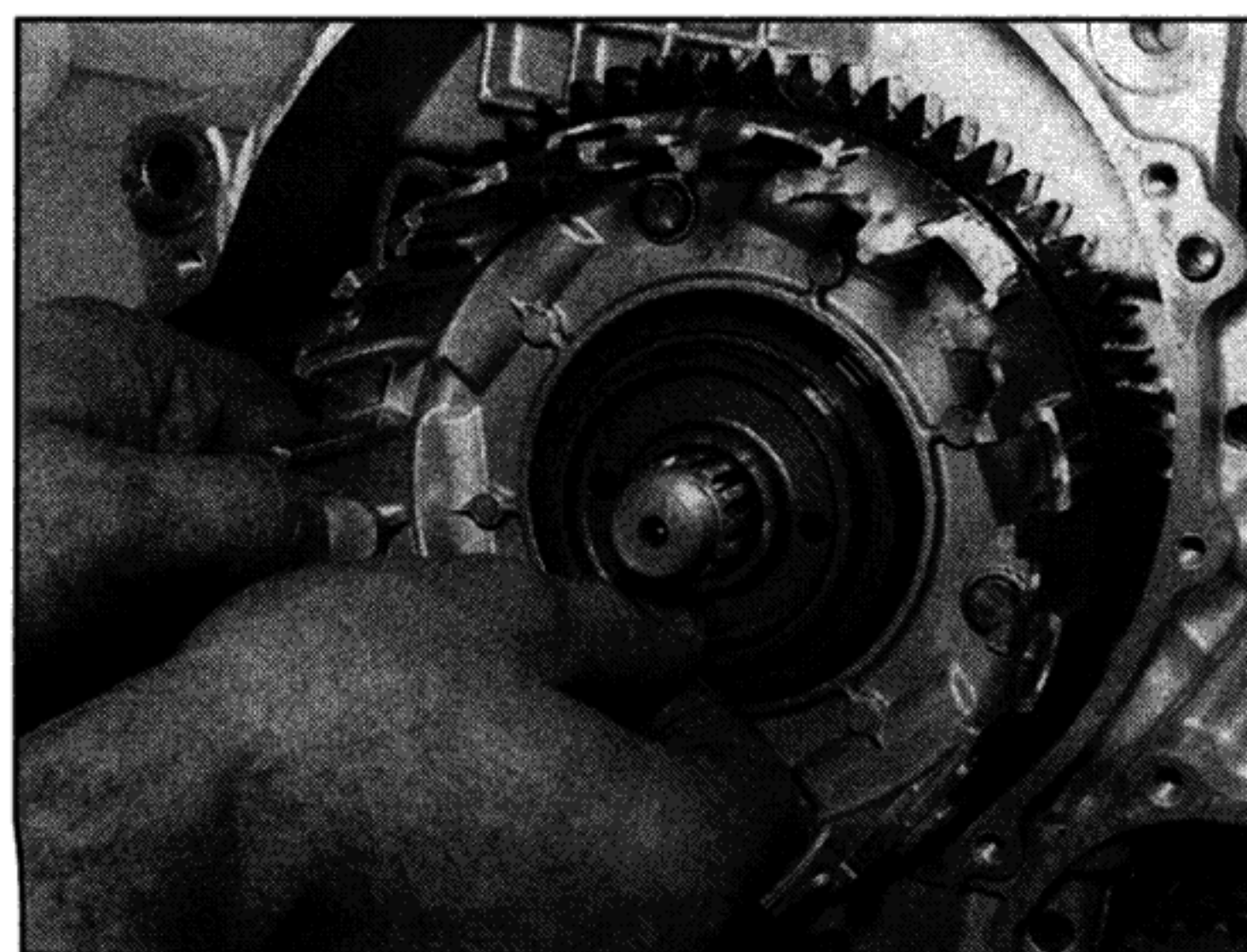
Inspection

13 After an extended period of service the clutch friction plates will wear and promote 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

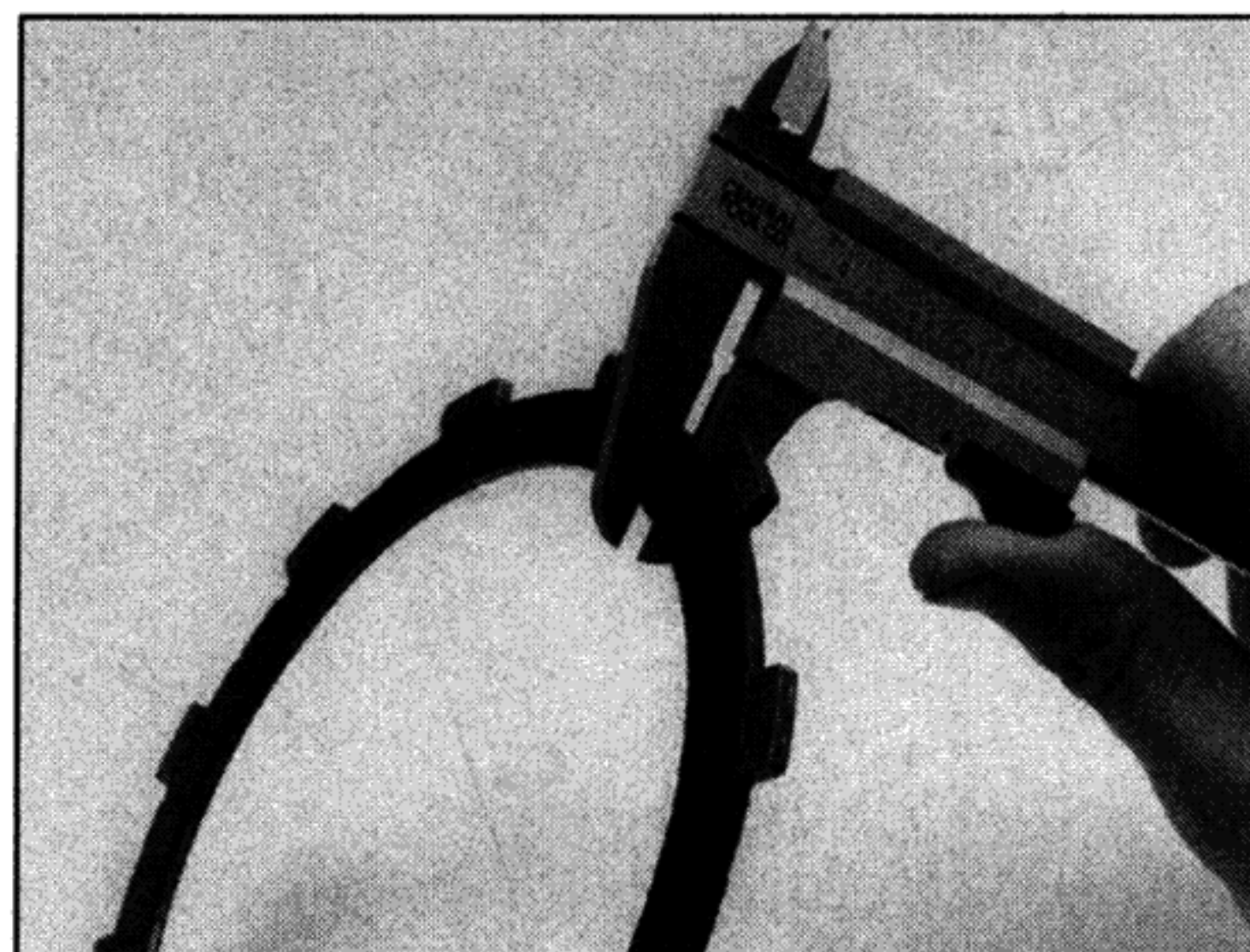
TOOL TIP



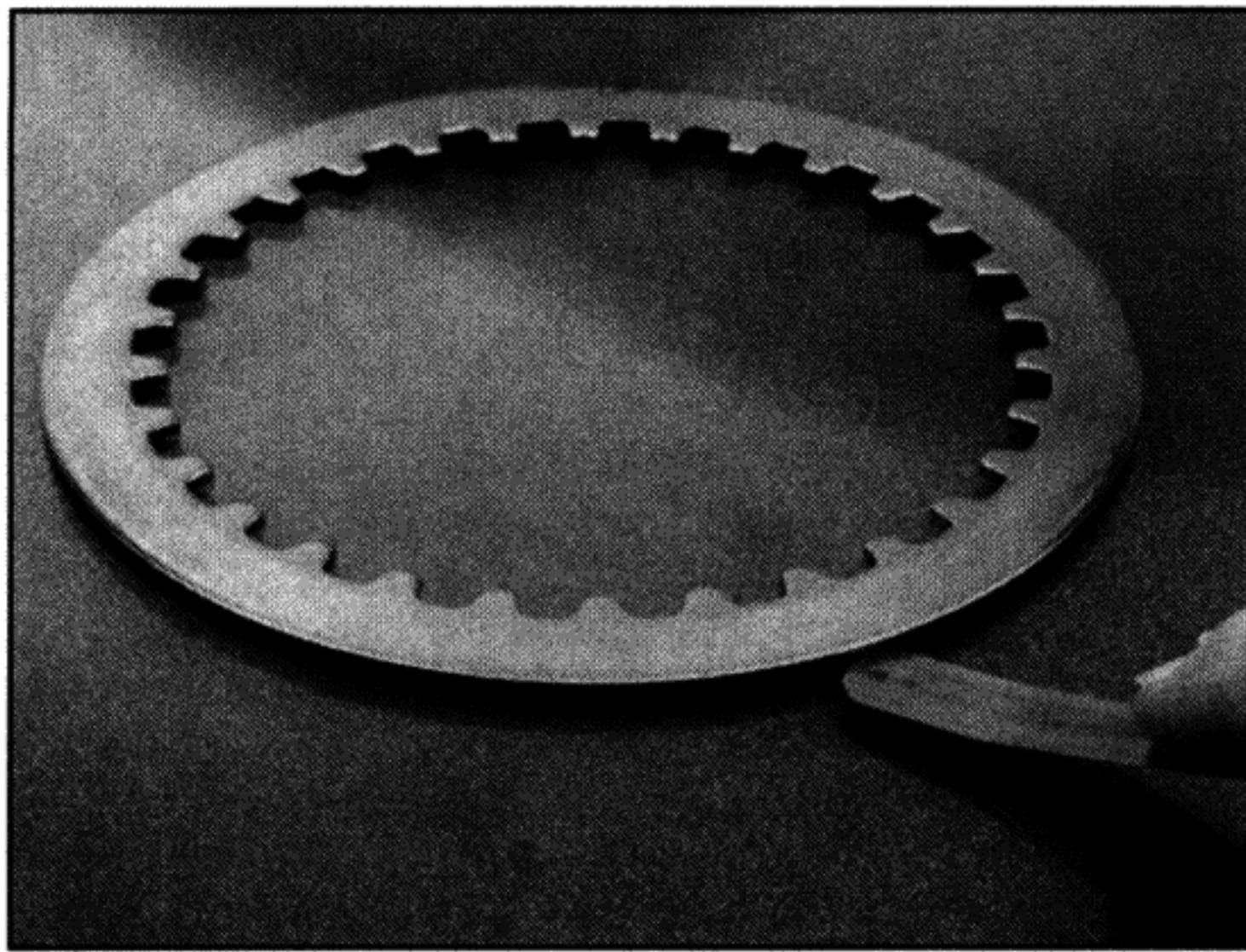
A clutch centre holding tool can easily be made using two strips of steel with the ends bent over, and bolted together in the middle



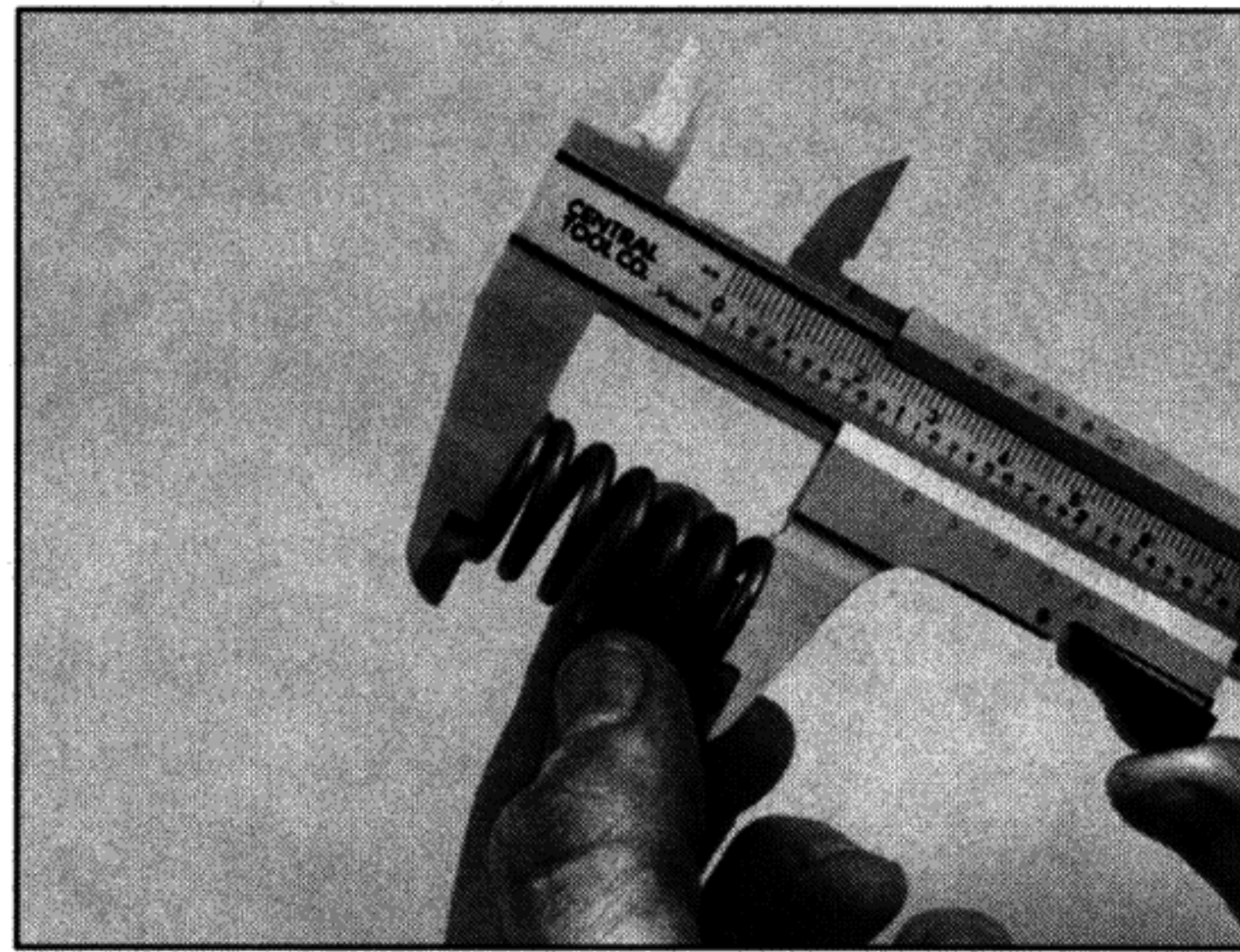
16.9 Remove the inner sleeve as described



16.13 Measuring clutch friction plate thickness



16.14 Check the plain plates for warpage



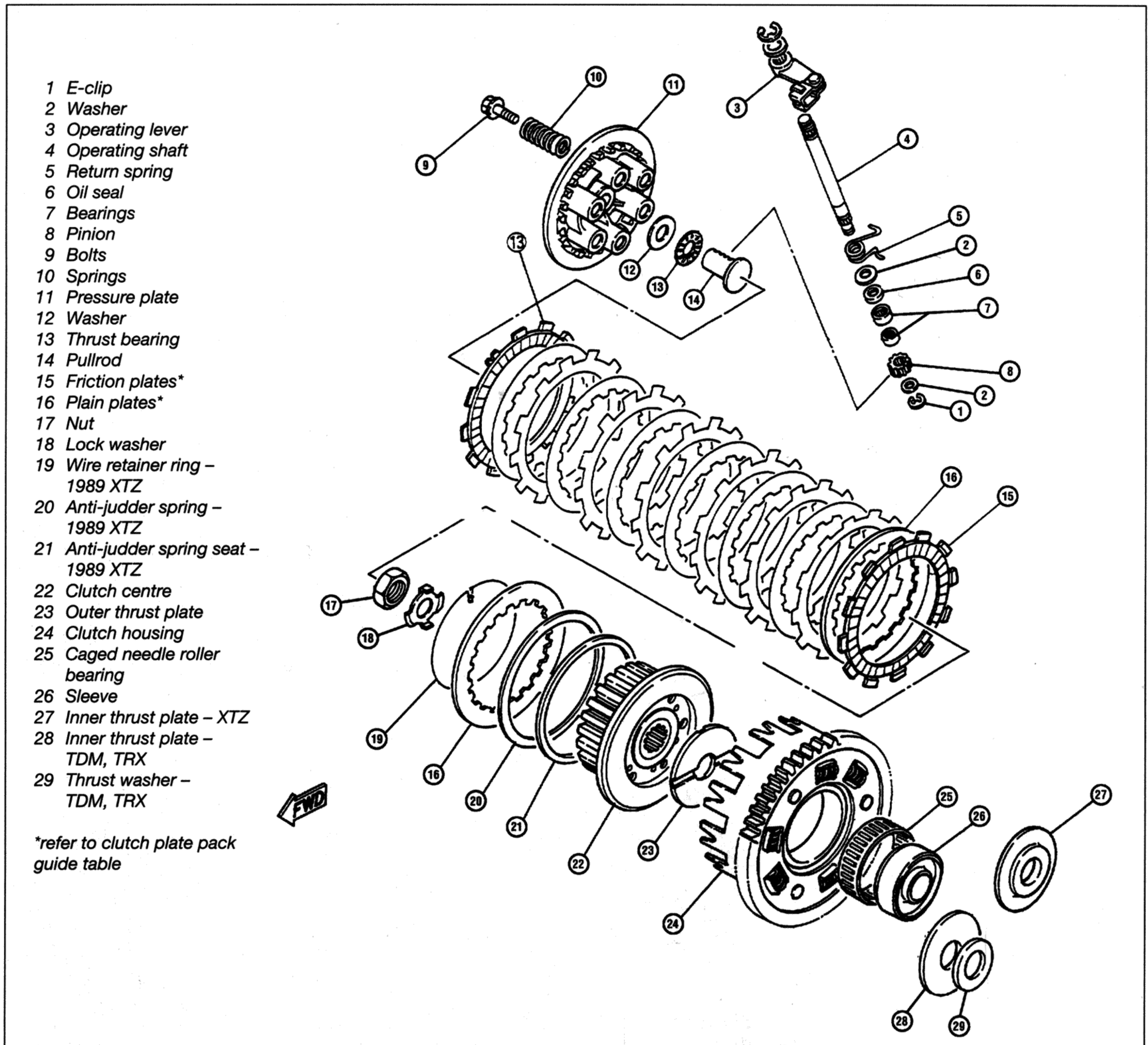
16.15 Measure the free length of the springs as shown

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.

14 The plain plates should not show any signs of excess heating (bluing). Check for warpage using a flat surface and feeler gauges (see illustration). If any plate exceeds the maximum permissible amount of warpage, or shows signs of bluing, all plain plates must be renewed as a set.

15 Measure the free length of each clutch spring using a vernier caliper (see illustration). If any spring is below the service limit specified, renew all the springs as a set.

16 Inspect the clutch assembly for burrs and



16.20 Clutch assembly

Clutch plate pack guide		
Model	No. of plates	Order of fitting to clutch centre
1991-93 TDM	8 friction, 8 plain	start with the special 'slick' plain plate, then alternate friction and plain plates until ending with special friction plate which has a slot in one of its tabs.
1994-95 TDM	8 friction, 8 plain	start with the special 'slick' plain plate, then alternate friction and plain plates.
1996-98 TDM and all TRX	9 friction, 8 plain	start with friction plate, then alternate plates until ending with a friction plate.
1999 TDM	9 friction, 8 plain	start with a special friction plate (black), then alternate plain and friction plates until ending with a special friction plate (black).
1989 XTZ	8 friction, 8 plain	special plain plate fitted as part of anti-judder assembly, then alternate friction and plain plates, until ending with special friction plate which has a slot in one of its tabs.
1990-94 XTZ	8 friction, 8 plain	start with the special 'slick' plain plate, then alternate friction and plain plates until ending with special friction plate which has a slot in one of its tabs.
1995 XTZ	8 friction, 8 plain	start with the special 'slick' plain plate, then alternate friction and plain plates.

indentations on the edges of the protruding tangs of the friction plates and/or slots in the edge of the housing with which they engage. Similarly check for wear between the inner tongues of the plain plates and the slots in the clutch centre. Wear of this nature will cause clutch drag and slow disengagement during gear changes, since 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 this is excessive the worn components should be renewed.

17 Inspect the sleeve and caged needle roller bearing in conjunction with the clutch housing's internal bearing surface. If there are any signs of wear, pitting or other damage the affected parts must be renewed.

18 Check the pressure plate, thrust bearing and plate washer for signs of roughness, wear or damage, and renew any parts as necessary.

19 On 1989 XTZ models, if removed, check the clutch centre anti-judder assembly components (consisting of the wire retainer ring, plain plate, anti-judder spring and spring seat) for wear or damage, and renew any parts as necessary.

20 Check the clutch operating mechanism in the clutch cover for smooth operation. Check the pinion and pullrod teeth for signs of damage. If necessary, prise off the E-clip securing the pinion to the actuating shaft, and withdraw the shaft from the cover (**see**

illustration). Check the two needle roller bearings for roughness, wear or damage. If they need to be renewed, heat the cover in very hot water to ease removal and drift them out. If the shaft is removed, lever out the oil seal and renew it. Clean all components and lubricate the seal and bearings with grease.

Installation

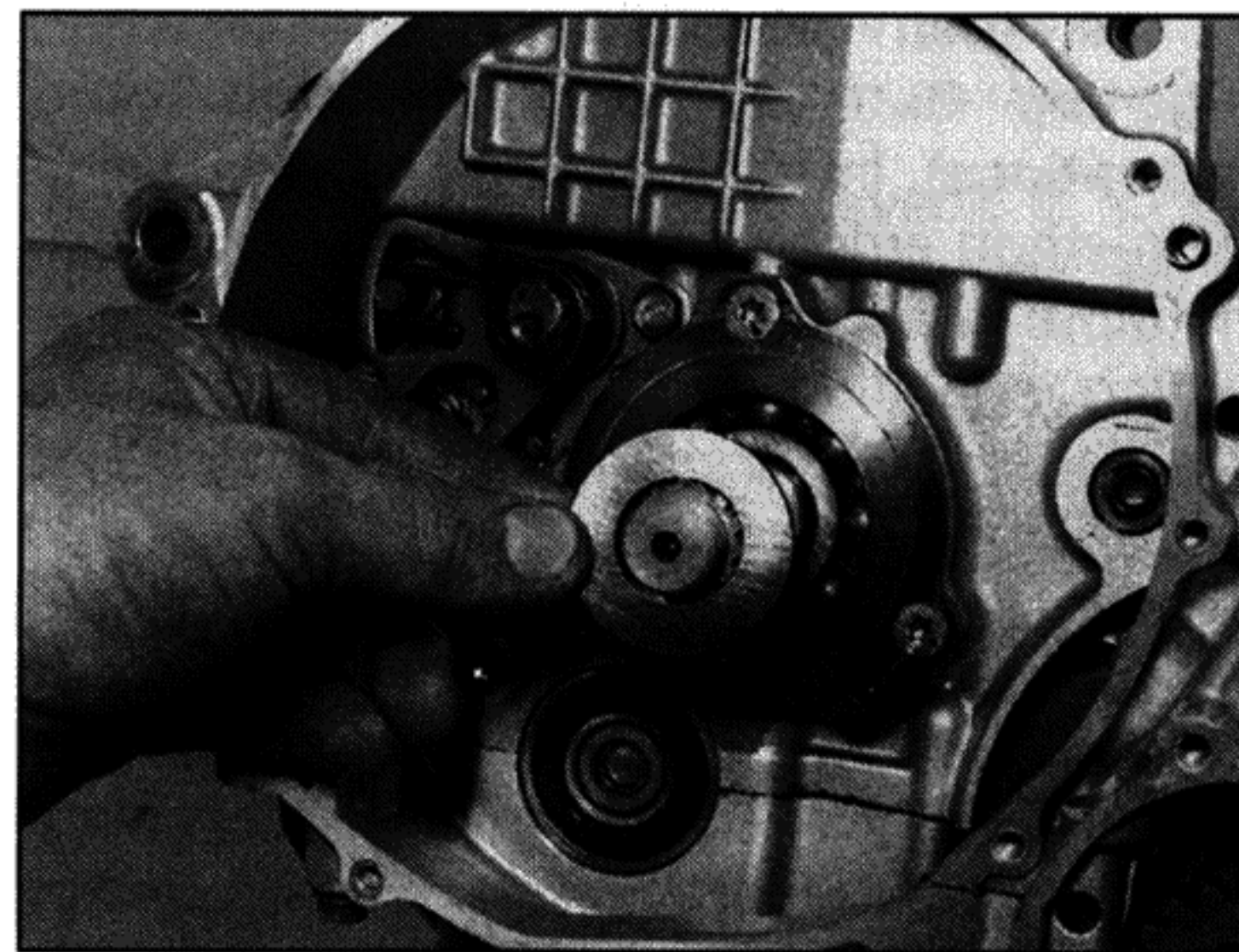
21 Remove all traces of old gasket from the crankcase and clutch cover surfaces. On 1989 XTZ models, if disassembled, reassemble the clutch centre anti-judder assembly components, fitting the spring seat, the anti-judder spring, the plain plate and the wire retainer ring in that order.

22 On all except 1989 to 1991 XTZ models, fit the thrust washer and the inner thrust plate onto the shaft (**see illustrations**). On 1989 to 1991 XTZ models, fit the inner thrust plate onto the shaft with its shouldered side inwards.

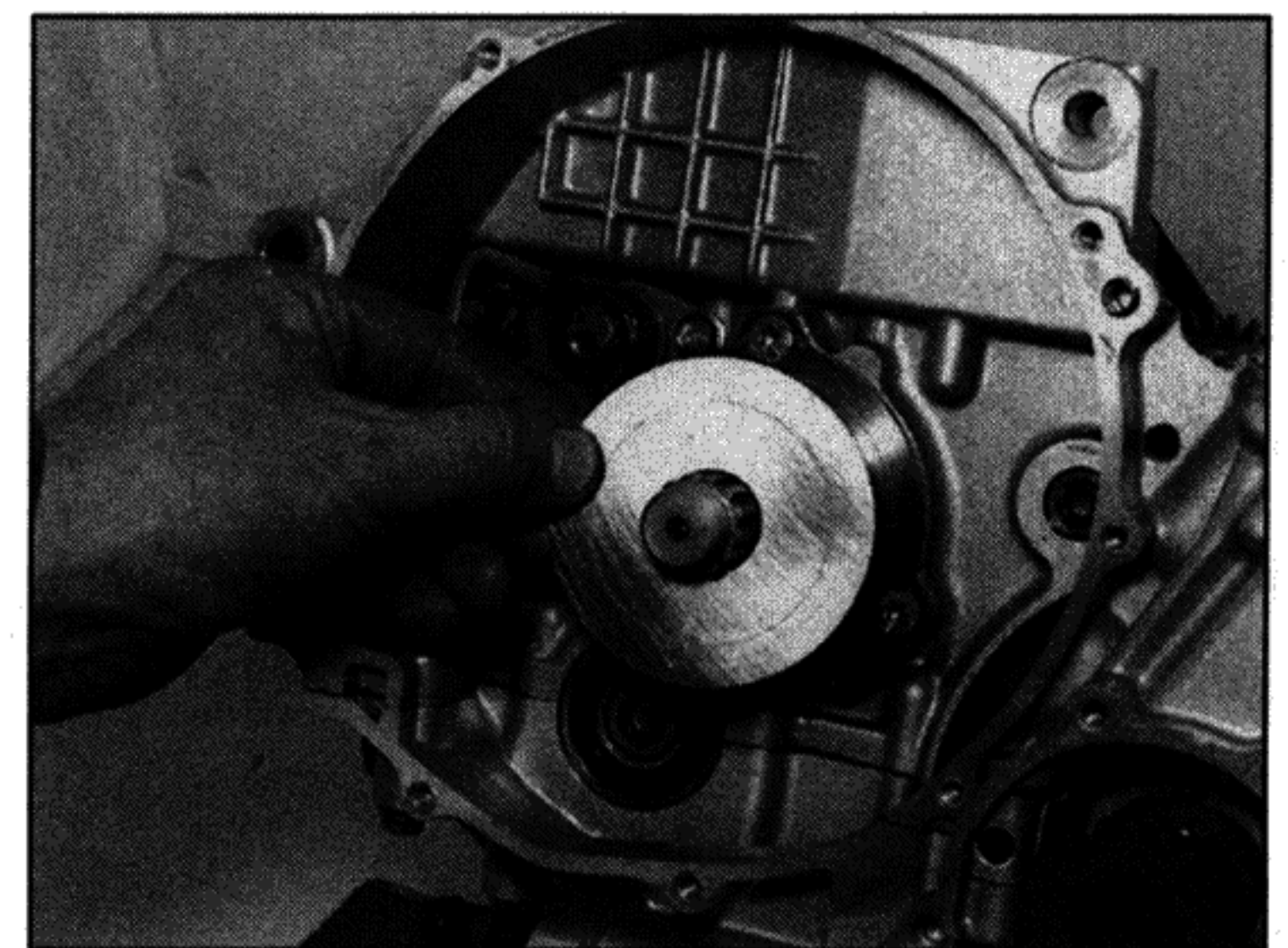
23 Lubricate the needle roller bearing and sleeve with clean engine oil. Install the clutch housing, without its needle roller bearing and sleeve, and support it in position, making sure it is engaged correctly with the primary drive gear on the crankshaft (**see illustration**).

24 Install the needle bearing and the sleeve into the middle of the clutch housing (**see illustrations**).

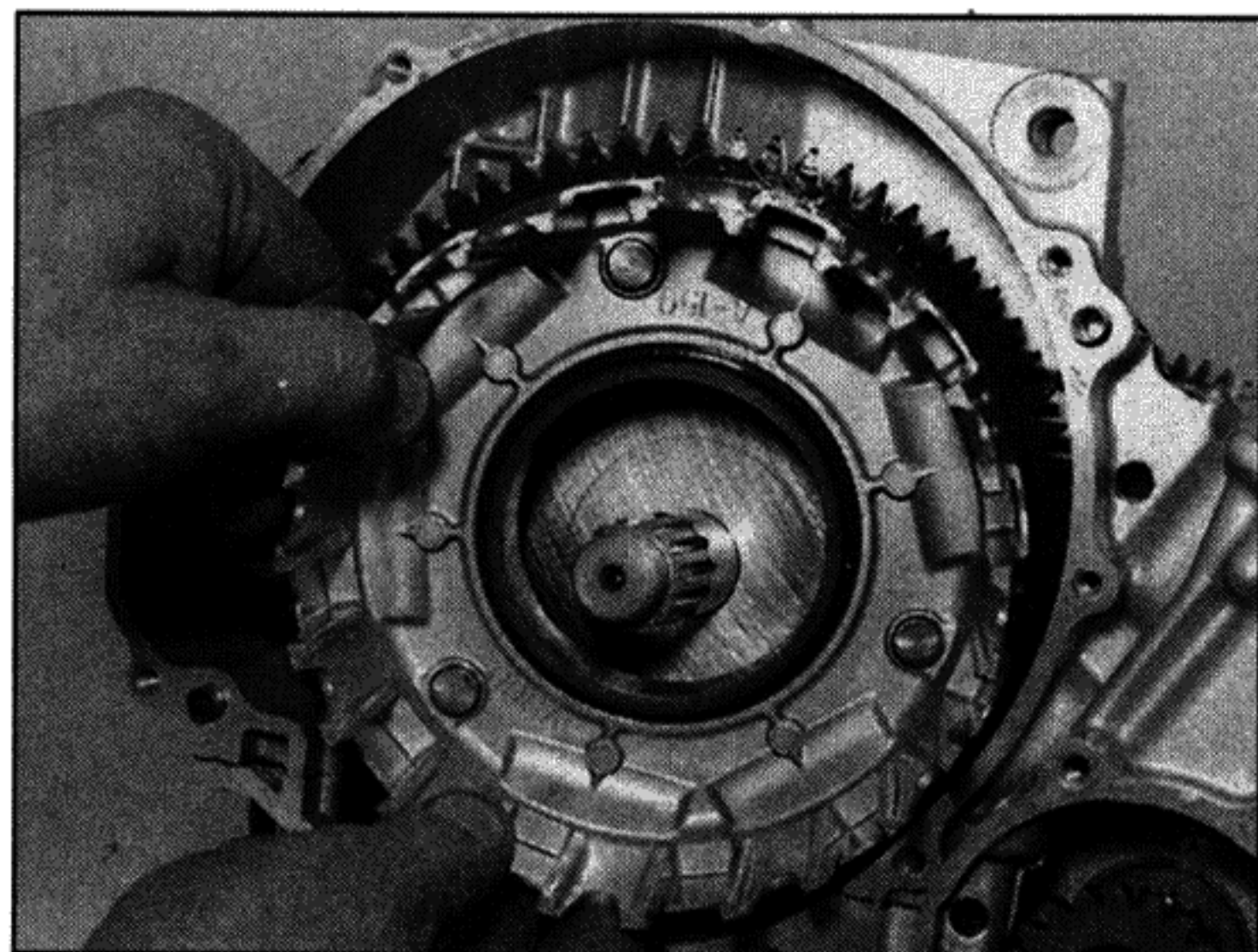
25 Lubricate the outer thrust plate with clean



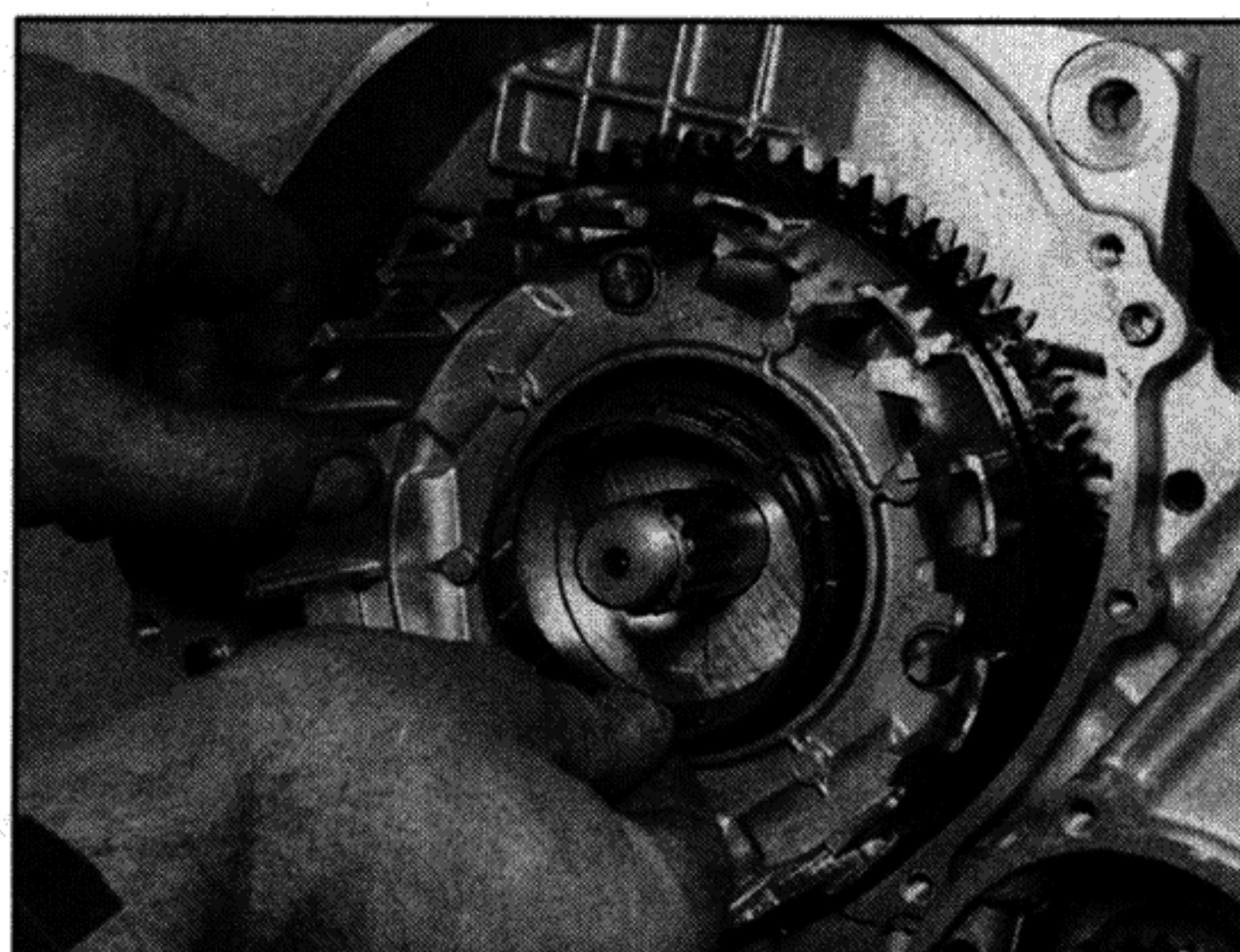
16.22a Fit the thrust washer ...



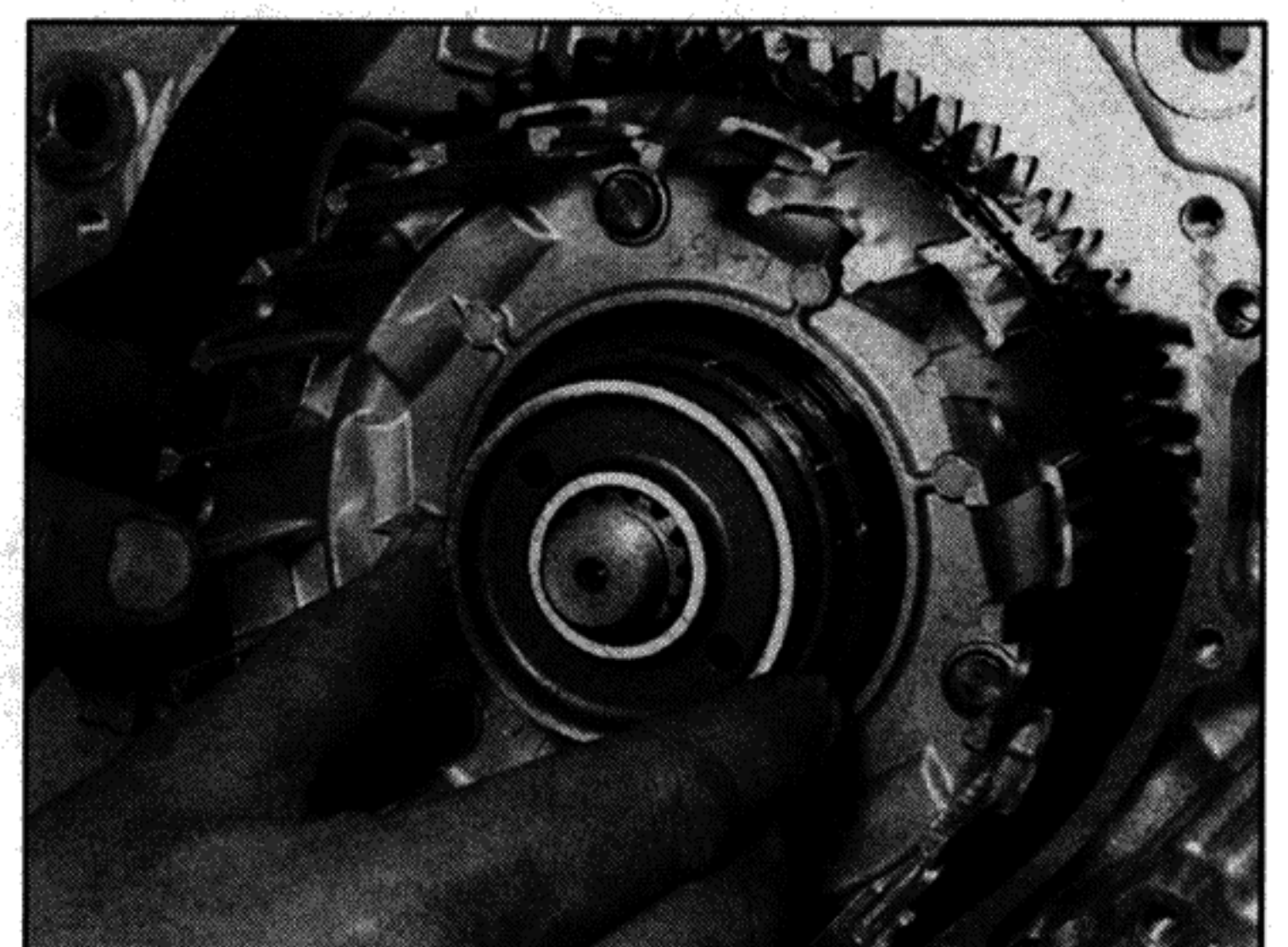
16.22b ... and inner thrust plate onto the shaft



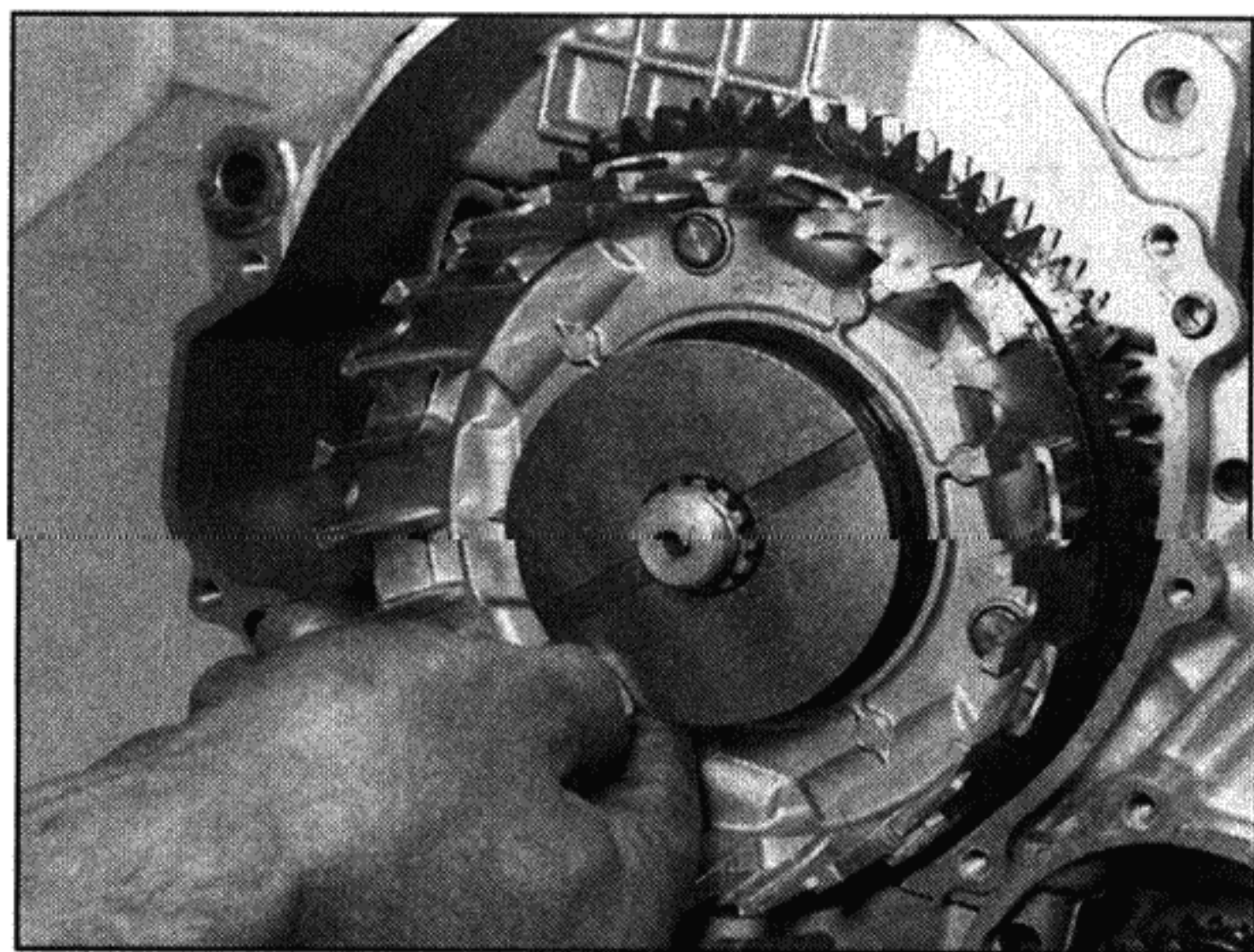
16.23 Slide the housing into place so that it engages the primary drive gear ...



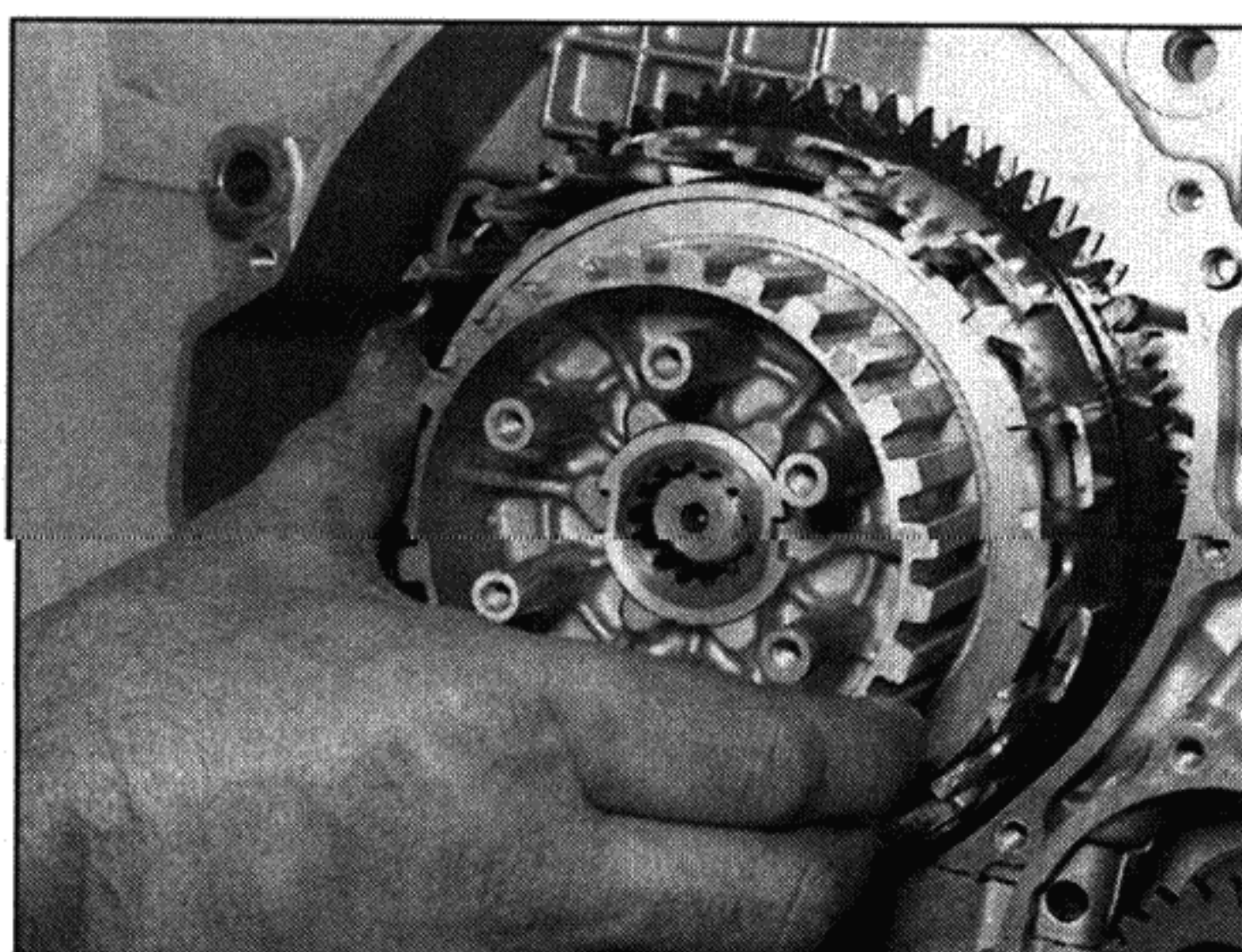
16.24a ... then fit the needle bearing ...



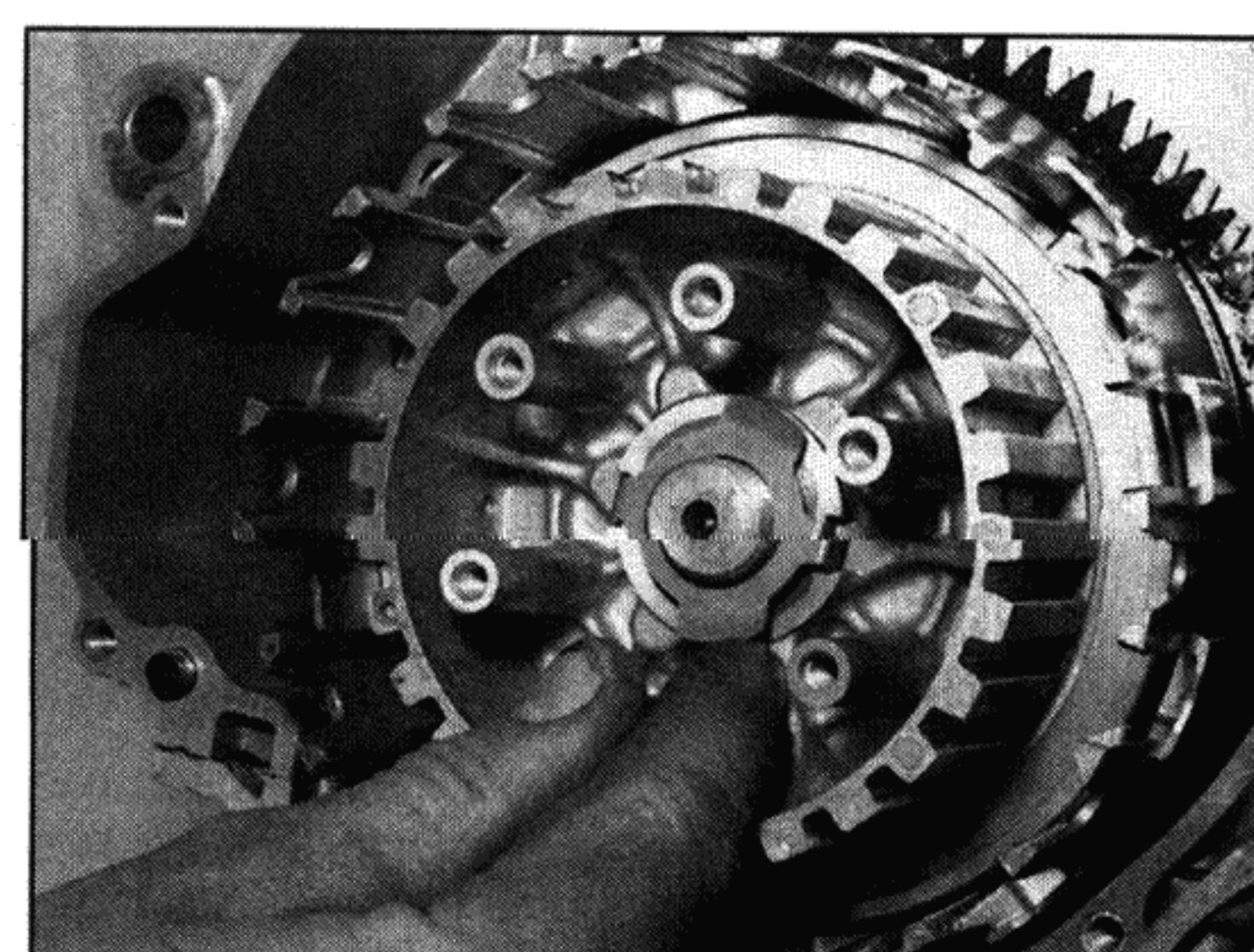
16.24b ... and the sleeve into the middle of the housing



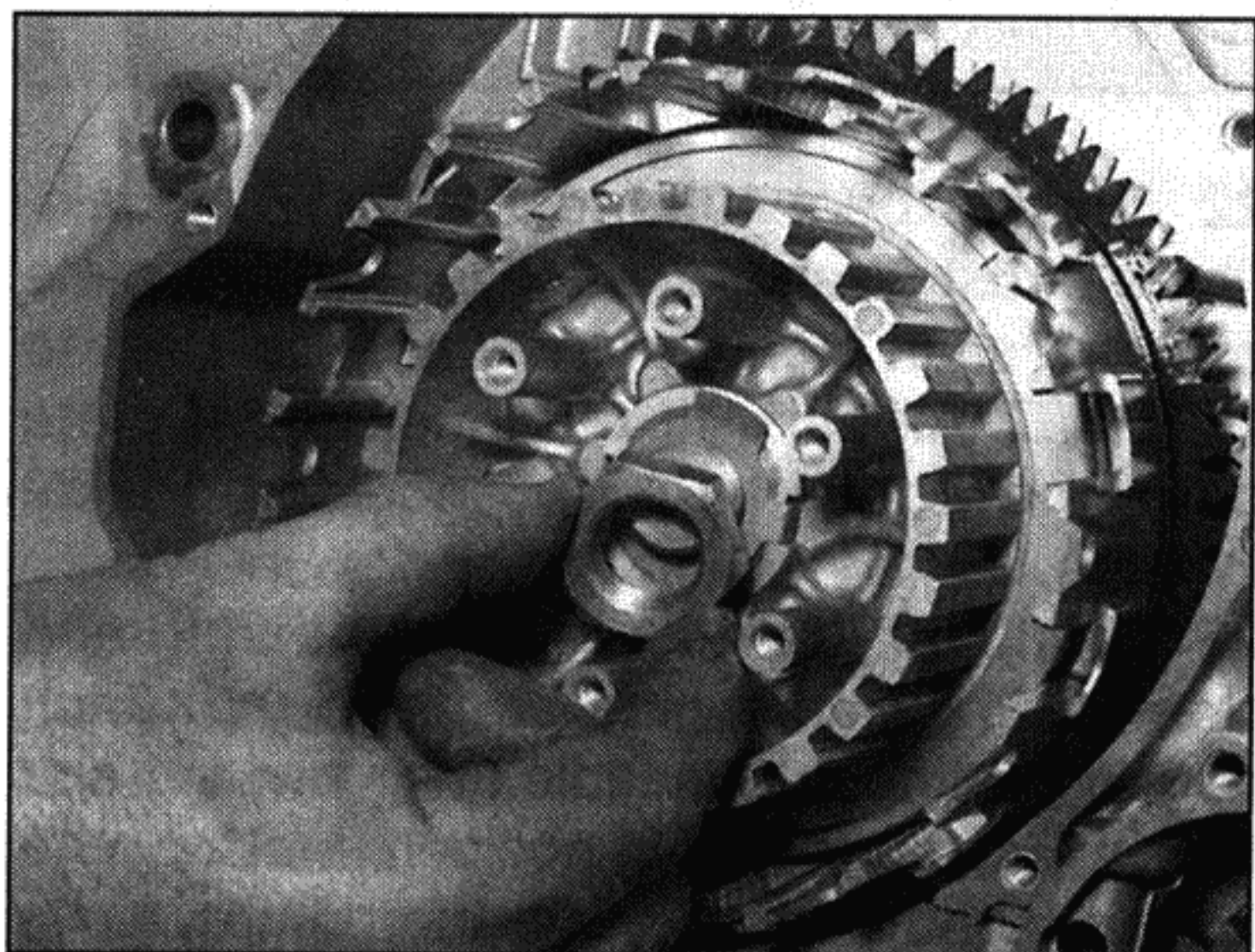
16.25 Fit the outer thrust plate . . .



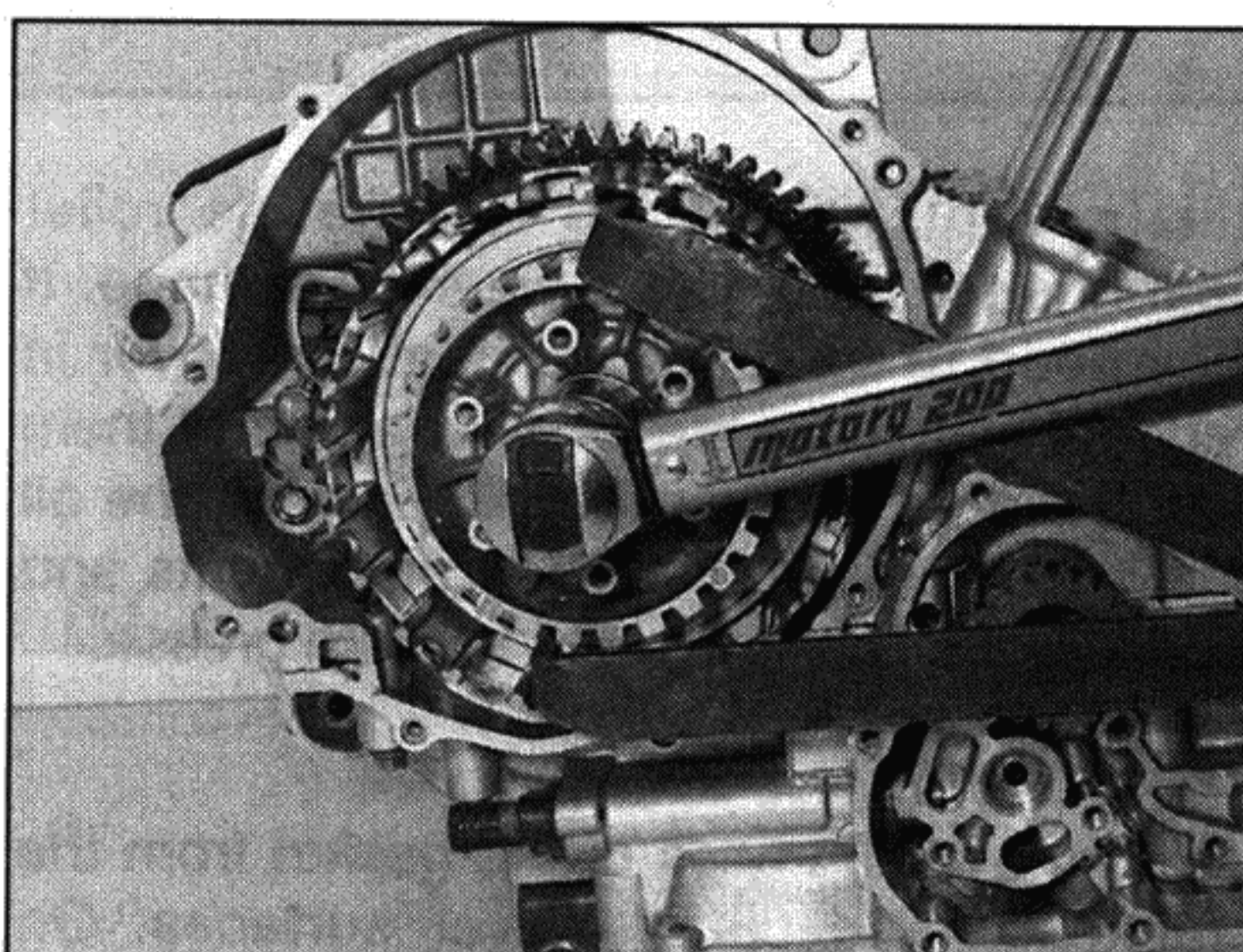
16.26a . . . then slide the clutch centre onto the splines



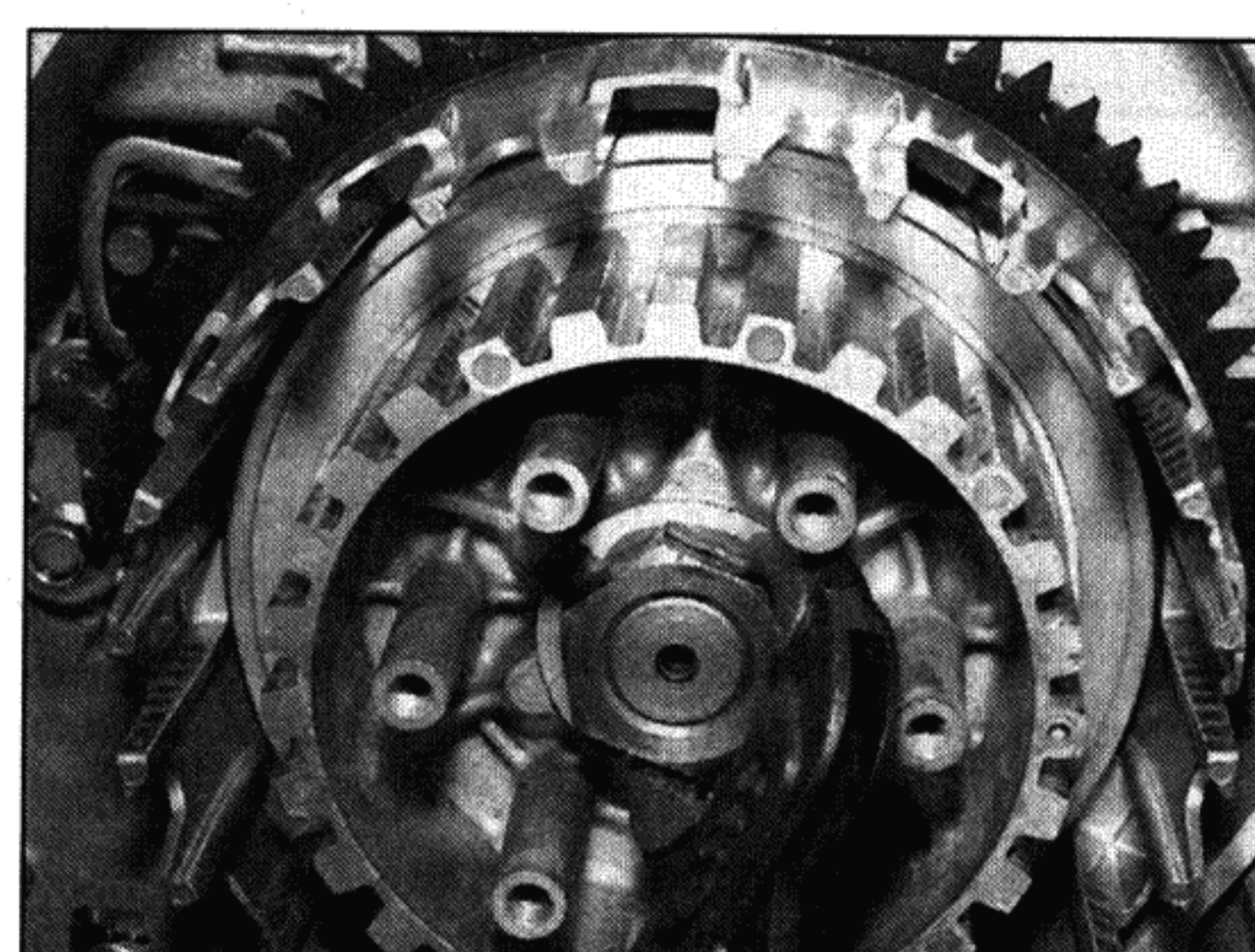
16.26b Install the lockwasher, fitting the smaller bent tabs into the slots in the centre



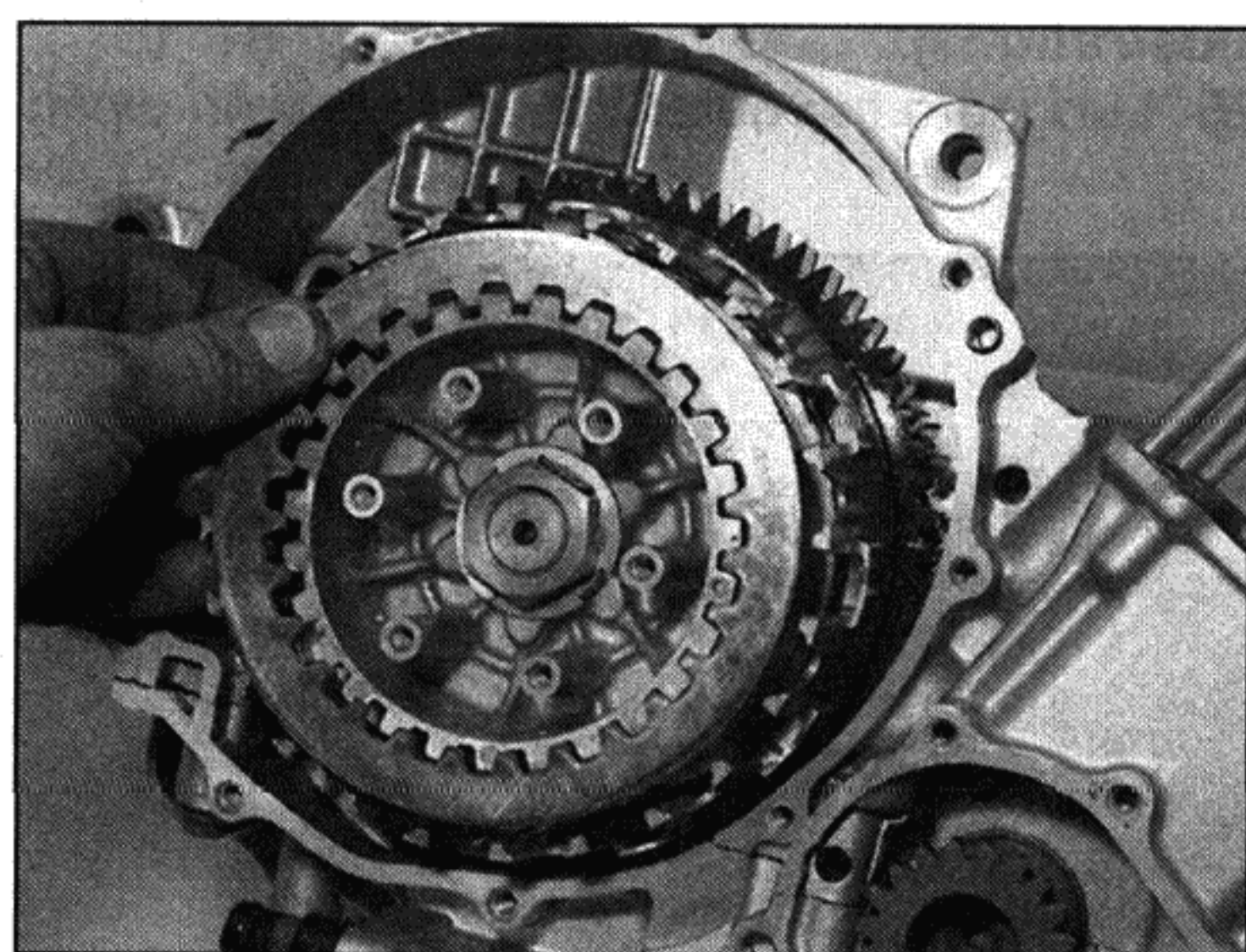
16.26c Fit the nut . . .



16.26d . . . and tighten it to the specified torque, counter-holding the clutch centre



16.26e Bend up the lockwasher tabs to secure the nut



16.27 On the stated models, fit the inner plate

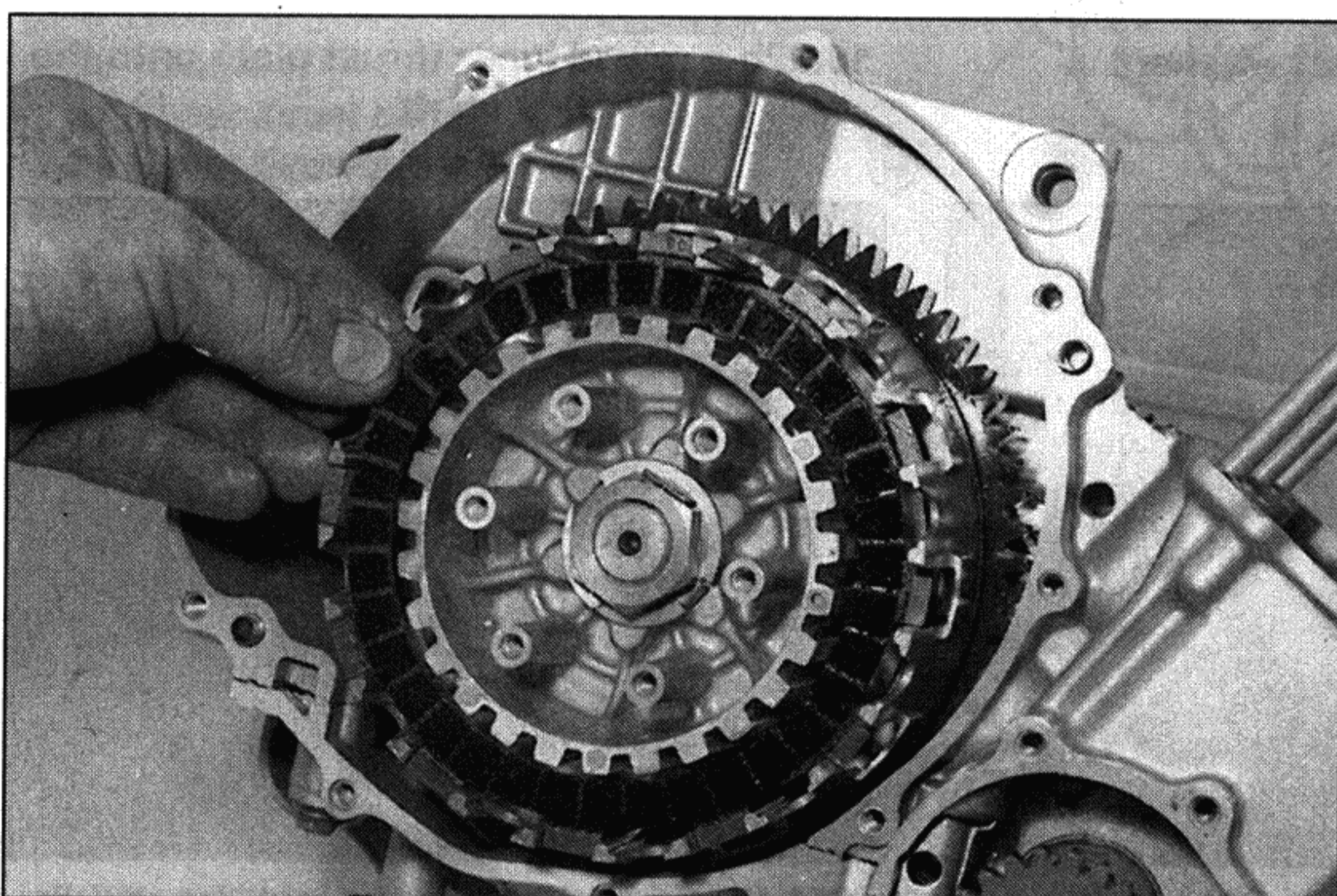
engine oil and fit it onto the shaft (*see illustration*).

26 Install the clutch centre onto the shaft splines, then install the new lockwasher, engaging its tabs with the slots (*see illustrations*). Install the clutch nut and, using the method employed on dismantling to lock the input shaft, tighten the nut to the torque setting specified at the beginning of the Chapter (*see illustrations*). **Note:** Check that the clutch centre rotates freely after tightening. Bend up the tabs of the lockwasher to secure the nut (*see illustration*).

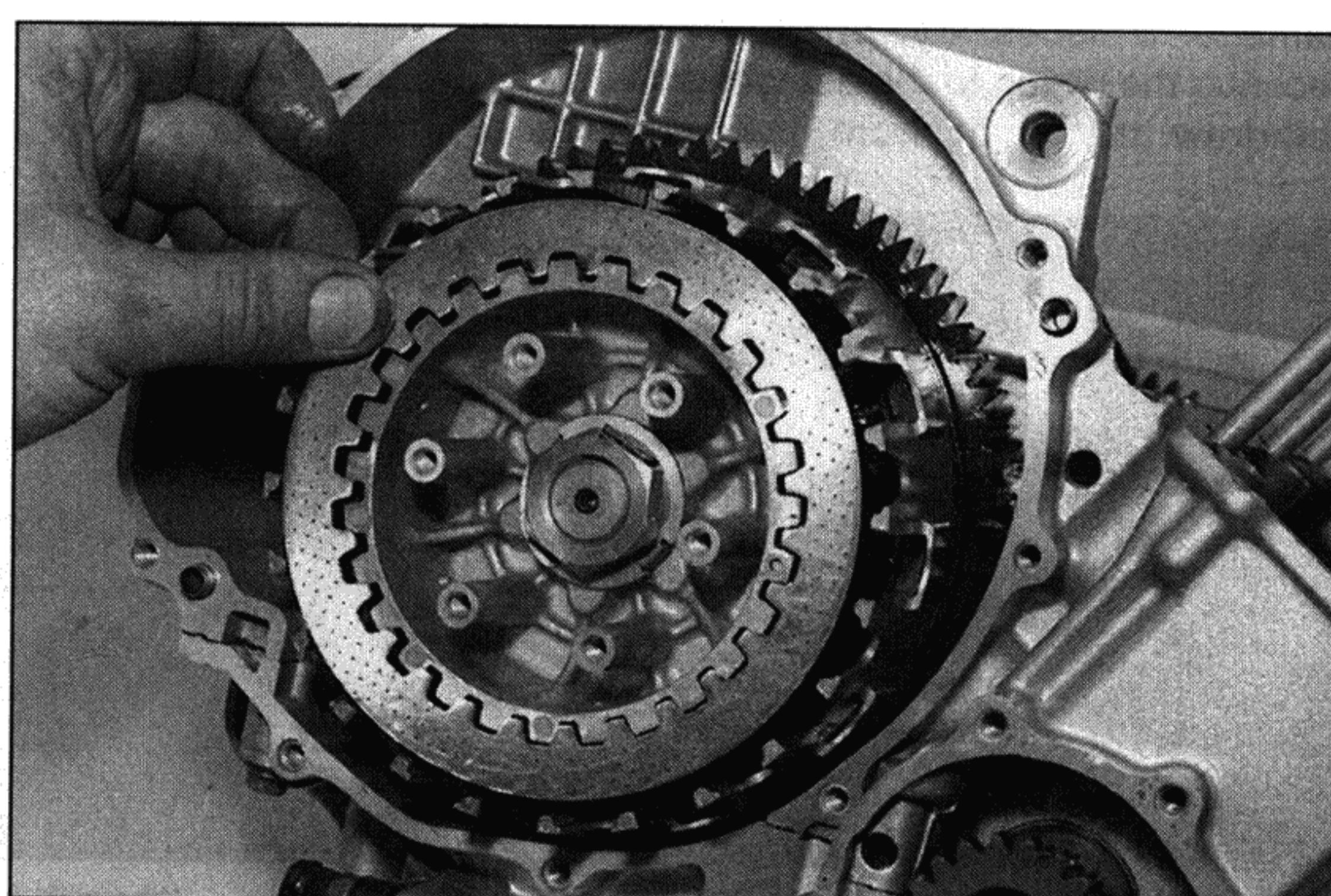
27 On 1991 to 1995 TDM models and 1990-on XTZ models, fit the inner plain plate

on the clutch centre – if it has become muddled with the rest, it is distinguishable by its slick surface (*see illustration*).

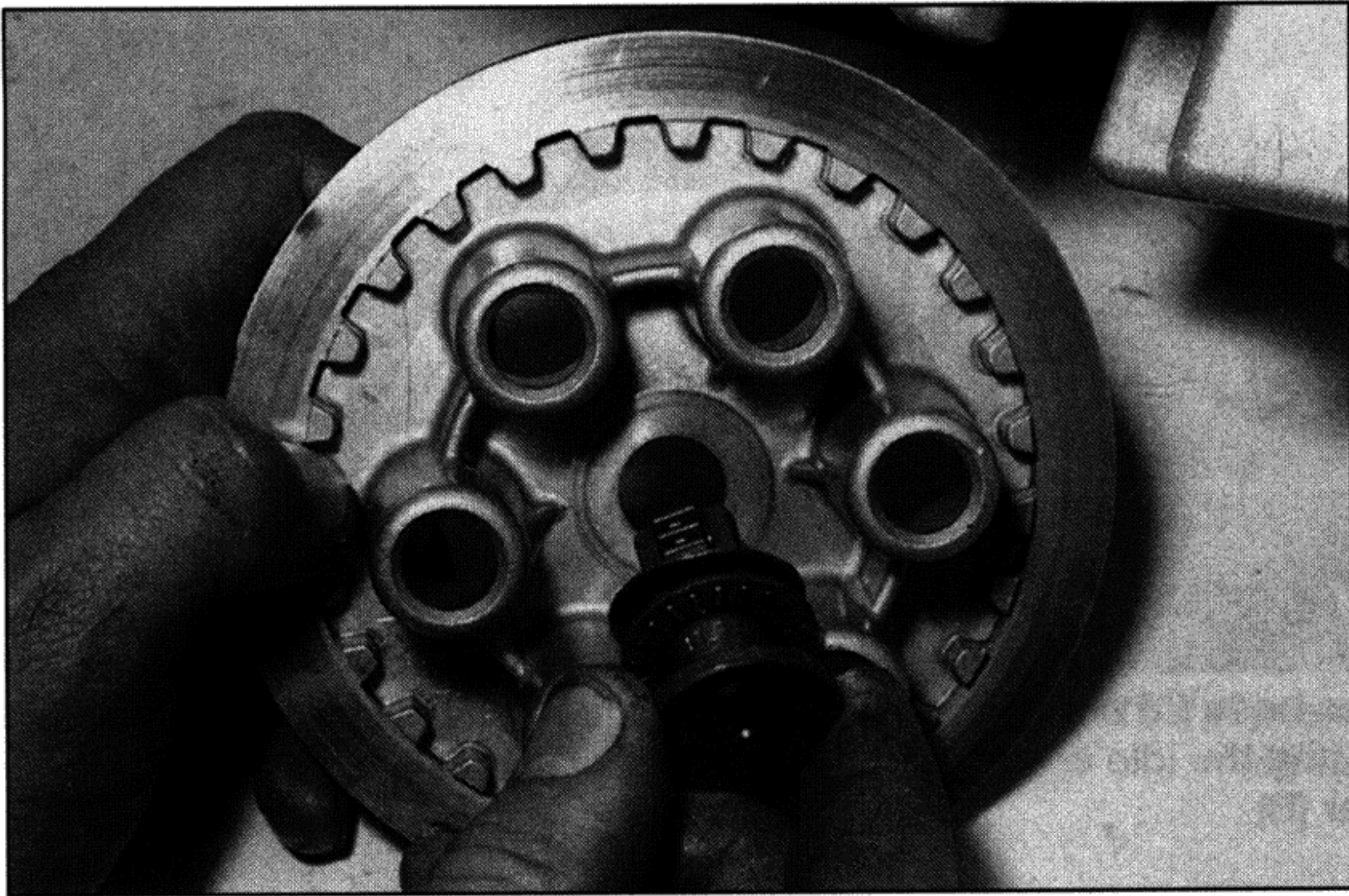
28 Build up the clutch plates, starting with a friction plate, then a plain plate and alternating friction and plain plates until all are installed (*see illustrations*). Coat each plate with engine oil prior to installation. On 1991 to 1993 TDM models and 1989 to 1994 XTZ models, make sure the friction plate with the slot in one of its tabs is fitted last, and align the slot with the embossed marks on the outside of the clutch housing. **Note:** Refer to the table accompanying illustration 16.20 for plate fitting details per model.



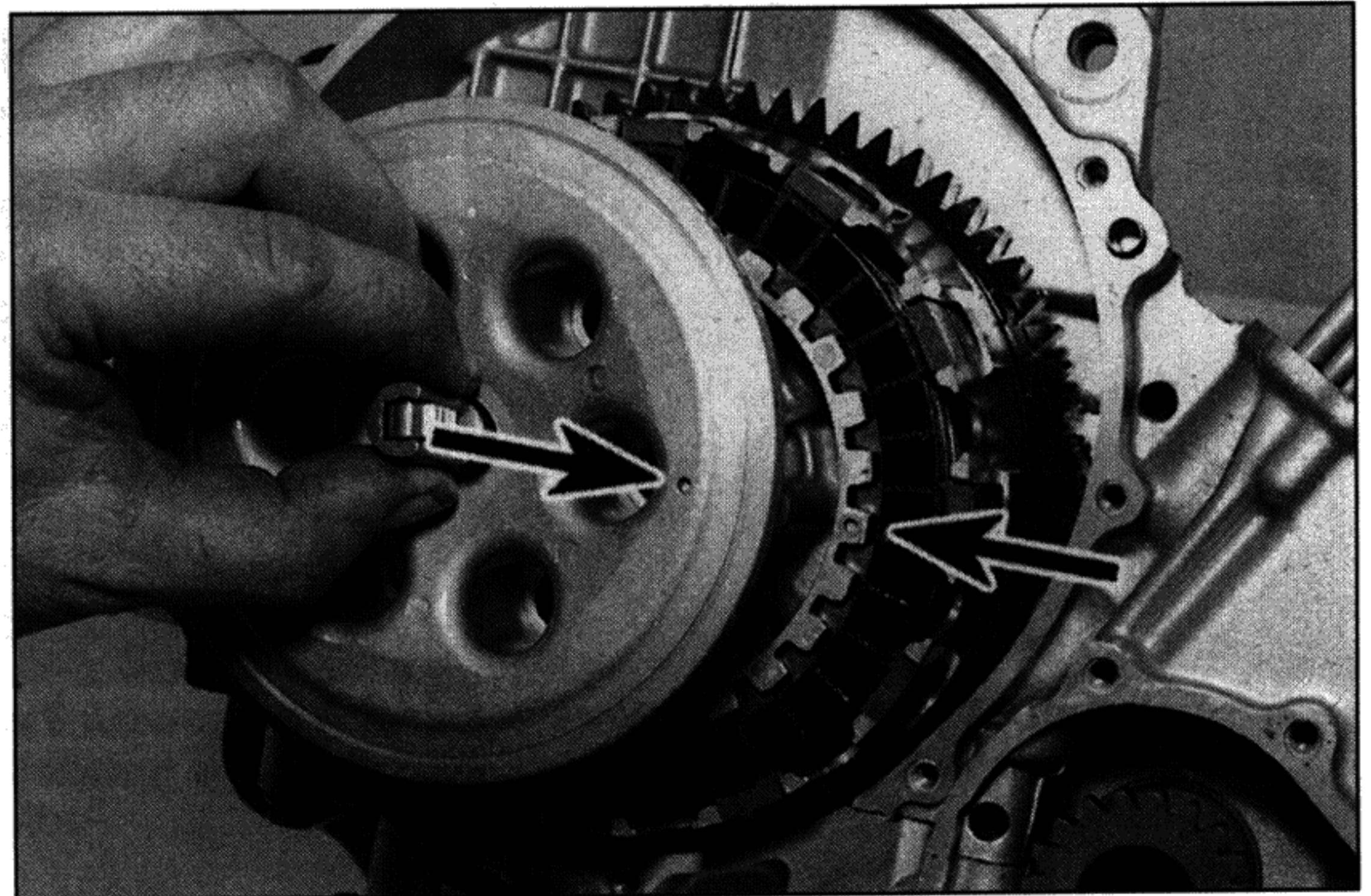
16.28a Start with a friction plate . . .



16.28b . . . then fit a plain plate



16.29 Fit the pullrod assembly in the back of the pressure plate



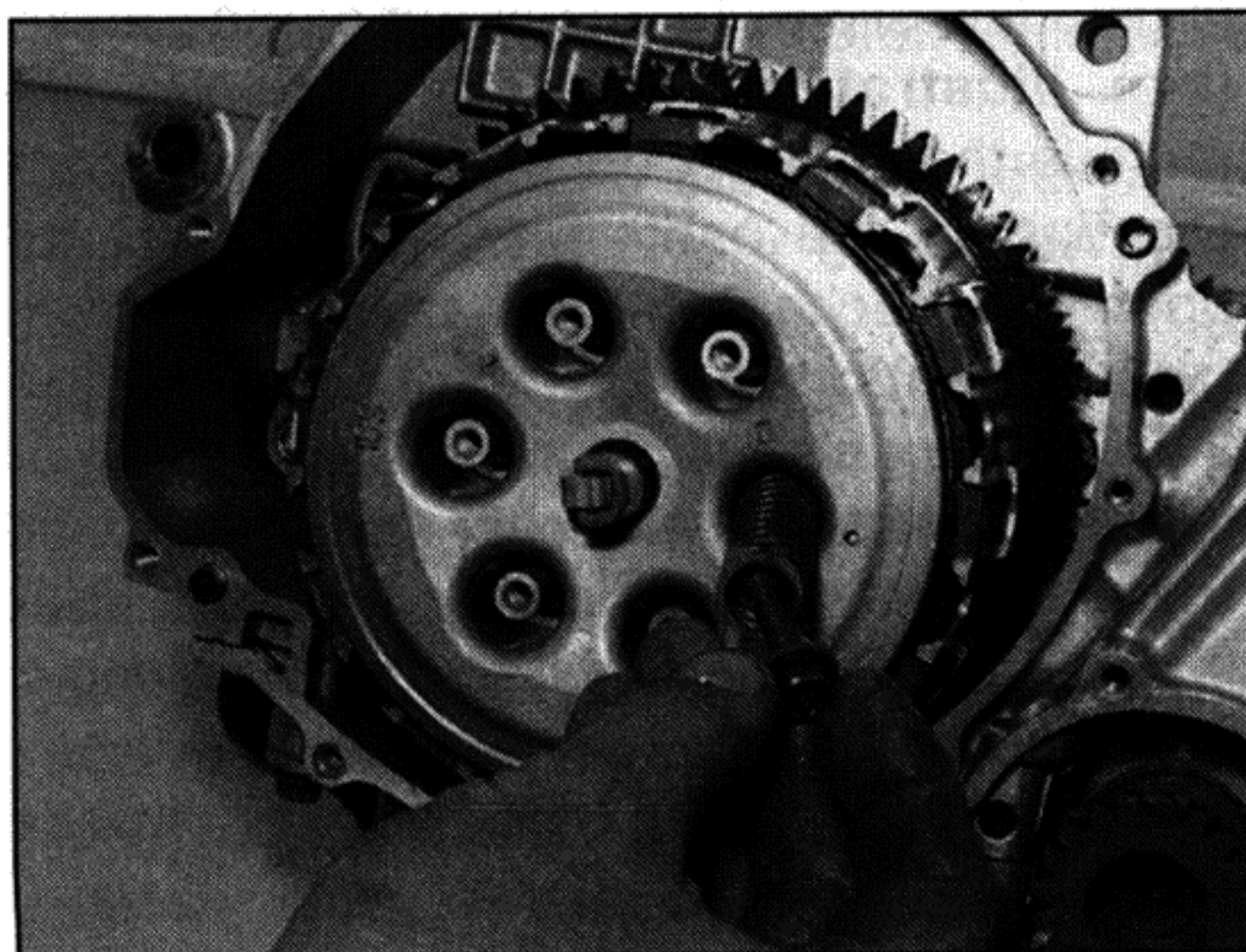
16.30a Install the pressure plate, aligning the punch marks (arrowed) . . .

29 Lubricate the thrust bearing and washer with molybdenum disulphide oil (a 50/50 mixture of molybdenum disulphide grease and engine oil). Install the thrust bearing and plate washer onto the pullrod, then install the pullrod assembly in through the back of the clutch pressure plate (**see illustration**).

30 Install the pressure plate onto the clutch, aligning the punch mark on the plate with that on the clutch centre (**see illustration**). Install the springs and the bolts with their washers, and tighten the bolts evenly in a criss-cross sequence to the specified torque setting (**see illustration**). Counter-hold the clutch housing to prevent it turning. Check that the pullrod rotates freely.

31 If disassembled, install the clutch operating mechanism in the clutch cover. Align the shaft so that the operating lever is facing back but angled out slightly.

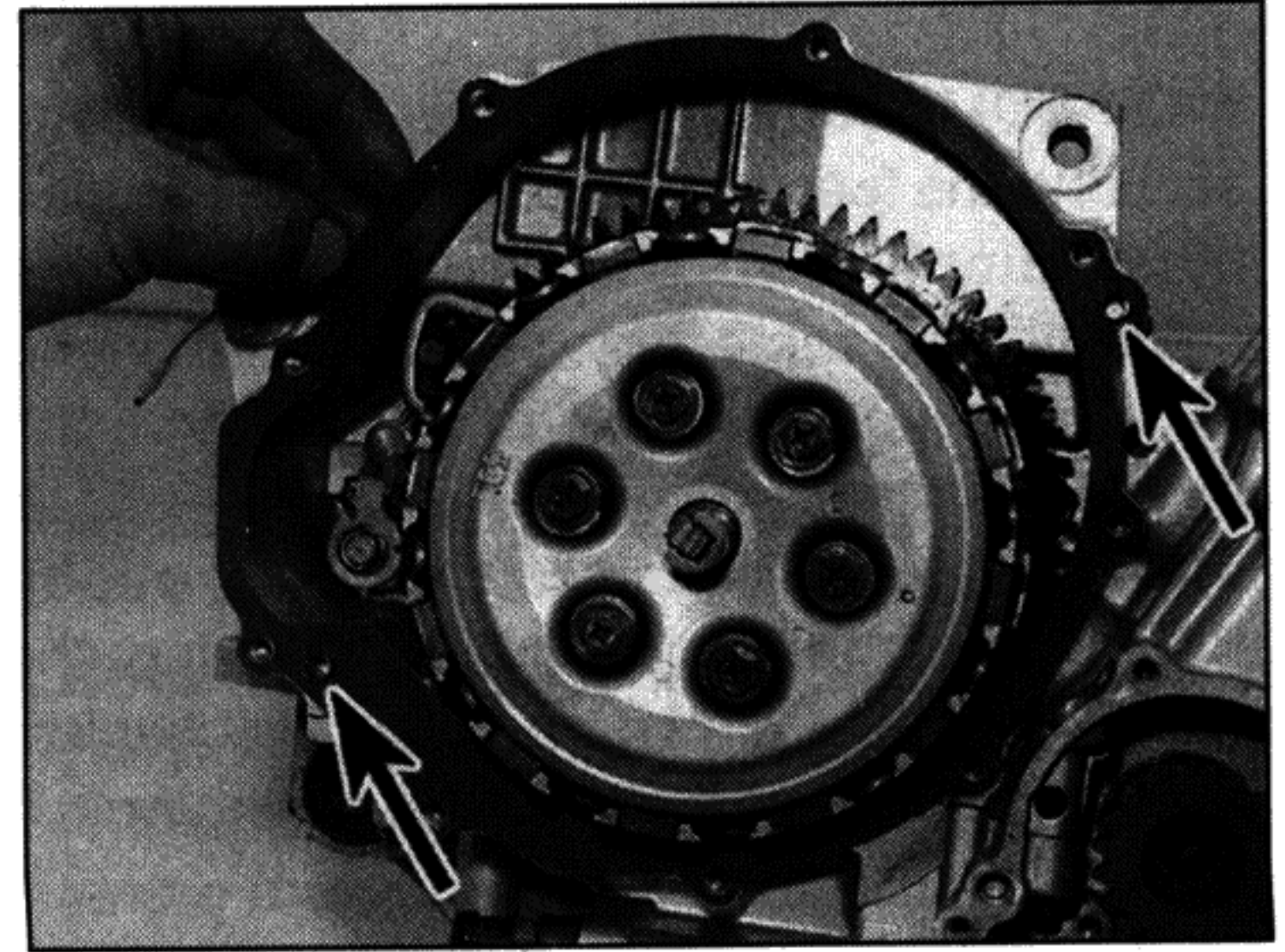
32 Insert the dowels in the crankcase, then set the pullrod so that its teeth point towards the rear. Install the clutch cover using a new



16.30b . . . then fit the springs, washers and bolts, and tighten them as described

gasket and tighten its bolts evenly in a criss-cross sequence to the specified torque setting (**see illustrations**).

33 Push the clutch operating lever forward or in (according to model) until all the freeplay in the operating mechanism has been taken up. At this point the mark on the lever should align with the mark on the cover (**see illustration**).

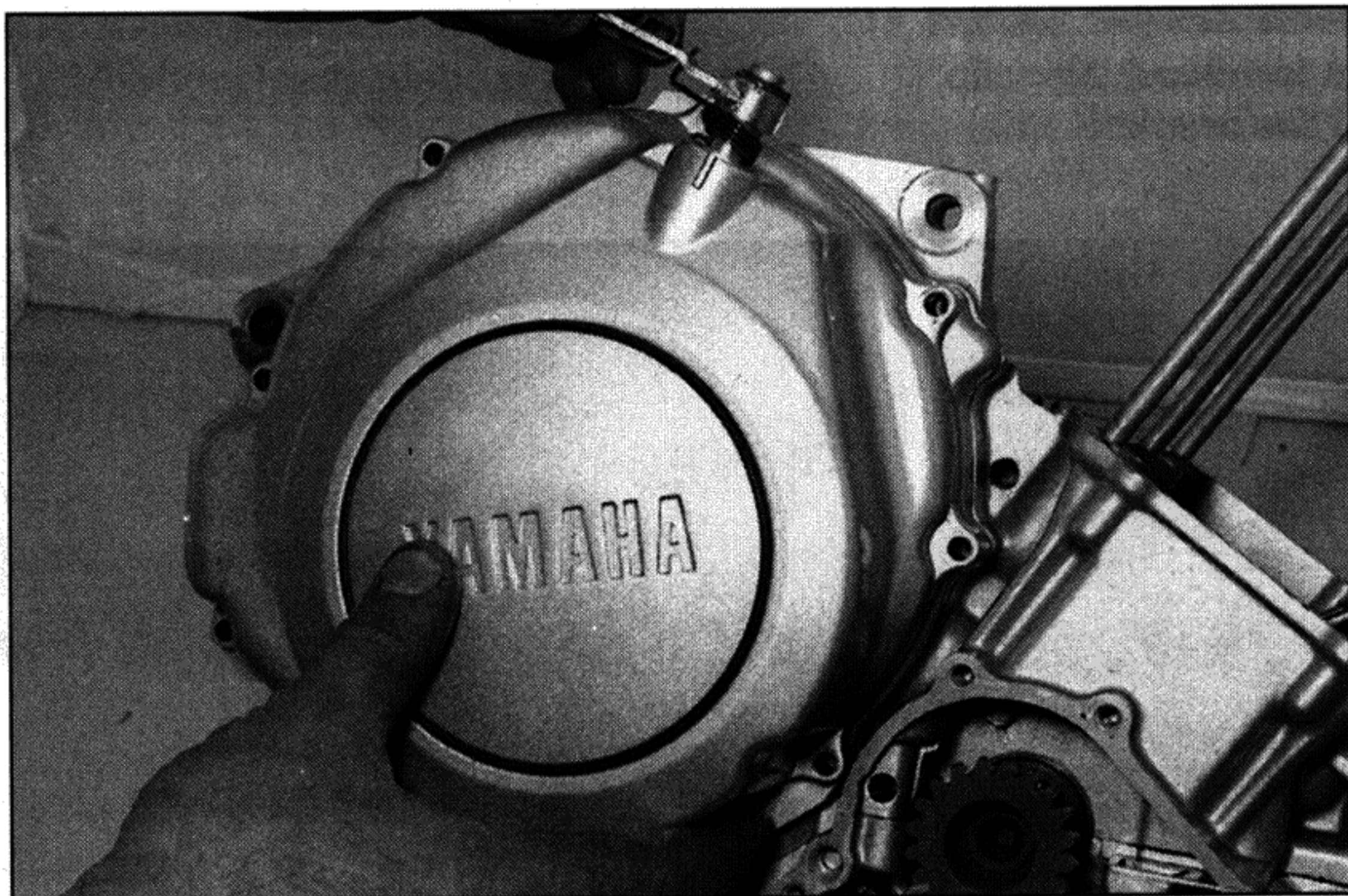


16.32a Fit the gasket onto the dowels (arrowed) . . .

If the marks do not align, remove the E-clip and the lever, noting how the spring fits, and move the lever around on the splines of the shaft until they do. Make sure the spring is correctly set on the lever and install the E-clip.

34 Install the clutch cable onto the lever (**see Section 17**).

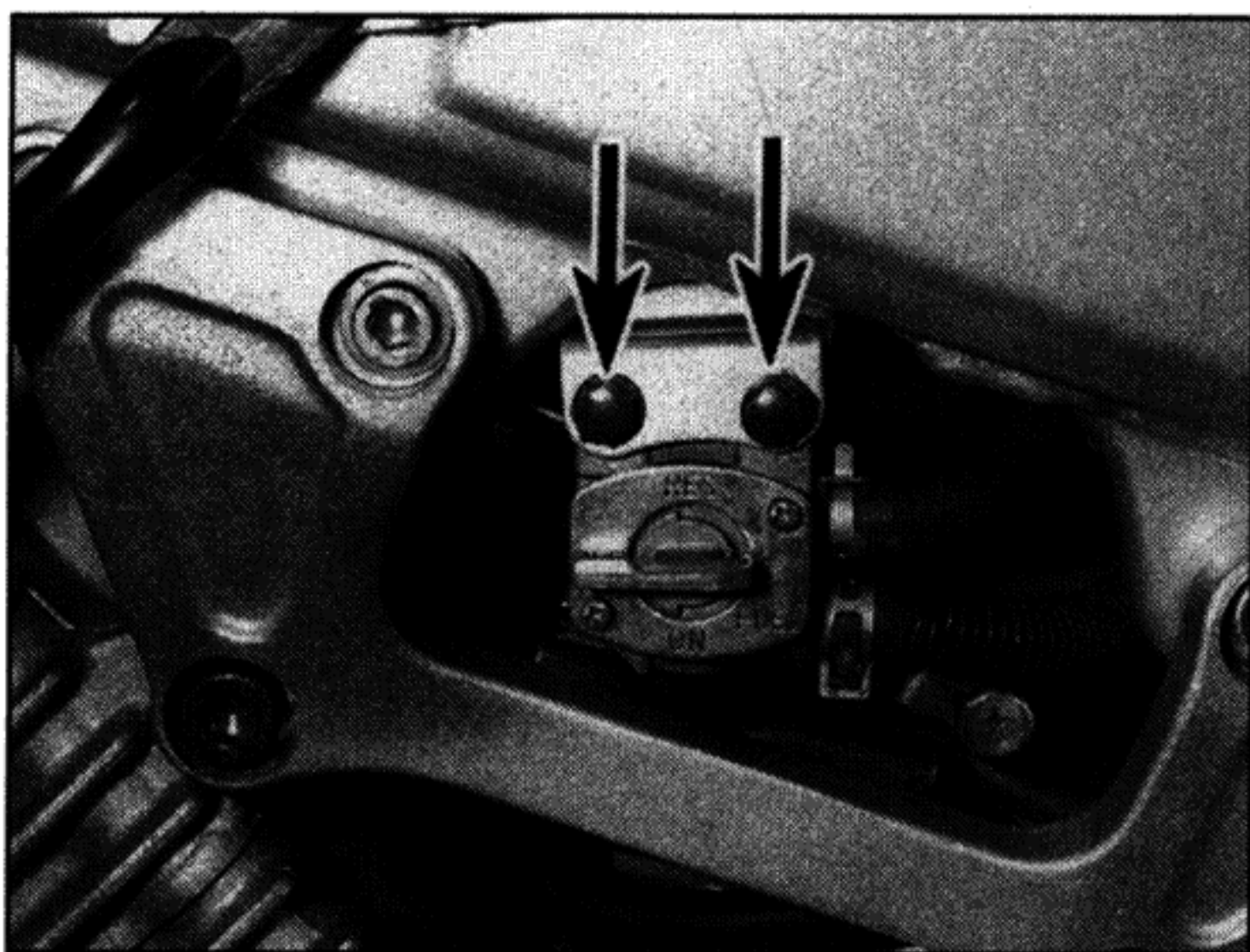
35 Refill the engine with oil (**see Chapter 1**).



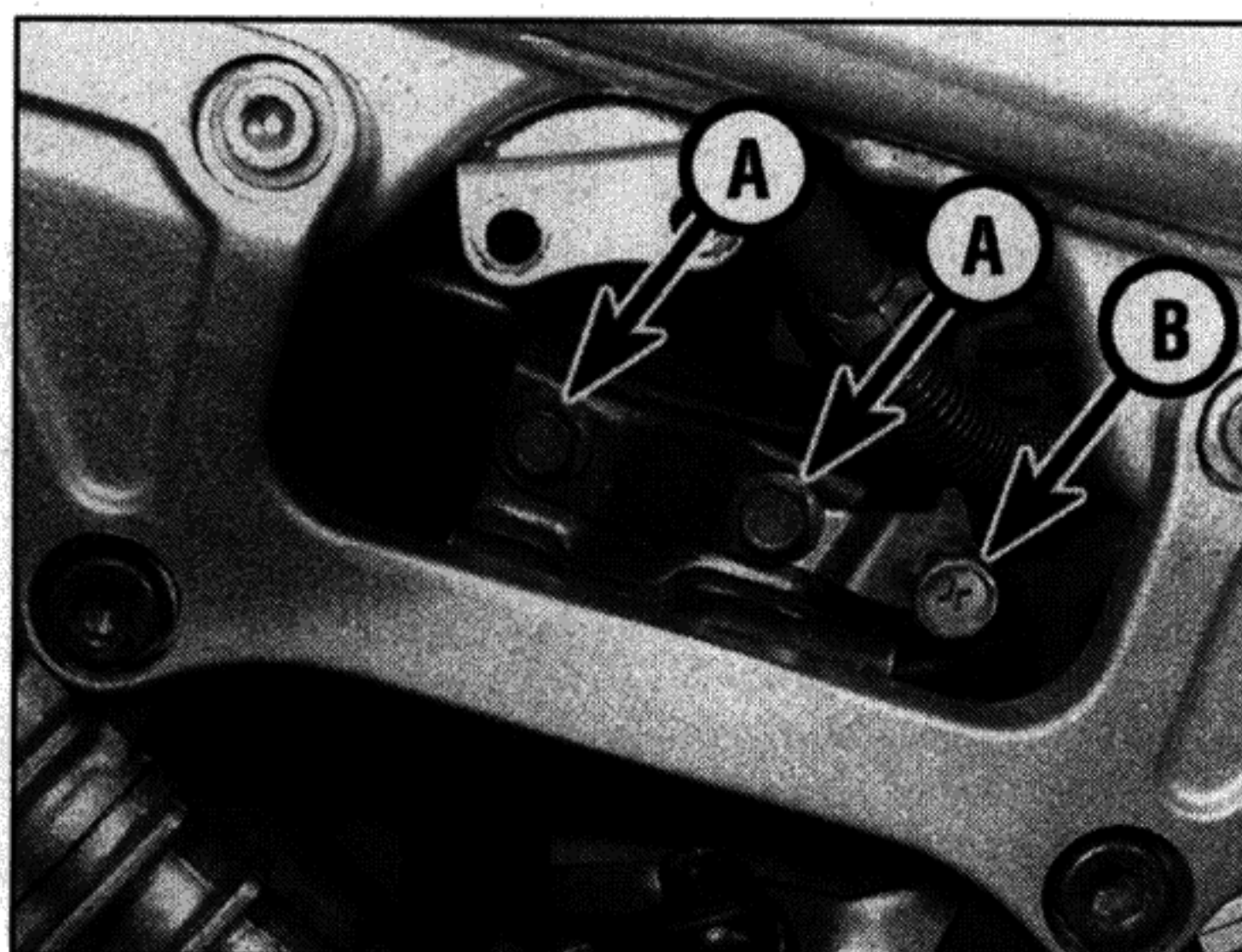
16.32b . . . then fit the cover



16.33 With the freeplay taken up the marks (arrowed) should align - TDM shown



17.1a Unscrew the two bolts (arrowed) and displace the tap



17.1b Unscrew the two bolts (A) securing the cable bracket, noting the idle speed adjuster (B)



17.1c Bend back the retaining tab . . .

17 Clutch cable – removal and installation

1 On TDM models, unscrew the two bolts securing the fuel tap and displace the tap (**see illustration**). Now unscrew the two bolts securing the cable bracket to the left-hand engine mounting bracket and detach the bracket, noting how the rear bolt also secures the idle speed adjuster (**see illustration**). Bend back the retaining tab securing the cable end in the clutch operating mechanism lever and disconnect the cable, noting how it

fits (**see illustrations**).

2 On TRX and XTZ models, fully slacken the adjuster nuts on the threaded section in the cable bracket on the right-hand side of the engine and slip the adjuster out of the bracket (**see illustration**). On TRX models, first remove the adjuster cover (**see illustration**). Disconnect the cable end from the clutch operating mechanism lever, noting how it fits (**see illustrations 17.1c and d**).

3 On all models fully slacken the locking on the adjuster at the handlebar end of the cable then screw the adjuster fully in (**see illustration**). This resets it to the beginning of its adjustment span.

4 Align the slots in the adjuster and lockwheel

with that in the lever bracket, then pull the outer cable end from the socket in the adjuster and release the inner cable from the lever (**see illustrations**). Remove the cable from the machine, noting its routing and any guides or clips.

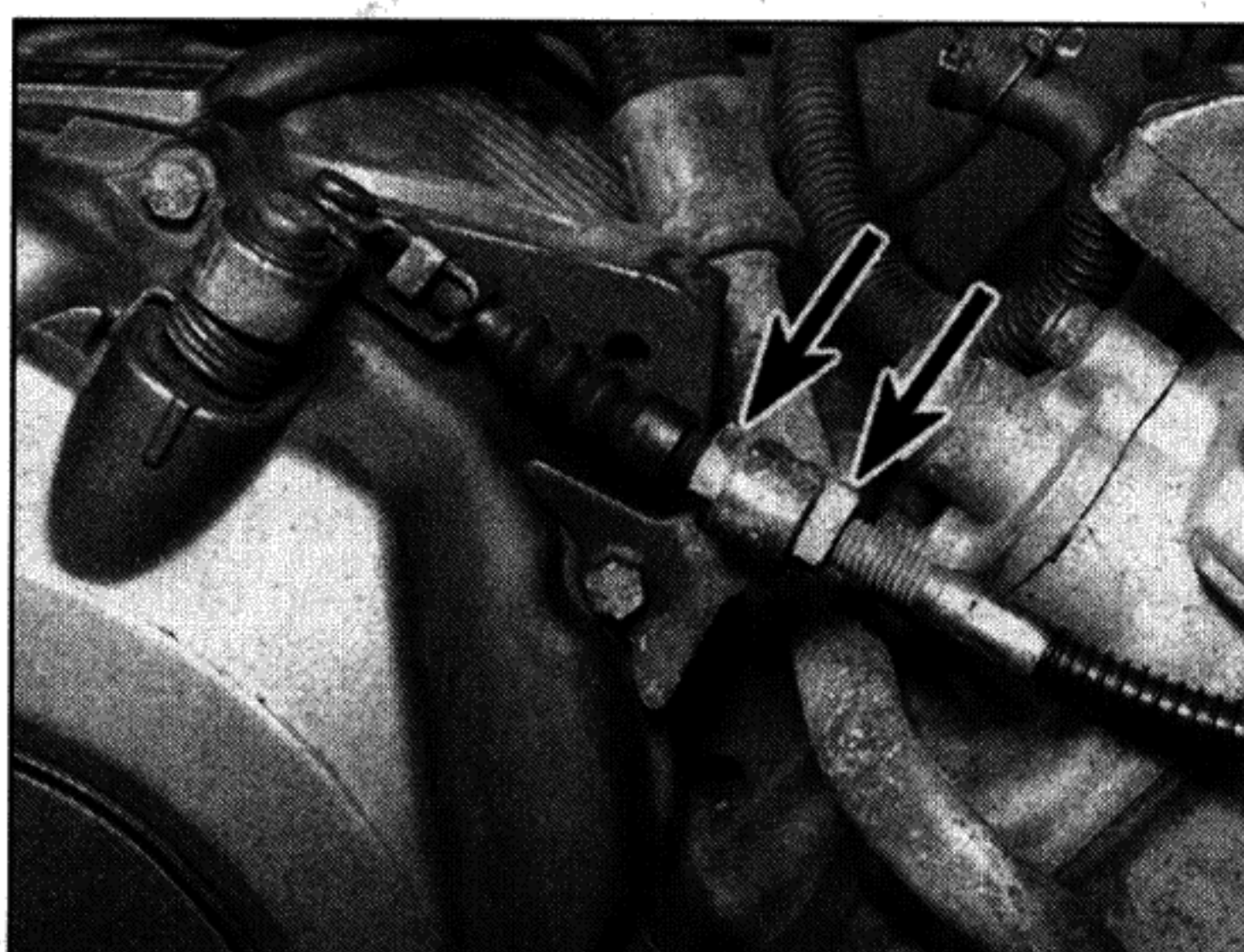
HAYNES
HiNT

Before removing the cable from the bike, tape the lower end of the new cable to the upper end of the old cable.

Slowly pull the lower end of the old cable out, guiding the new cable down into position. Using this method will ensure the cable is routed correctly.



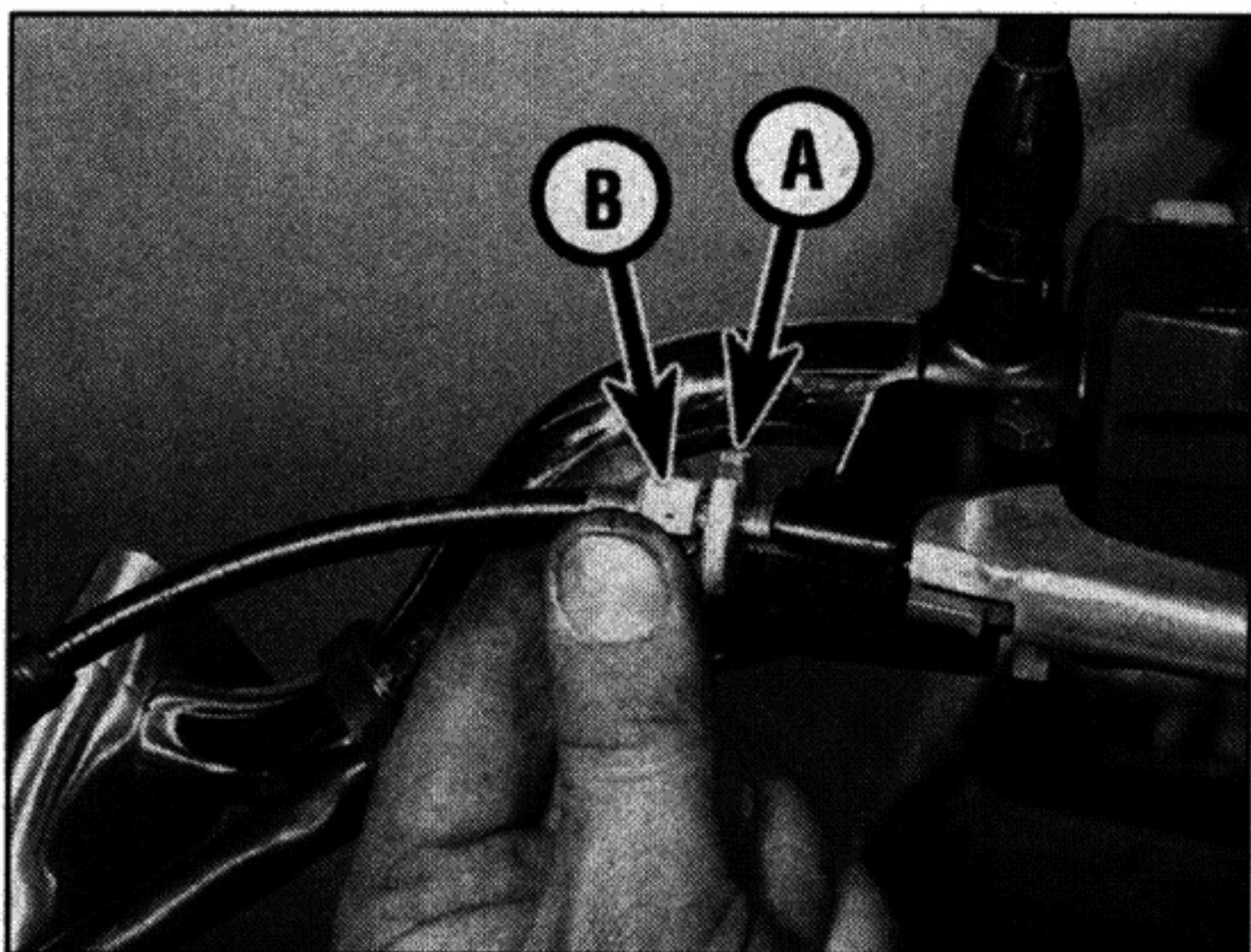
17.1d . . . and detach the cable



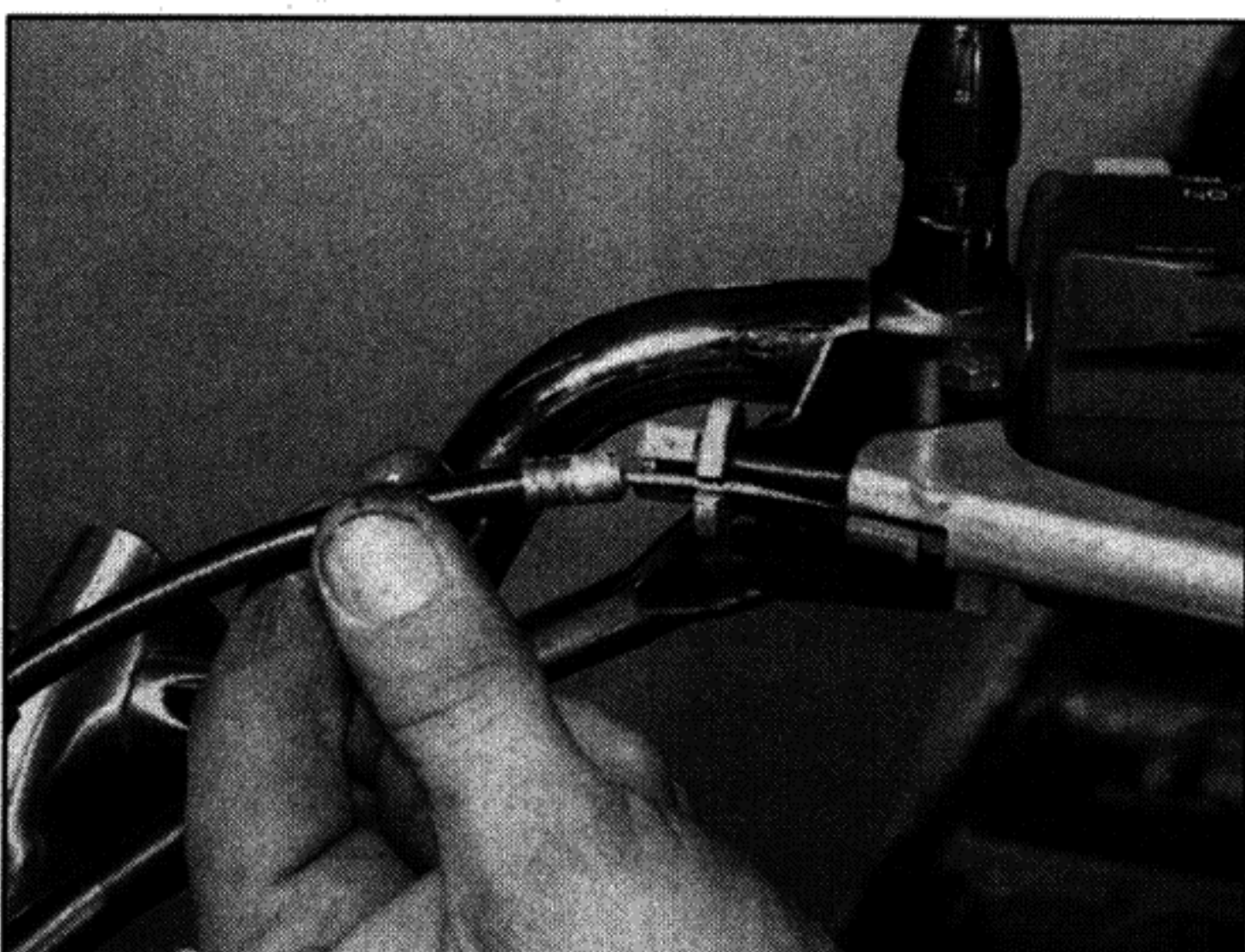
17.2a Slacken the nuts (arrowed) and slip the cable out of the bracket



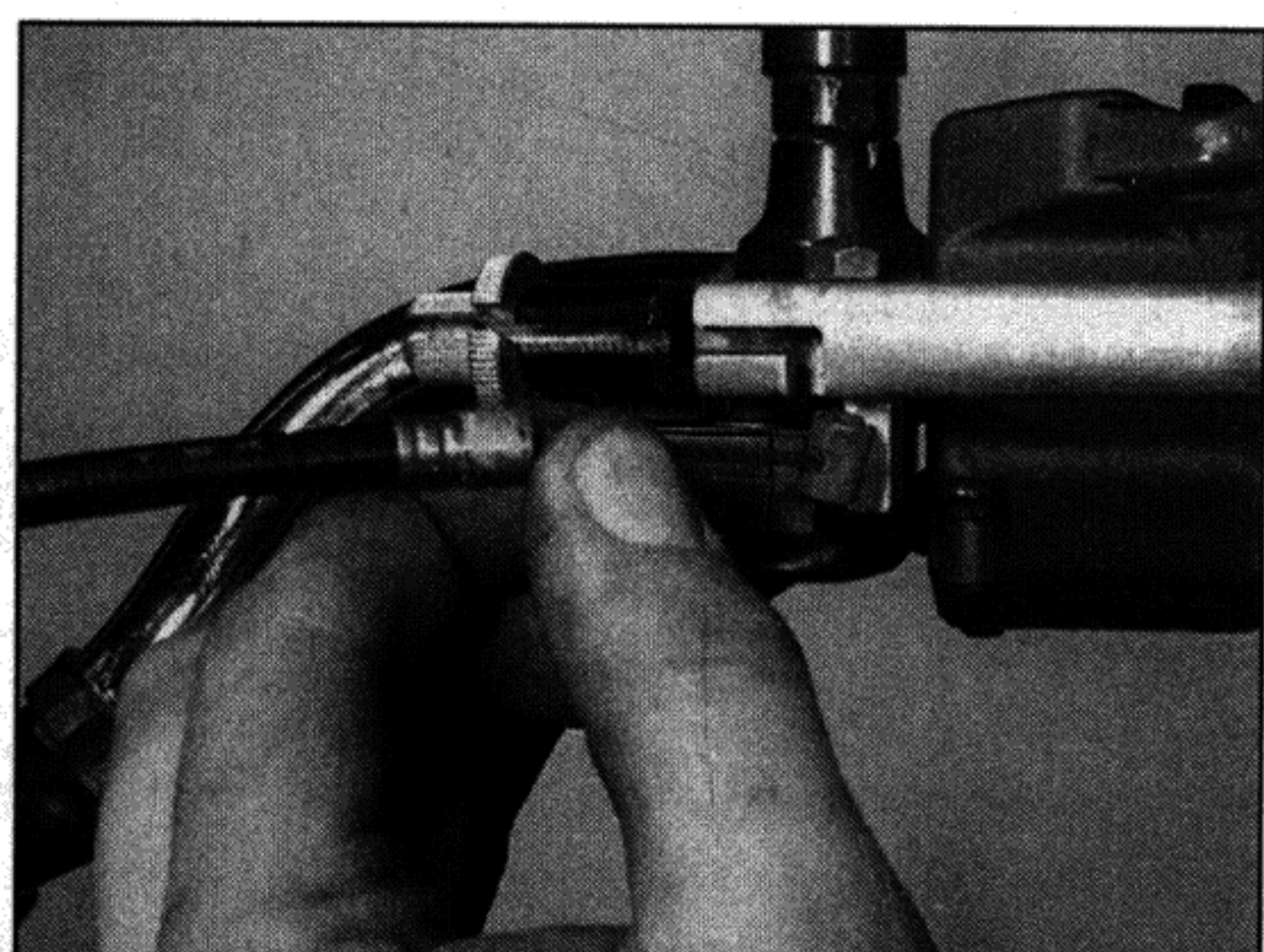
17.2b On TRX models, first remove the cover



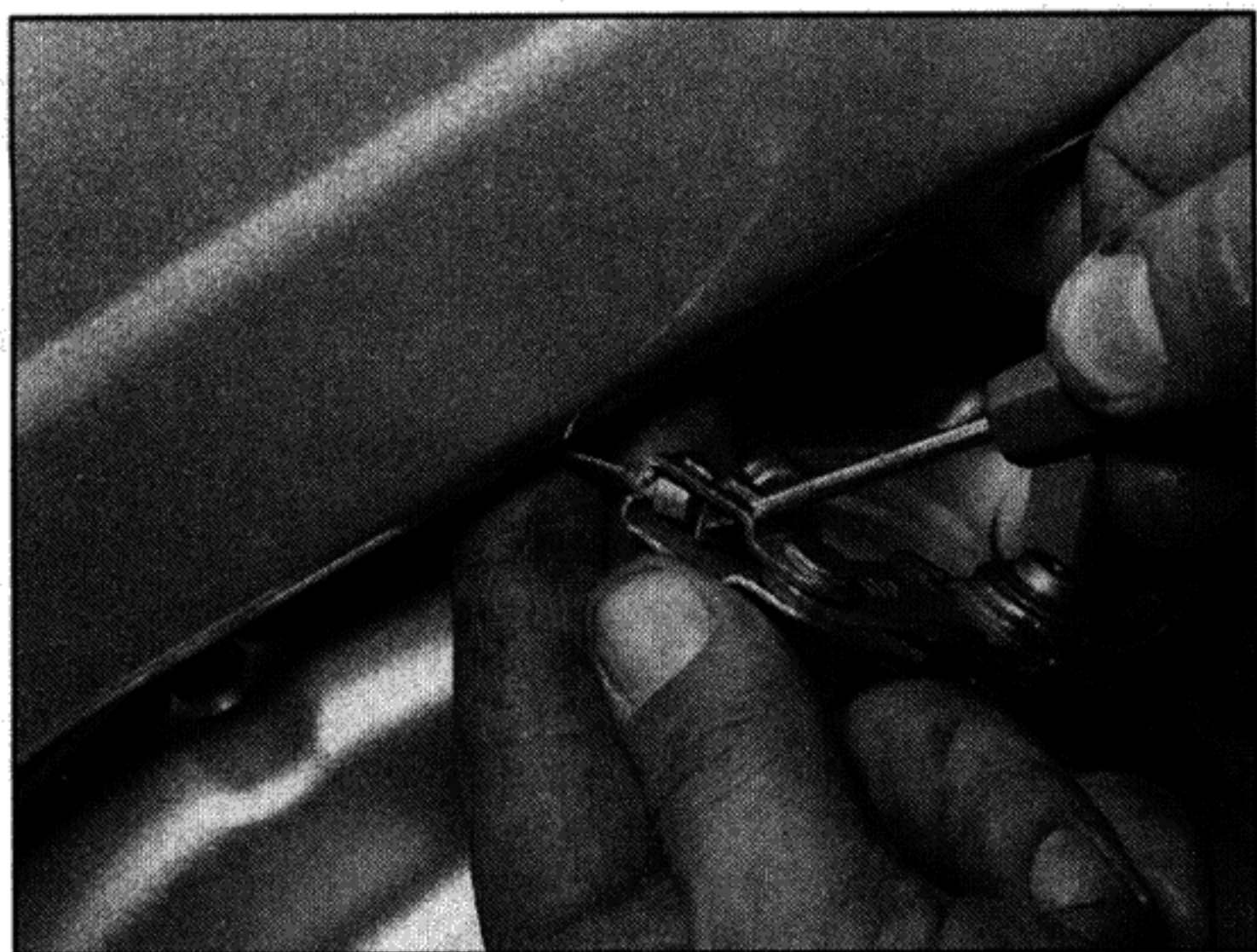
17.3 Slacken the lockring (A) and thread the adjuster (B) in



17.4a Align the slots and slip the cable out of the bracket . . .



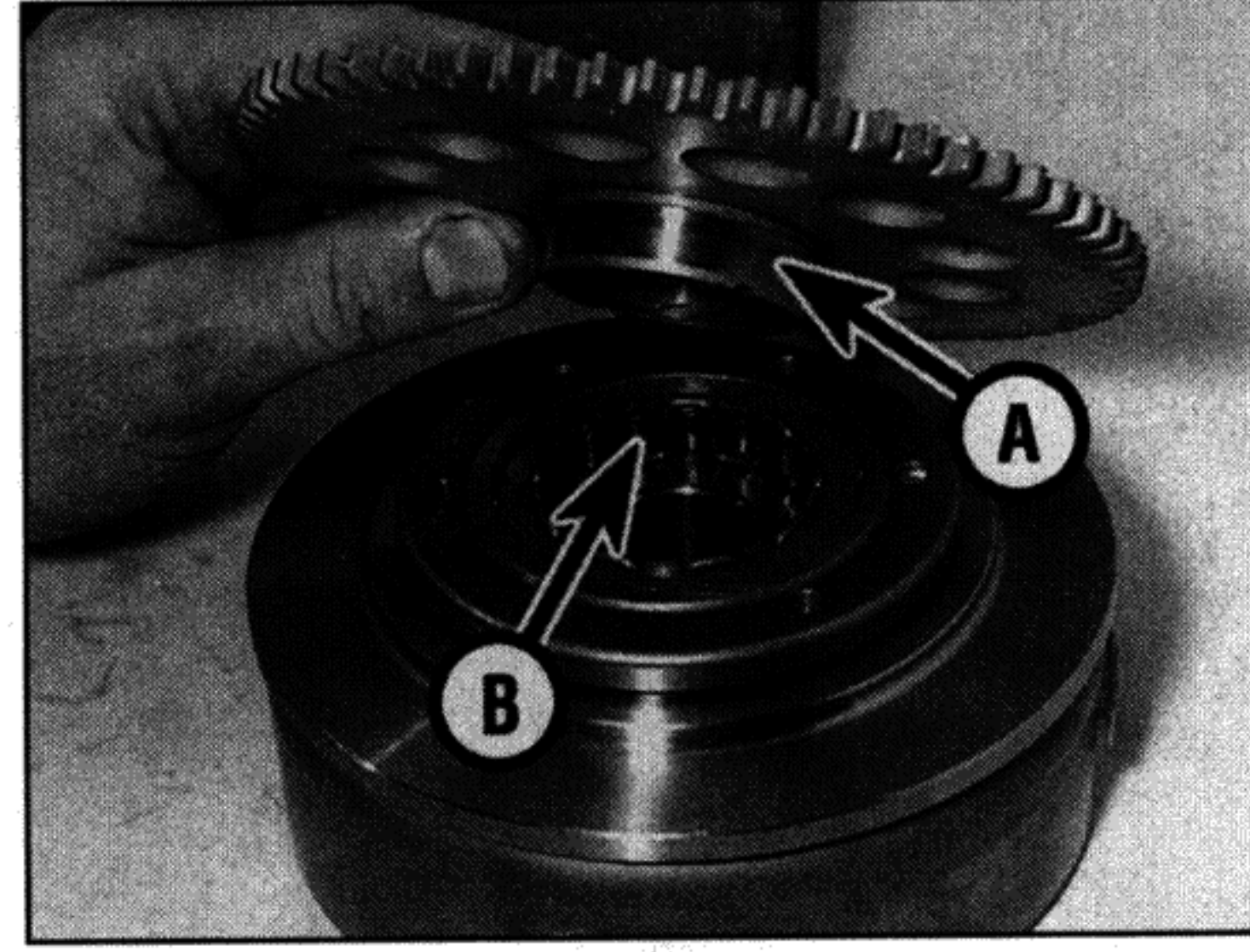
17.4b . . . and the nipple from the lever



17.5 Bend the tab to secure the cable in the lever



18.2 The gear should rotate freely in the direction shown



18.4 Check the surface of the hub (A) and the sprags (B) as described

5 Installation is the reverse of removal. Apply grease to the cable ends. Make sure the cable is correctly routed. Secure the cable end in the operating lever by bending the tab against it (see illustration). Adjust the amount of clutch lever freeplay (see Chapter 1).

18 Starter clutch and idle/reduction gear – removal, inspection and installation



Removal

1 Remove the alternator rotor (see Chapter 9). The starter driven gear should come away with the rotor. If it doesn't, remove it from the crankshaft. The starter clutch is secured to the back of the rotor by three Allen bolts on the inside of the rotor.

Inspection

2 Install the starter driven gear into the starter clutch (if removed) and, with the rotor face down on a workbench, check that the gear rotates freely in an anti-clockwise direction and locks against the rotor in a clockwise direction (see illustration). If it doesn't, renew the starter clutch – no replacement parts are available.

3 Withdraw the starter driven gear from the

starter clutch (see illustration 18.4). If it appears stuck, rotate it anti-clockwise as you withdraw it to free it from the starter clutch. Note the thrust washer fitted inside the starter clutch and remove it for safekeeping (see illustration 18.7).

4 Check the bearing surface of the starter driven gear hub and the condition of the sprags inside the clutch body (see illustration). If the bearing surface shows signs of excessive wear or the sprags are damaged, marked or flattened at any point, the starter clutch should be renewed.

5 Examine the teeth of the starter idle/reduction gear and the corresponding teeth of the starter driven gear and starter motor shaft. Renew the gears and/or starter motor if worn or chipped teeth are discovered.

6 To renew the starter clutch sprag assembly, hold the alternator rotor in a rotor holder then undo the three bolts securing the clutch to the rotor. Remove the clutch from the back of the rotor and install the new one back onto the rotor. Tighten the bolts to the torque setting specified at the beginning of the Chapter, using the rotor holder to hold the rotor. Lubricate the starter clutch sprags with new engine oil.

Installation

7 Install the thrust washer in the starter clutch (see illustration). Lubricate the hub of the

starter driven gear with clean engine oil, then install it into the clutch, rotating it clockwise as you do so to spread the rollers and allow the hub of the gear to enter (see illustration 18.4).

8 Install the alternator rotor (see Chapter 9).

19 Gearchange mechanism external components – removal, inspection and installation



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

Removal

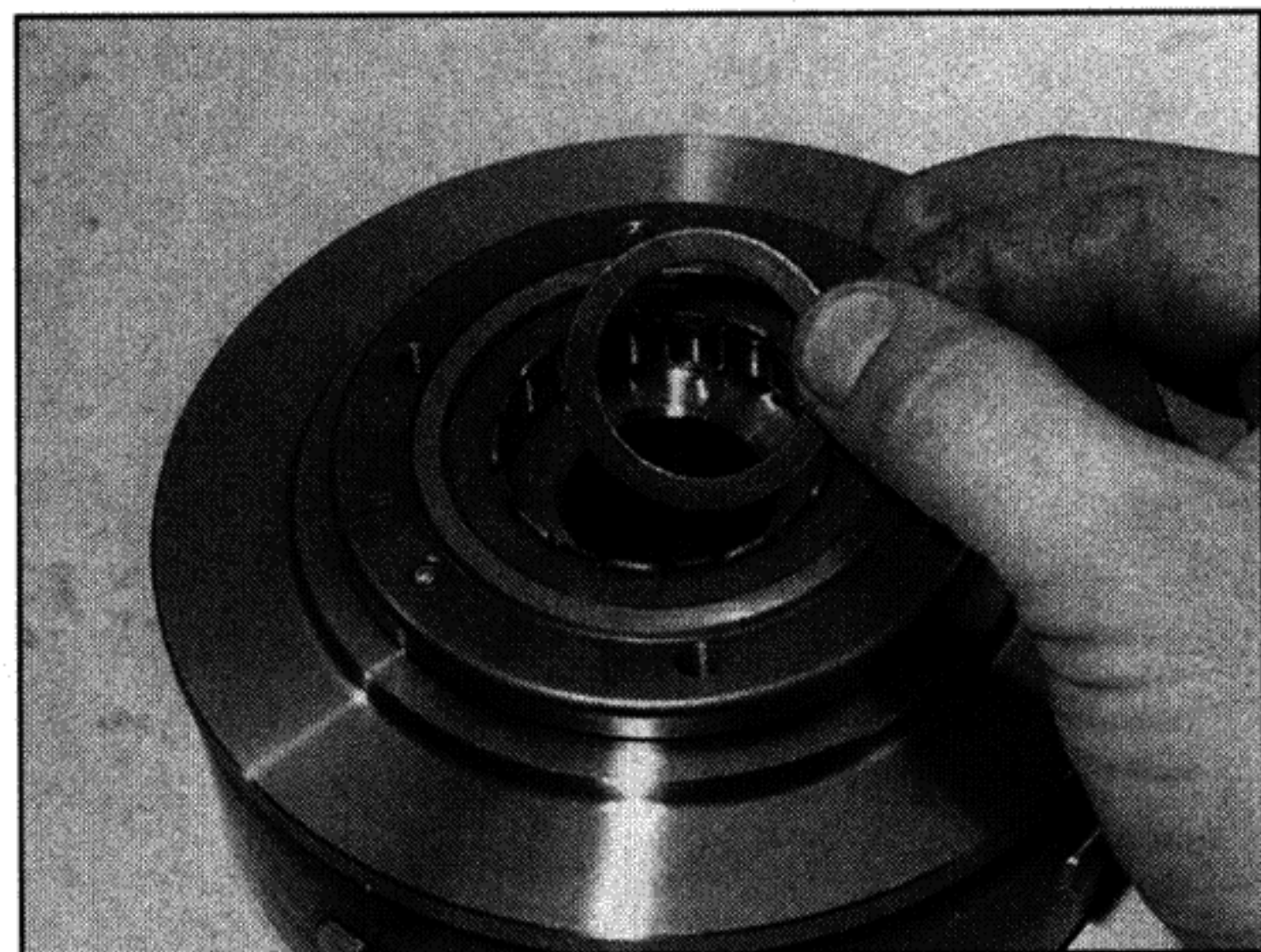
1 Make sure the transmission is in neutral.

2 Remove the alternator cover (see Chapter 9). If required, disconnect the alternator and pick-up coil wiring connectors, otherwise ignore those Steps and lay the cover down so as not to strain the wiring.

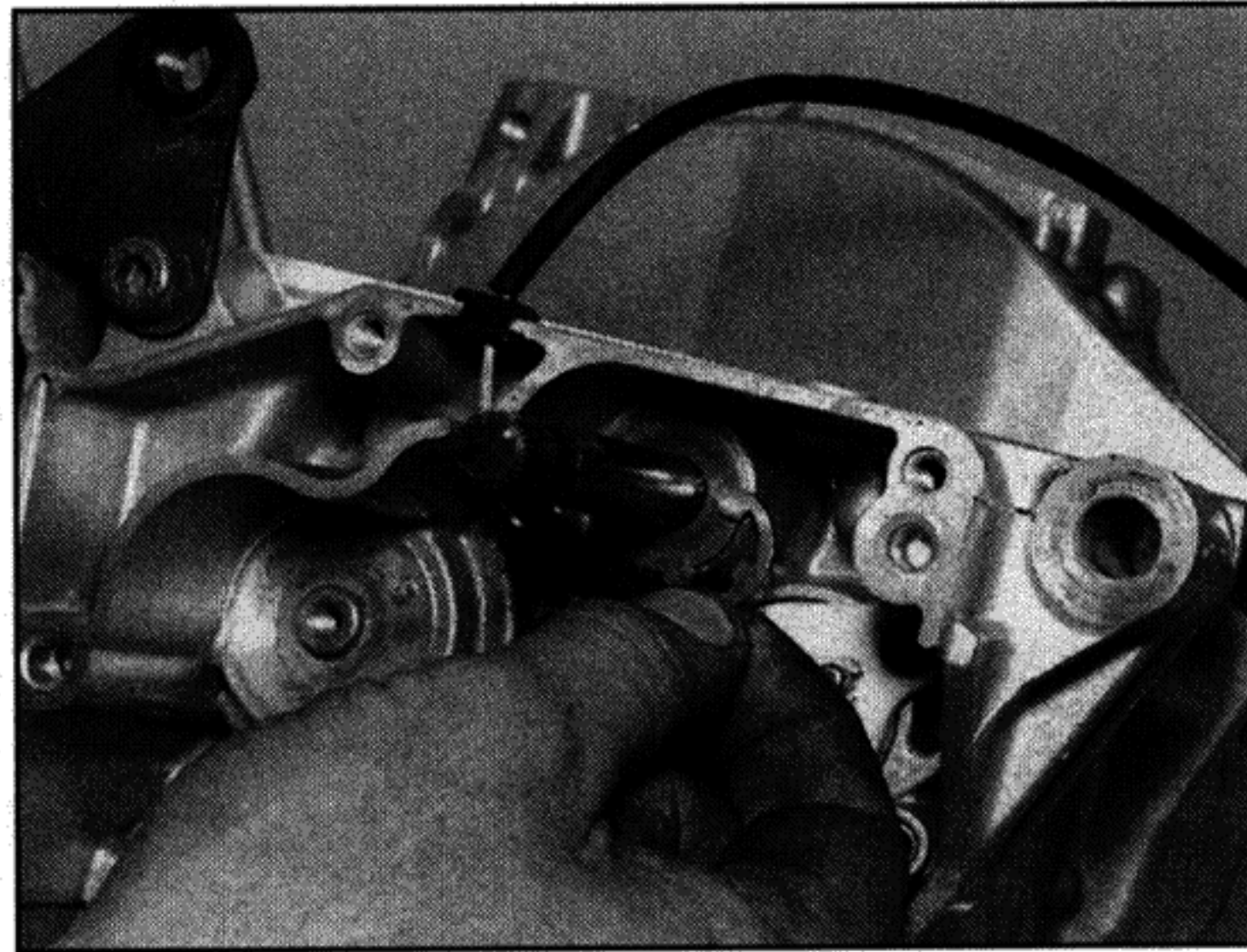
3 Remove the clutch (see Section 16).

4 Remove the E-clip securing the left-hand end of the gearchange shaft in the crankcase, and slide the washer off the shaft (see illustrations).

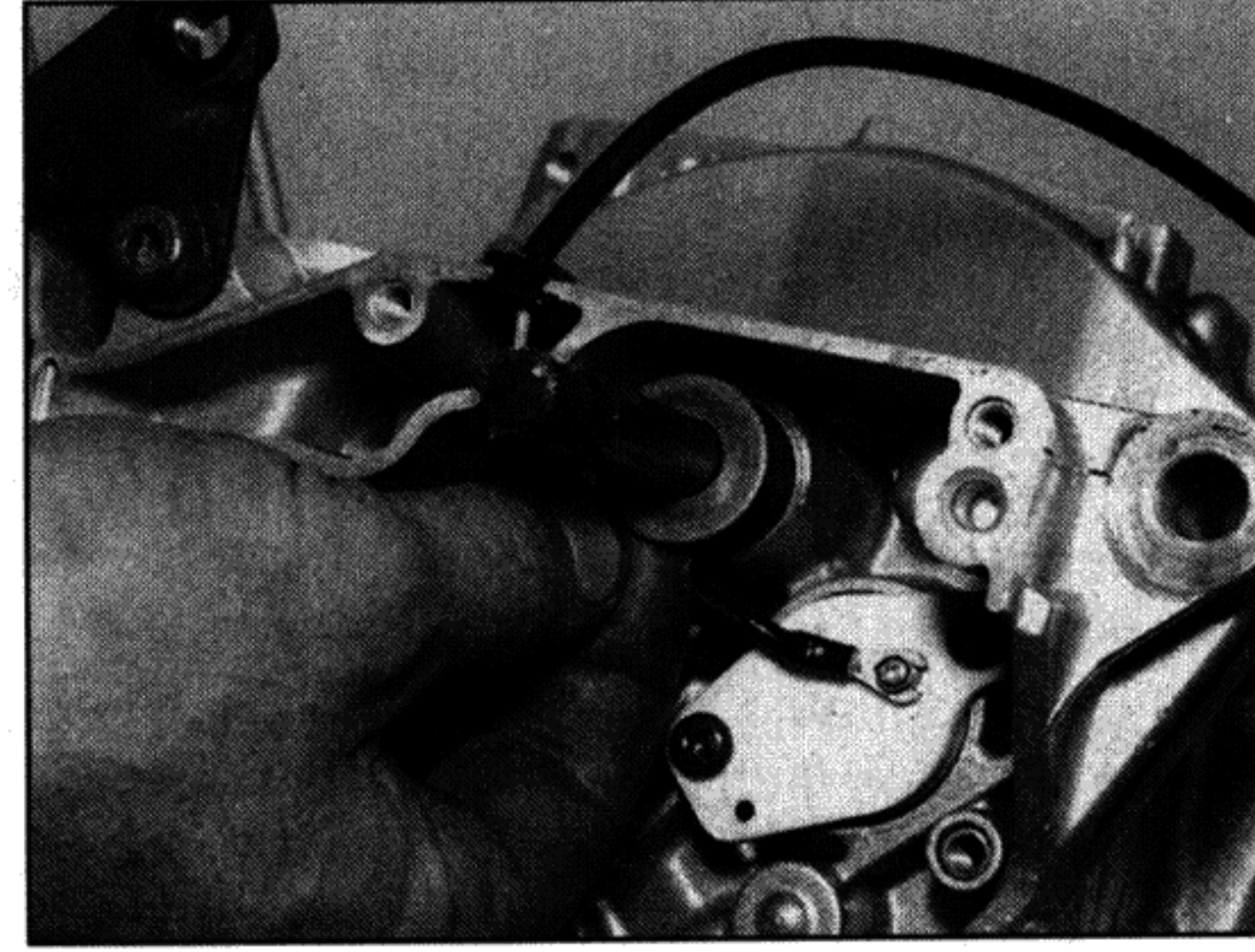
5 Note how the gearchange shaft centralising spring ends fit on each side of the locating pin in the casing, and how the pawls on the



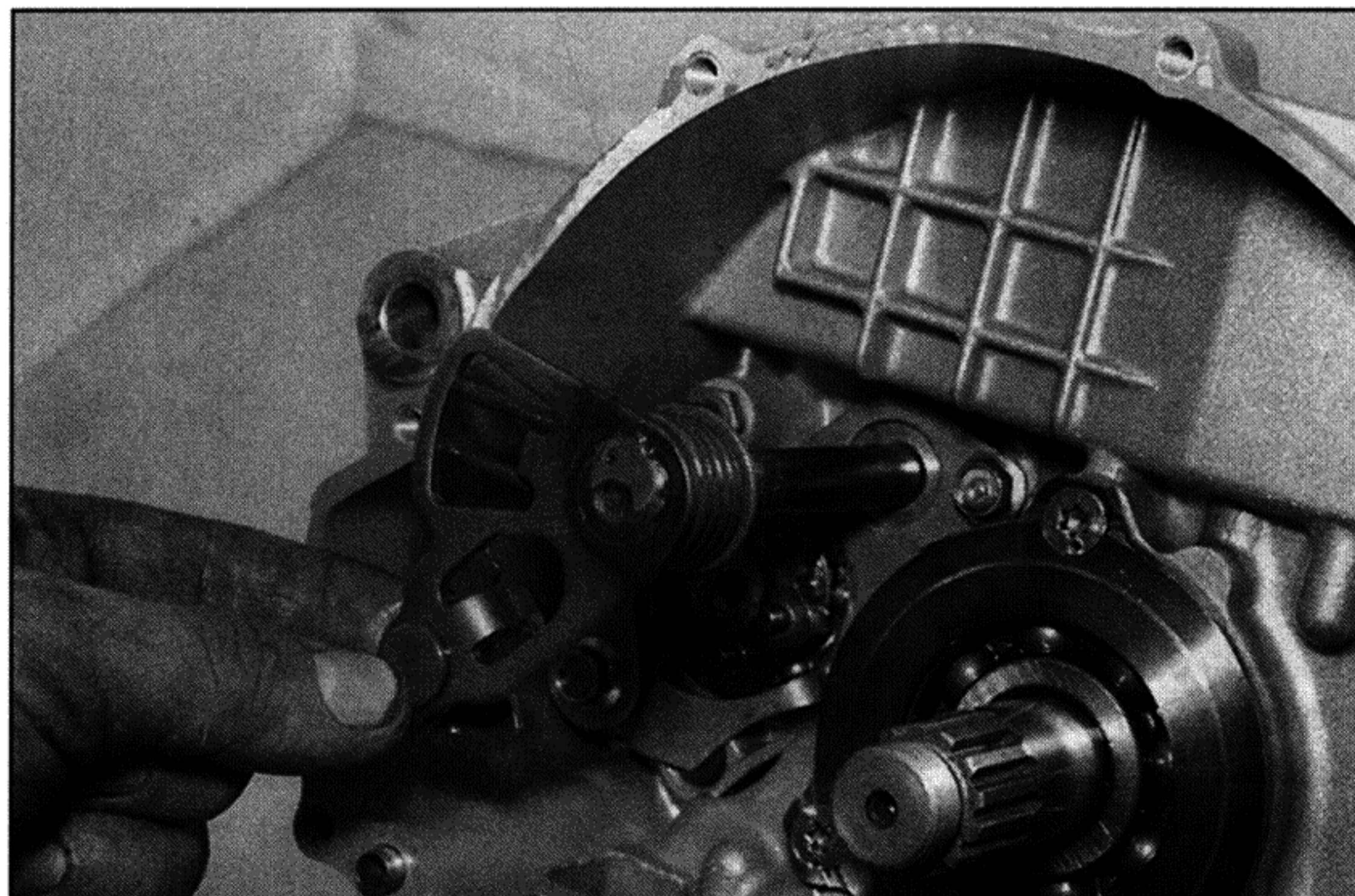
18.7 Do not omit the thrust washer



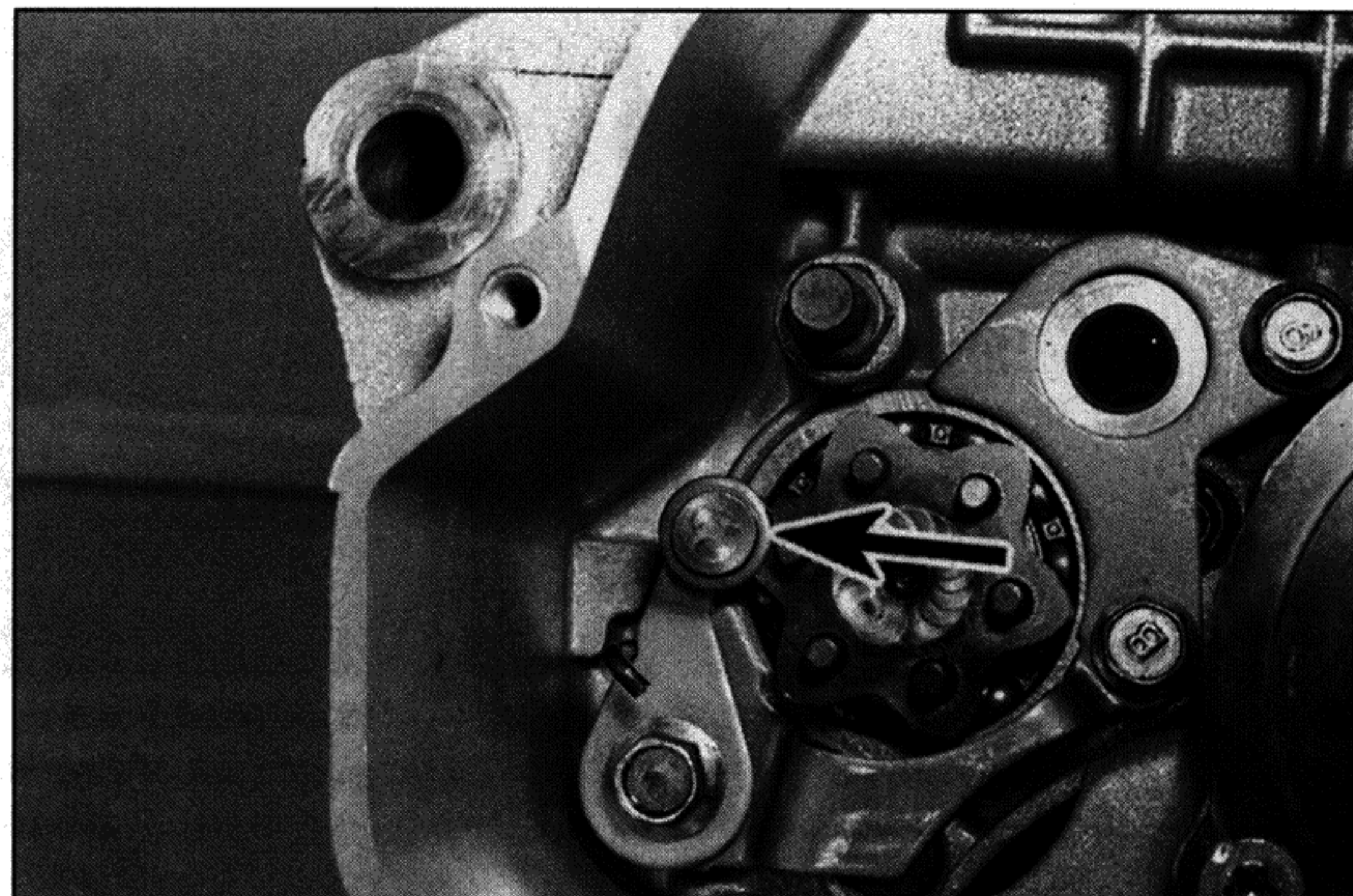
19.4a Remove the E-clip ...



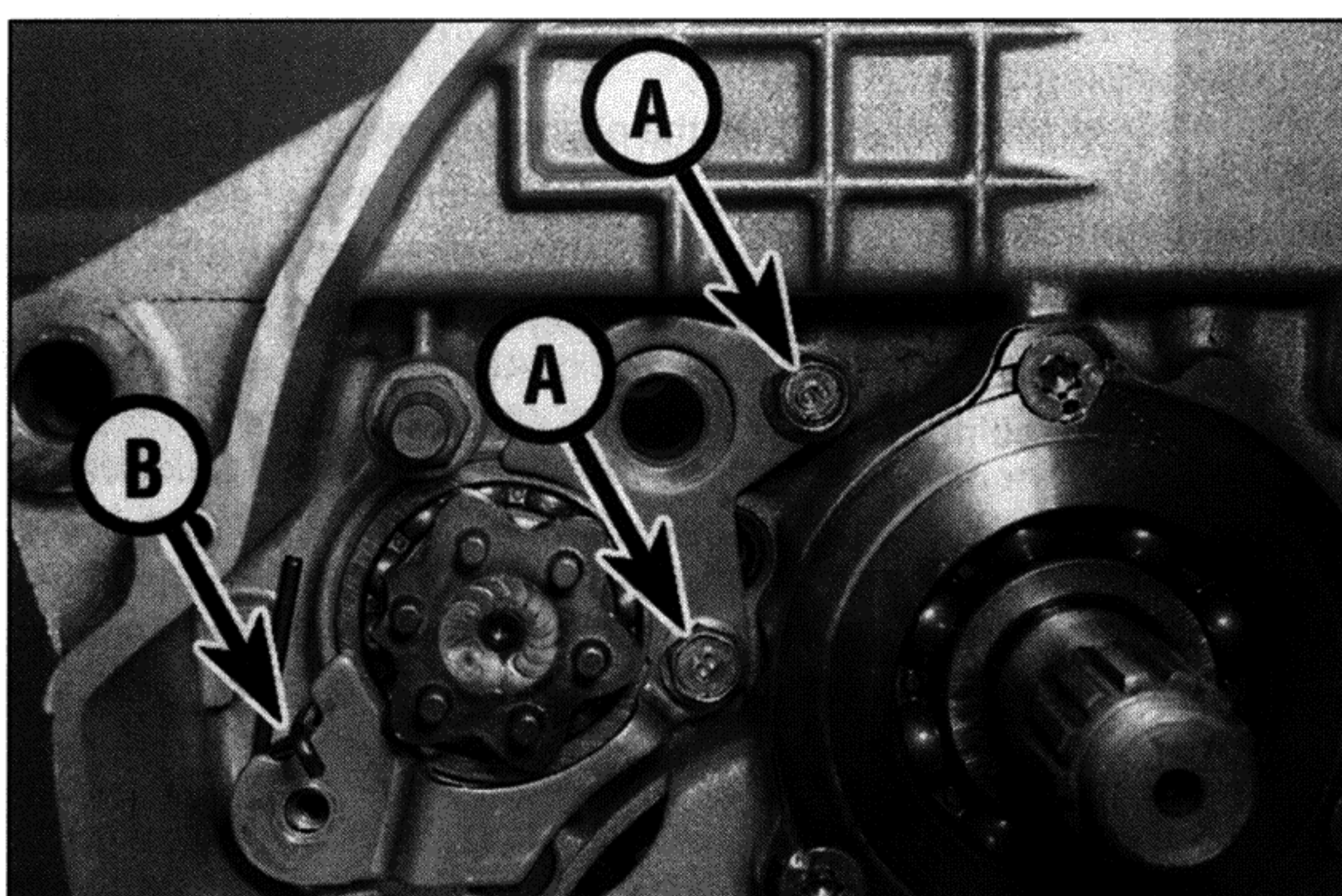
19.4b ... and slide off the washer



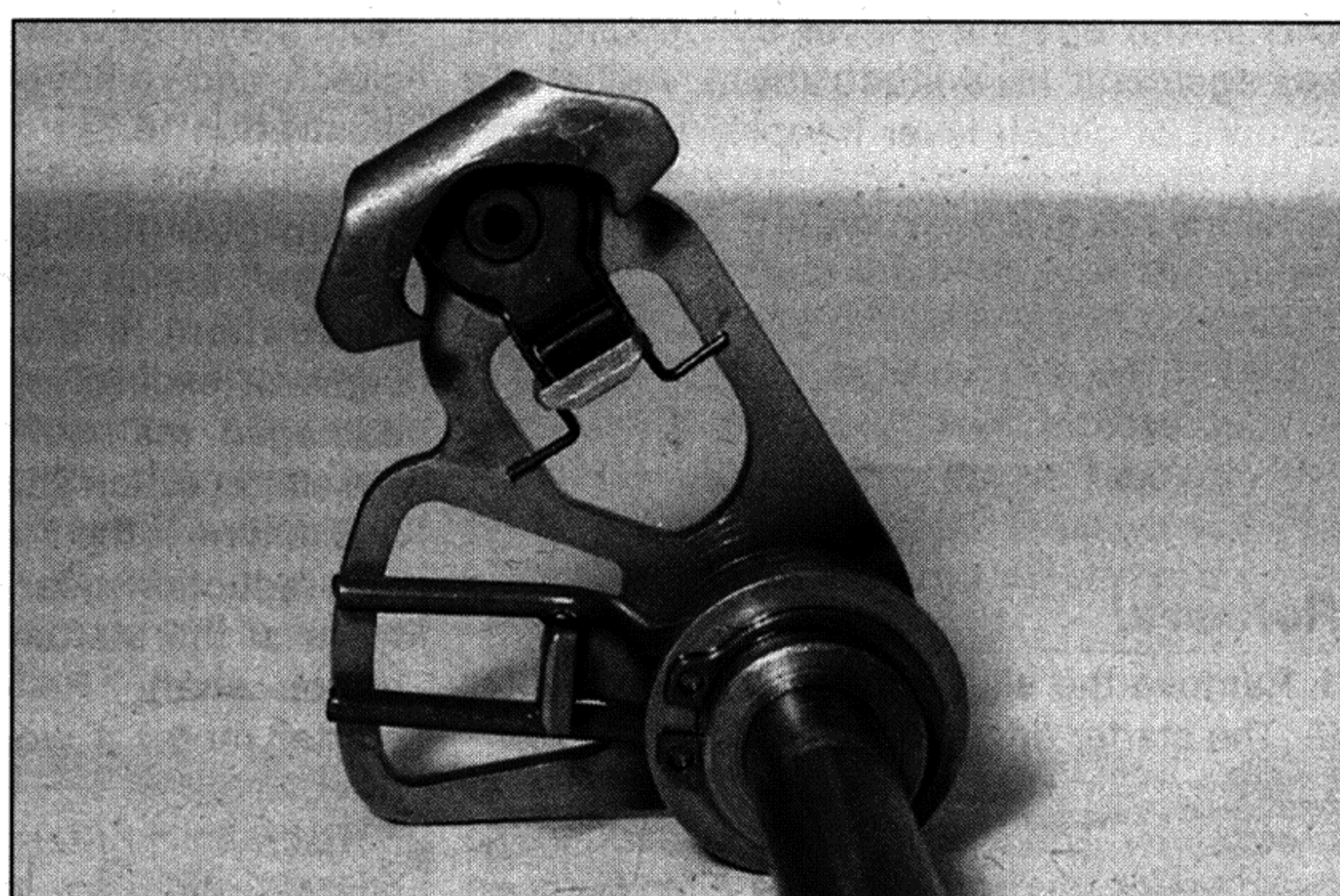
19.5 Draw the gearchange shaft and selector arm assembly off the selector drum and out of the casing



19.6a Note how the roller locates in the neutral detent (arrow), then unscrew the bolt and remove the stopper arm



19.6b If required, unscrew the bolts (A) and remove the plate and the spring (B)



19.8 Gearchange shaft centralising spring can be removed after releasing circlip and washer from shaft

selector arm locate onto the pins on the end of the selector drum (see illustration 19.12). Grasp the end of the shaft and withdraw the shaft/arm assembly (see illustration).

6 Note how the stopper arm spring ends locate and how the roller on the arm locates in the neutral detent on the selector drum (gearbox in neutral), then unscrew the stopper arm bolt and remove the arm, and on 1996-on TDM models and all TRX models, the spacer (see illustration). To remove the spring, unscrew the two remaining bolts securing the selector drum retainer plate and remove the plate – the spring sits behind the plate (see illustration).

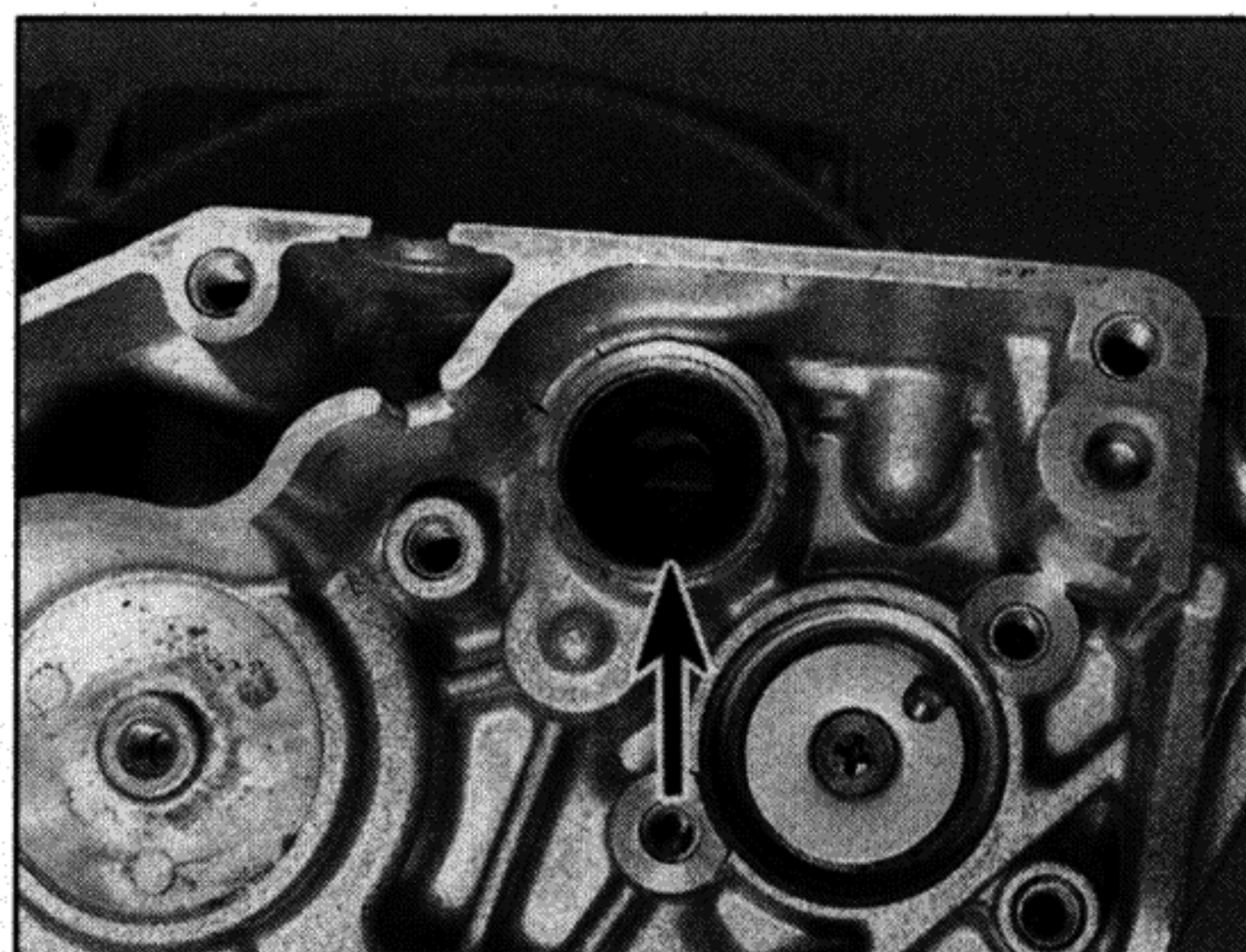
Inspection

7 Check the selector arm for cracks, distortion and wear of its pawls, and check for any corresponding wear on the selector pins in the selector drum. Also check the stopper arm roller and the detents in the selector drum for any wear or damage, and make sure the roller turns freely. Renew any components that are worn or damaged.

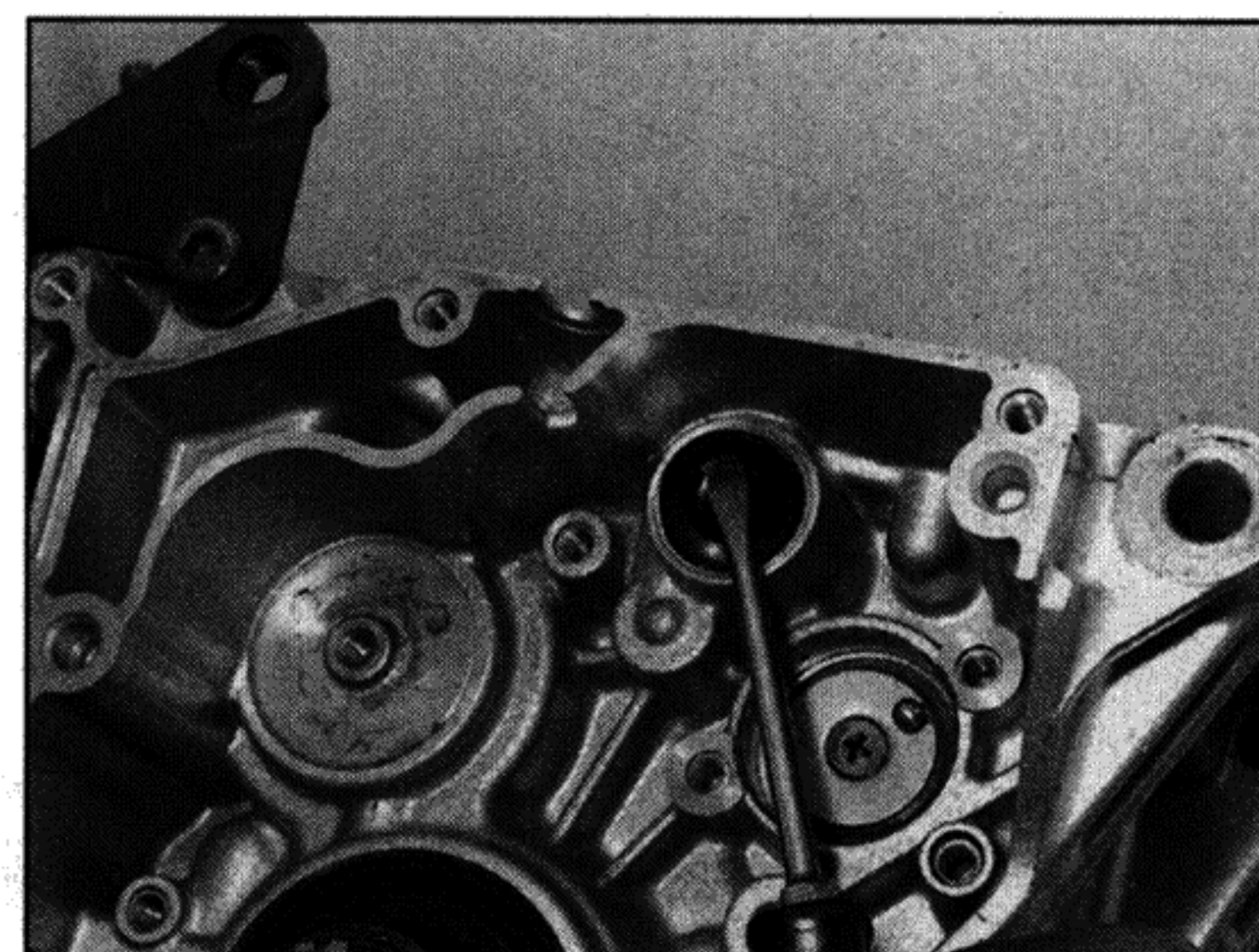
8 Inspect the shaft centralising spring (see illustration) and the stopper arm return spring for fatigue, wear or damage; renew them if necessary. The centralising spring is retained on the shaft by a circlip and washer – a new circlip should be used if removed. The stopper arm spring is secured by the retainer plate (see Step 6). 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 securely.

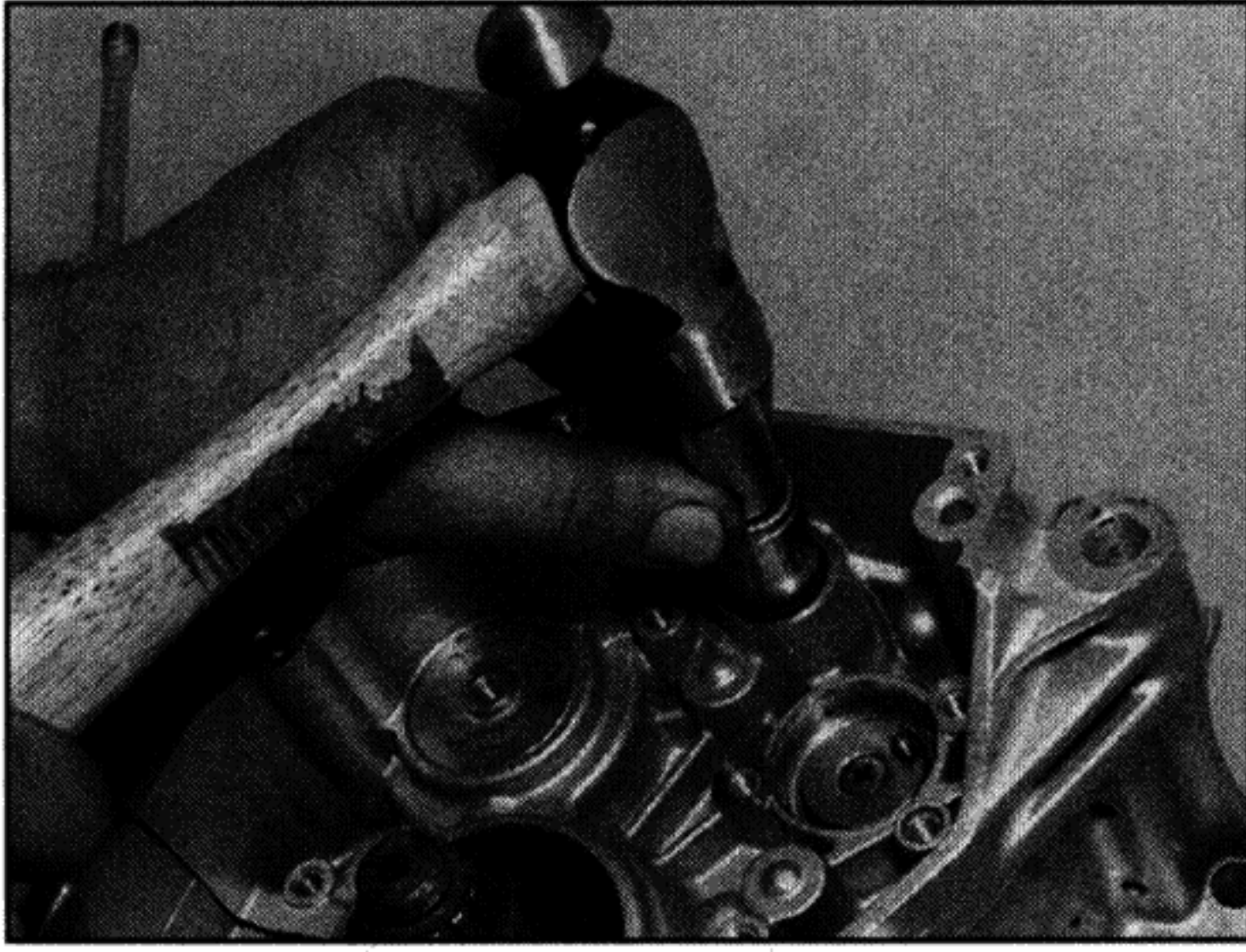
9 Check the gearchange shaft for straightness and damage to the splines. If the shaft is bent you can attempt to straighten it, but if the splines are damaged the shaft must be renewed. Also check the condition of the shaft oil seal in the left-hand side of the crankcase (see illustration). If it is damaged,



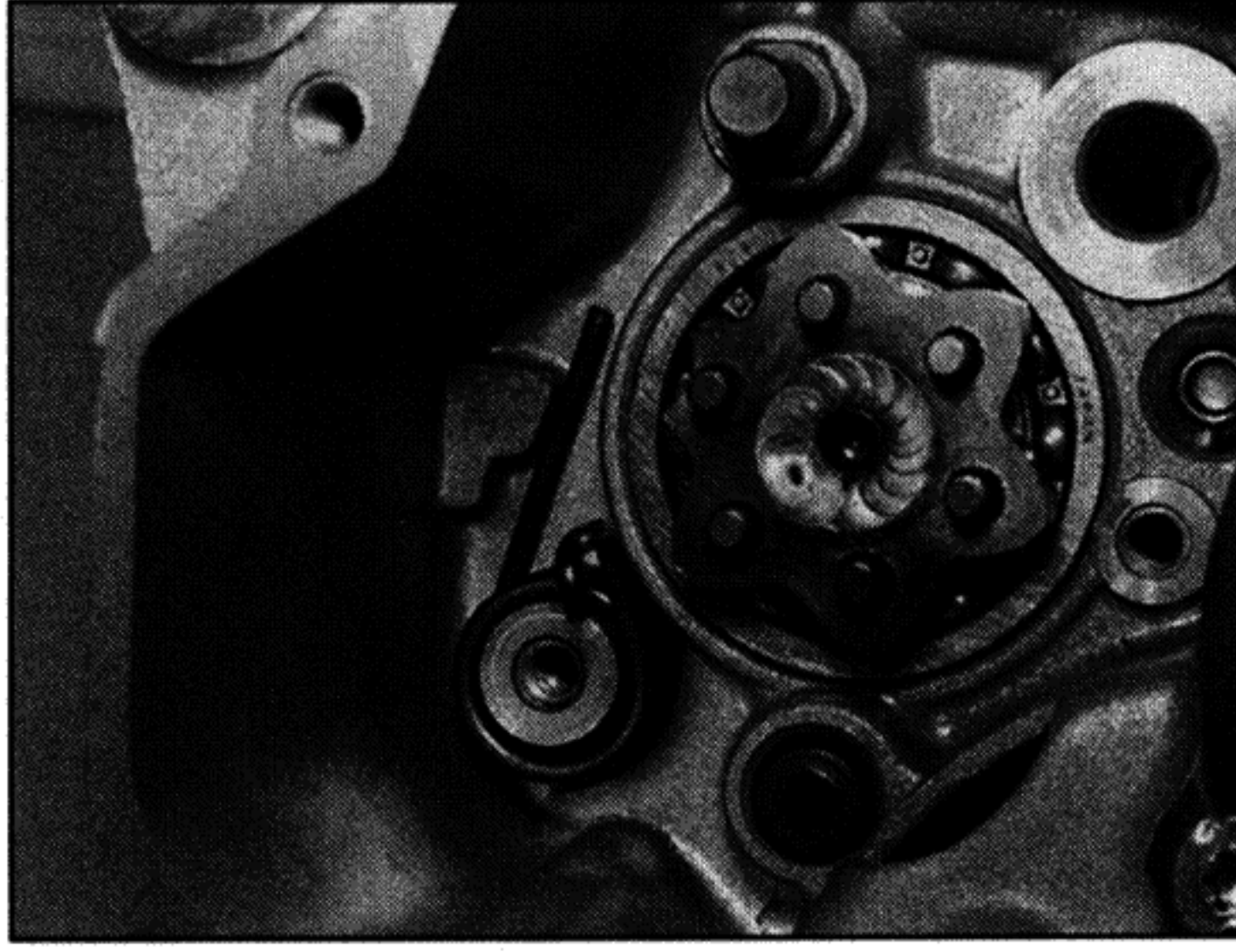
19.9a Check the shaft oil seal (arrowed)



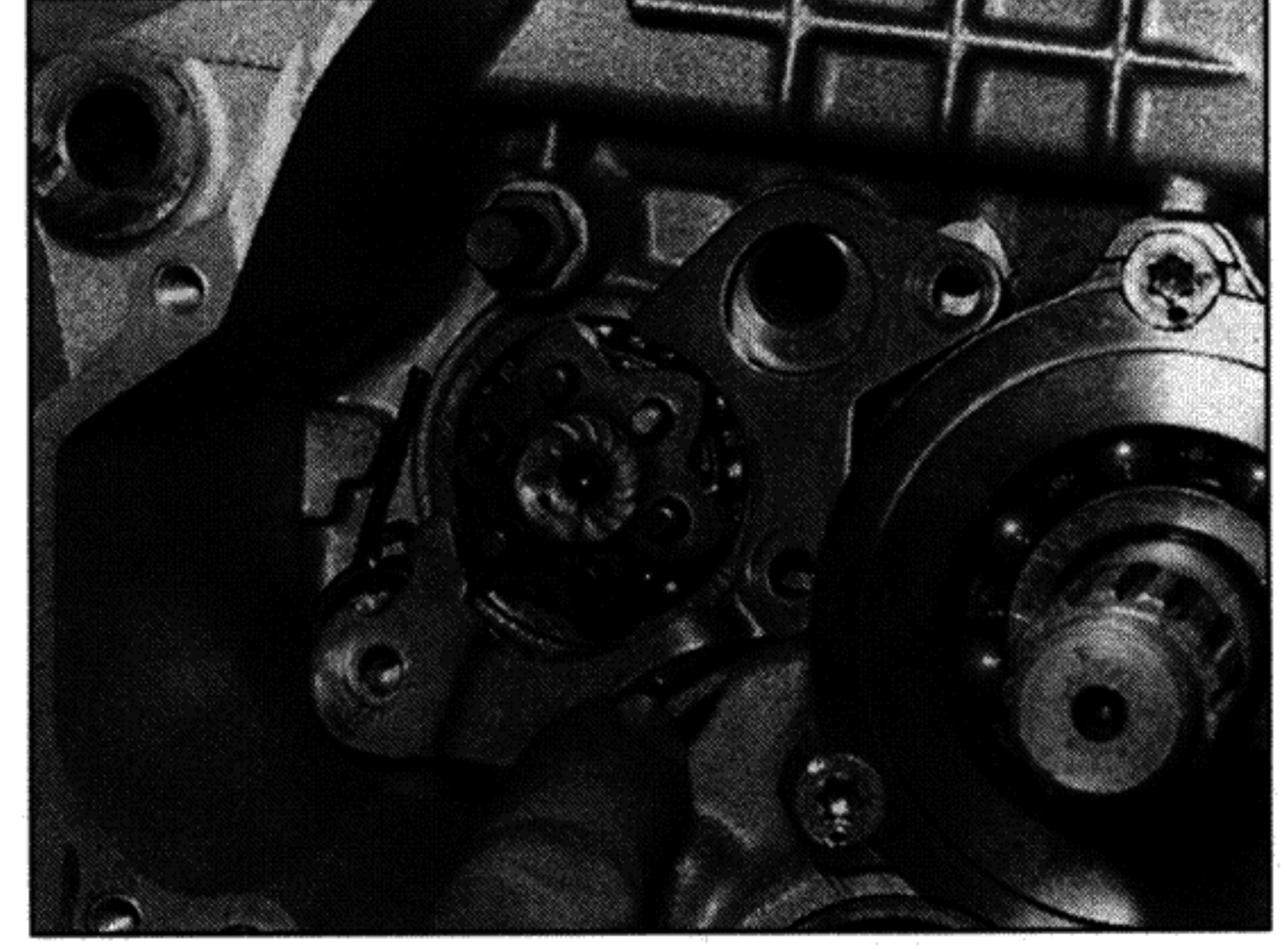
19.9b If required, lever out the old seal . . .



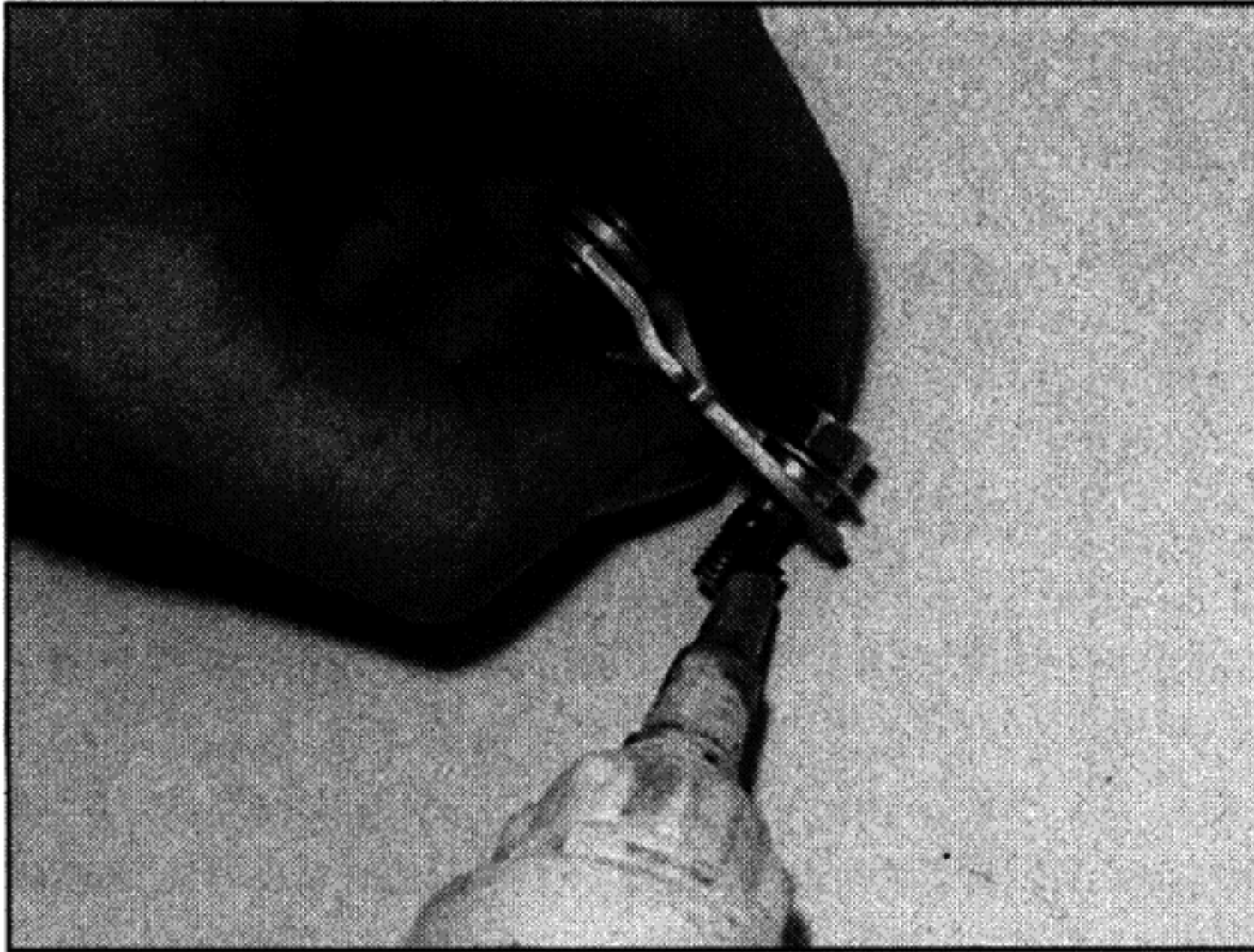
19.9c ... and press or drive a new one in



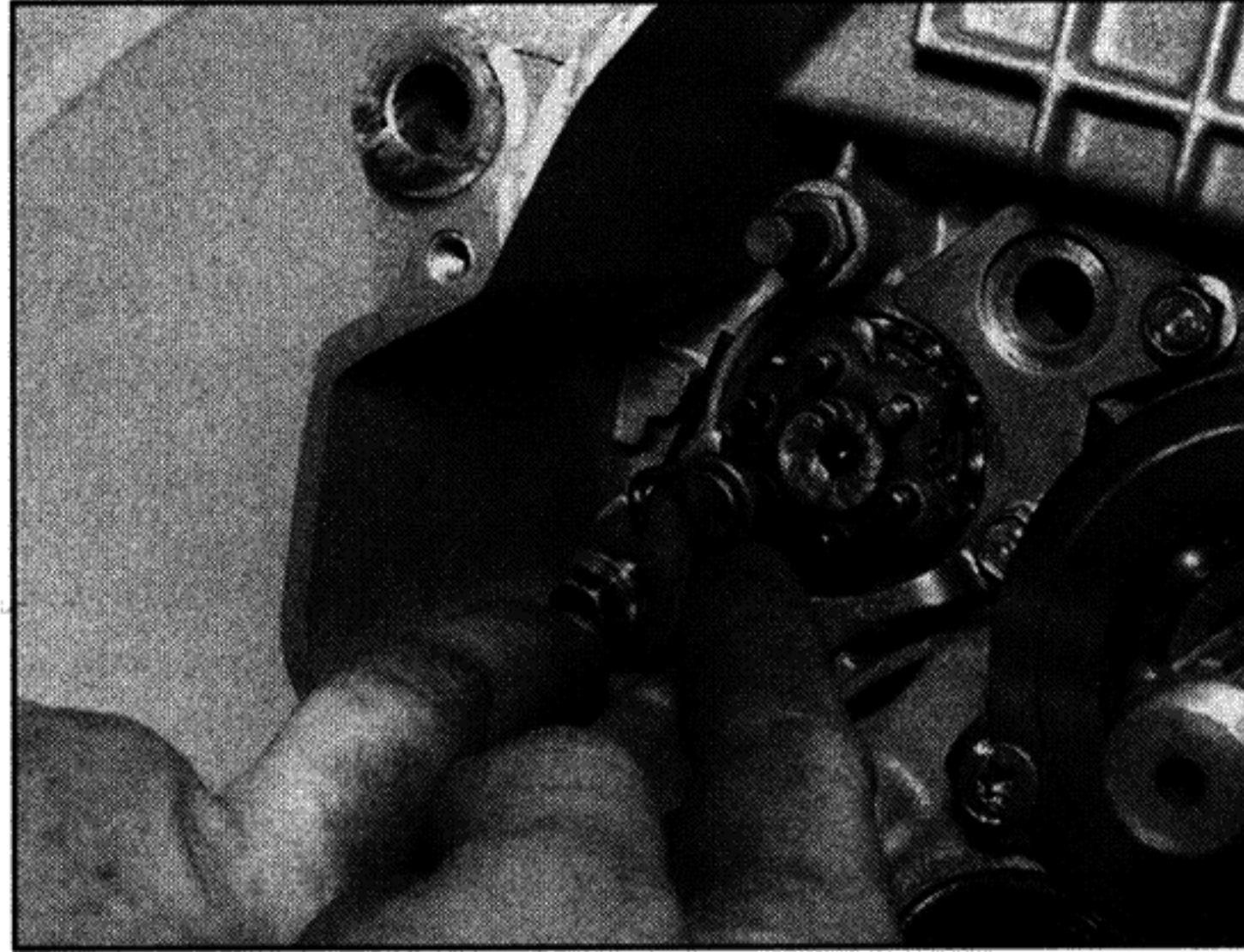
19.10a Locate the stopper arm spring ...



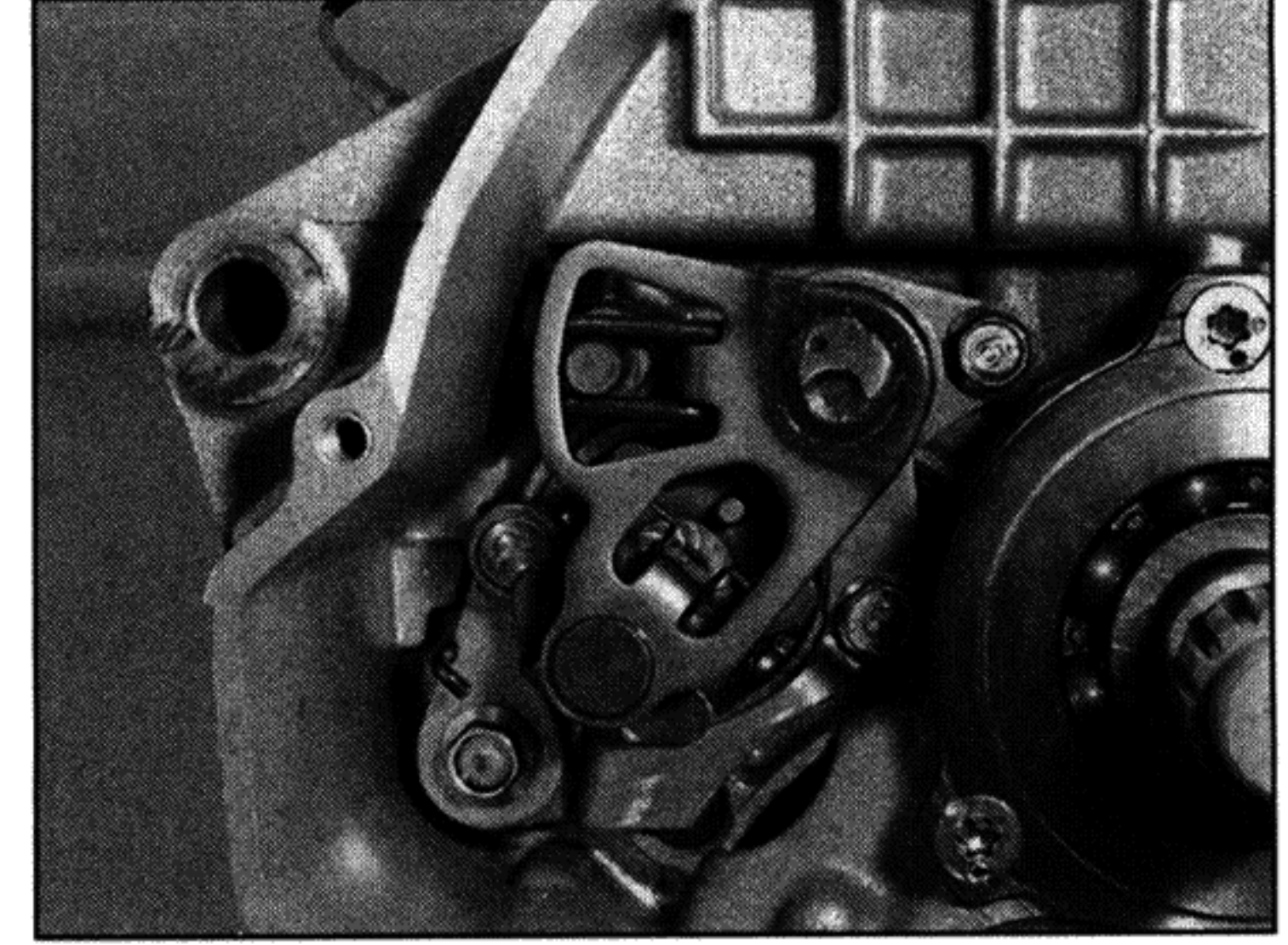
19.10b ... then fit the retainer plate



19.11a Apply thread lock to the bolt ...



19.11b ... then fit the stopper arm into the neutral detent on the selector drum and make sure the spring ends locate correctly



19.12 The installed assembly should be as shown

deteriorated or shows signs of leakage it must be renewed. Lever out the old seal and drive the new one squarely into place, with its lip facing inward, using a seal driver or suitable socket (see illustrations).

Installation

10 If removed, locate the stopper arm spring, then install the selector drum retainer plate (see illustrations). Apply a suitable non-permanent thread locking compound to the two front bolts and tighten them to the torque setting specified at the beginning of the Chapter (see illustration 19.6b).

11 Apply a suitable non-permanent thread locking compound to the stopper arm bolt (see illustration). Install the stopper arm, and on 1996-on TDM models and all TRX models, the spacer, making sure the spring ends are positioned correctly (see illustration). Locate the arm onto the neutral detent on the selector drum, then tighten the bolt to the specified torque setting (see illustration 19.6a).

12 Slide the gearchange shaft into place and push it all the way through the case until the splined end comes out the other side (see illustration 19.5). Locate the selector arm pawls onto the pins on the selector drum. Make sure the centralising spring ends locate correctly on each side of the locating pin (see illustration).

13 Slide the washer onto the left-hand end of the shaft, then fit the E-clip into its groove,

making sure it is secure (see illustrations 19.4b and a).

14 Install the clutch (see Section 16).

15 Install the alternator cover (see Chapter 9). Connect the alternator and pick-up coil wiring connectors, if disconnected.

20 Oil pumps – removal, inspection and installation

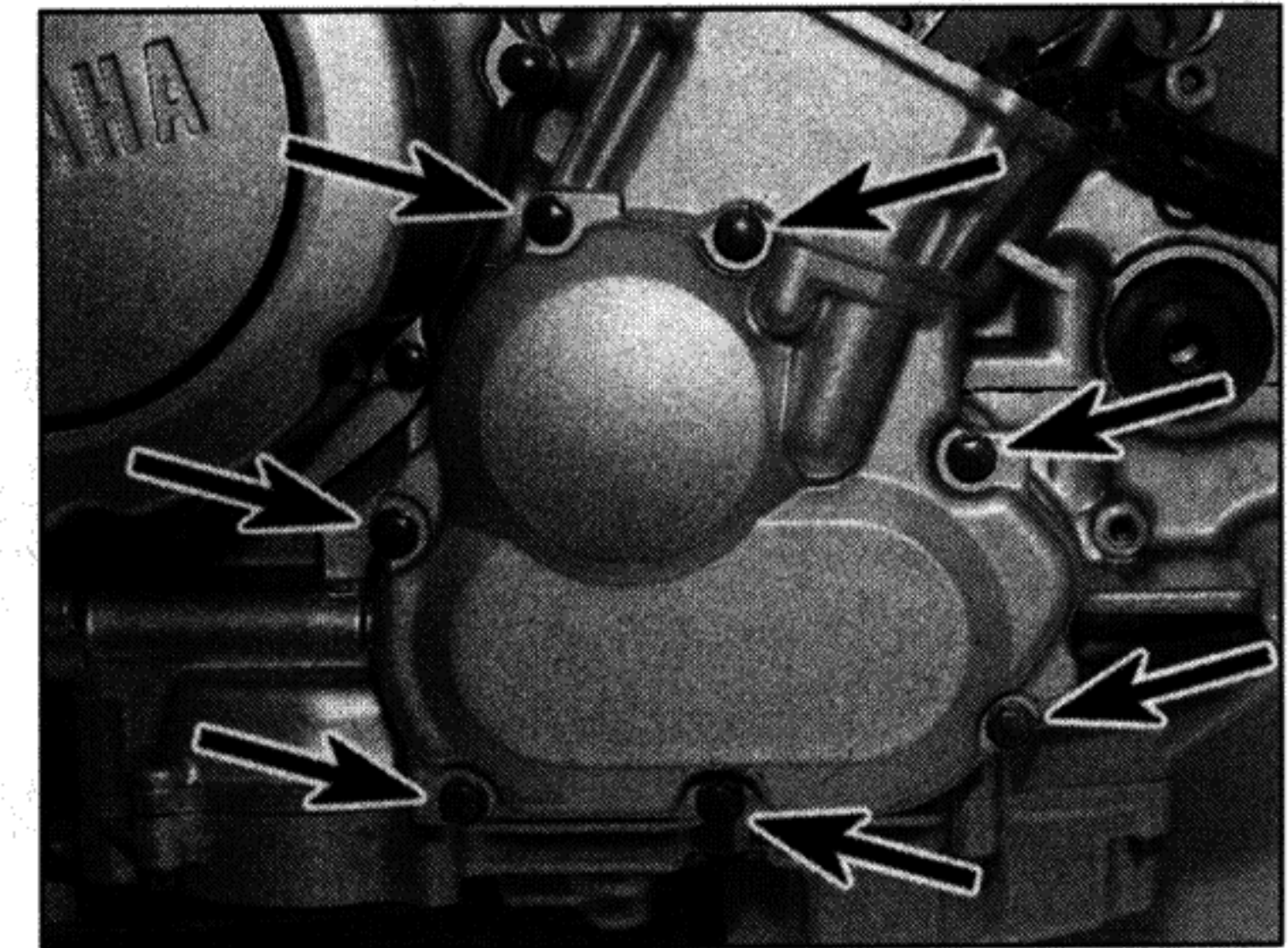
Note: The oil pumps can be removed with the engine in the frame. If the engine has been removed, ignore the steps which don't apply.

Removal

1 Two oil pumps are fitted, a feed pump to



20.3 Unscrew the two bolts (arrowed) and detach the pipe



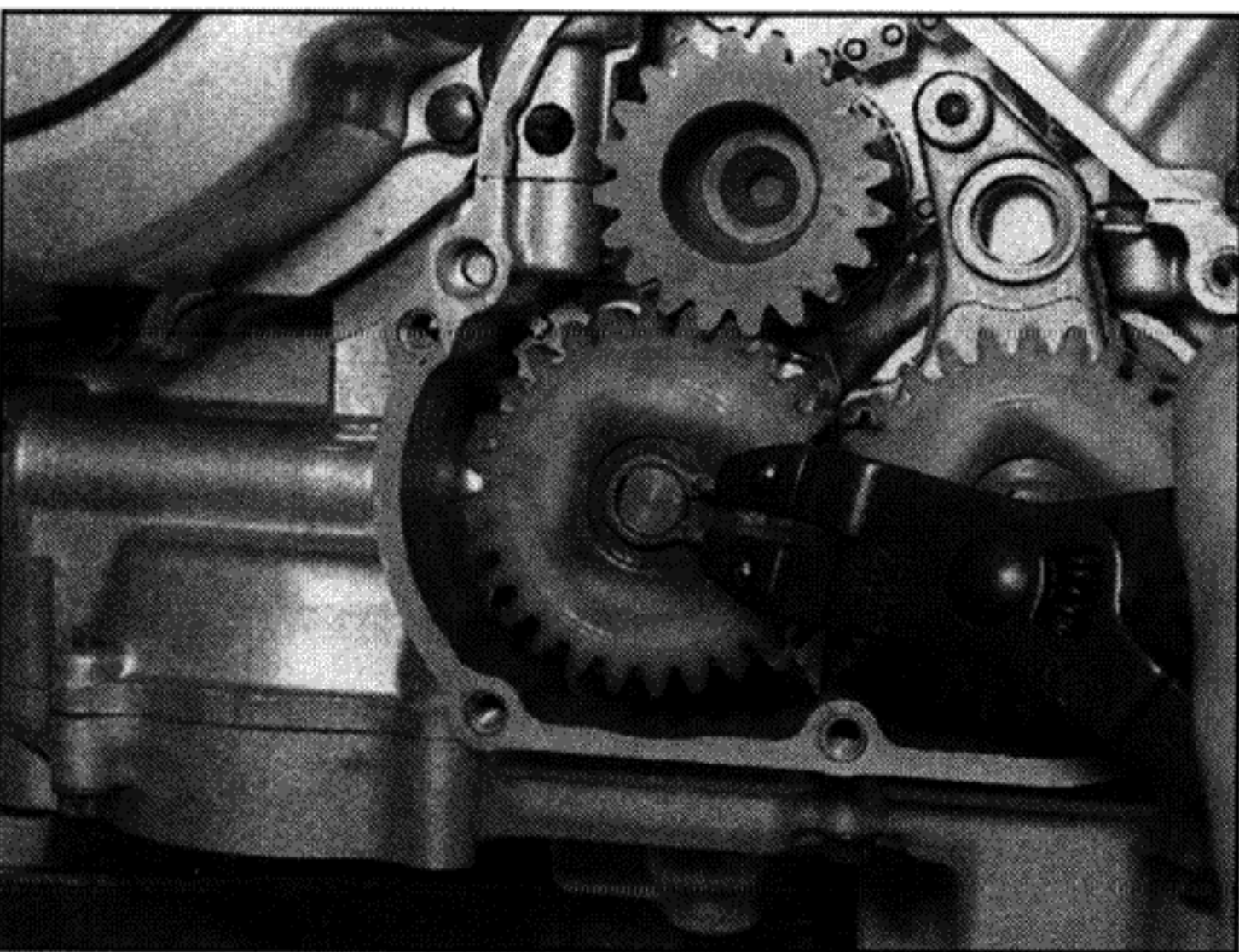
20.4 Oil pump cover bolts (arrowed)

lubricate the engine and a scavenge pump to return oil to the tank. As you look at the engine from the right-hand side, the feed pump is the left-hand pump and the scavenge pump is the right-hand pump (see illustration 20.6).

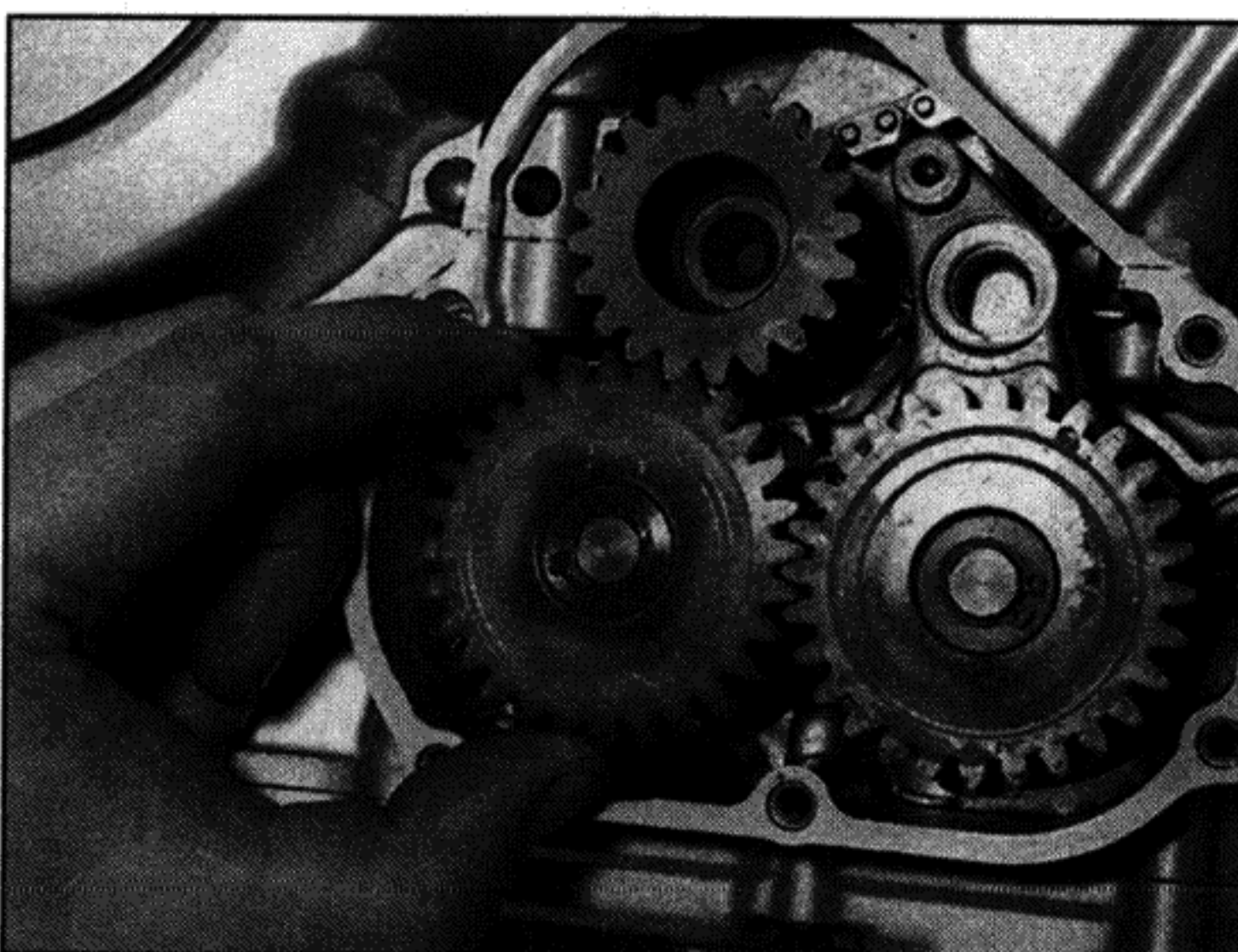
2 Drain the engine oil (see Chapter 1). On XTZ models, remove the engine bashplate (see Chapter 8) and the exhaust system (see Chapter 4).

3 Unscrew the two bolts securing the oil pipe to the oil pump cover on the right-hand side of the engine (see illustration). Detach the pipe and discard the O-ring as a new one must be used.

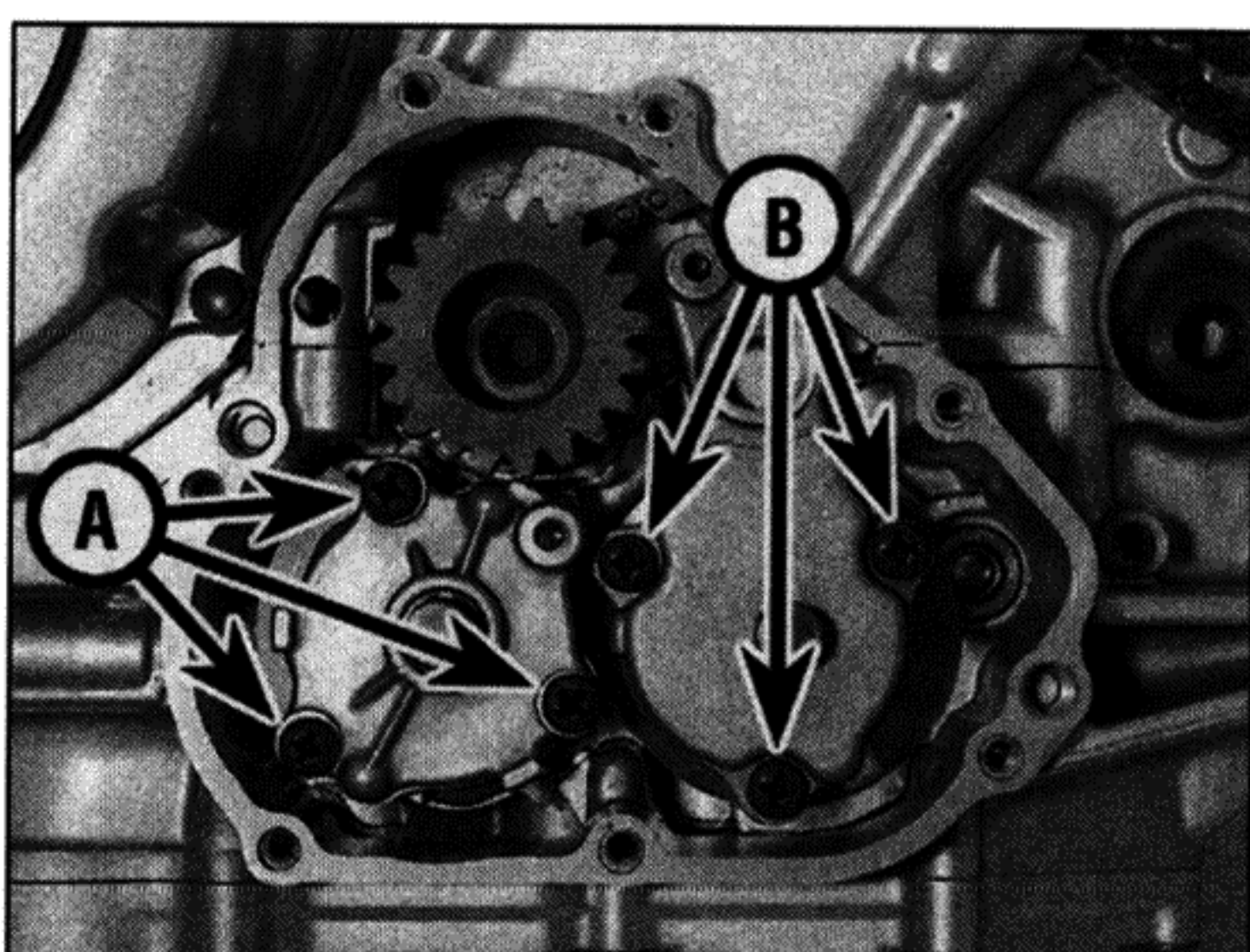
4 Unscrew the bolts securing the oil pump cover and remove the cover, being prepared to catch any residue oil (see illustration).



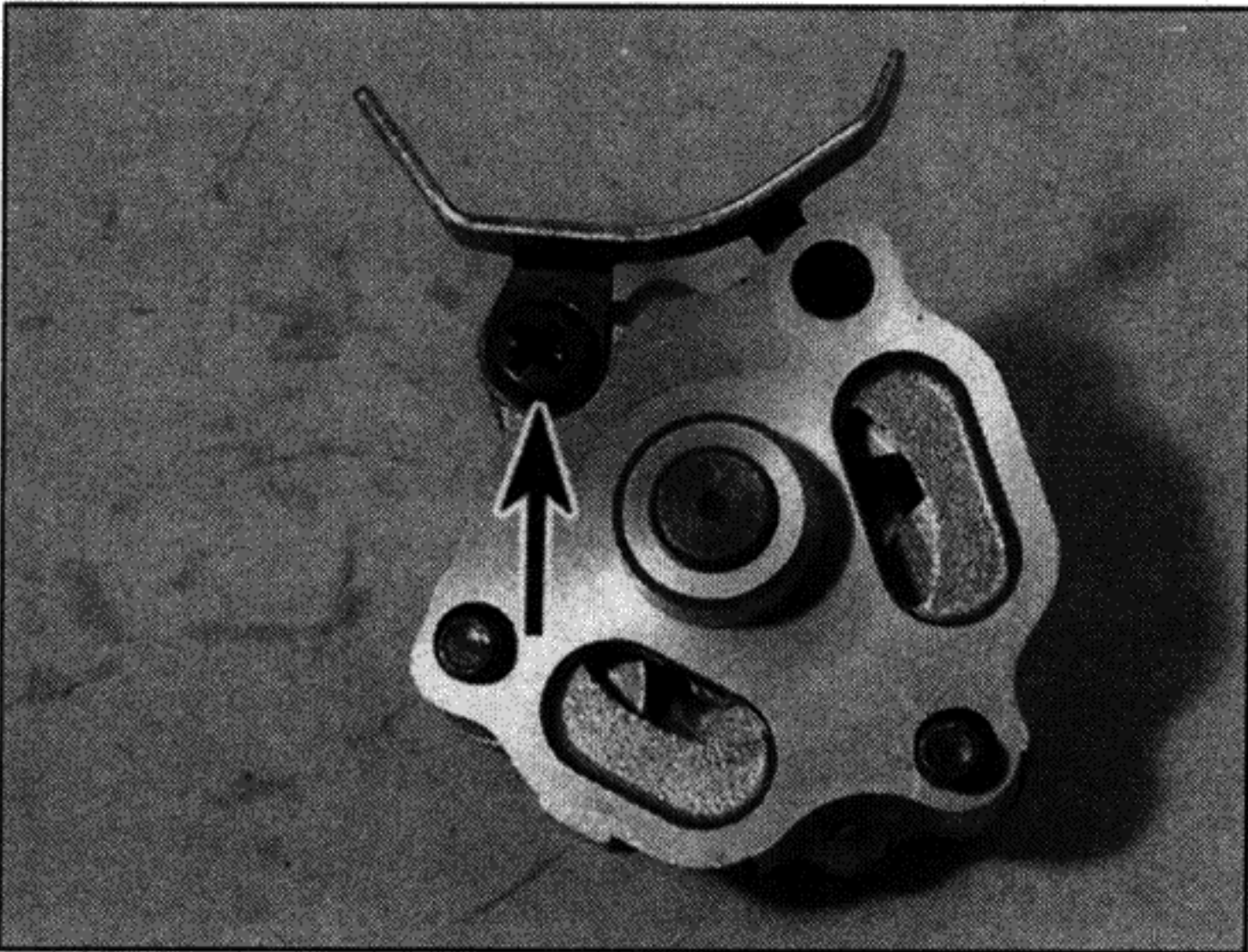
20.5a Remove the circlip . . .



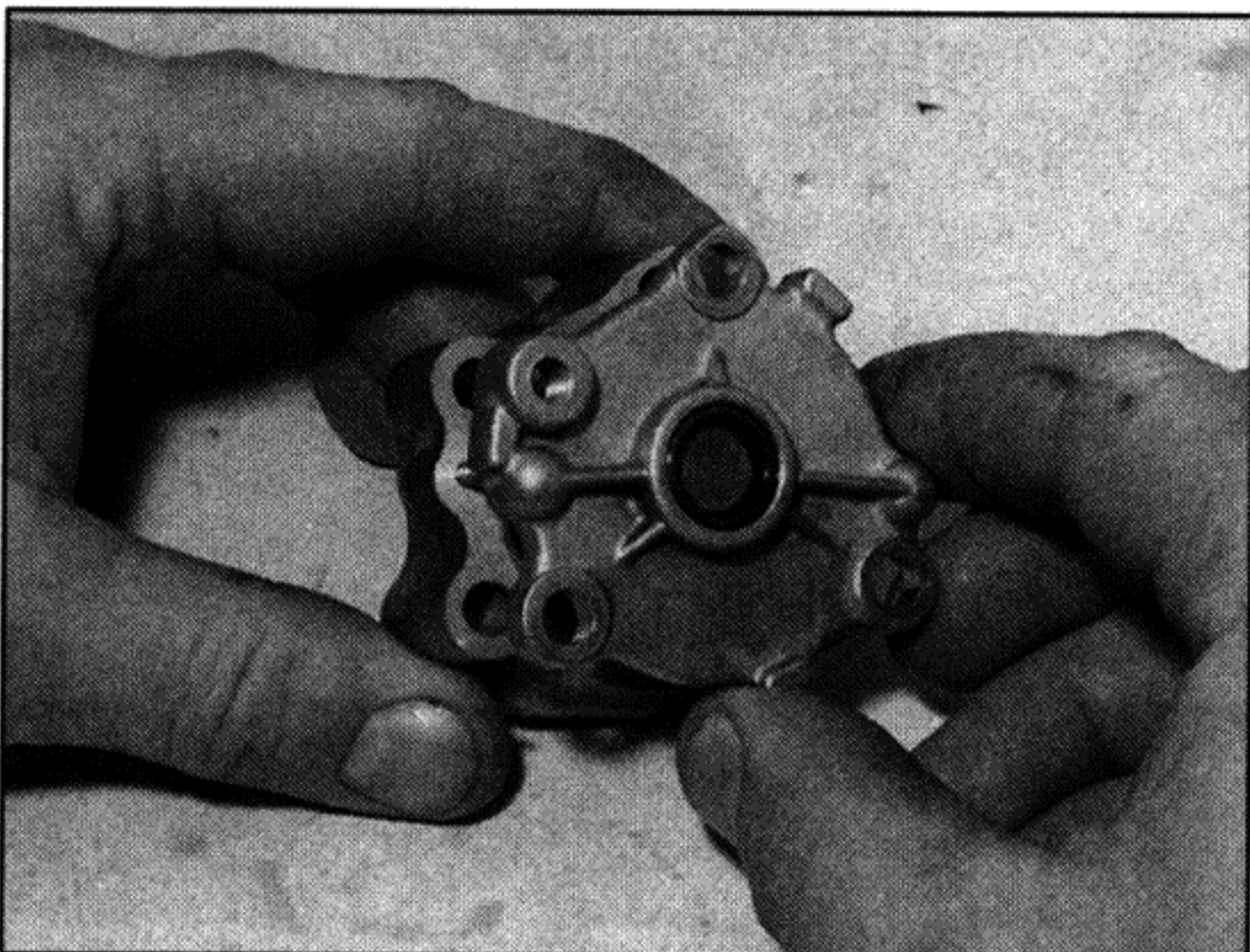
20.5b . . . and slide off the gear



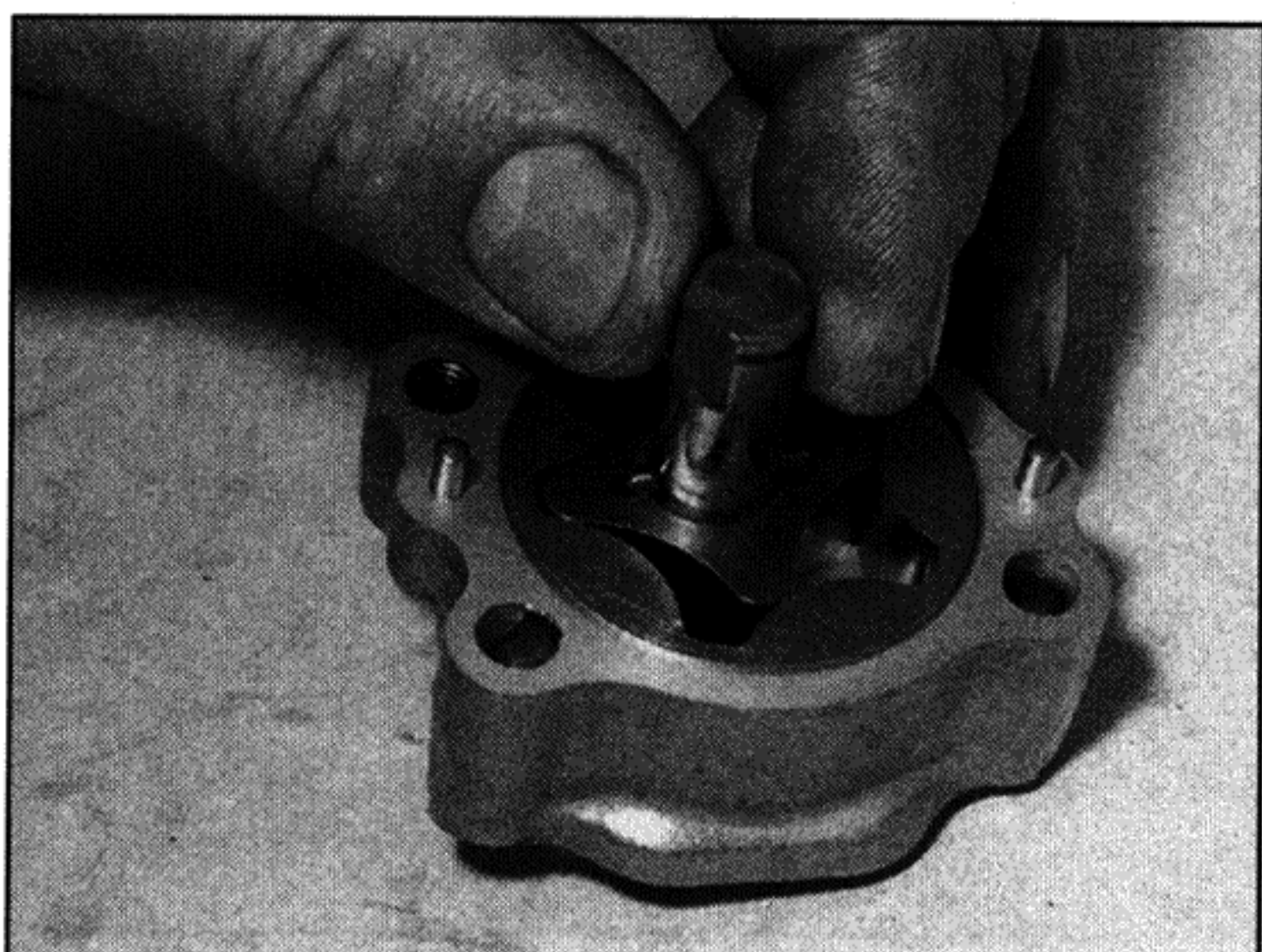
20.6 Feed pump screws (A), scavenge pump screws (B)



20.7a Remove the screw (arrowed) . . .



20.7b . . . and separate the housing



20.7c Draw out the shaft and remove the rotors

Discard the gasket as a new one must be used. Remove the dowels from either the cover or the crankcase if they are loose. Also note the oil passage collar located in the orifice in the scavenge pump cover. Discard the O-ring as a new one must be used, and remove the collar if required (**see illustration 20.18**).

5 Remove the circlip securing the oil pump driven gear to the feed pump shaft and remove the gear (**see illustrations**). Discard the circlip as a new one should be used. Do the same to free the driven gear from the scavenge pump.

6 Each pump is secured by three screws (**see illustration**). Remove the screws and remove the pump, noting how it fits. Discard the gasket as a new one must be used. Note the dowel locating the scavenge pump and remove it if it is loose.

Inspection

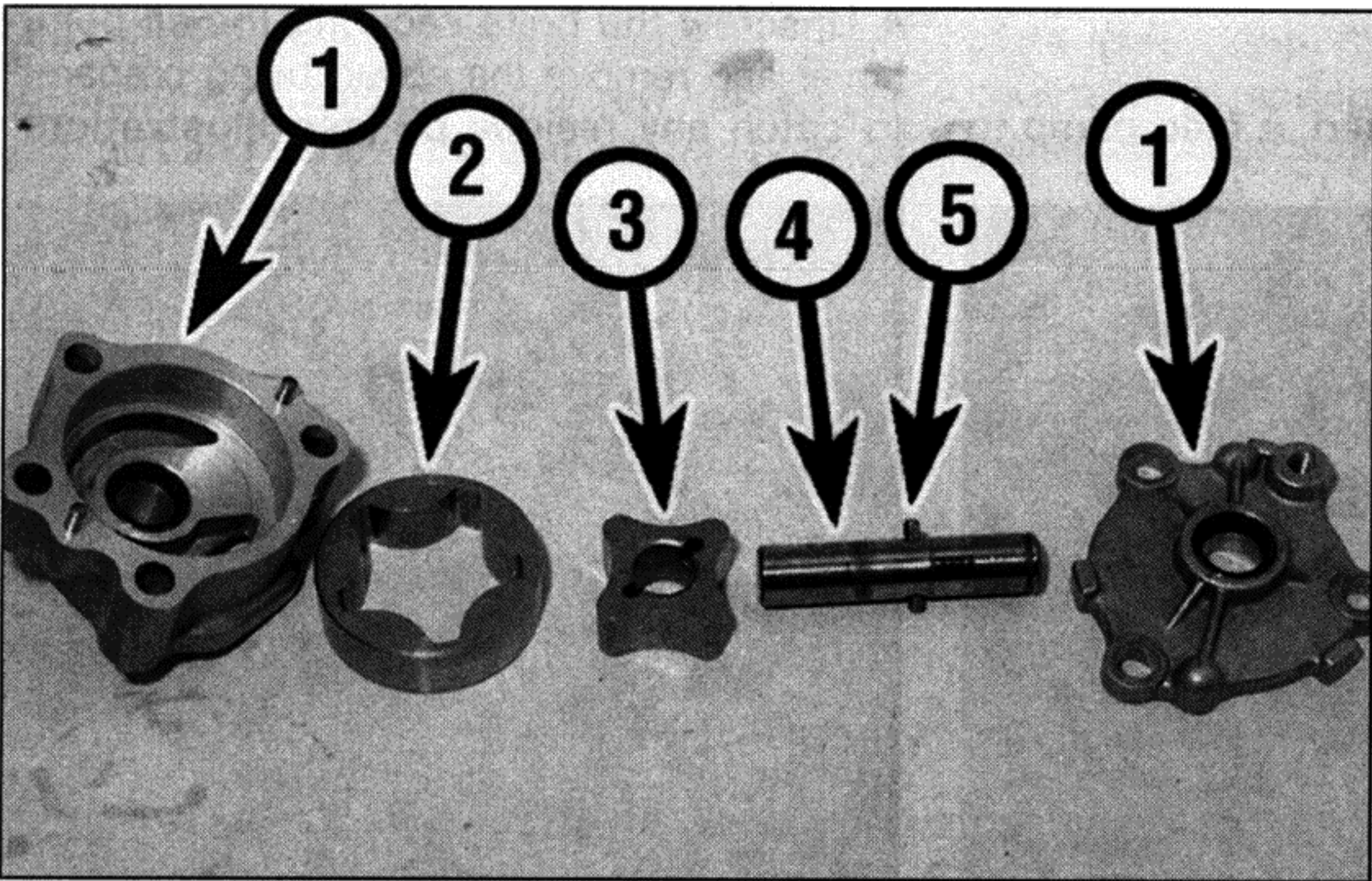
7 If required, the pumps can be disassembled for cleaning. Remove the single assembly screw and separate the pump housing, on the feed pump noting how the cam chain guide fits (**see illustrations**). Remove the housing locating pins if they are loose. Draw the inner rotor with the

driveshaft out of the pump housing, then remove the outer rotor (**see illustration**). Note which way round the rotors fit and how the driveshaft pin locates in the slots in the inner rotor.

8 Clean all the components in solvent (**see illustration**).

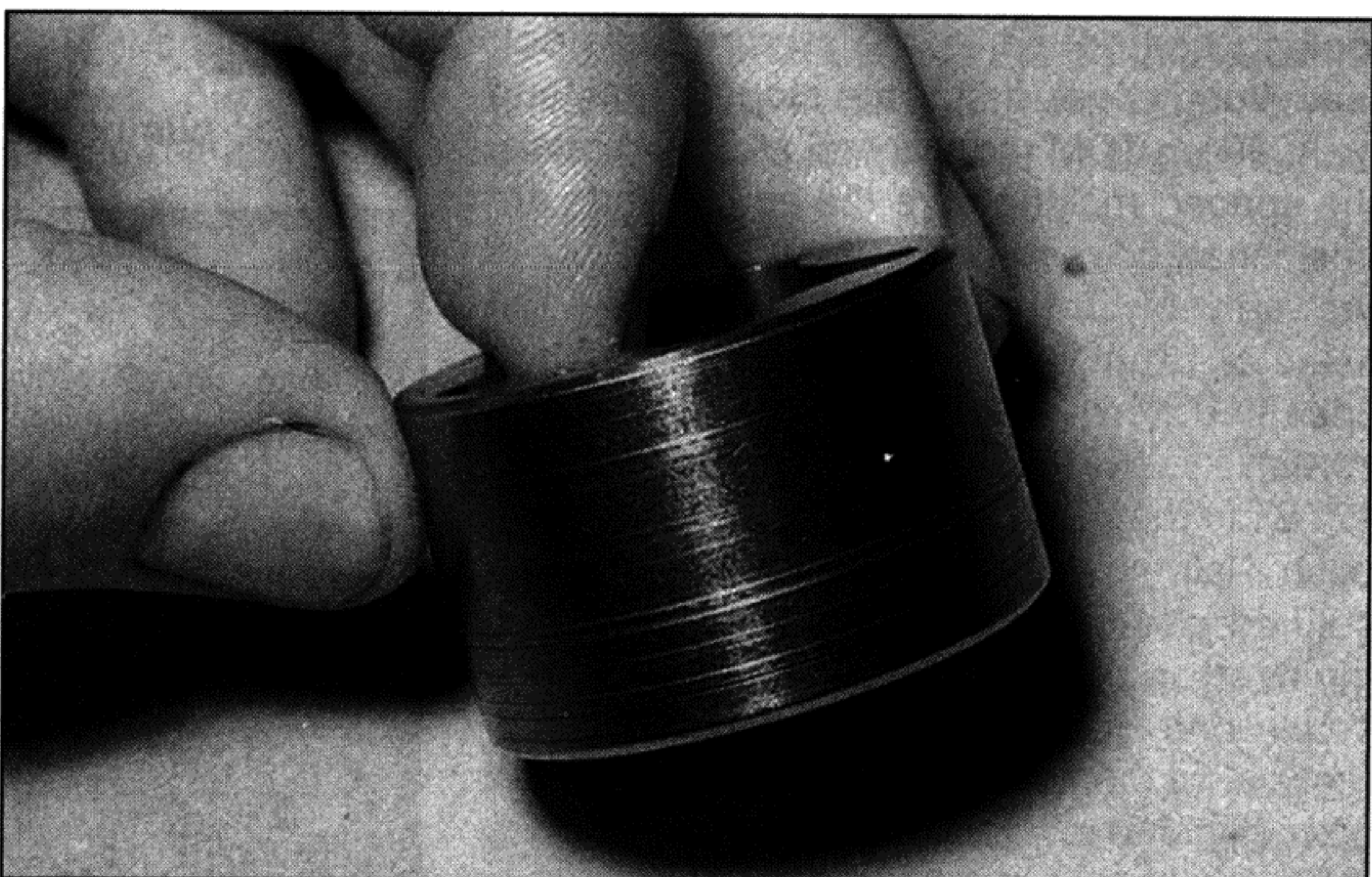
9 Inspect the pump body and rotors for scoring and wear (**see illustration**). If any damage, scoring or uneven or excessive wear is evident, renew the pump (individual components are not available).

10 Fit the outer rotor into the pump body. Fit the drive pin into the shaft, then slide the shaft into the inner rotor, locating the drive pin ends

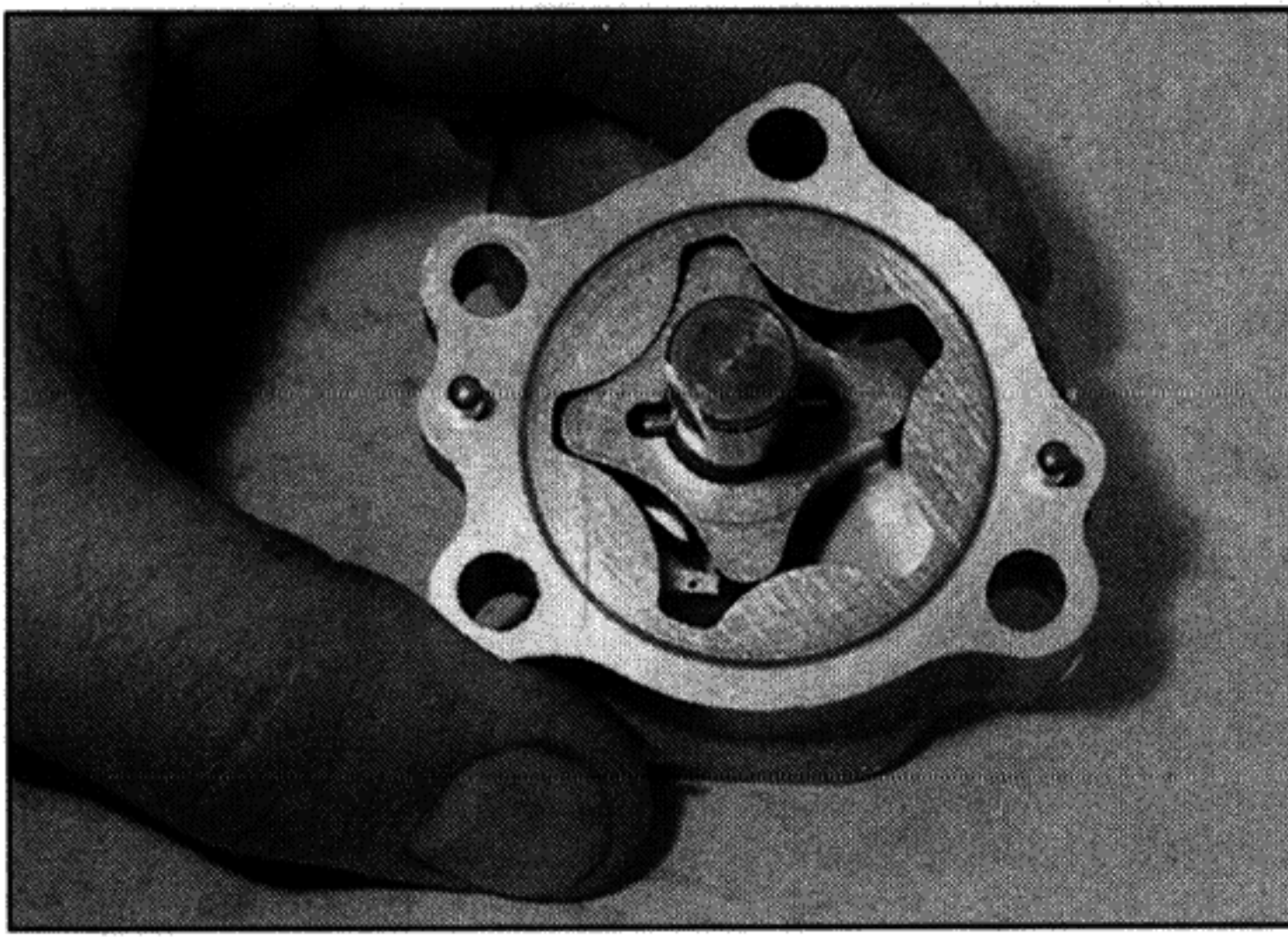


20.8 Oil pump components

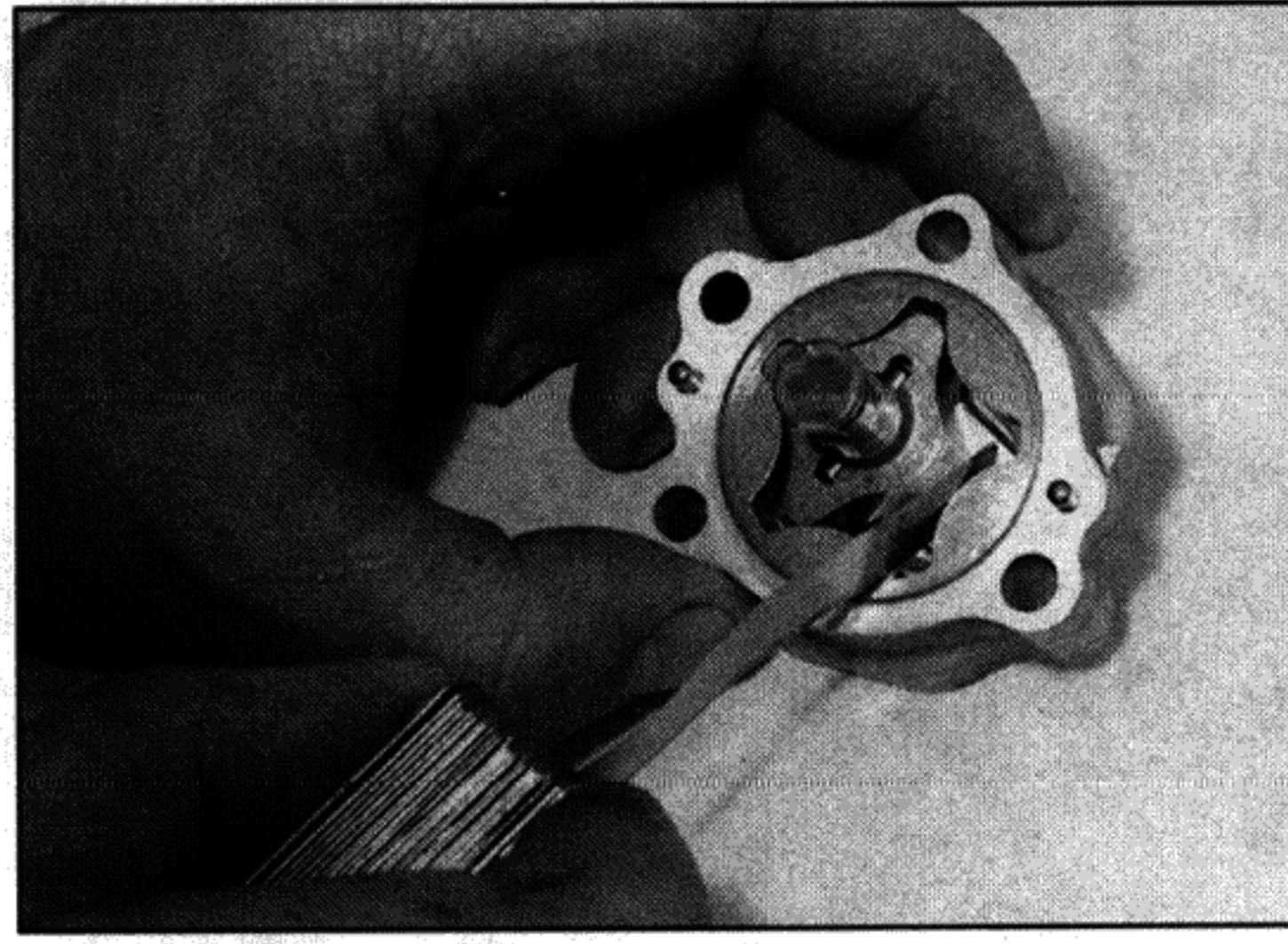
1 Housing 2 Outer rotor 3 Inner rotor 4 Shaft 5 Drive pin



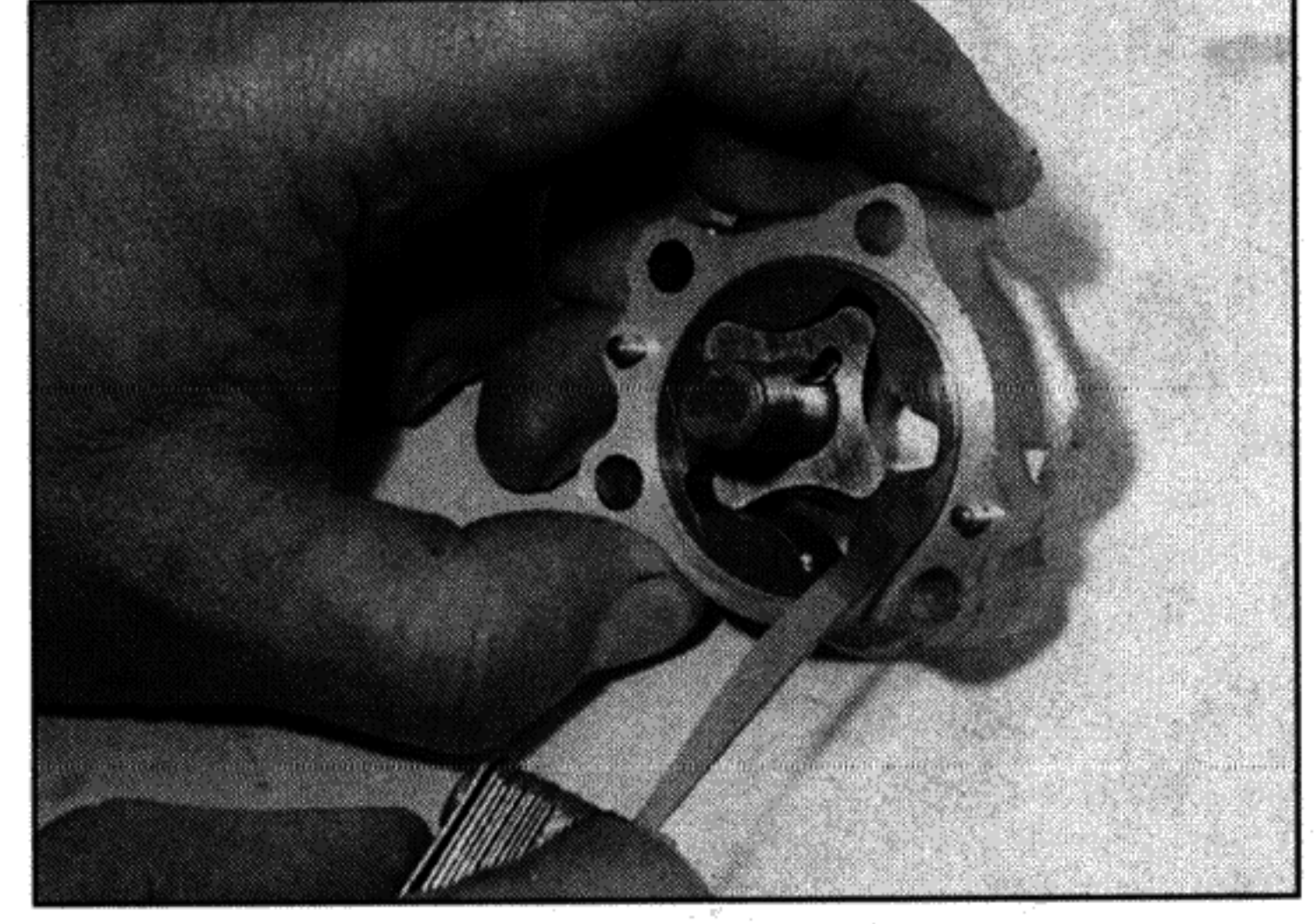
20.9 Look for scoring and wear, such as on this outer rotor



20.10a Assembled oil pump



20.10b Measuring inner rotor tip-to-outer rotor tip clearance



20.11 Measuring outer rotor-to-body clearance

in the slots in the rotor, then fit the inner rotor into the outer rotor (**see illustration**). Measure the clearance between the inner rotor tip and the outer rotor with a feeler gauge and compare it to the maximum clearance listed in the specifications at the beginning of the Chapter (**see illustration**). If the clearance measured is greater than the maximum listed, renew the pump.

11 Measure the clearance between the outer rotor and the pump body with a feeler gauge and compare it to the maximum clearance listed in the specifications at the beginning of the Chapter (**see illustration**). If the clearance measured is greater than the maximum listed, renew the pump.

12 On 1996-on TDM models and all TRX models, lay a straight-edge across the rotors and

the pump body and, using a feeler gauge, measure the rotor end-float (the gap between the rotors and the straight-edge (**see illustration**). If the clearance measured is greater than the maximum listed, renew the pump. No specifications are given for other models.

13 Check the nylon pump driven gears for wear or damage, and renew them if necessary. Damage to the steel drive gear is unlikely, but if found will necessitate crankshaft renewal.

14 If the pump is good, make sure all the components are clean, then lubricate them with new engine oil. Assemble the housing, making sure the pins locate correctly, and tighten the assembly screw to the torque setting specified at the beginning of the Chapter, not forgetting the cam chain guide on

the feed pump (**see illustration 20.7b and a**).

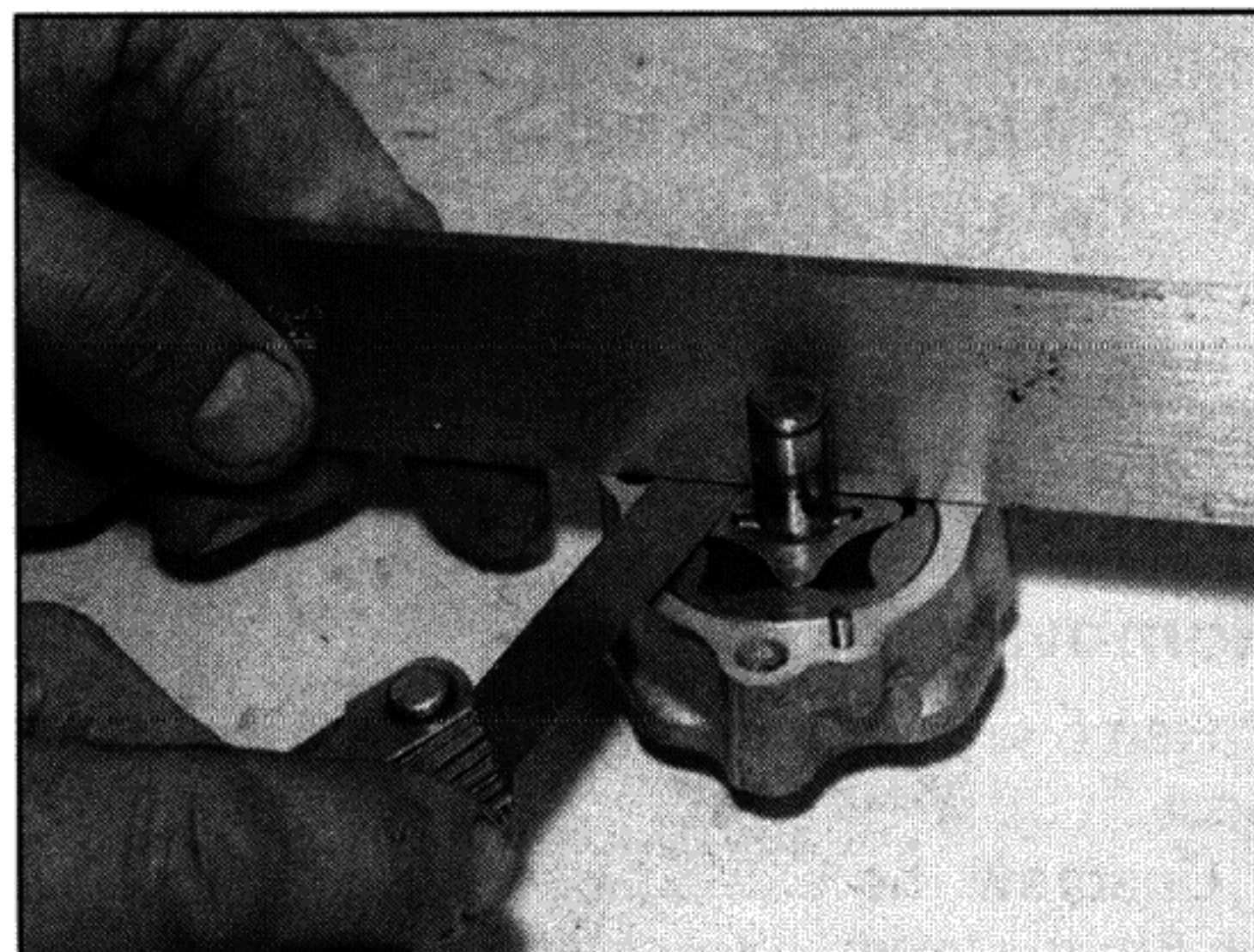
15 Rotate the pump shaft by hand and check that the rotors turn smoothly and freely. If not, renew the pump.

Installation

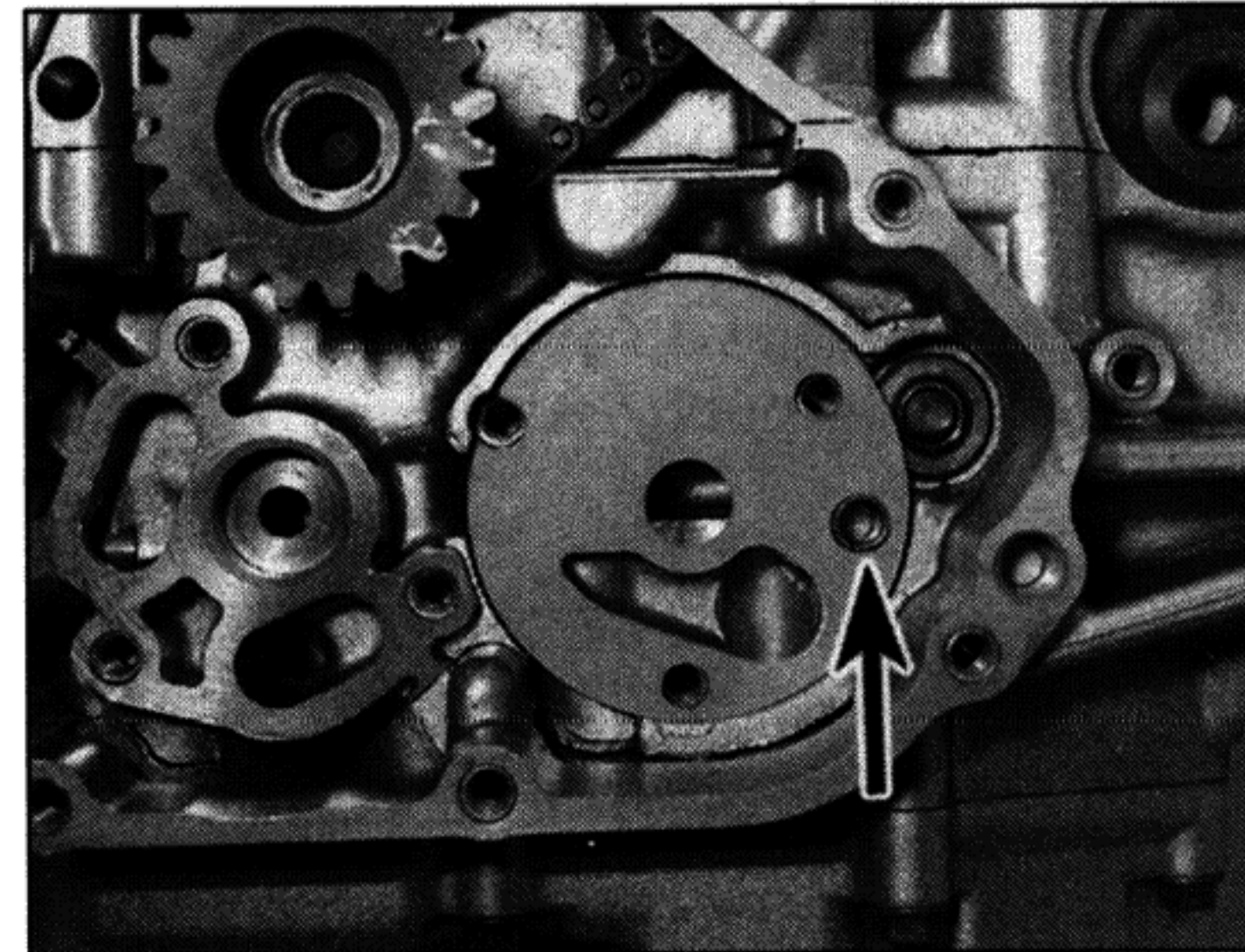
16 Install the pump using a new gasket, not forgetting the locating dowel for the scavenge pump, if removed, and tighten the screws to the torque setting specified at the beginning of the Chapter (**see illustrations**).

17 Locate the pump driven gear onto its shaft, aligning the flat in the gear with that on the shaft, and secure it using a new circlip (**see illustrations 20.5b and a**). Align the open end of the circlip with the flat on the shaft (**see illustration**).

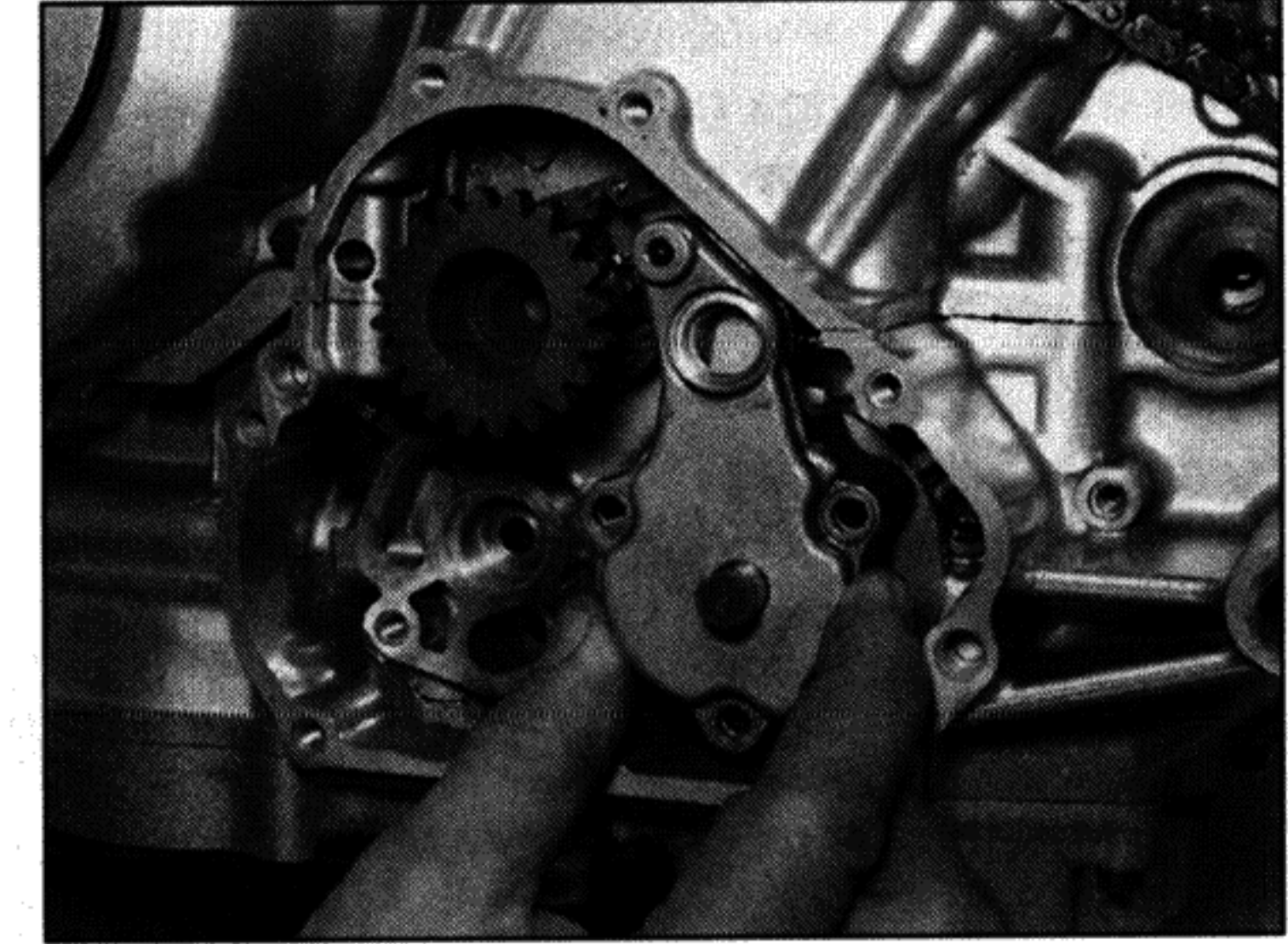
18 If removed, install the oil passage collar



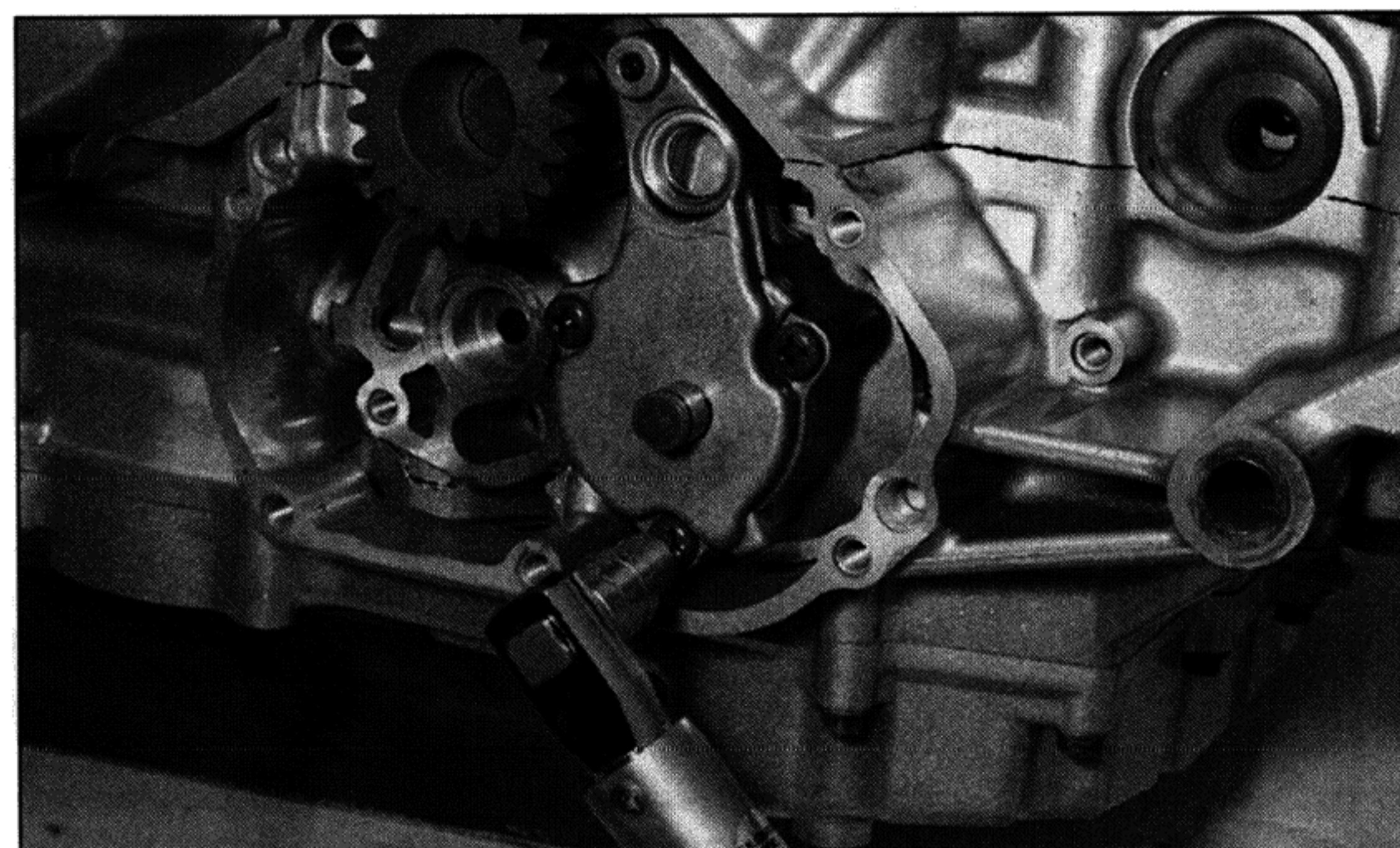
20.12 Measuring rotor end-float



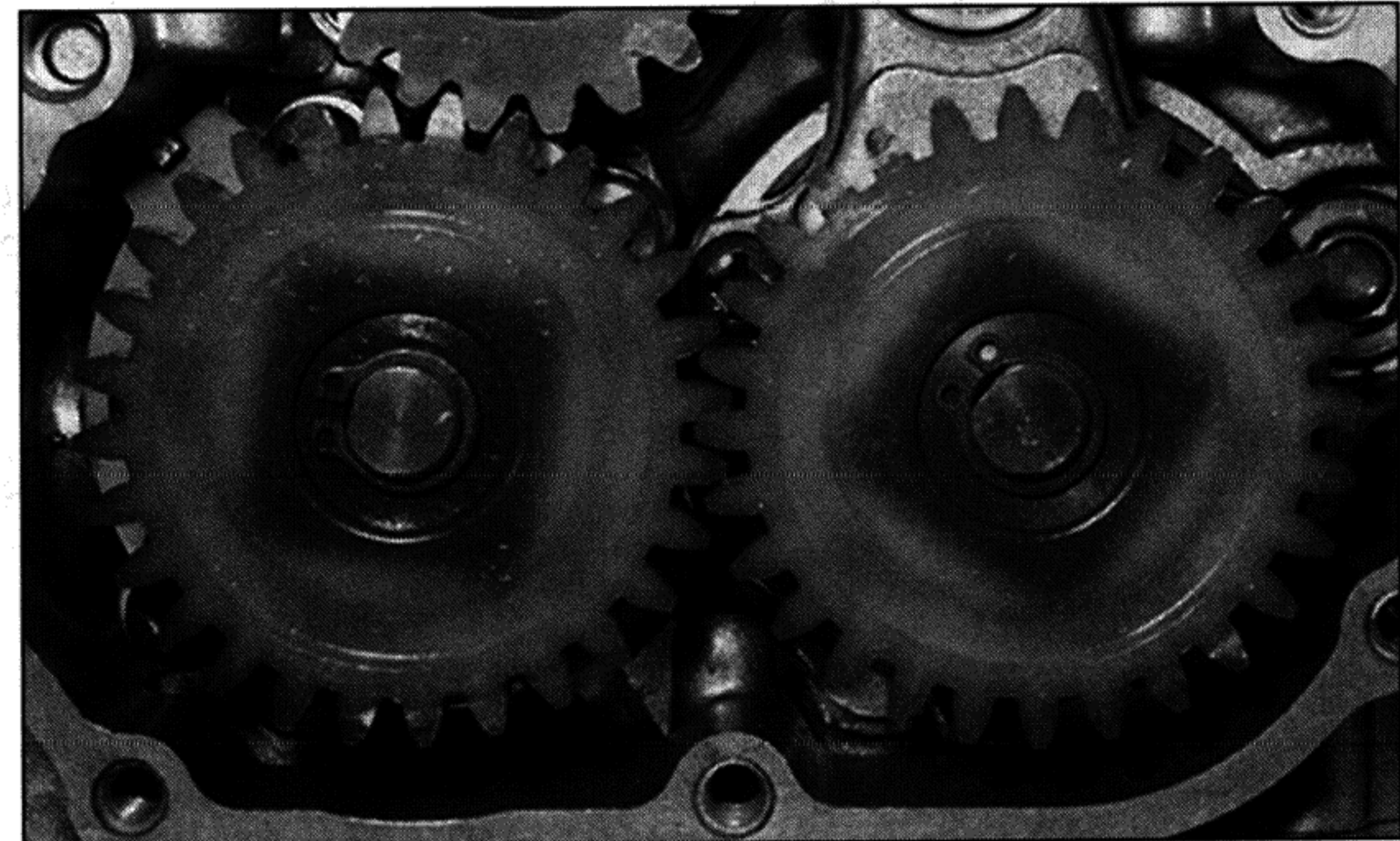
20.16a Fit the gasket, on the scavenge pump locating it onto the dowel (arrowed)



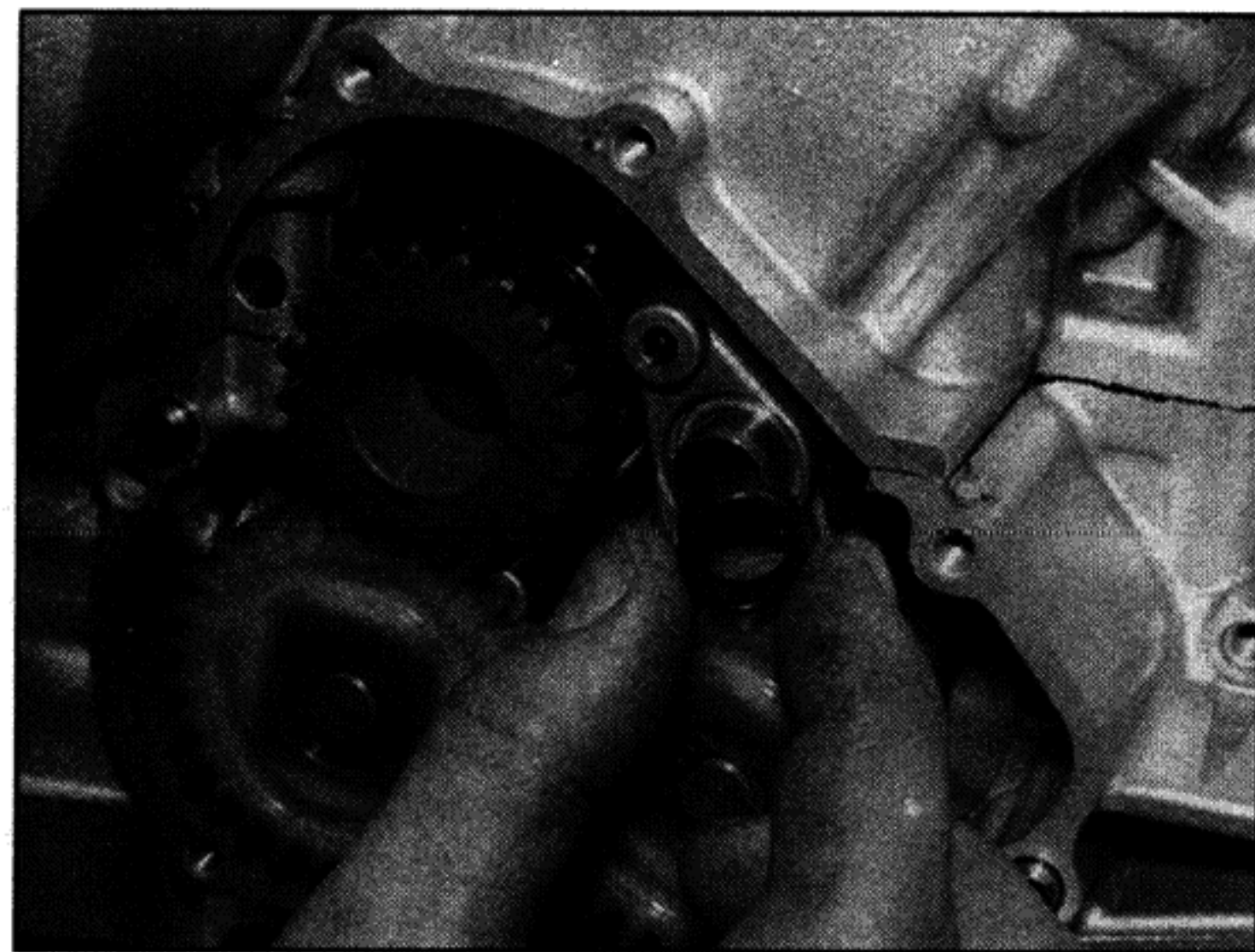
20.16b Install the pump . . .



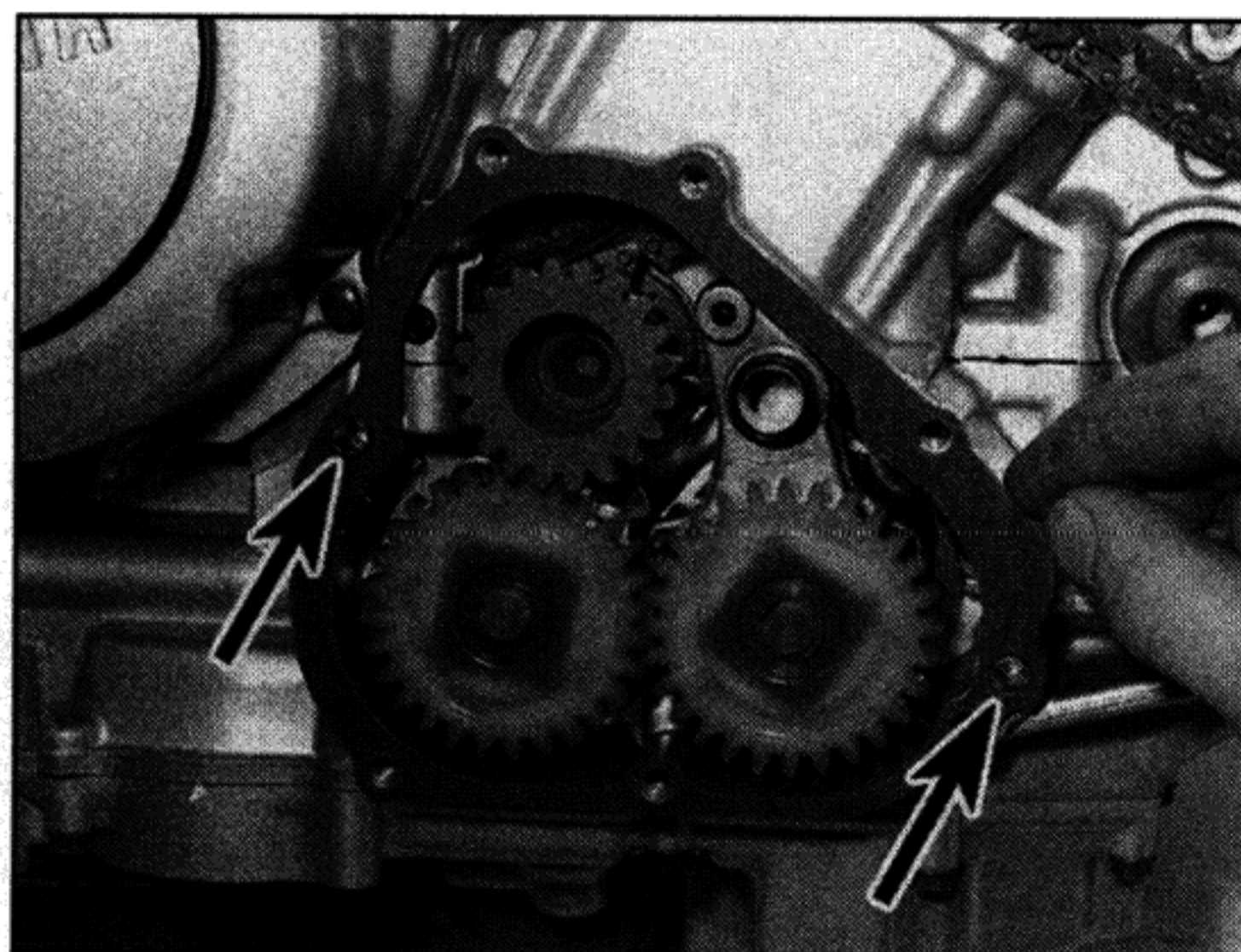
20.16c . . . and tighten its screws to the specified torque



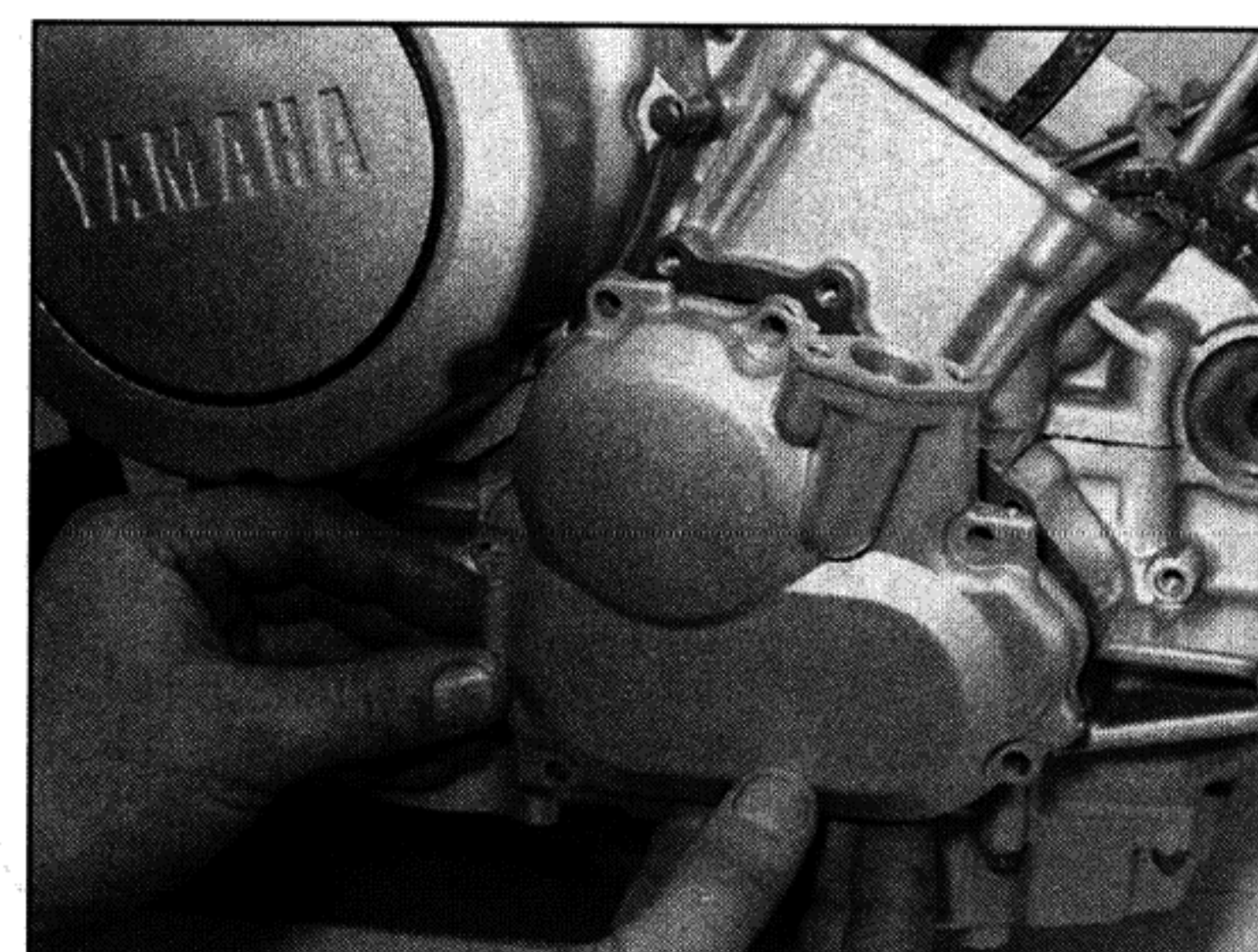
20.17 Align the open ends of the circlips with the flats on the shafts



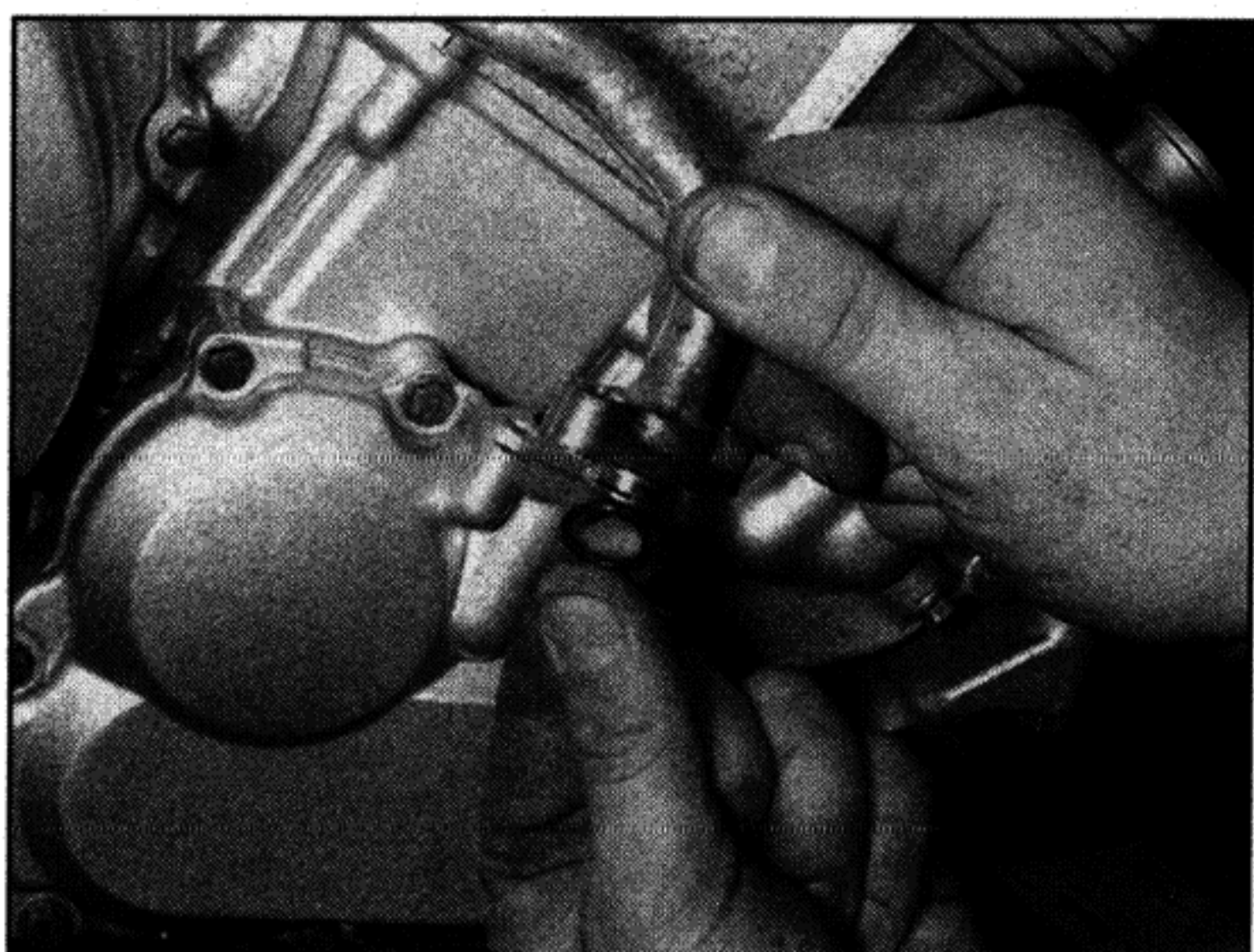
20.18 Fit a new O-ring around the collar



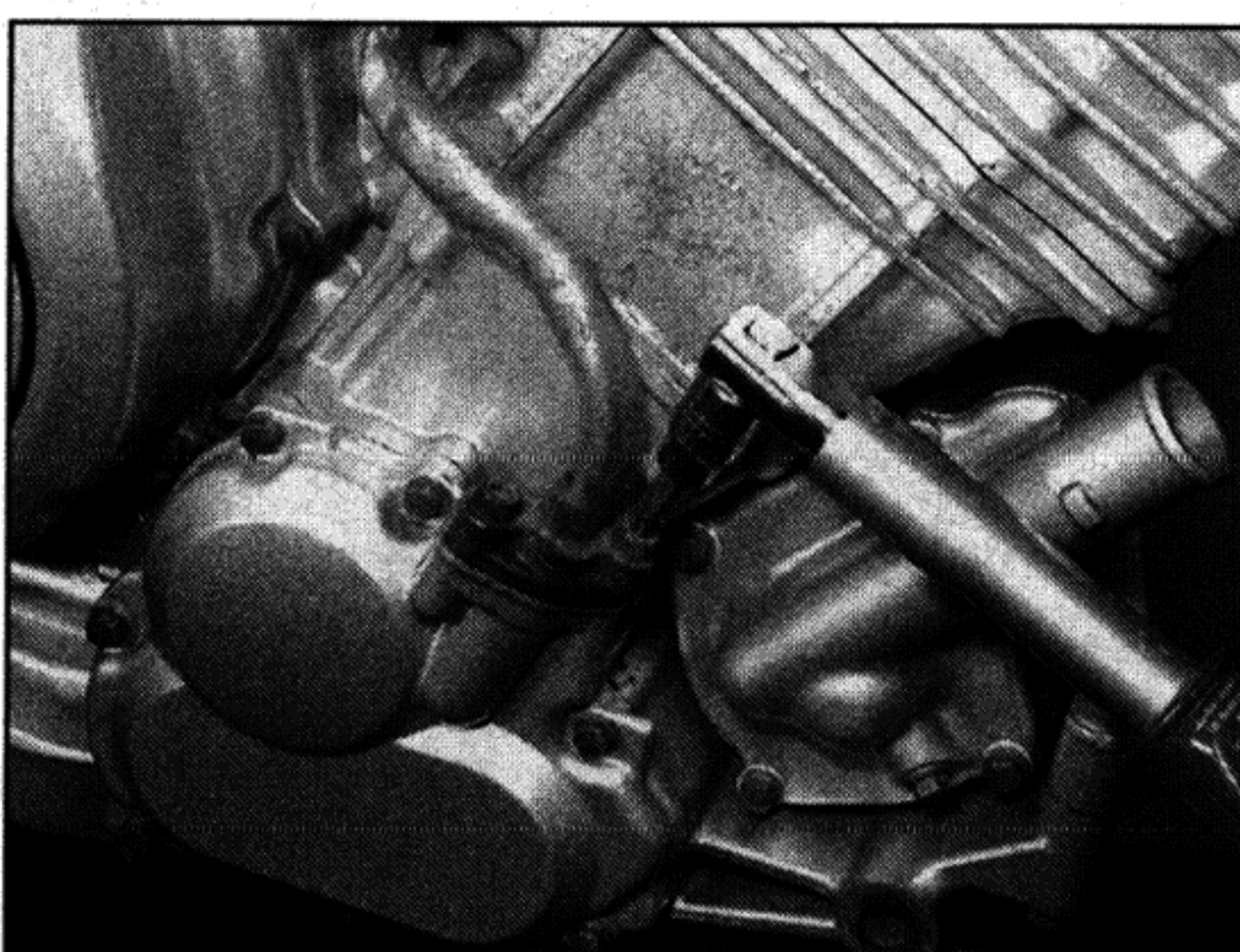
20.19a Make sure the gasket fits onto the dowels (arrowed) . . .



20.19b . . . then install the cover



20.20a Use a new O-ring on the oil pipe union . . .



20.20b . . . and tighten its bolts to the specified torque

into the orifice in the scavenge pump, then fit a new O-ring (**see illustration**).

19 If removed, fit the oil pump cover dowels into the crankcase, then install the cover using a new gasket, making sure it locates correctly onto the dowels (**see illustration**). Tighten the cover bolts evenly in a criss-cross sequence to the specified torque setting (**see illustration**).

20 Fit the oil pipe onto the cover using a new O-ring and tighten the bolts to the specified torque setting (**see illustrations**).

21 On XTZ models, install the exhaust system (see Chapter 4) and the engine bashplate (see Chapter 8).

22 Fill the engine with the specified quantity and type of new engine oil (see Chapter 1).

21 Oil tank – removal and installation (1996-on TDM models and all TRX models)



Note: To remove the oil tank, the engine must be removed from the frame.

Removal

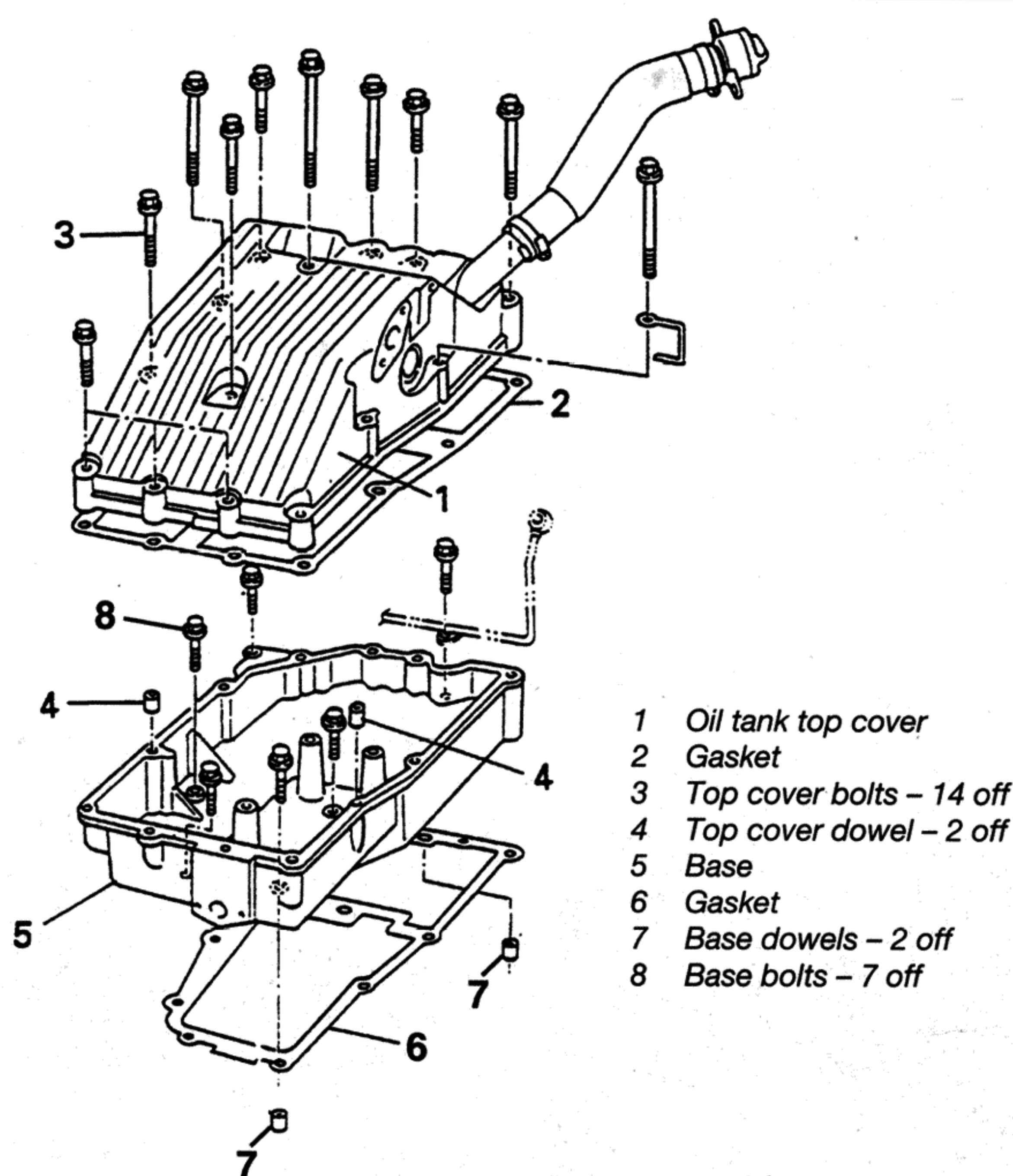
1 Remove the engine from the frame (see Section 5).

2 Unscrew the banjo bolts securing the oil pipe to the left-hand side of the oil tank and to the cylinder head, and the pipe bracket bolt, and remove the pipe. Discard the banjo bolt sealing washers as new ones must be used.

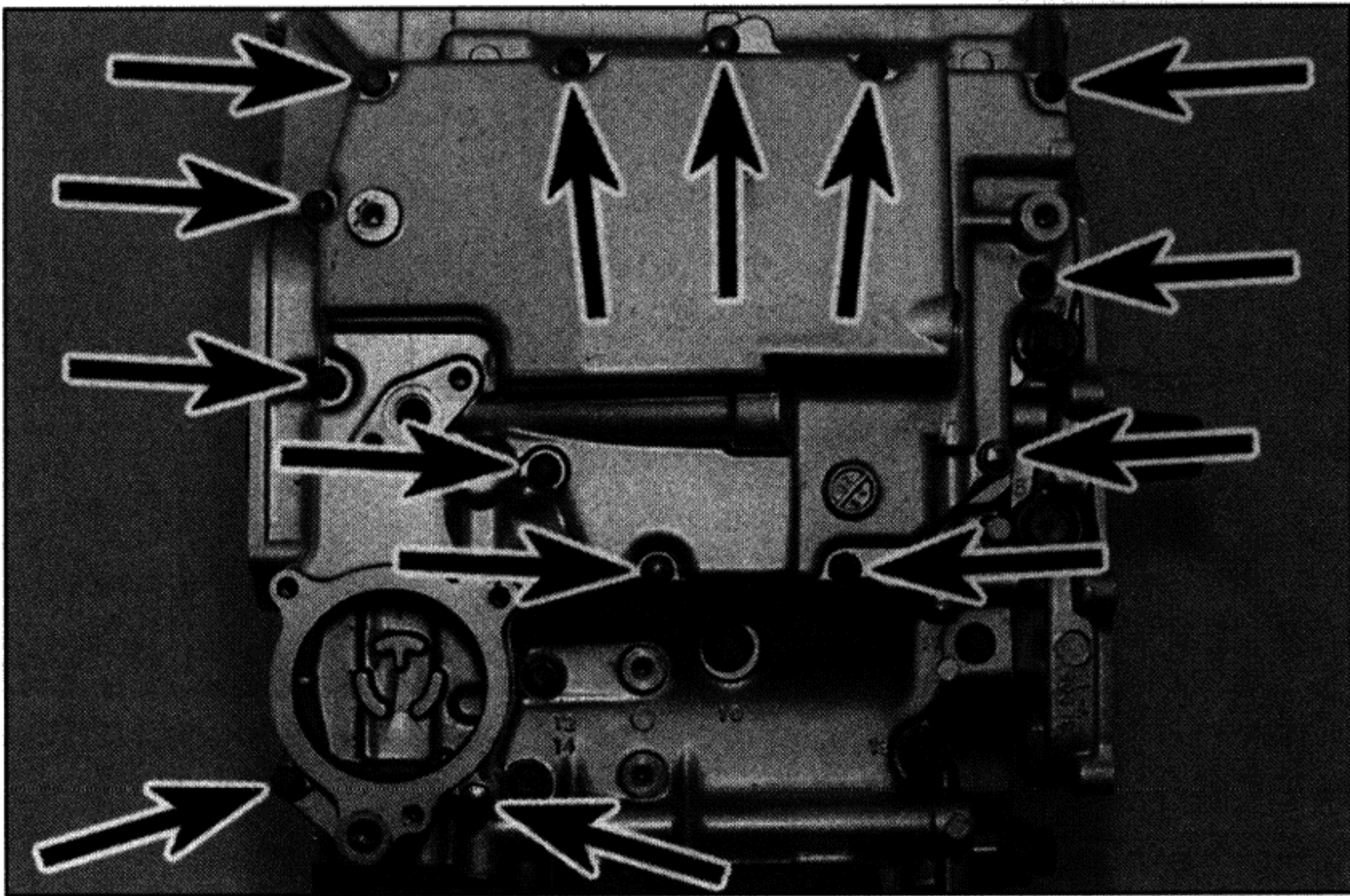
3 Unscrew the two bolts securing the oil pipe to the right-hand side of the oil tank and detach the pipe. Discard the O-ring as a new one must be used.

4 Slacken the clamp securing the oil pipe (from the rear of the oil tank) in the oil hose and detach the pipe from the hose. Unscrew the two bolts securing the pipe to the oil tank and withdraw the pipe. Discard the O-ring as a new one must be used.

5 Unscrew the bolts securing the top of the oil tank, noting which fits where as they are of different lengths, and noting the clip secured by the bolt on the right-hand side (**see illustration**). Lift off the top of the tank, being prepared to catch any residue oil. Discard the gasket as a new one must be used. Note the



21.5 Oil tank (1996-on TDM and all TRX models)



22.3 Unscrew the bolts (arrowed) and remove the sump

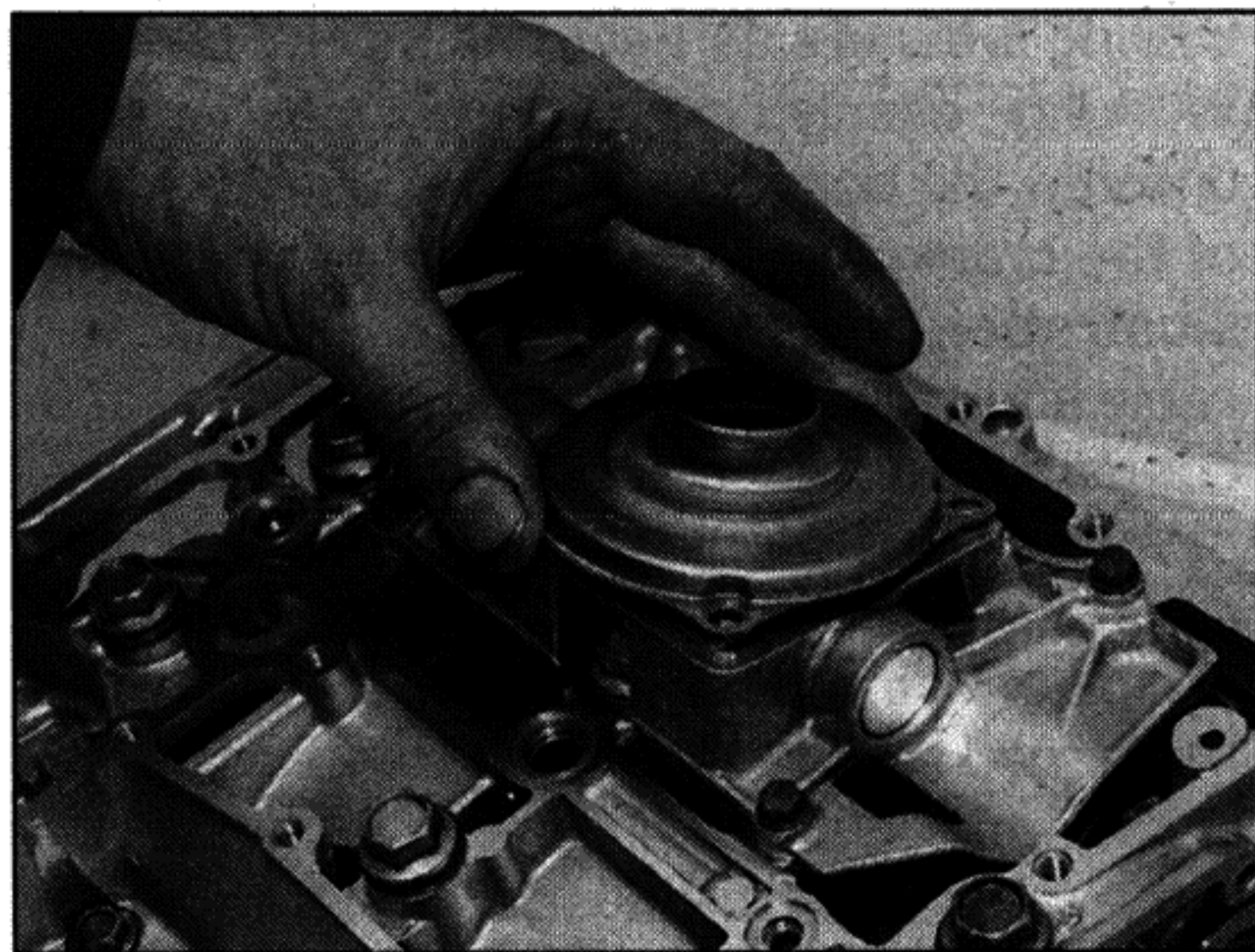
positions of the two dowels and remove them if they are loose.

6 Unscrew the bolts securing the base of the oil tank to the crankcase and lift off the base. Discard the gasket as a new one must be used. Note the positions of the two dowels and remove them if they are loose.

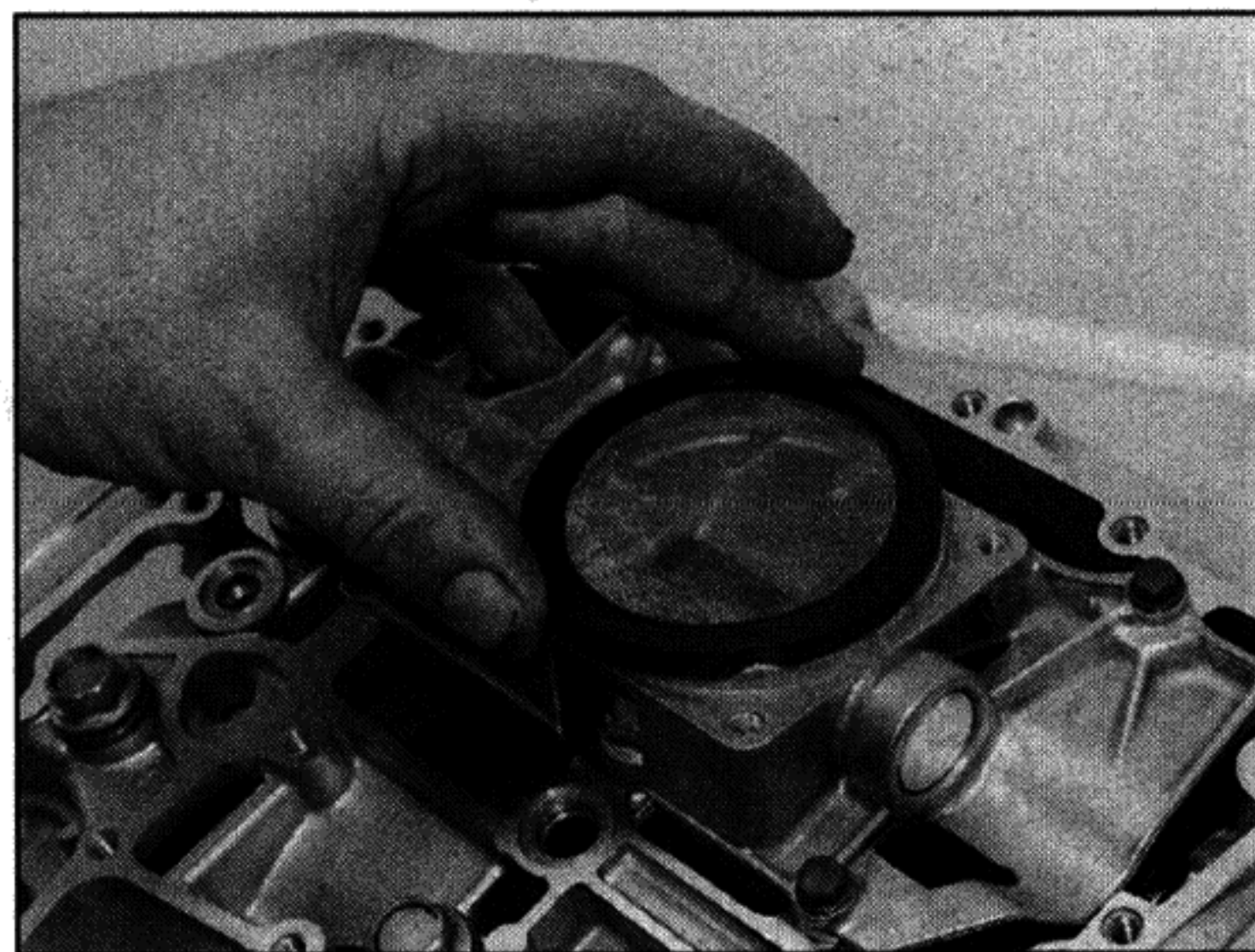
Installation

7 Installation is the reverse of removal, noting the following points:

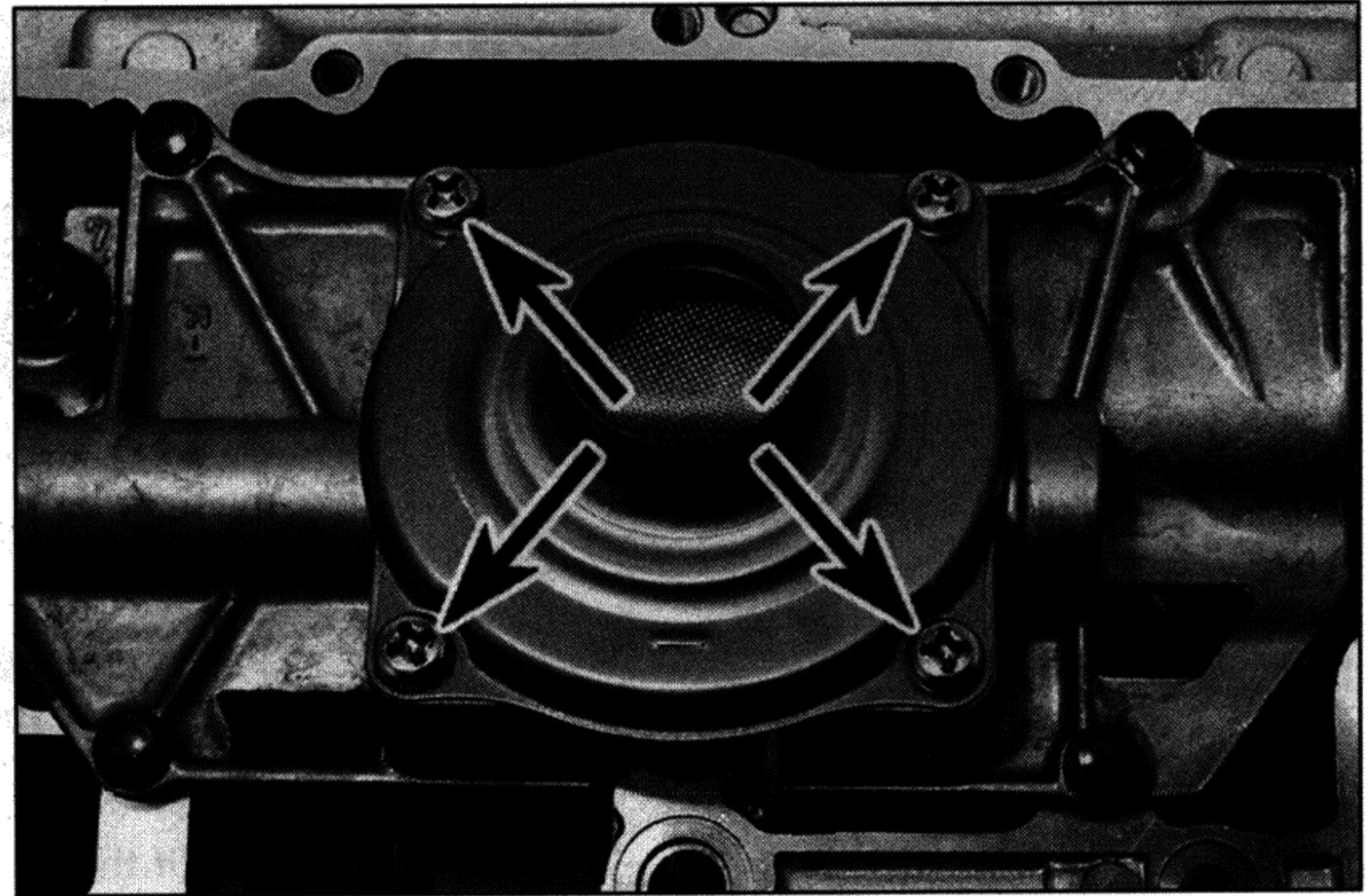
- Clean the oil tank in solvent and dry it using compressed air, if available.
- Make sure the dowels are correctly located.
- Use new gaskets.



22.4b ... and lift off the cover ...



22.4c ... and the strainer



22.4a Remove the screws (arrowed) ...

- Tighten the oil tank base and top bolts to the torque setting specified at the beginning of the Chapter.
- Use new sealing washers on each side of the oil pipe banjo unions and tighten the banjo bolts to the specified torque setting.
- Use new O-rings on the oil pipe unions and tighten the bolts to the specified torque setting.

22 Oil sump, oil strainer and pressure relief valve – removal, inspection 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

- On 1991 to 1995 TDM models and XTZ models, remove the engine bashplate (see Chapter 8). On TDM and TRX models remove the exhaust system (see Chapter 4).
- Drain the engine oil and remove the oil filter (see Chapter 1).
- Unscrew the sump bolts, slackening them evenly in a criss-cross sequence to prevent distortion, and remove the sump (see

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

4 Remove the screws securing the oil strainer cover and remove the cover and the strainer (see illustration).

5 Remove the bolt securing the pressure relief valve holder and remove the holder (see illustration). Withdraw the valve and discard the O-ring as a new one must be used.

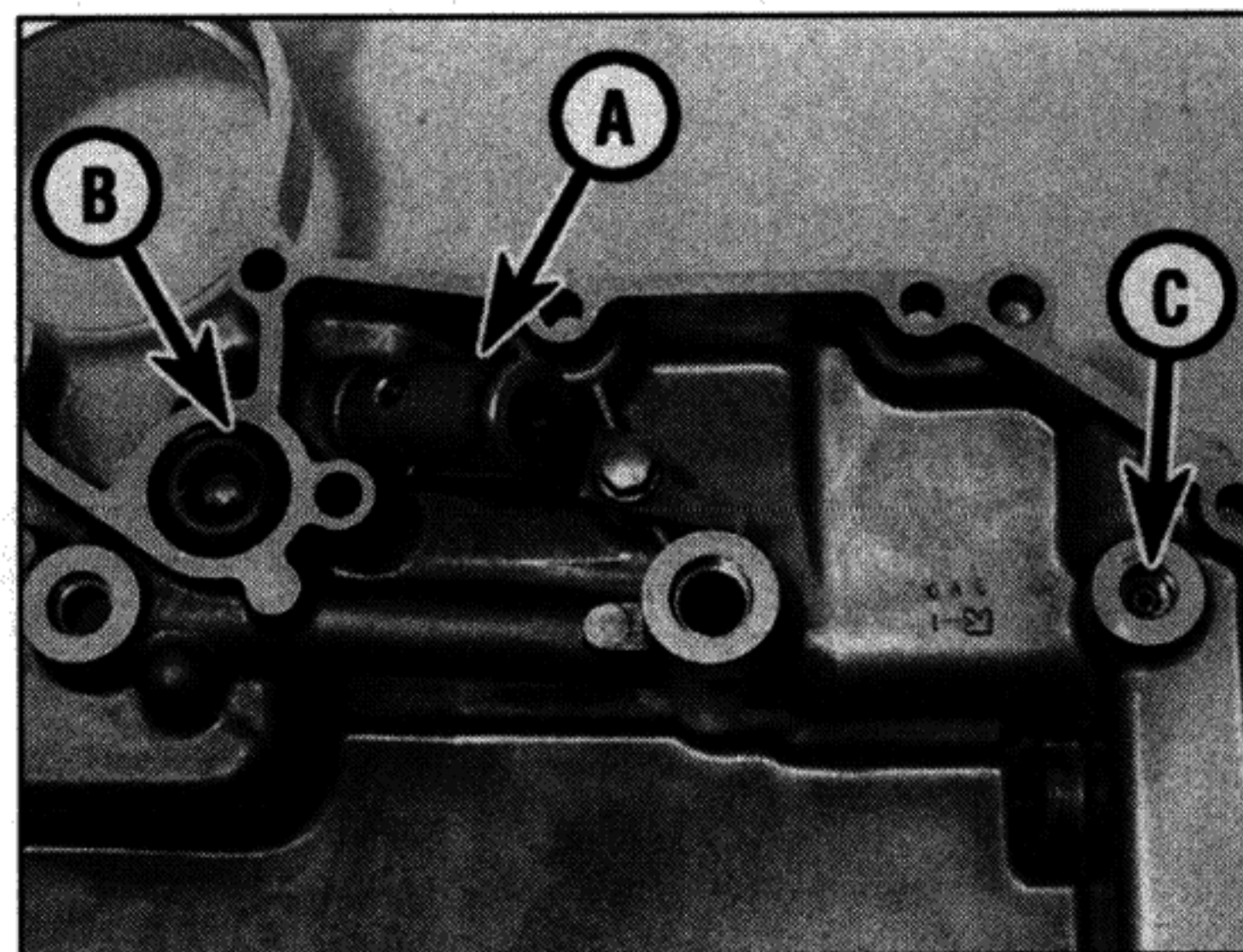
Inspection

6 Remove all traces of gasket from the sump and crankcase mating surfaces, and clean the inside of the sump with solvent.

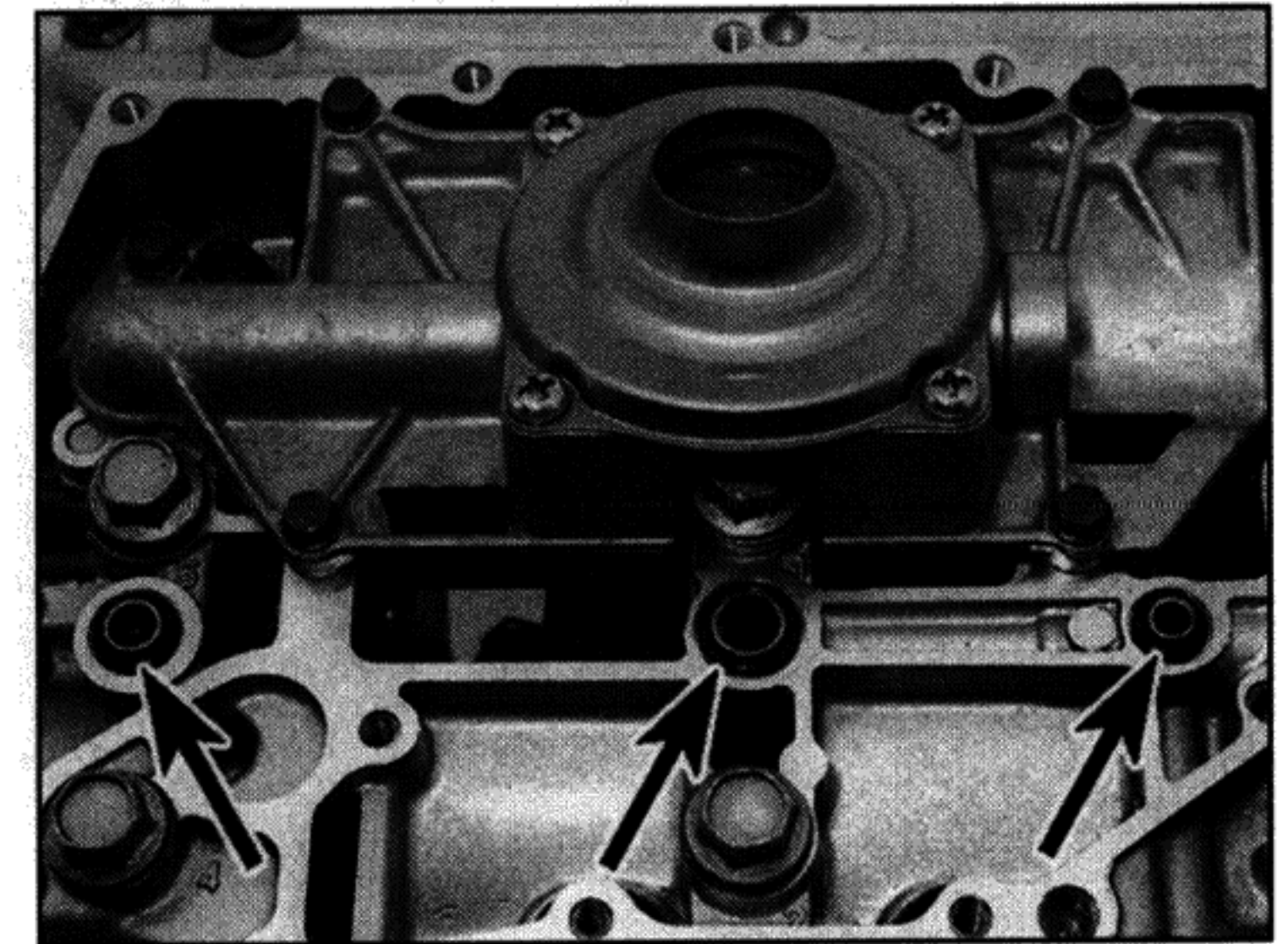
7 Clean the oil strainer in solvent and remove any debris caught in its mesh. Inspect the strainer for any signs of wear or damage and renew it if necessary.

8 Push the relief valve plunger into the valve body and check that it moves smoothly and freely against the spring pressure. If not, renew the relief valve – individual components are not available. Similarly check that the bypass valve ball can be pushed into its bore and is not stuck (see illustration 22.5). Also check that the oil nozzle is securely screwed into its bore and has not worked loose.

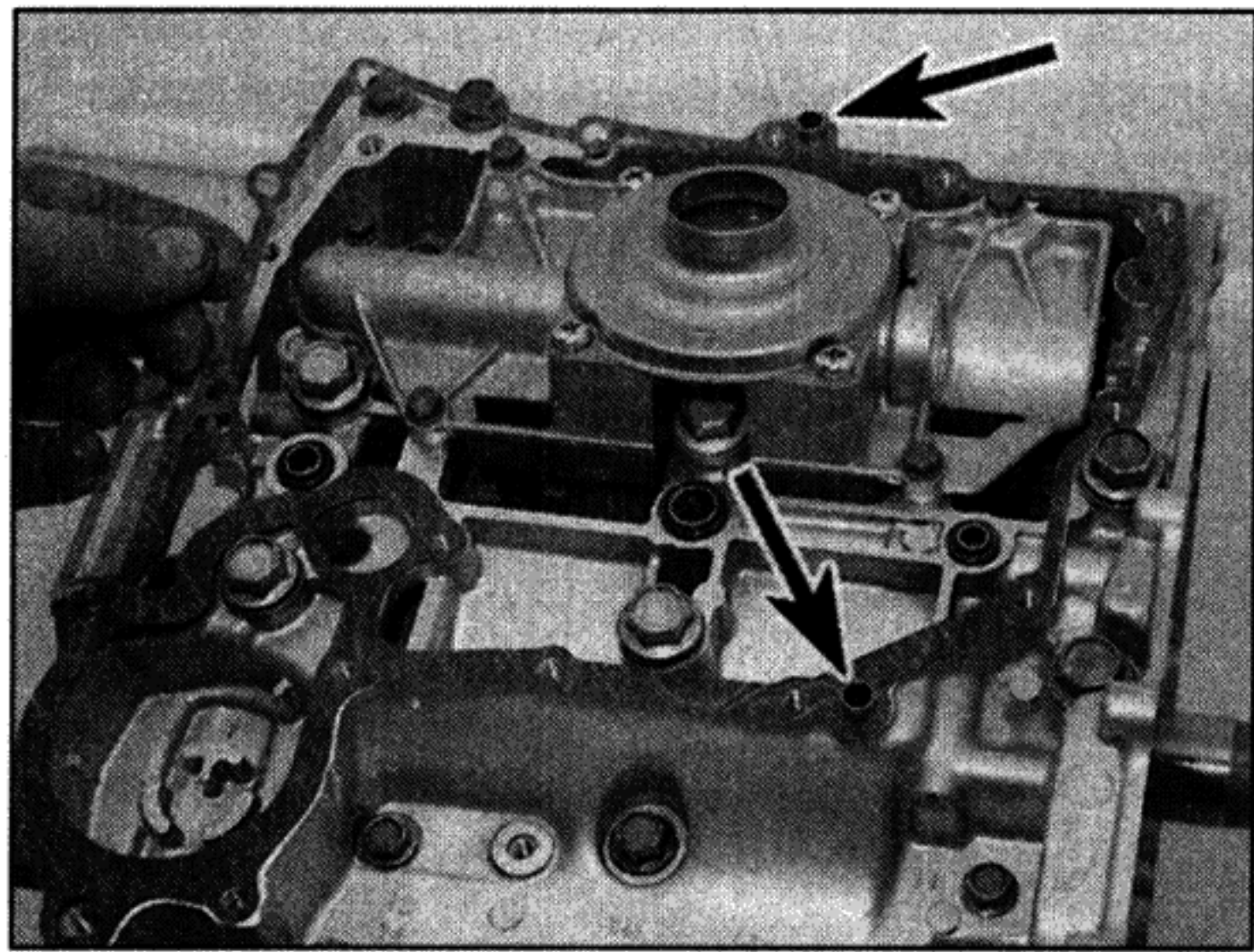
9 Renew the O-rings around the oil passage collars in the crankcase (see illustration). Note their different sizes.



22.5 Pressure relief valve (A), bypass valve (B), oil nozzle (C)



22.9 The O-rings (arrowed) should be renewed



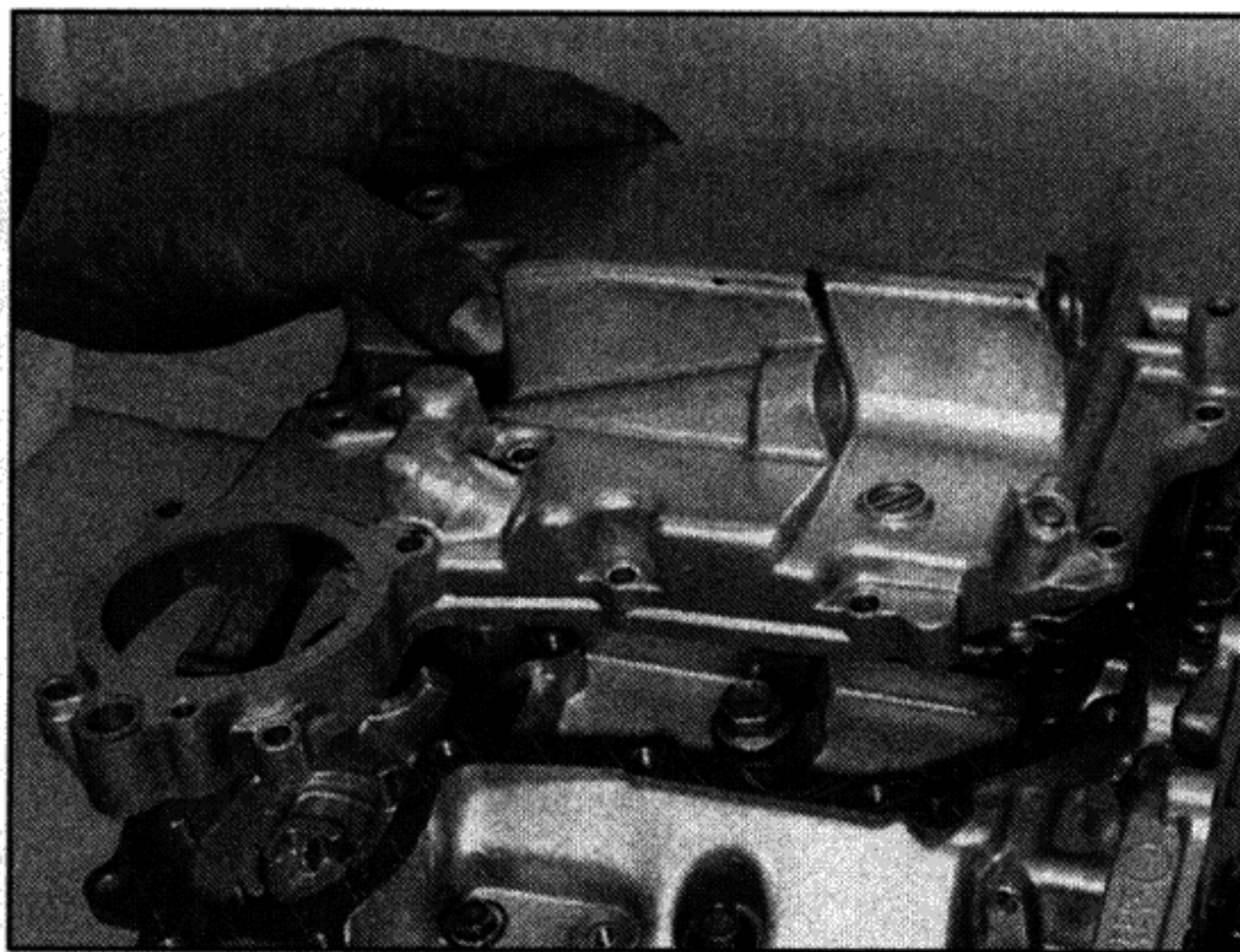
22.12 Fit the new gasket, making sure the dowels (arrowed) are in place . . .

Installation

10 Fit a new O-ring onto the relief valve and smear it with clean oil, then push the valve into its socket in the crankcase. Fit the holder, then apply a suitable non-permanent thread locking compound to the bolt and tighten it to the torque setting specified at the beginning of the Chapter (see illustration 22.5).

11 Install the oil strainer and its cover (see illustrations 22.4c, b and a). Apply a suitable non-permanent thread locking compound to the cover screws and tighten them to the torque setting specified at the beginning of the Chapter.

12 If removed, fit the sump dowels into the crankcase. Lay a new gasket onto the sump (if the engine is in the frame) or onto the



22.13 . . . then fit the sump

crankcase (if the engine has been removed and is positioned upside down on the work surface) (see illustration). Make sure the holes in the gasket align correctly with the bolt holes.

13 Position the sump onto the crankcase, then apply a suitable non-permanent thread locking compound to the bolts and install them finger-tight (see illustration). Tighten the bolts evenly in a criss-cross pattern to the specified torque setting.

14 Install the oil filter and cover and fill the engine with the correct type and quantity of oil (see Chapter 1).

15 On TDM and TRX models install the exhaust system (see Chapter 4). On 1991 to 1995 TDM models and XTZ models, install the

engine bashplate (see Chapter 8). Start the engine and check that there are no oil leaks around the sump and oil filter cover.

23 Balancer shafts – removal, inspection and installation



Note: On 1991 to 1995 TDM models and XTZ models, the balancer shafts can be removed with the engine in the frame. If the engine has been removed, ignore the steps which do not apply. On 1996-on TDM models and all TRX models, the engine must be removed from the frame.

Removal

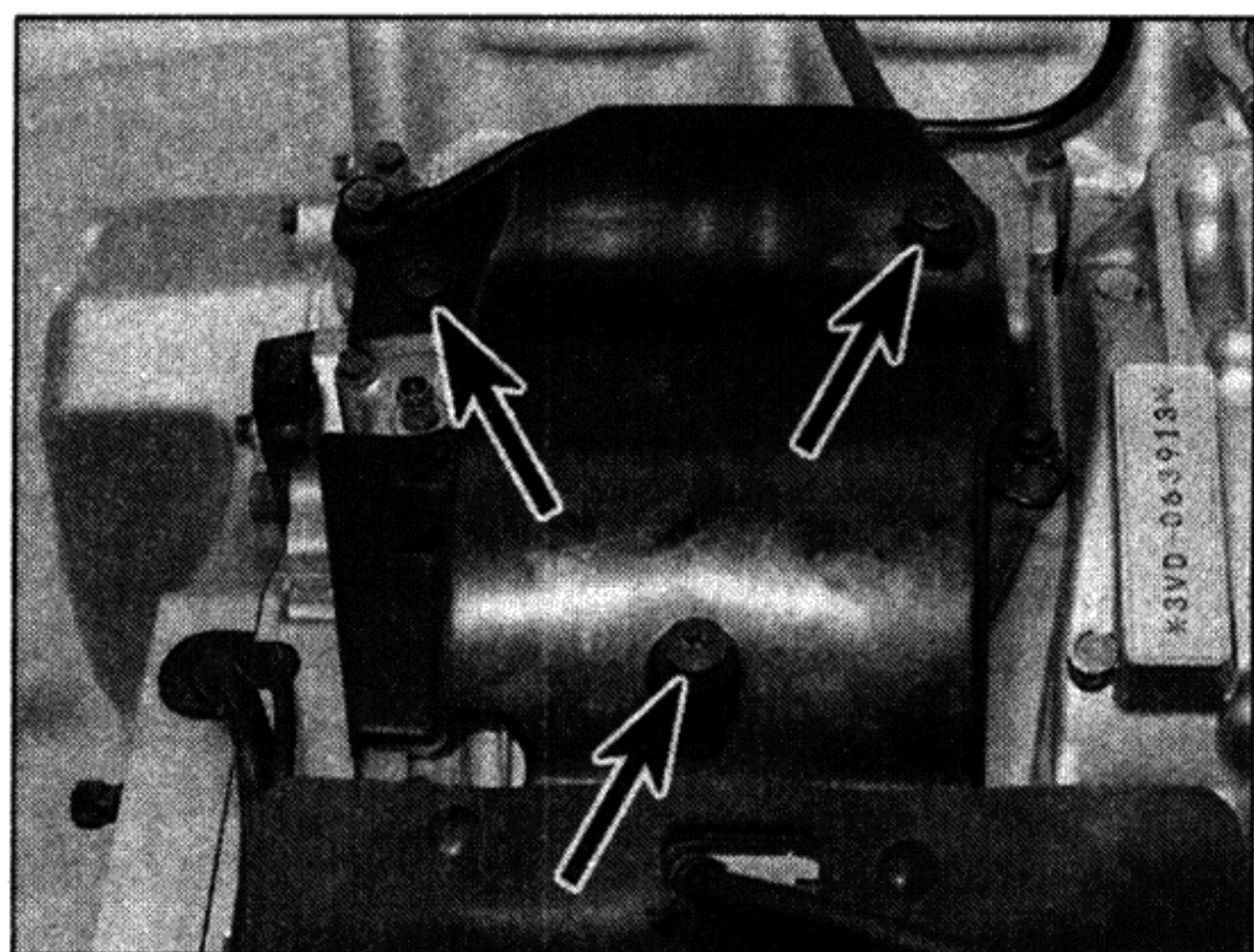
1 On 1991 to 1995 TDM models and XTZ models, remove the seat, side covers and engine bashplate (see Chapter 8), the fuel tank and exhaust system (see Chapter 4), the starter clutch and idle/reduction gear (see Section 18), and the oil sump (see Section 22).

2 On 1996-on TDM models and TRX models, remove the oil tank (see Section 21), the starter clutch and idle/reduction gear (see Section 18), and the oil sump (see Section 22).

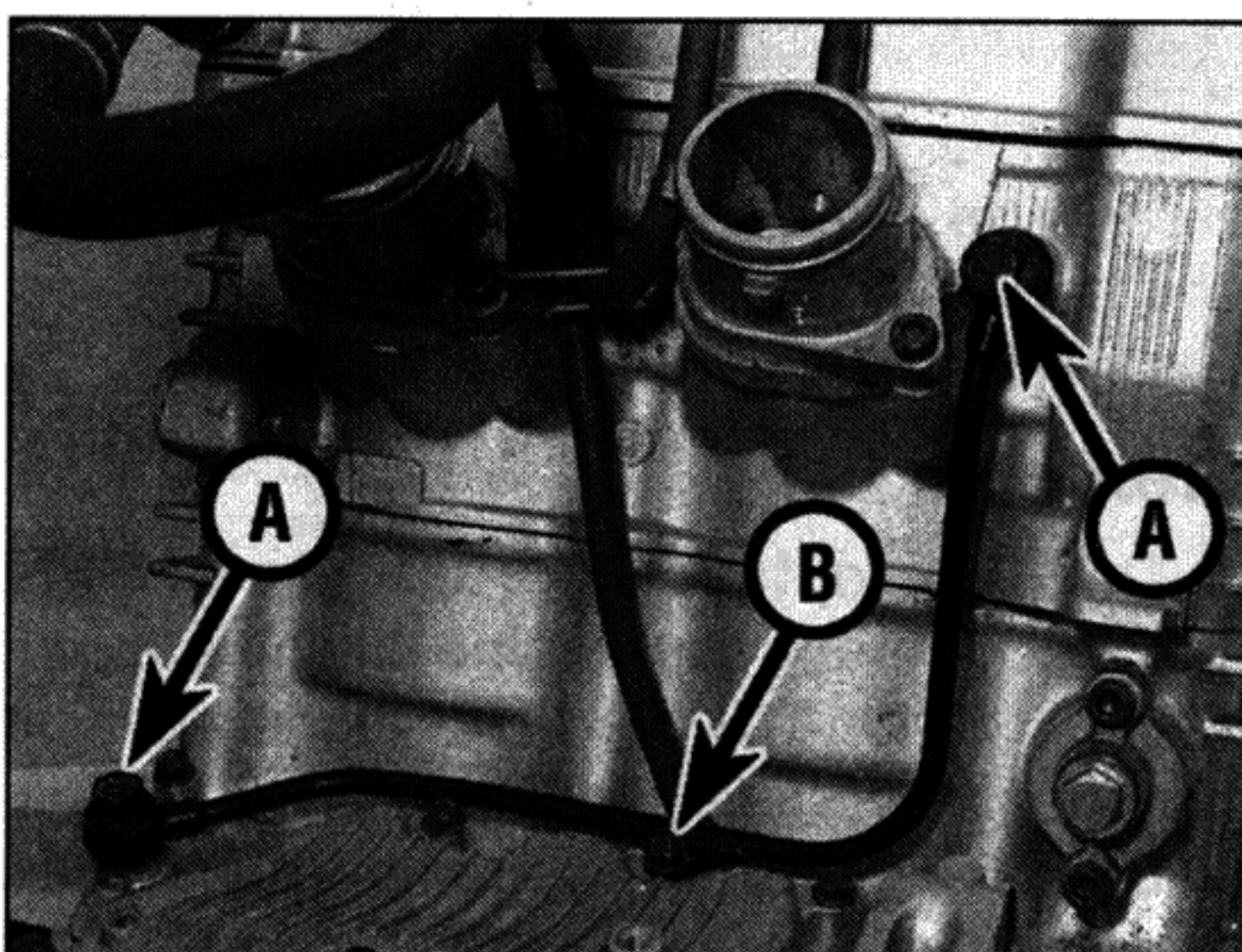
3 On 1992 to 1995 TDM models, unscrew the bolts securing the mudflap/engine top cover and remove the cover, feeding the earth cable through as you do (see illustration).

4 On 1991 to 1995 TDM models and XTZ models, unscrew the oil pipe banjo bolts and the bracket bolt securing the oil pipe to the cylinder head and the crankcase top cover and remove the pipe (see illustration). Discard the sealing washers as new ones must be used. Working evenly in a criss-cross pattern, unscrew the bolts securing the cover to the top of the crankcase and remove the cover (see illustration). Note the position of the earth cable and cable guide(s) and of the bolt with the copper sealing washer. Discard the gasket as a new one must be used. Note the positions of the dowels and remove them if they are loose.

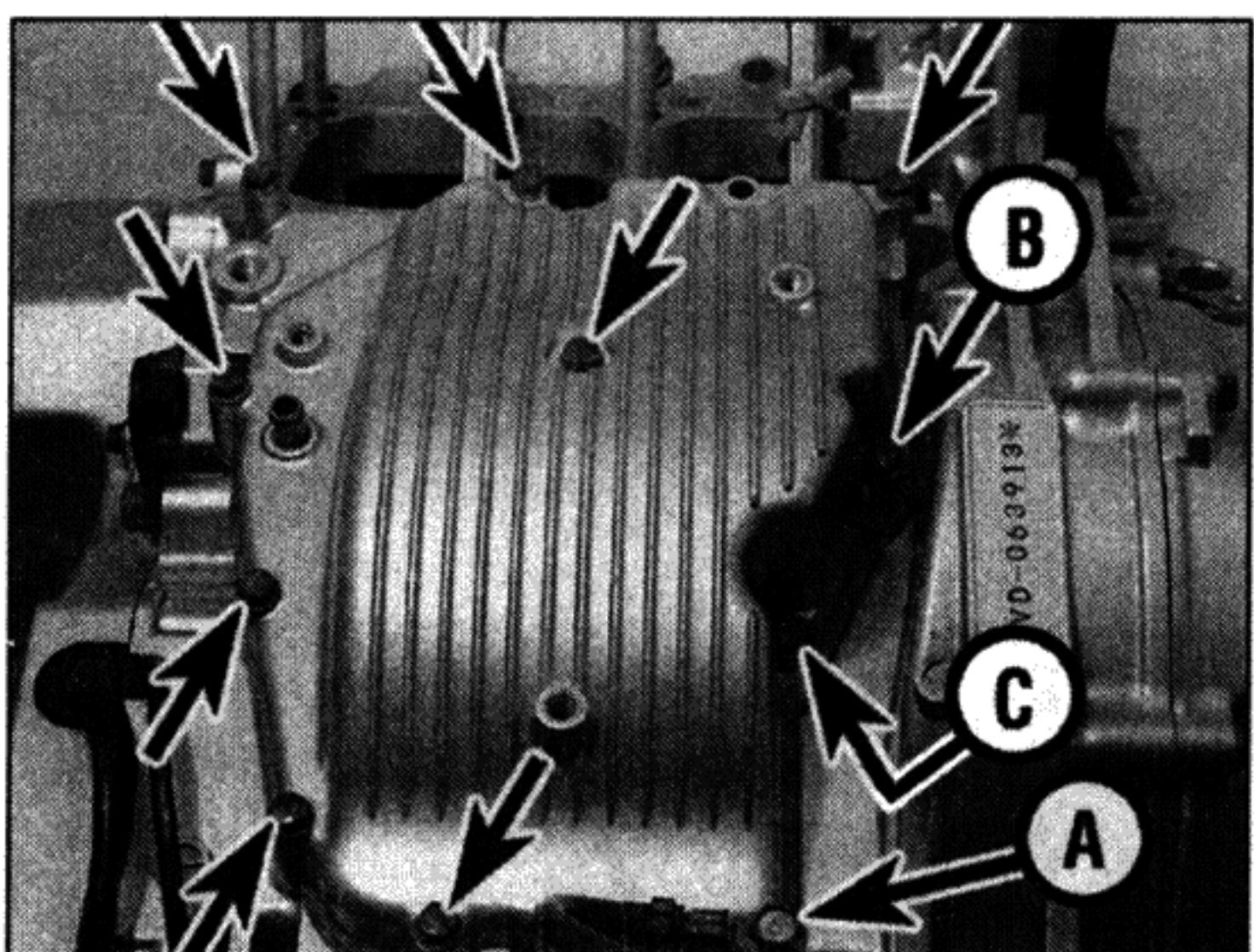
5 Unscrew the bolts securing the oil strainer holder and remove the holder (see illustration). Remove the O-ring from the oil passage collar in the crankcase (see illustration); a new O-ring is required for reassembly.



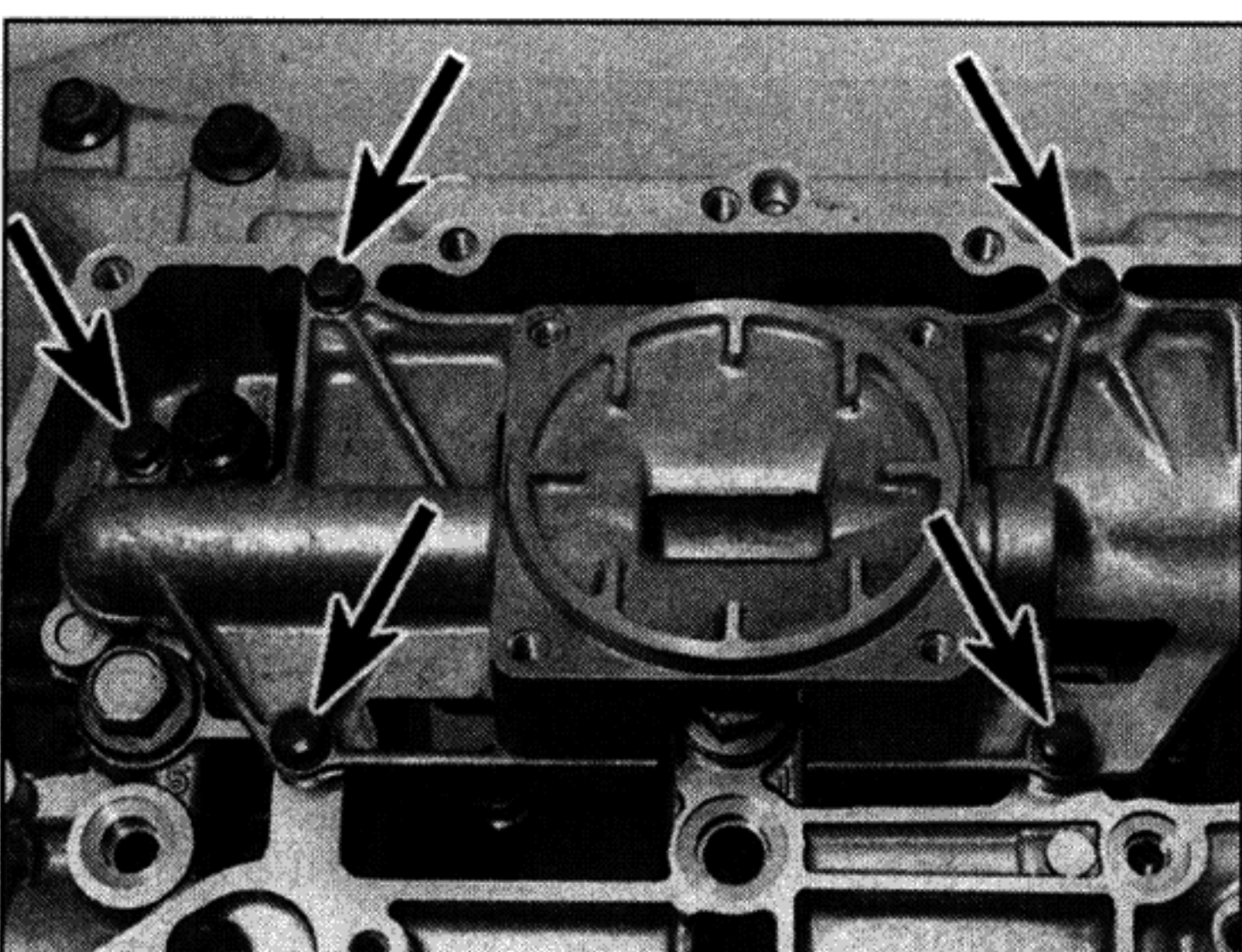
23.3 Remove the screws (arrowed) and lift off the cover



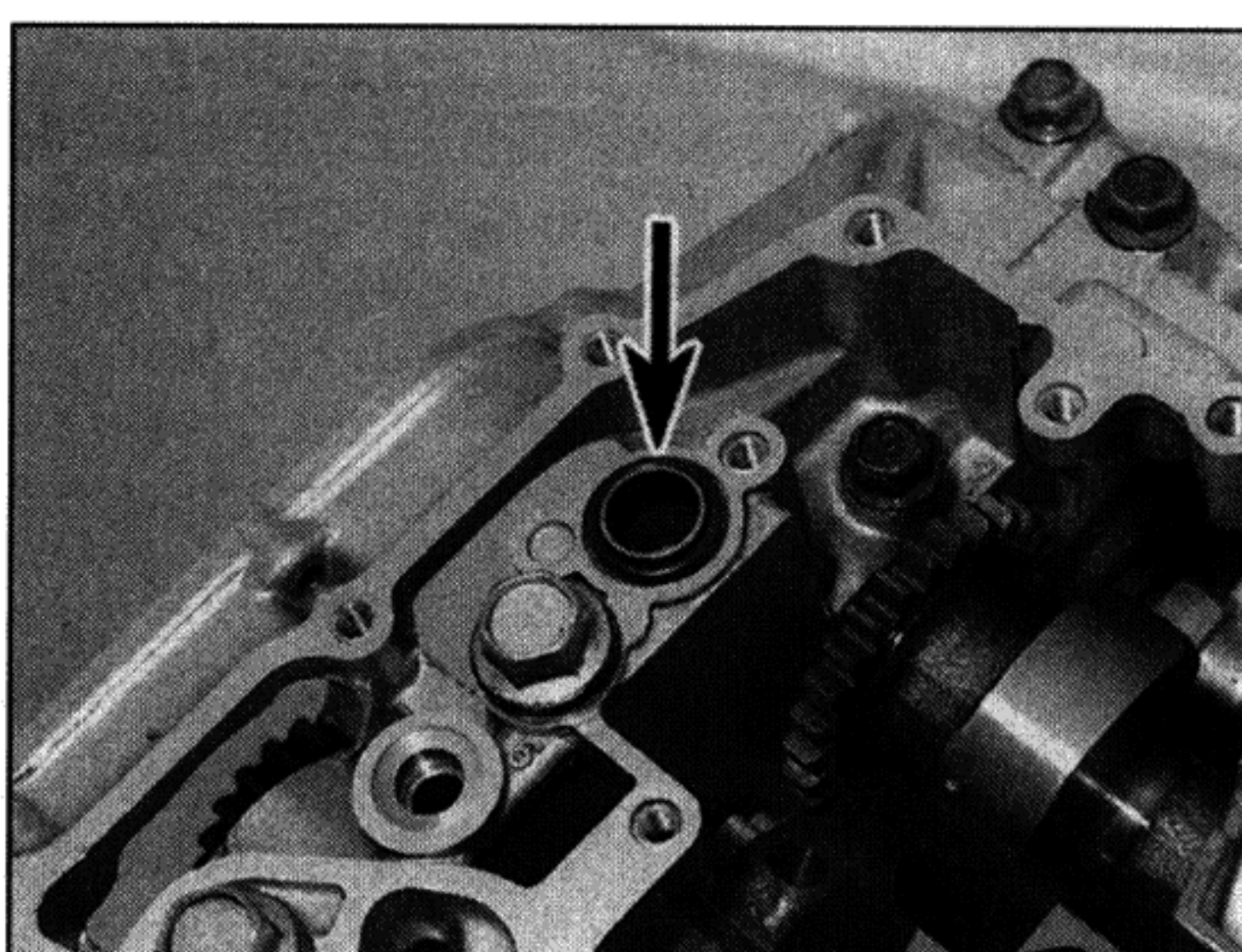
23.4a Unscrew the banjo bolts (A) and the bracket bolt (B) and remove the pipe



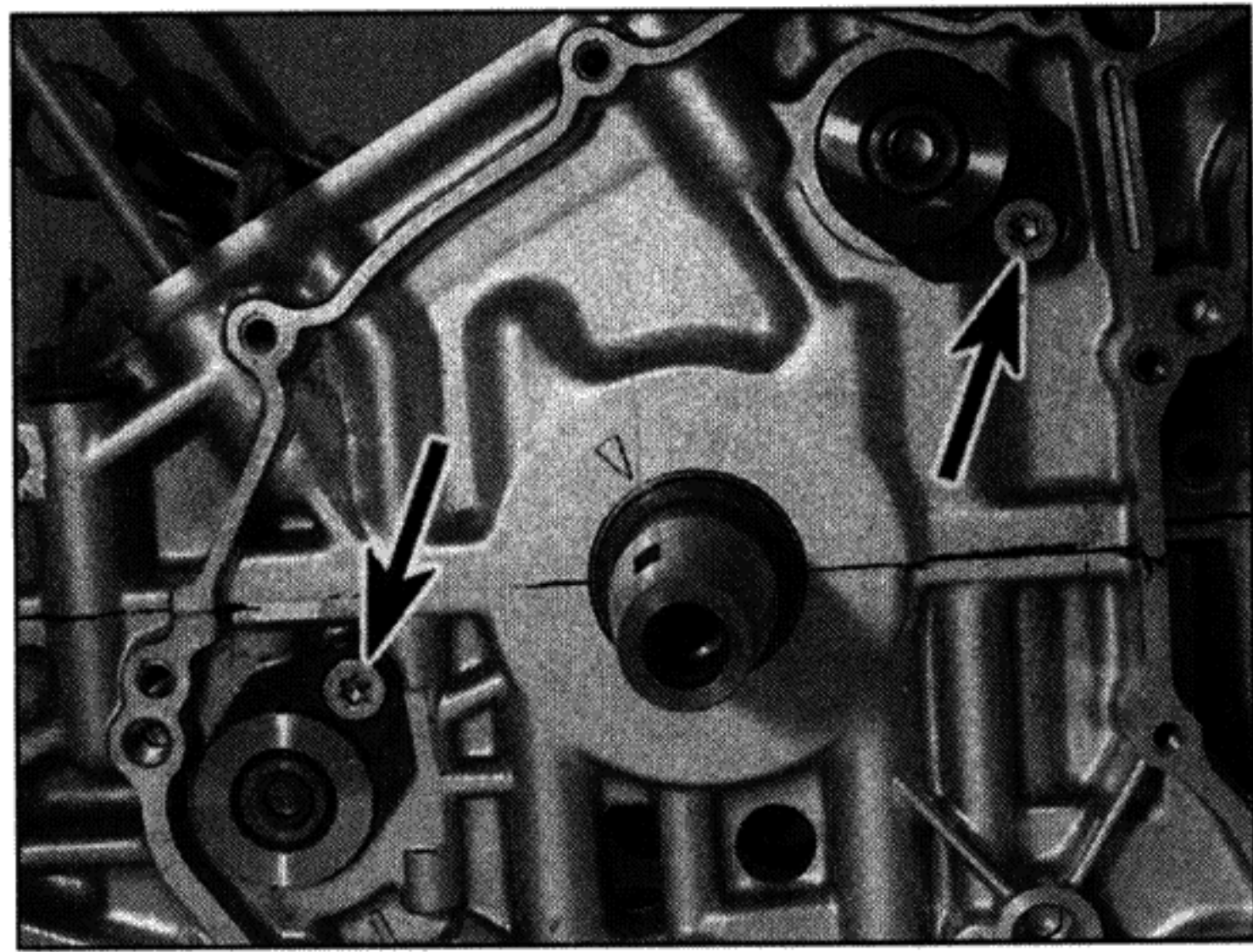
23.4b Unscrew the bolts (arrowed) and remove the cover, noting the earth cable (A), cable guide (B) and copper washer (C)



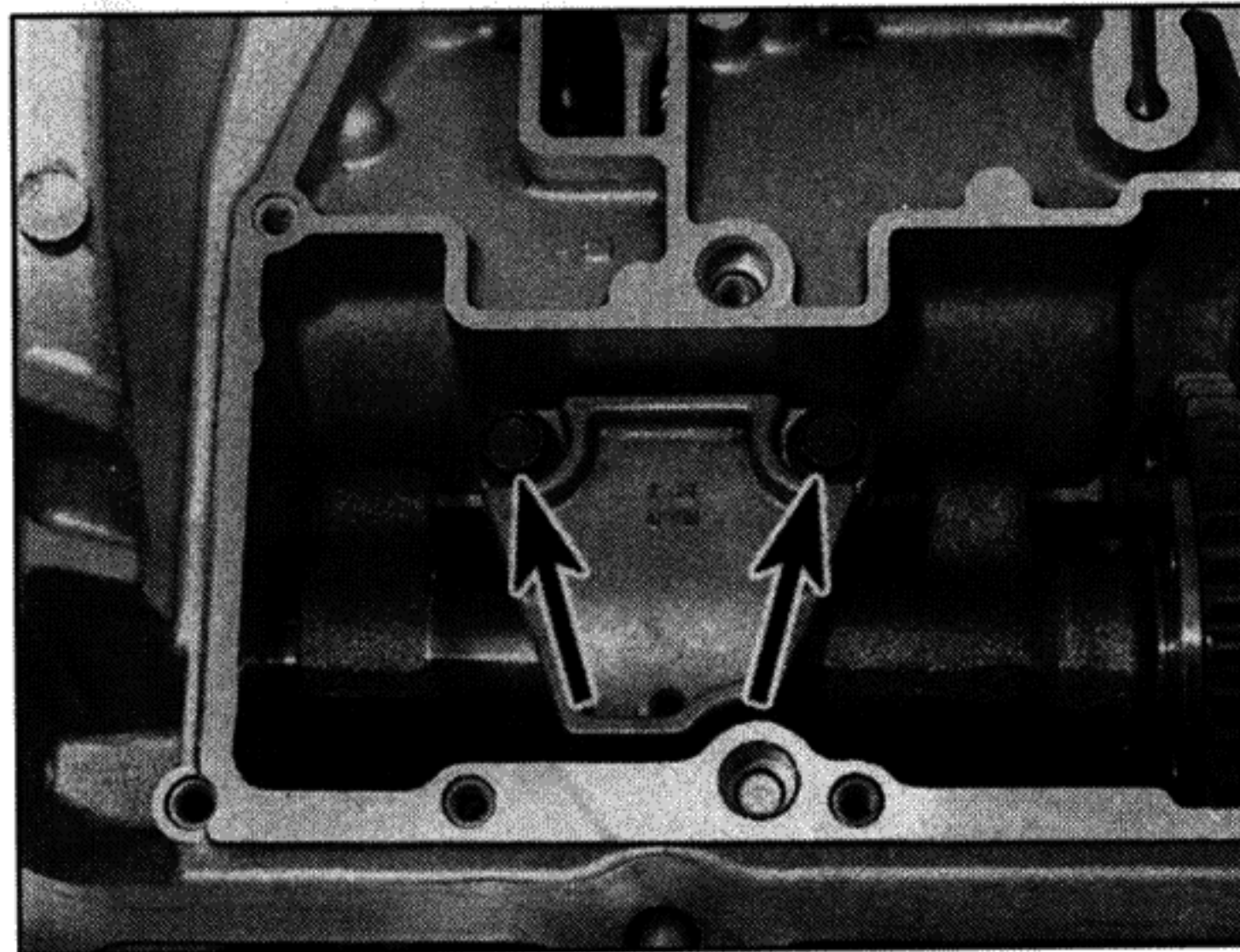
23.5a Unscrew the bolts (arrowed) and remove the holder



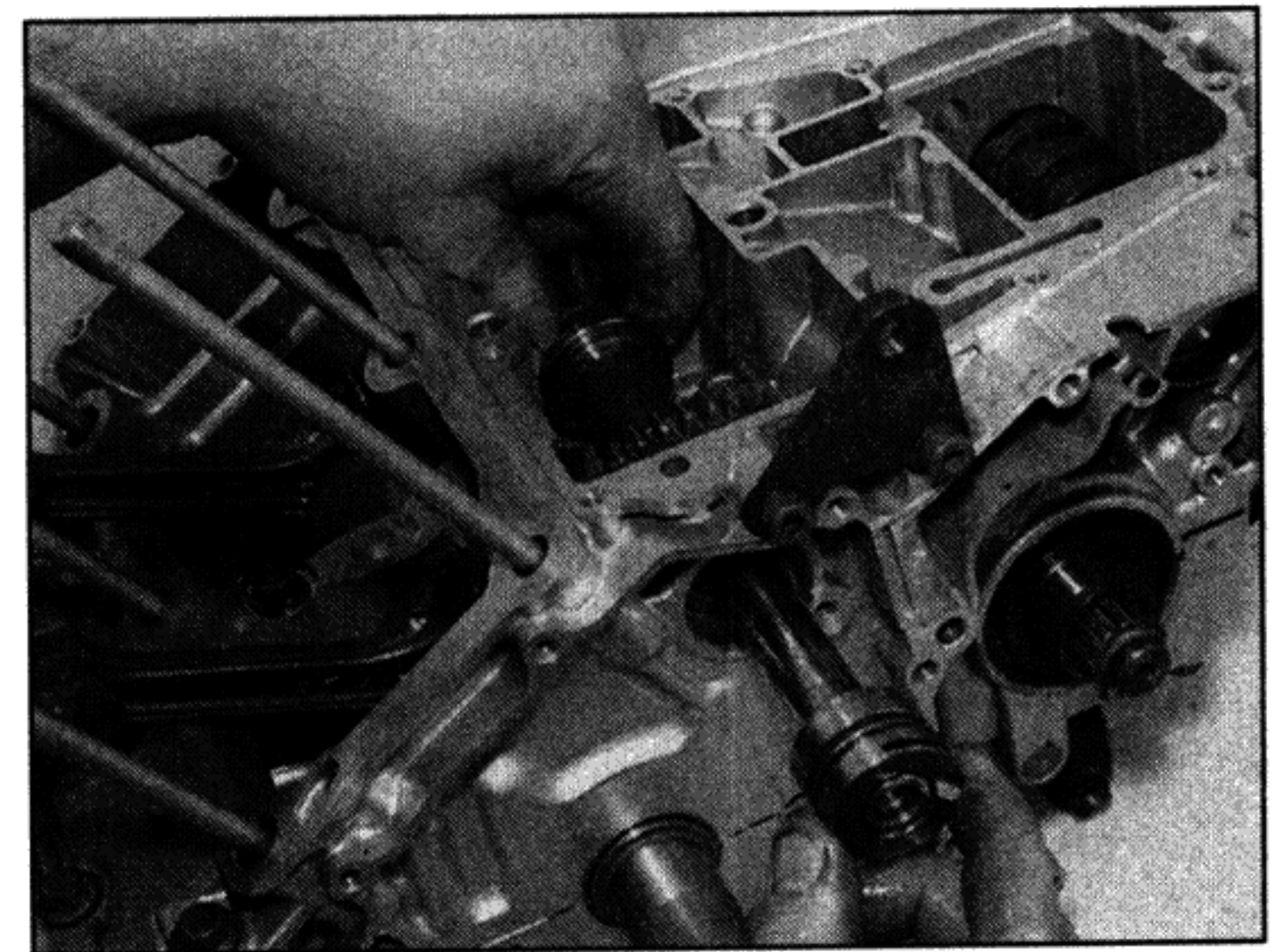
23.5b The O-ring (arrowed) should be renewed



23.6 Each retainer plate is secured by a Torx screw (arrowed)



23.7a Unscrew the bolts (arrowed) and remove the holder ...



23.7b ... then withdraw the shaft and lift out the rear weight

6 Unscrew the Torx bolt securing each balancer shaft retainer plate and remove the plates, noting how they fit (**see illustration**).

7 Unscrew the bolts securing the rear balancer shaft holder and remove the holder (**see illustration**). Remove the dowels if they are loose. Support the rear balancer shaft weight, then withdraw the shaft from the left-hand side of the crankcase and lift the weight out of the top (**see illustration**). Discard the shaft O-ring as a new one must be used. Keep the weight and shaft together as a matched pair, and do not confuse them with the front weight and shaft.

8 Unscrew the bolts securing the front balancer shaft holder and remove the holder (**see illustration**). Remove the dowels if they are loose. Support the front balancer shaft weight, then withdraw the shaft from the left-hand side of the crankcase and remove the weight from the bottom (**see illustration**).

Inspection

9 Check the weights for cracked, chipped and worn teeth on the driven gears and renew the weight if any are found. The drive gears on the crankshaft should also be checked. Check the condition of the needle bearings in the bore of the weight. If they are worn, the weight must be renewed as the bearings are not listed as being available separately, though it is worth checking with a Yamaha dealer or bearing specialist.

10 Check the shafts are straight by rolling them on a flat surface such as a piece of glass. Also check the bearing surfaces for scuffing and wear.

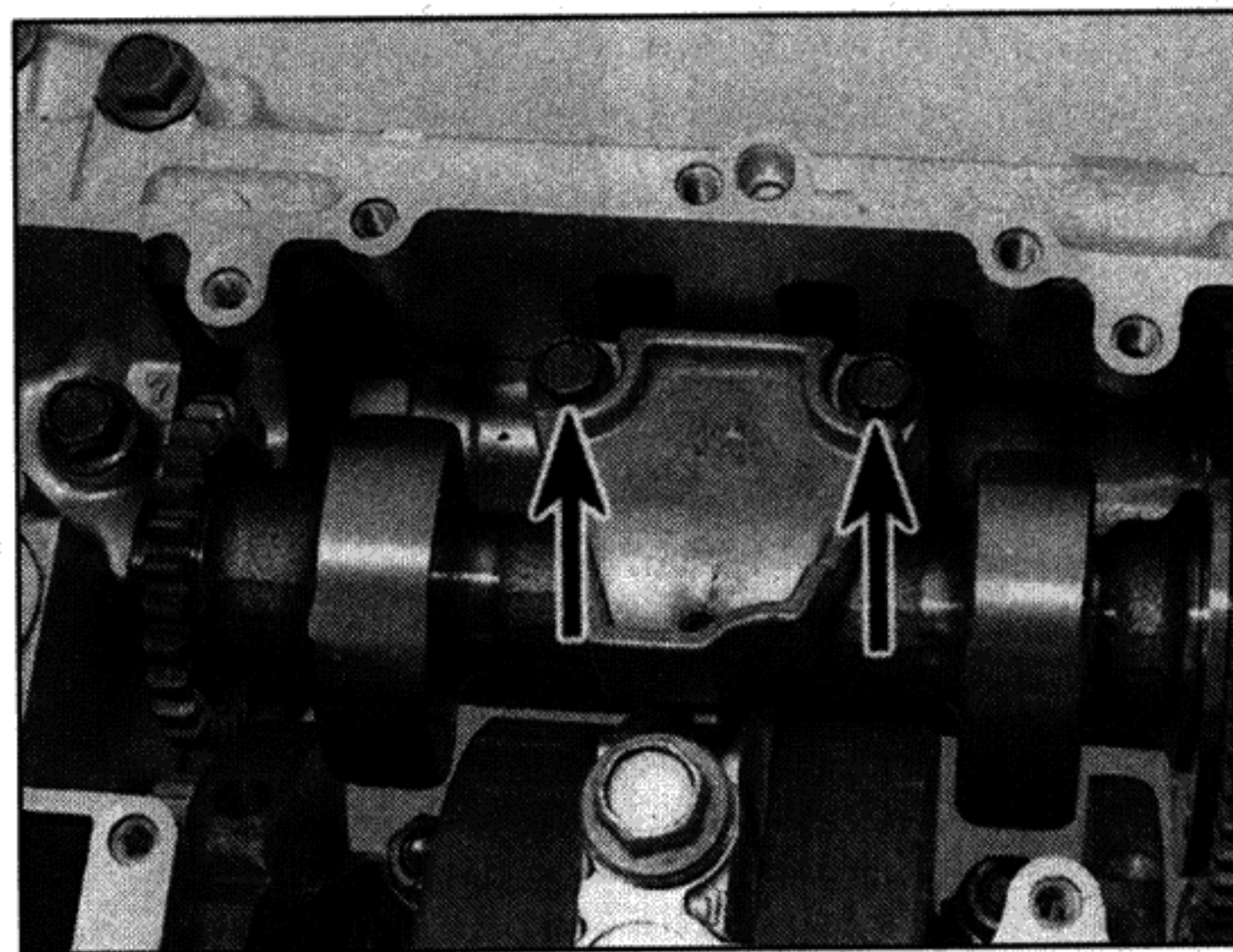
Installation

11 Turn the crankshaft until the Woodruff key slot (for the alternator rotor) on the left-hand end aligns with the triangular mark on the crankcase (**see illustration**). The best way to turn the engine with the alternator rotor removed is to engage a gear and use the front sprocket nut. If the engine is still in the frame, the rear wheel can be used. Turn the sprocket in an anti-clockwise direction only and remove the spark plugs (see Chapter 1) to release the compression in the engine,

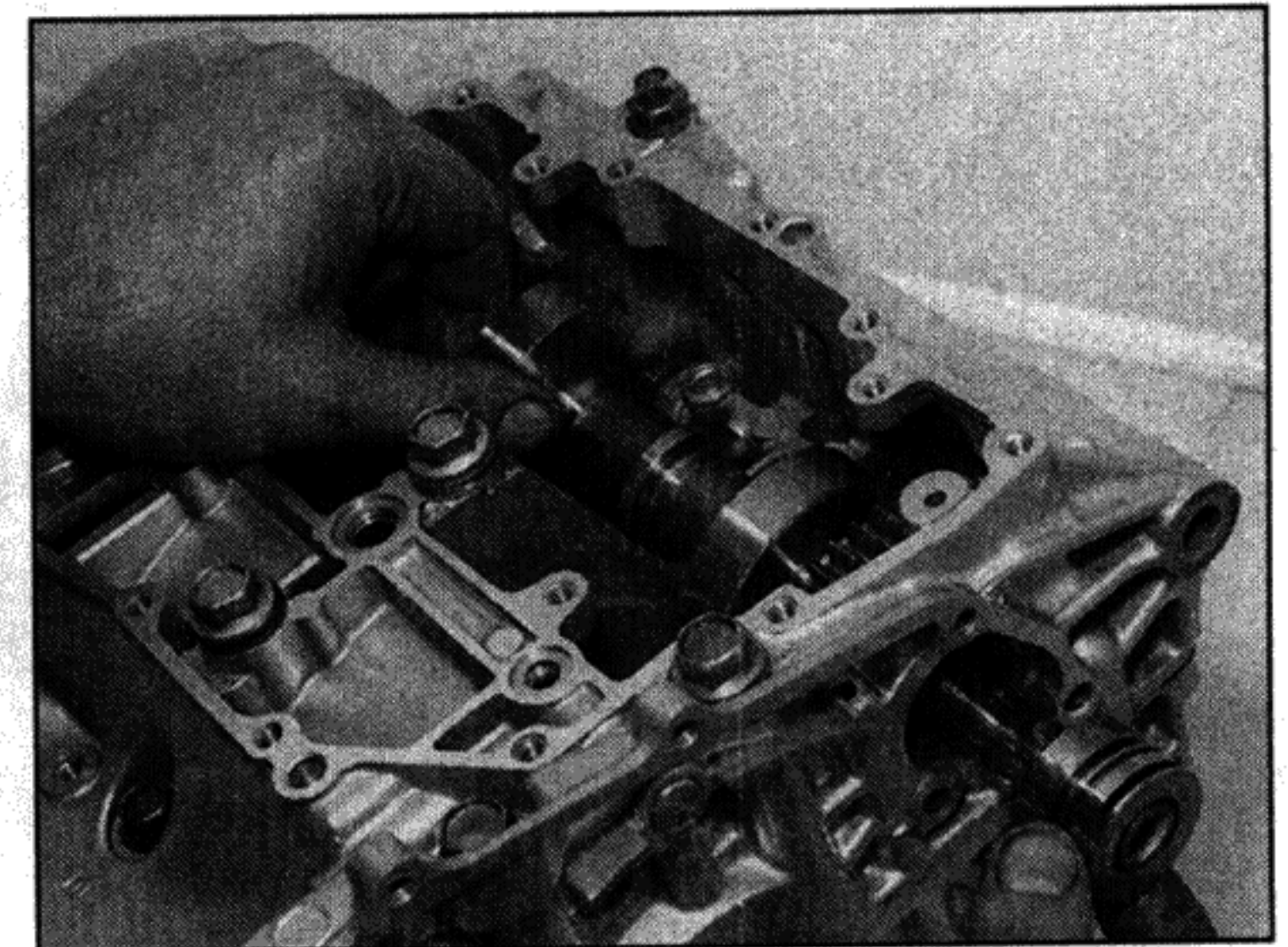
making it much easier to turn and to prevent the nut from undoing.

12 Apply clean engine oil to the front balancer shaft. Position the front balancer weight in the engine, aligning the punch mark on the larger gear with the mark on the crankcase, then slide the shaft in from the left-hand side until it is fully home (**see illustration and 23.8b**). Check that the marks on both the crankshaft and the balancer shaft are still correctly aligned. If removed, fit the balancer holder dowels, then install the holder and tighten its bolts to the torque setting specified at the beginning of the Chapter (**see illustration**).

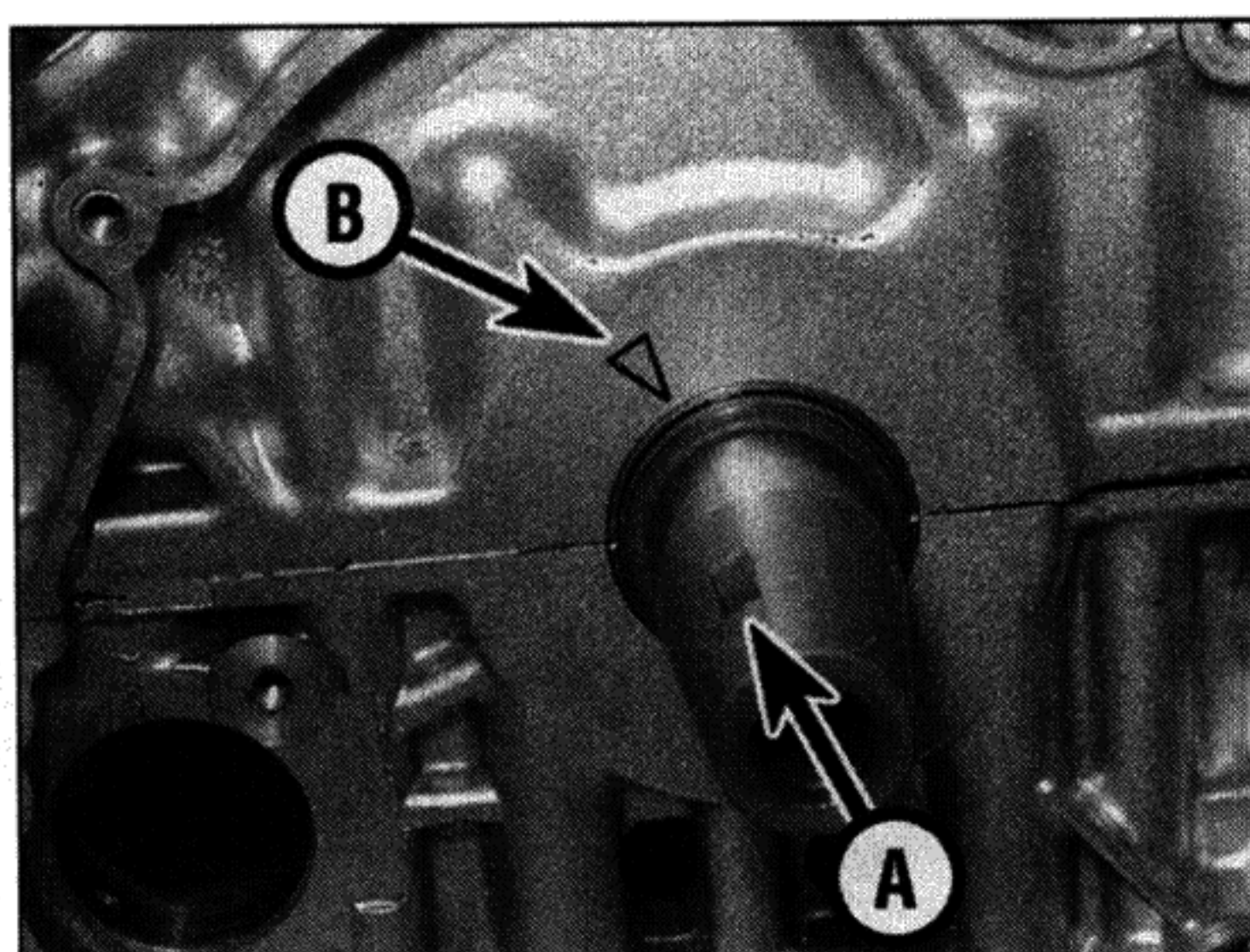
13 Fit a new O-ring onto the rear balancer shaft and smear it with lithium-based grease



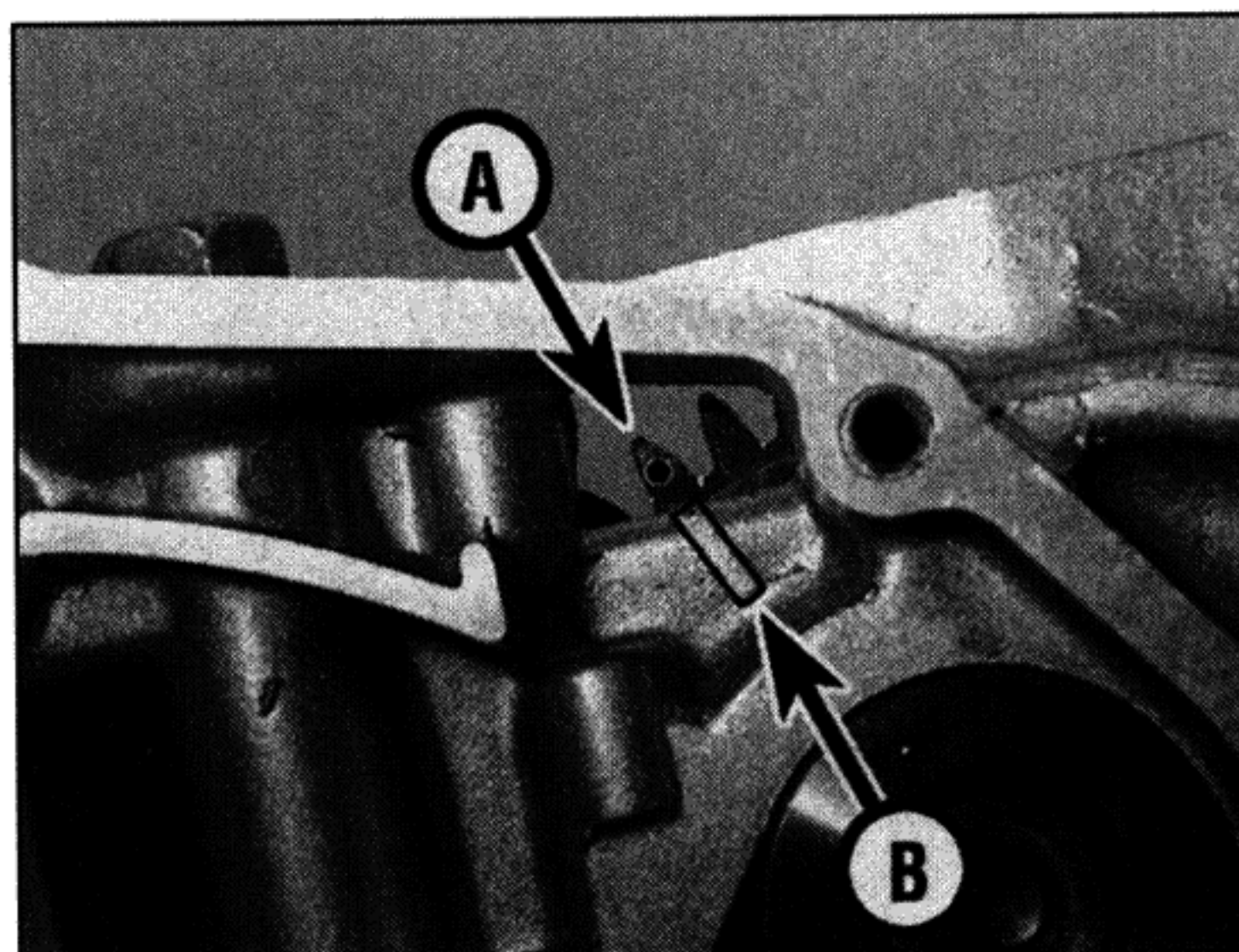
23.8a Unscrew the bolts (arrowed) and remove the holder ...



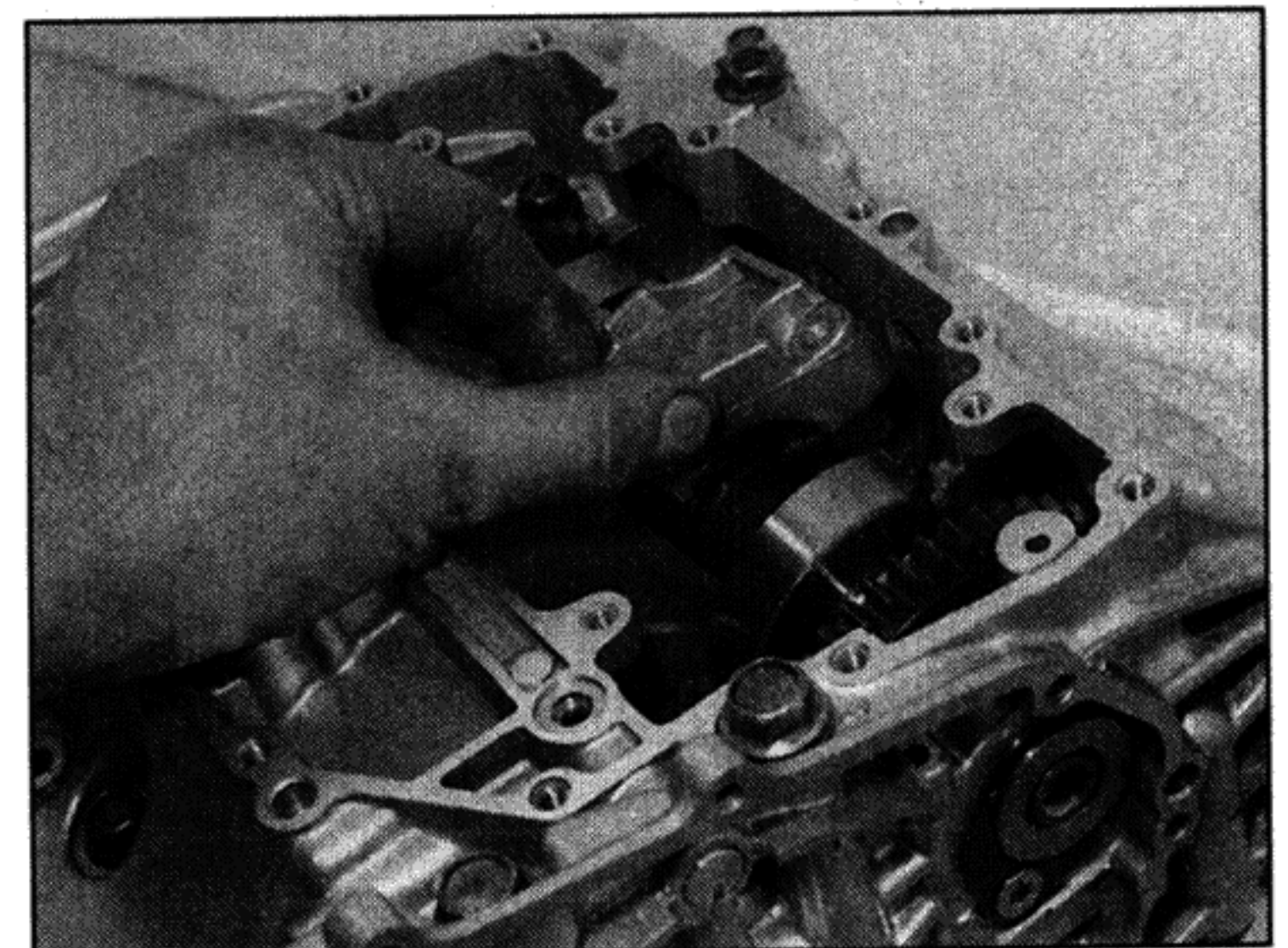
23.8b ... then withdraw the shaft and lift out the front weight



23.11 Align the Woodruff key slot (A) with the triangular mark (B)



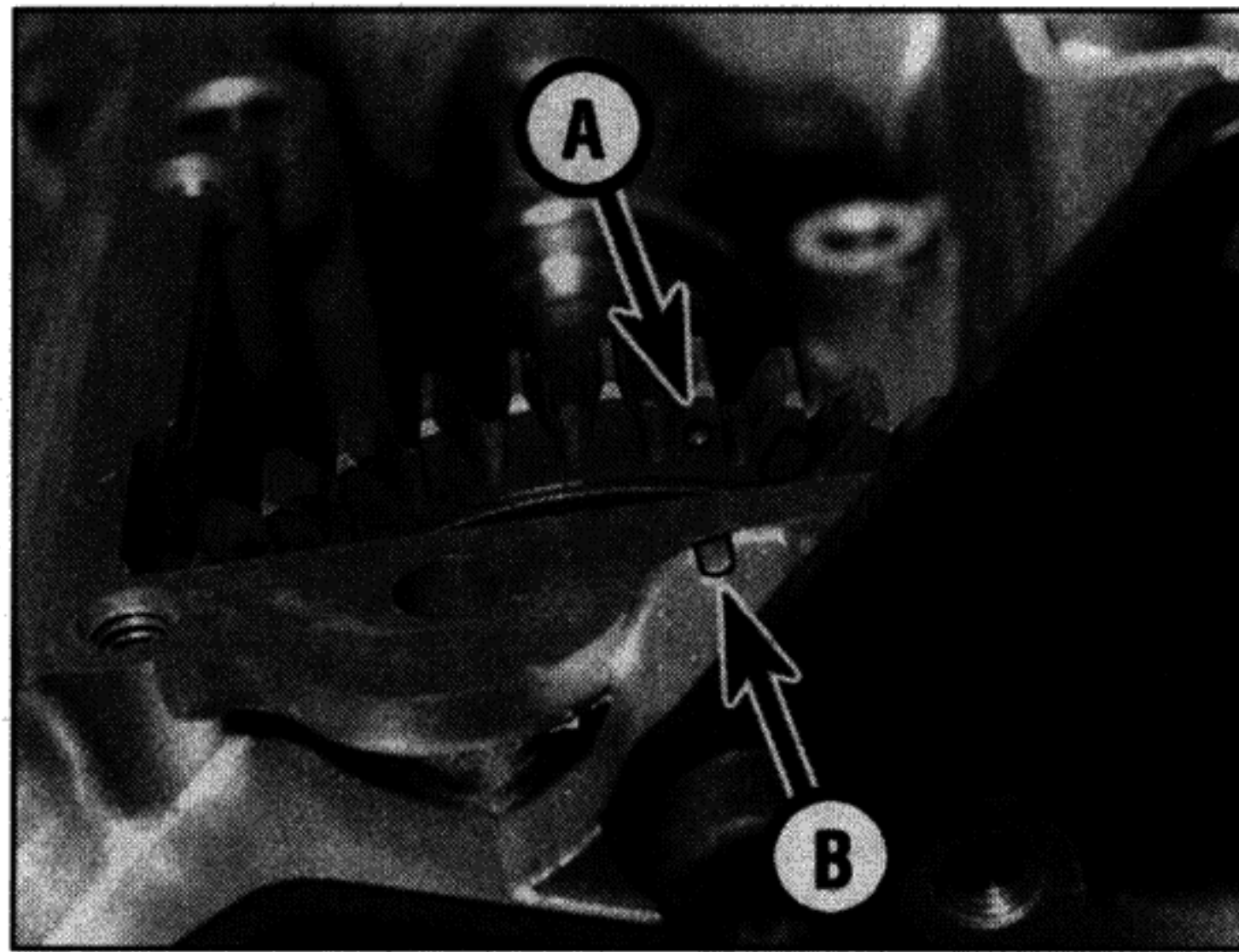
23.12a Align the punch mark on the gear (A) with the mark on the crankcase (B)



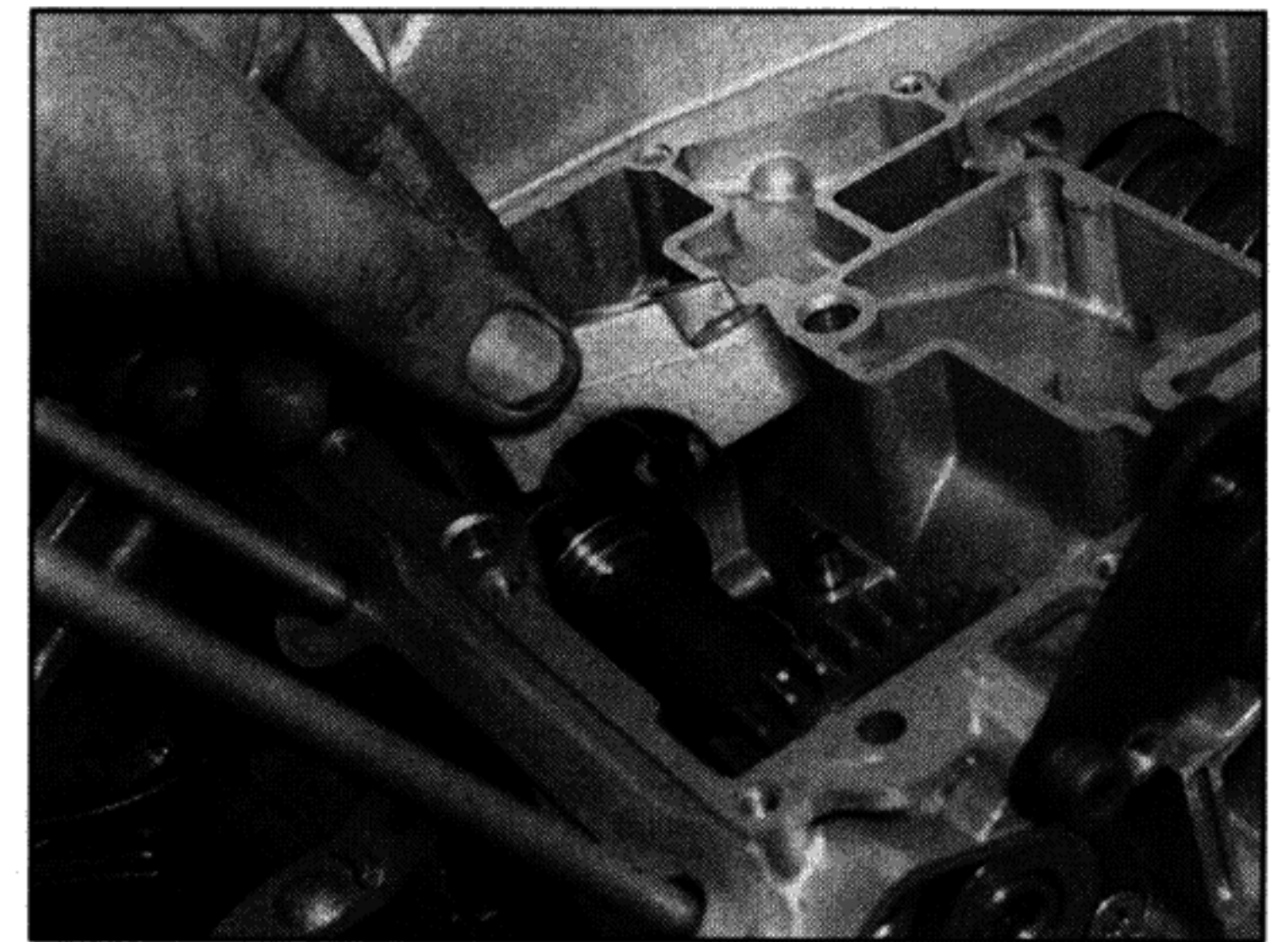
23.12b Fit the holder onto the dowels



23.13a Fit a new O-ring into the narrow groove



23.13b Align the punch mark on the gear (A) with the mark on the crankcase (B)



23.13c Fit the holder onto the dowels

(see illustration). Apply clean engine oil to the shaft. Position the rear balancer weight in the engine, aligning the punch mark on the larger gear with the mark on the crankcase, then slide the shaft in from the left-hand side until it is fully home (see illustration and 23.7b). Check that the marks on both the crankshaft and the balancer shaft are still correctly aligned. If removed, fit the balancer holder dowels, then install the holder and tighten its bolts to the torque setting specified at the beginning of the Chapter (see illustration).

14 Fit the shaft retainer plates with the

counter-sink for the screw heads on the outside, then apply a suitable non-permanent thread locking compound to the Torx screw threads and tighten them to the specified torque setting (see illustration).

15 Fit a new O-ring around the oil passage collar (see illustration 23.5b), then fit the oil strainer holder (see illustration). Apply a suitable non-permanent thread locking compound to the holder bolts and tighten them to the specified torque setting.

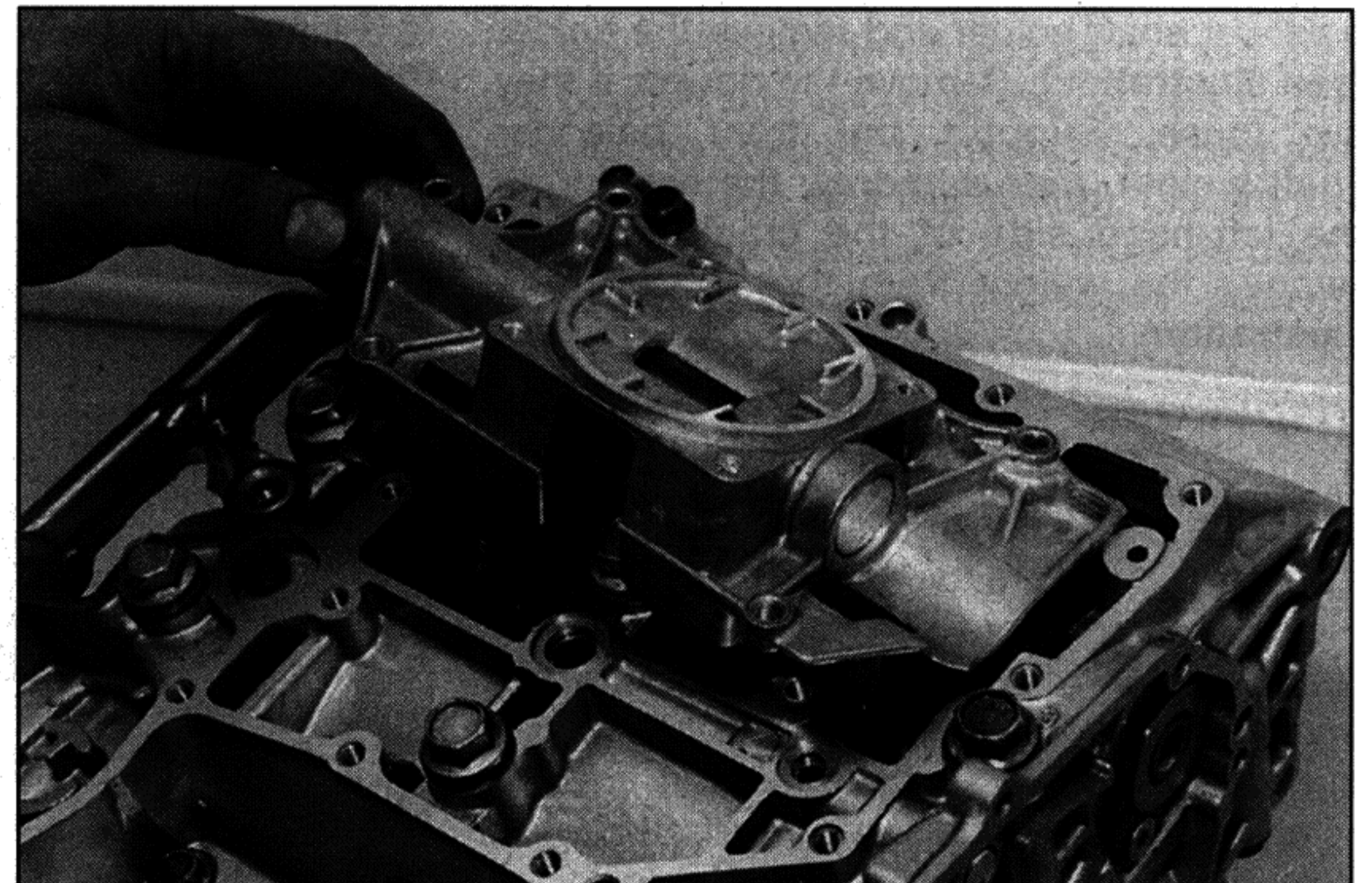
16 On 1991 to 1995 TDM models and XTZ models, if removed, install the crankcase top cover dowels. Fit the cover using a new

gasket, then tighten the bolts evenly in a criss-cross pattern to the specified torque, not forgetting the earth cable and cable guide(s) and making sure the bolt with the copper washer is positioned at the rear on the right-hand side (see illustrations). Install the oil pipe using new sealing washers on each side of the unions and tighten the banjo bolts and the bracket bolt to the specified torque settings (see illustration).

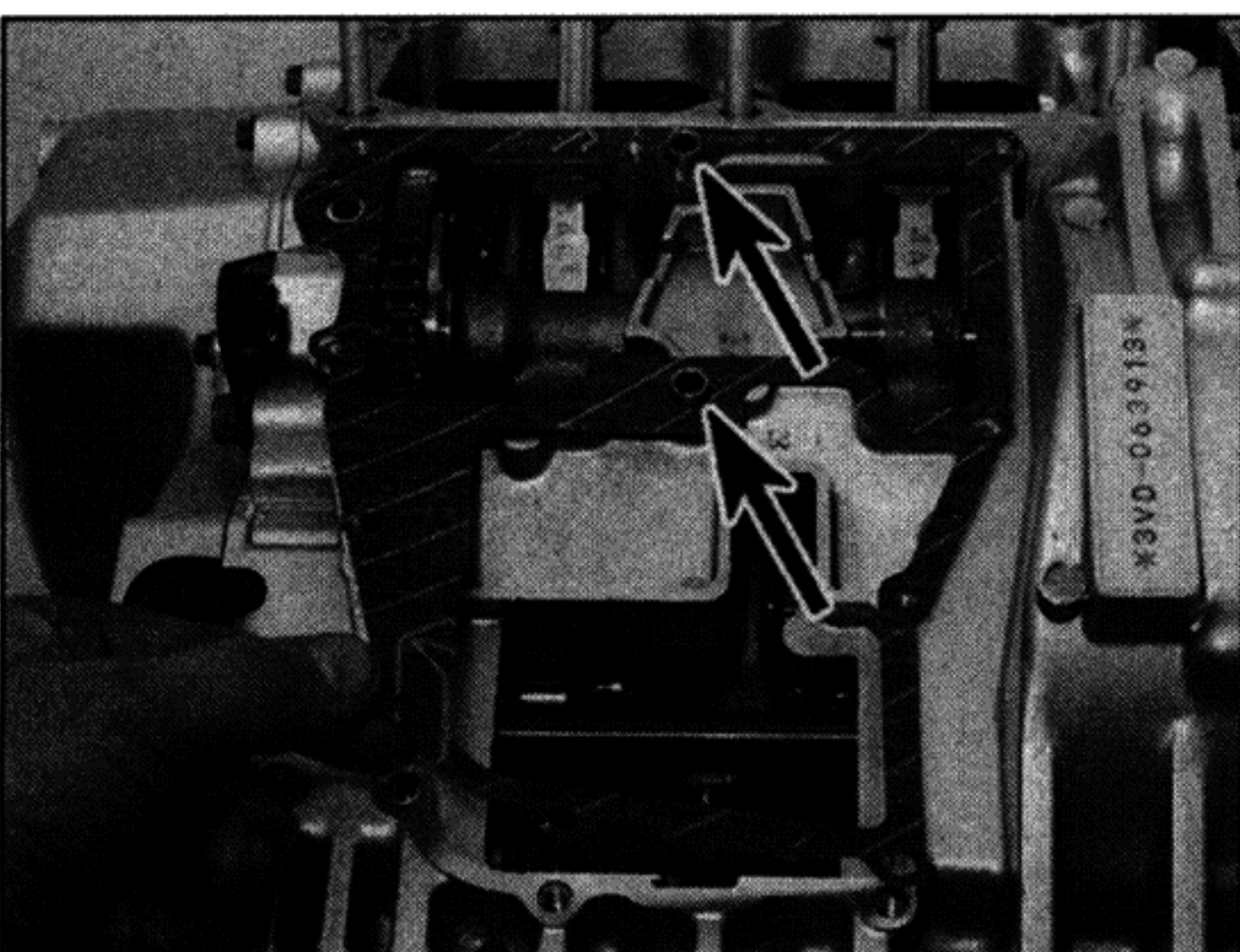
17 Install all remaining components or assemblies in a reverse of the removal procedure (see Steps 3, 2 and 1).



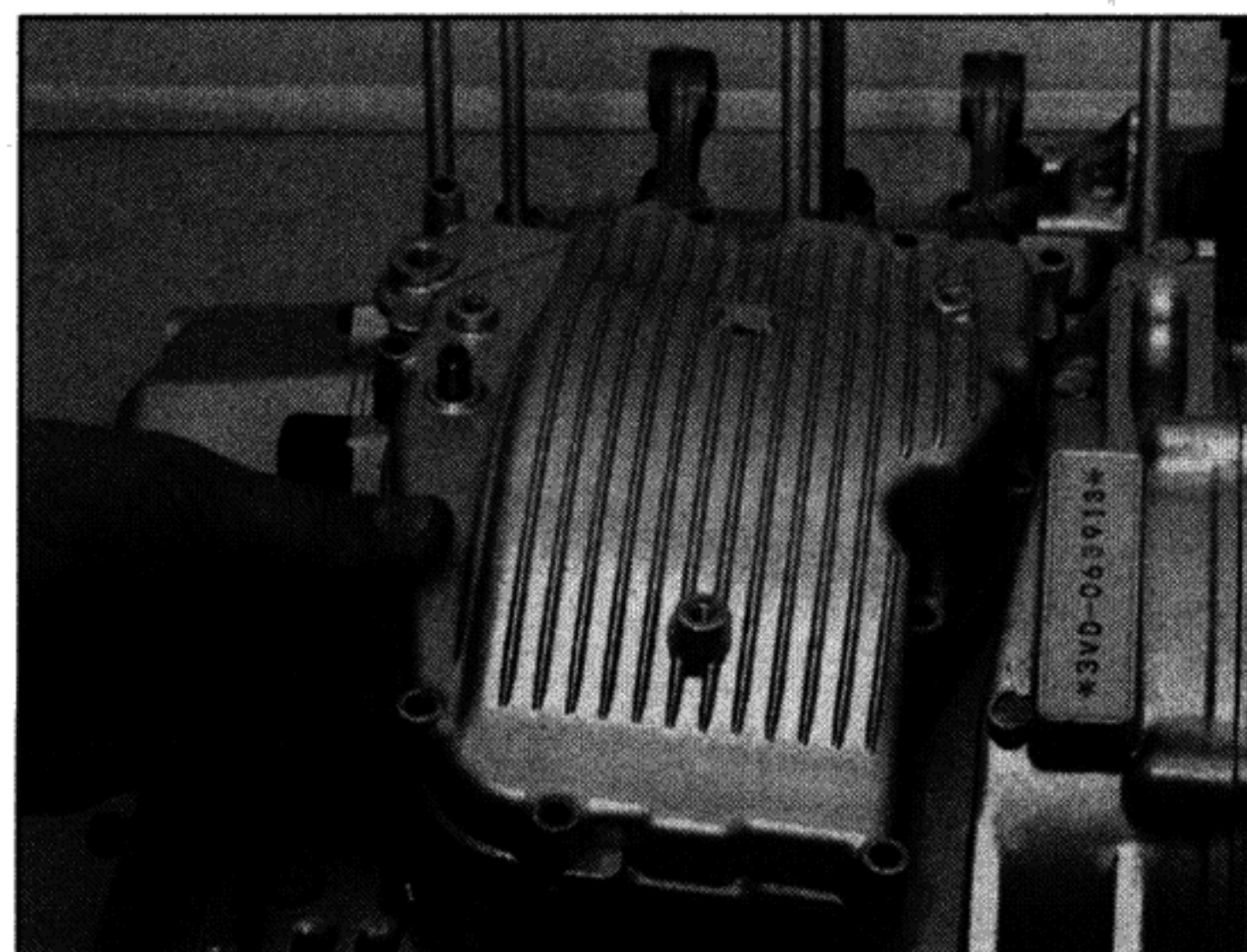
23.14 Fit each retainer plate into its slot in the shaft end



23.15 Install the strainer holder



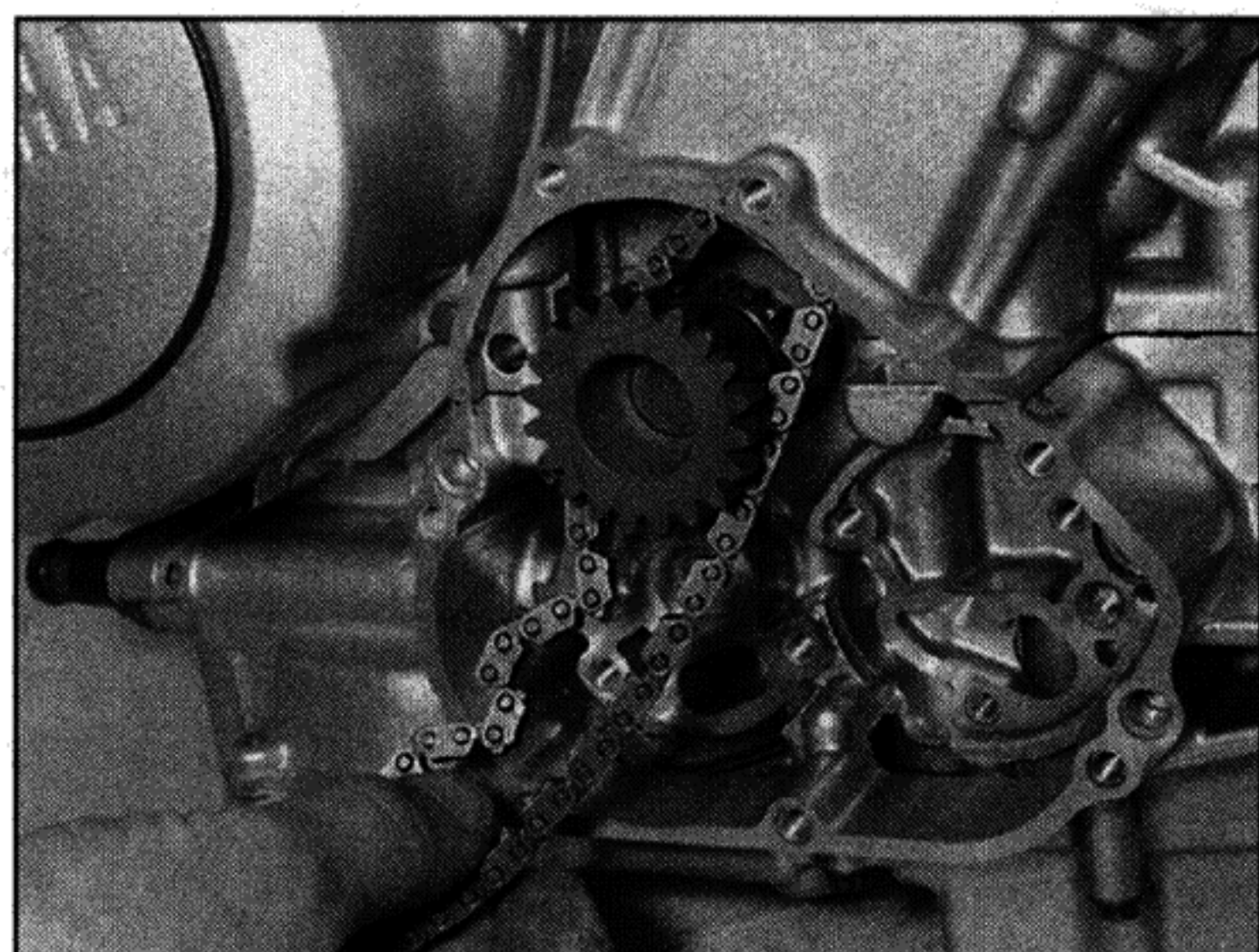
23.16a Fit the new gasket onto the dowels (arrowed) ...



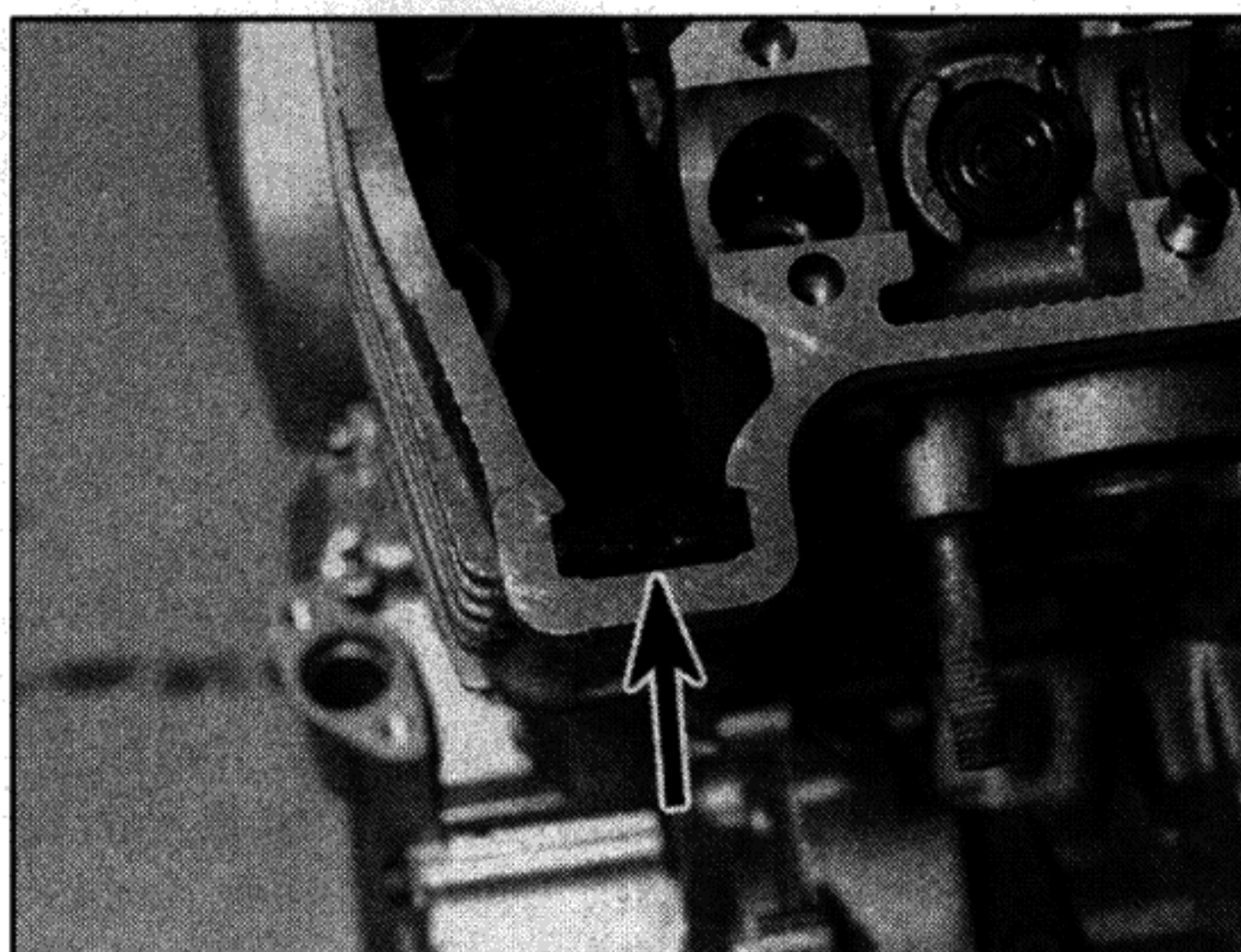
23.16b ... then install the cover



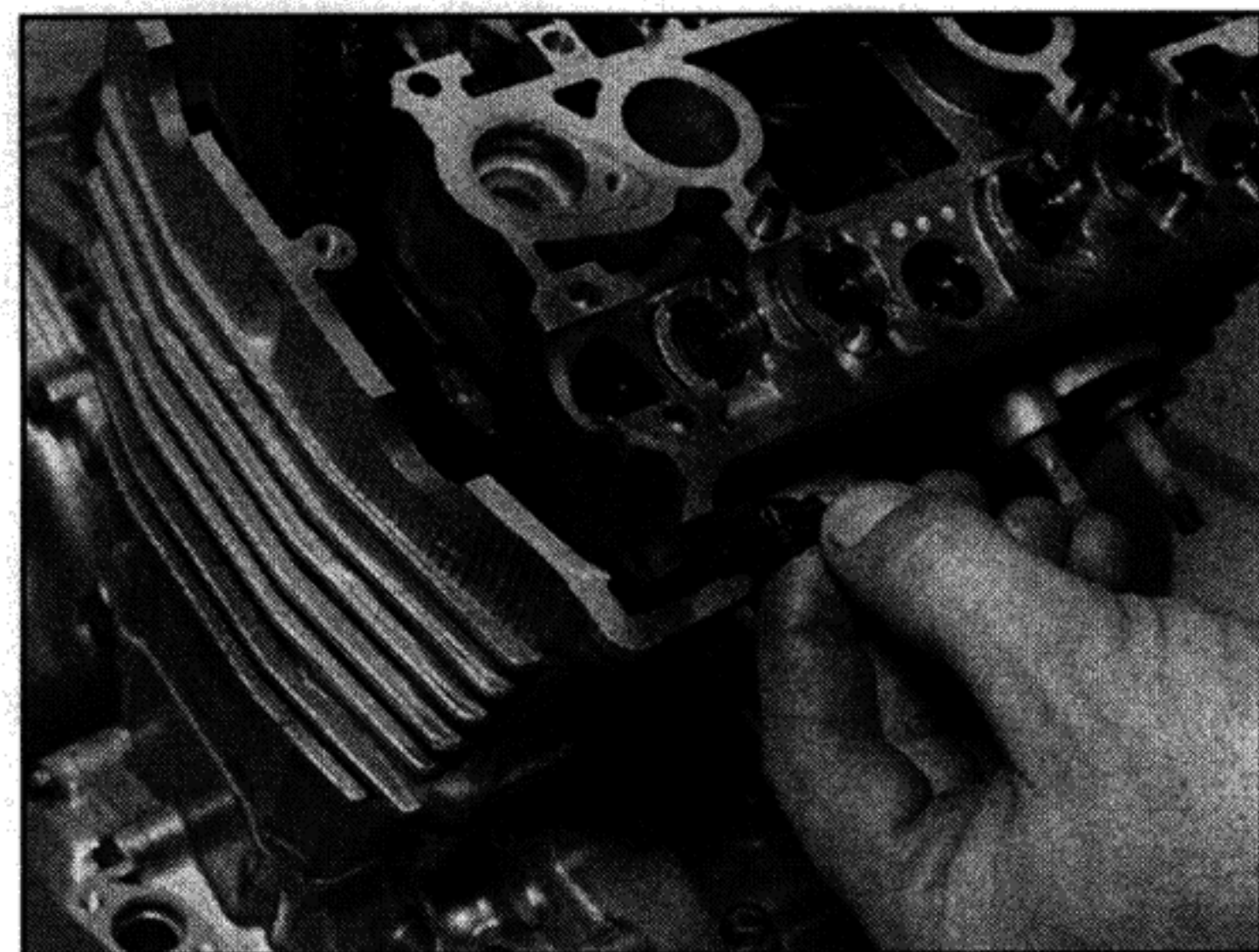
23.16c Use new sealing washers on each side of the union



24.2 Draw the cam chain out of the engine



24.4a Note how the front guide locates in the cylinder head (arrow) . . .



24.4b . . . and lift it out

24 Cam chain and guides – removal, inspection and installation

Removal

Cam chain

1 Remove the valve cover (see Section 7), the cam chain tensioner (see Section 9), the cam chain top guide and the camshaft sprockets (see Section 8), and the oil pumps (see Section 20).

2 Feed the cam chain down through the tunnel and draw it out of the oil pump housing (see illustration).

Chain guides

3 The cam chain top guide can be unbolted from the cylinder head after the valve cover has been removed (see Section 7) (see illustration 8.4).

4 The cam chain front guide can be lifted from the cylinder head after the cam chain tensioner (see Section 9) and the exhaust camshaft sprocket have been removed (see Section 8) (see illustrations). Note which way up and round the guide fits and how it locates.

5 The cam chain rear guide is secured by a pivot pin, which is located behind one of the 6 mm crankcase bolts. Remove the cam chain tensioner (see Section 9), the inlet camshaft sprocket (see Section 8) and the oil pump

cover (see Section 20). Unscrew the bolt (see illustration). As the pivot pin is set deep, its centre is threaded to accept a 5 mm bolt. Thread the bolt into the pin, then draw out the bolt with the pin attached and lift the guide out of the top of the tunnel (see illustrations).

Inspection

Cam chain

6 Check the chain for binding, kinks and any obvious damage and renew it if necessary. Check the camshaft sprocket teeth for wear and renew the cam chain and sprockets as a set if necessary (see Chapter 8).

Chain guides

7 Check the guides for excessive wear, deep grooves, cracking and other obvious damage, and renew them if necessary. Check the condition of the pivot hardware on the rear guide and renew any components that are damaged or deteriorated.

Installation

8 Installation of the chain and guides is the reverse of removal, noting the following:

- Apply engine oil to the faces of the guides, to the rear guide pivot pin, and to the chain.
- Use a piece of bent wire to hook up the cam chain and draw it up the tunnel.
- Tighten the 6 mm crankcase bolt for the rear guide to the torque setting specified at the beginning of the Chapter.

25 Crankcase halves – separation and reassembly

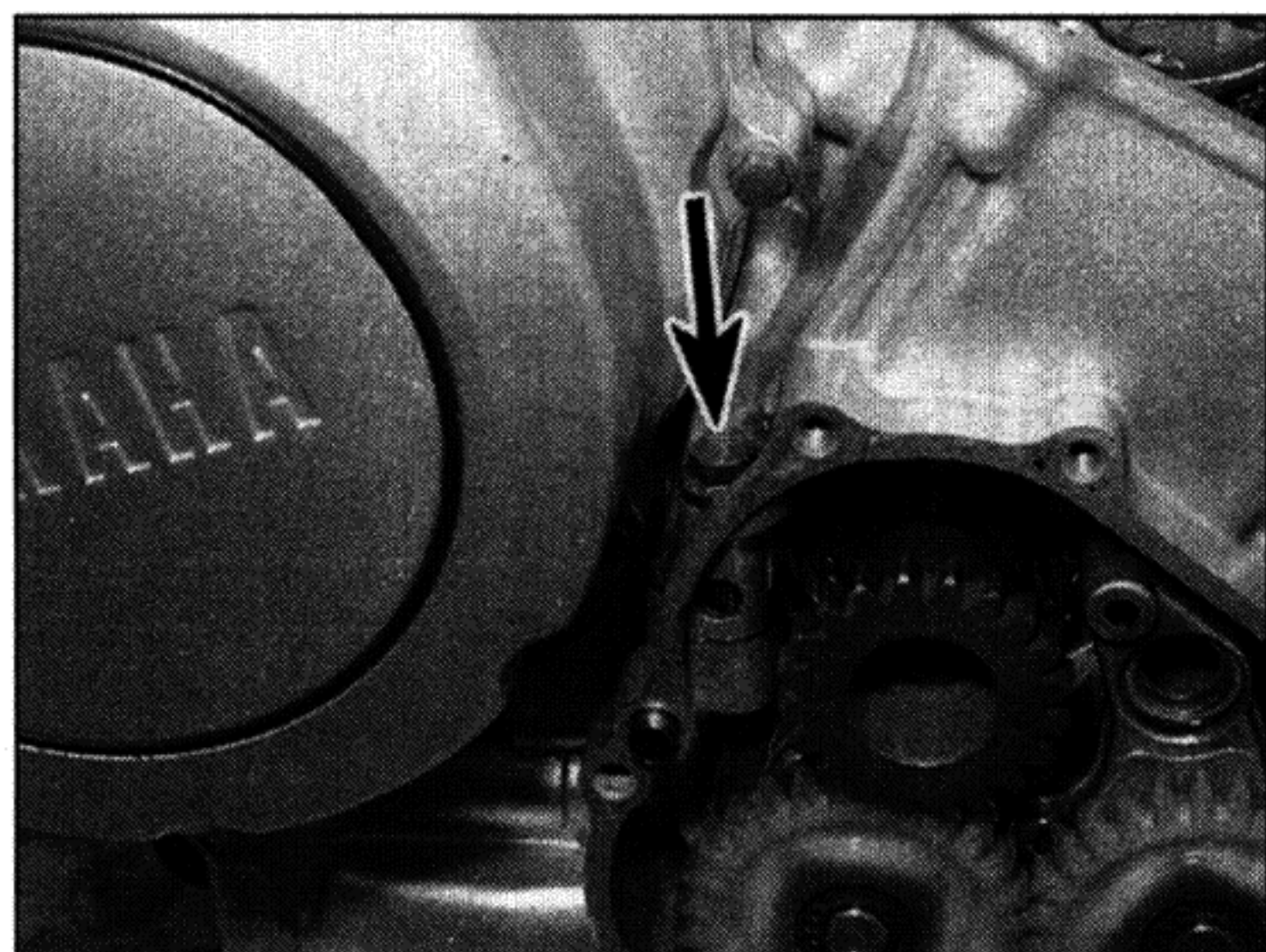
Note: To separate the crankcase halves, the engine must be removed from the frame.

Separation

1 To access the connecting rods, crankshaft, bearings, transmission shafts and the selector drum and forks, the crankcase must be split into two parts.

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

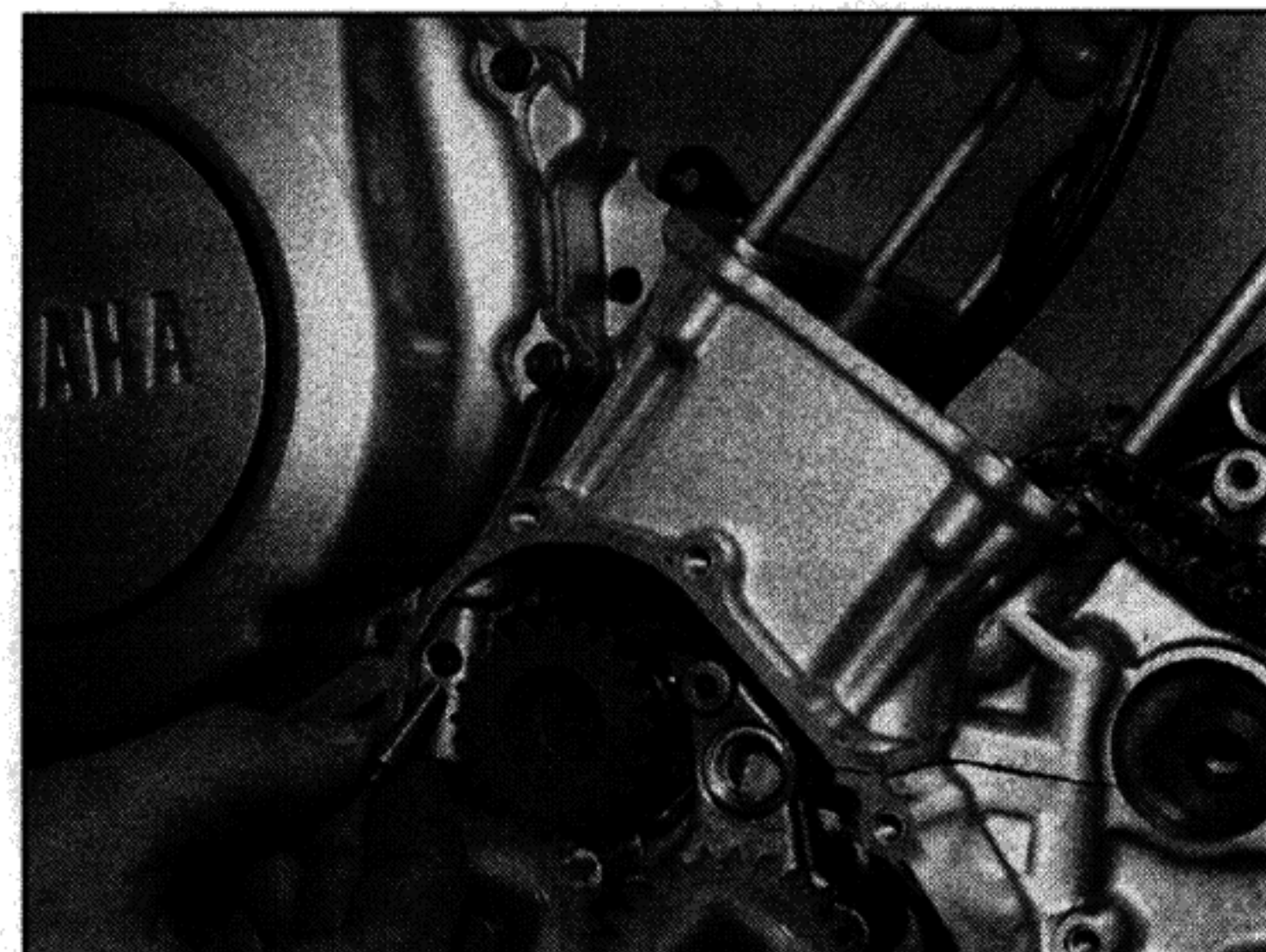
- Valve cover (Section 7).
- Cylinder head (Section 10).
- Cylinder block (Section 13).
- Pistons (Section 14).
- Clutch (Section 16).
- Starter clutch and idle/reduction gear (Section 18).
- Gearchange mechanism external components (Section 19).
- Oil pumps (Section 20).
- Cam chain and guides (Section 24).
- Oil tank (1996-on TDM models and all TRX models) (Section 21).
- Oil sump (Section 22).
- Balancer shafts (Section 23).
- Water pump (Chapter 3).
- Starter motor (if required) (Chapter 9).



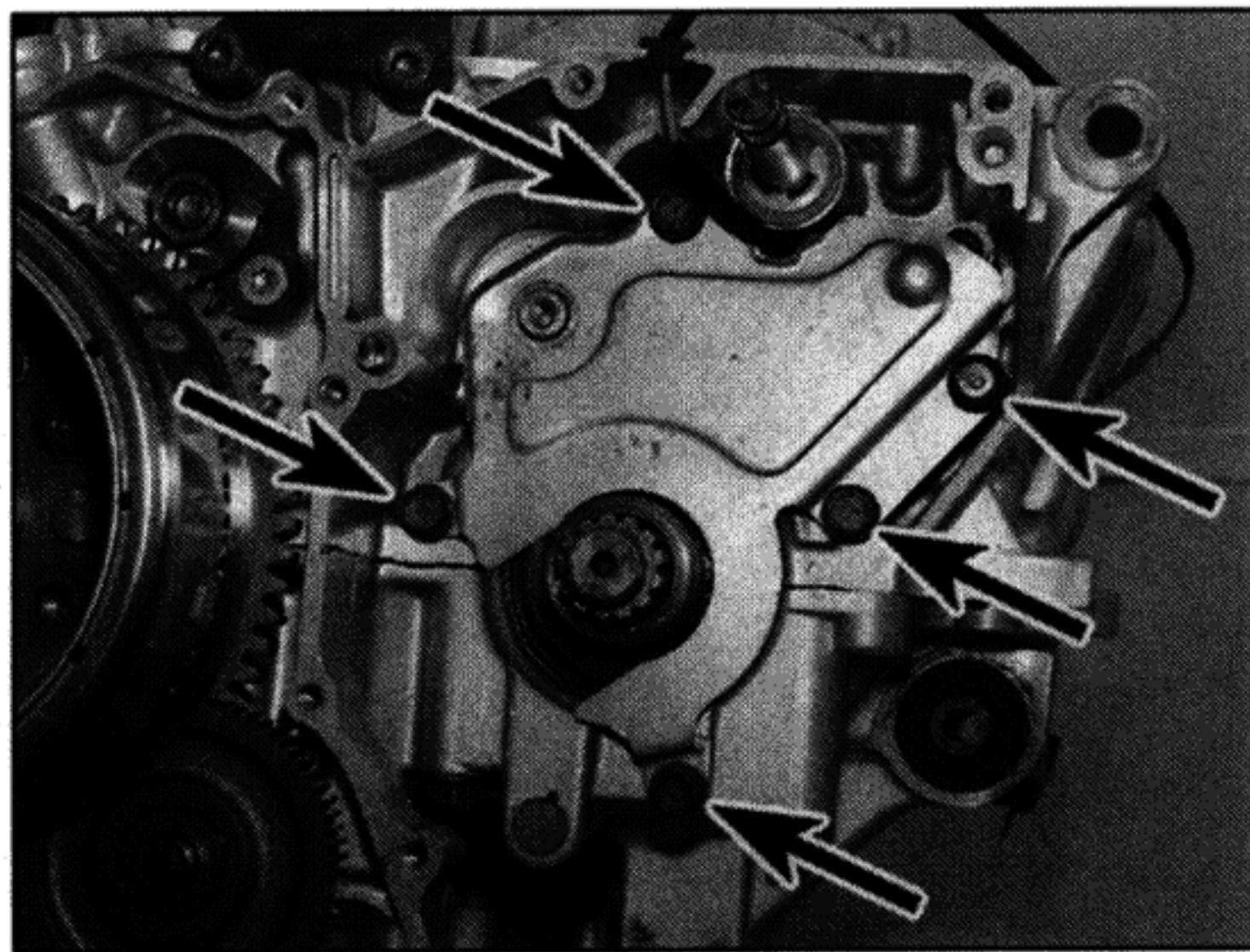
24.5a Unscrew the crankcase bolt (arrowed) . . .



24.5b . . . then thread a 5 mm bolt into the head of the pivot pin . . .



24.5c . . . then withdraw the pin and lift out the guide



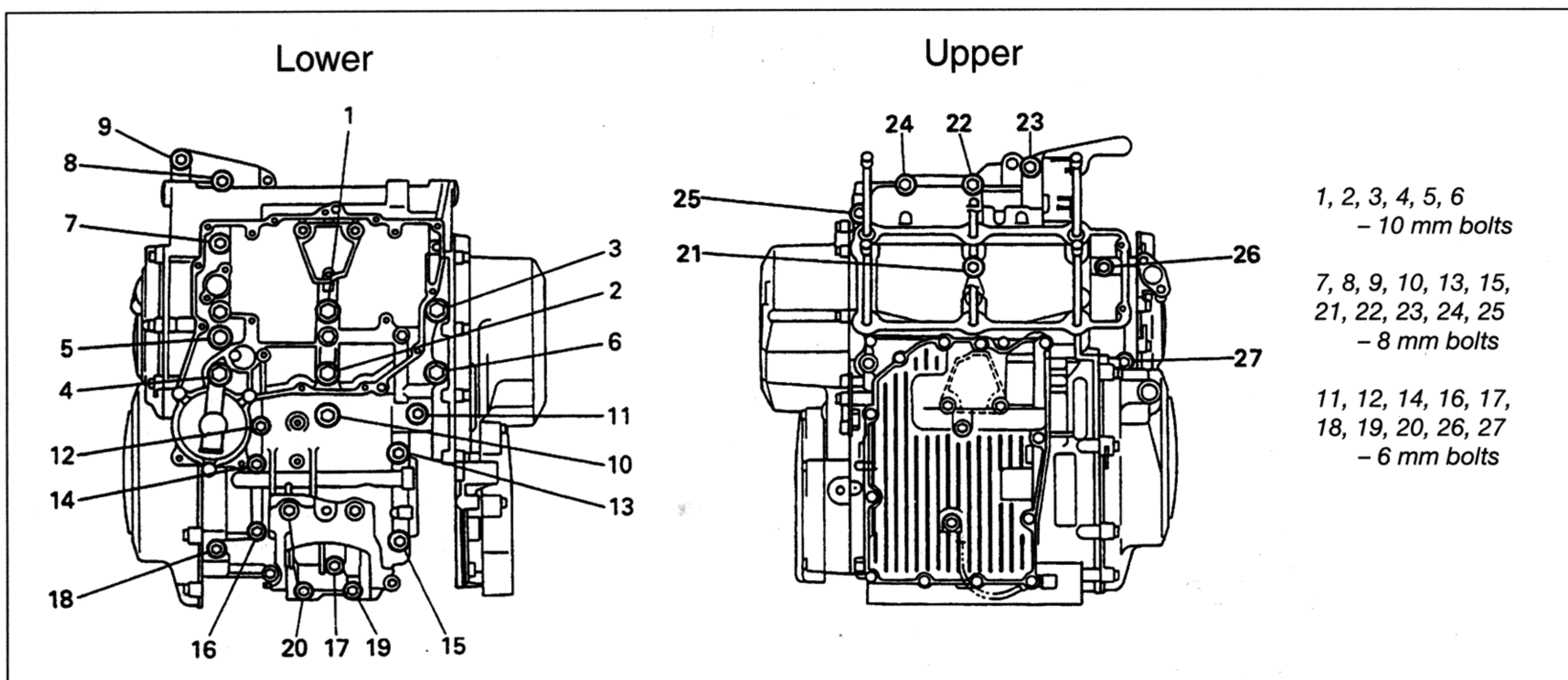
25.3 Unscrew the bolts (arrowed) and remove the plate

3 Unscrew the bolts securing the transmission output shaft retainer plate to the left-hand side of the crankcase and remove the plate (see illustration).

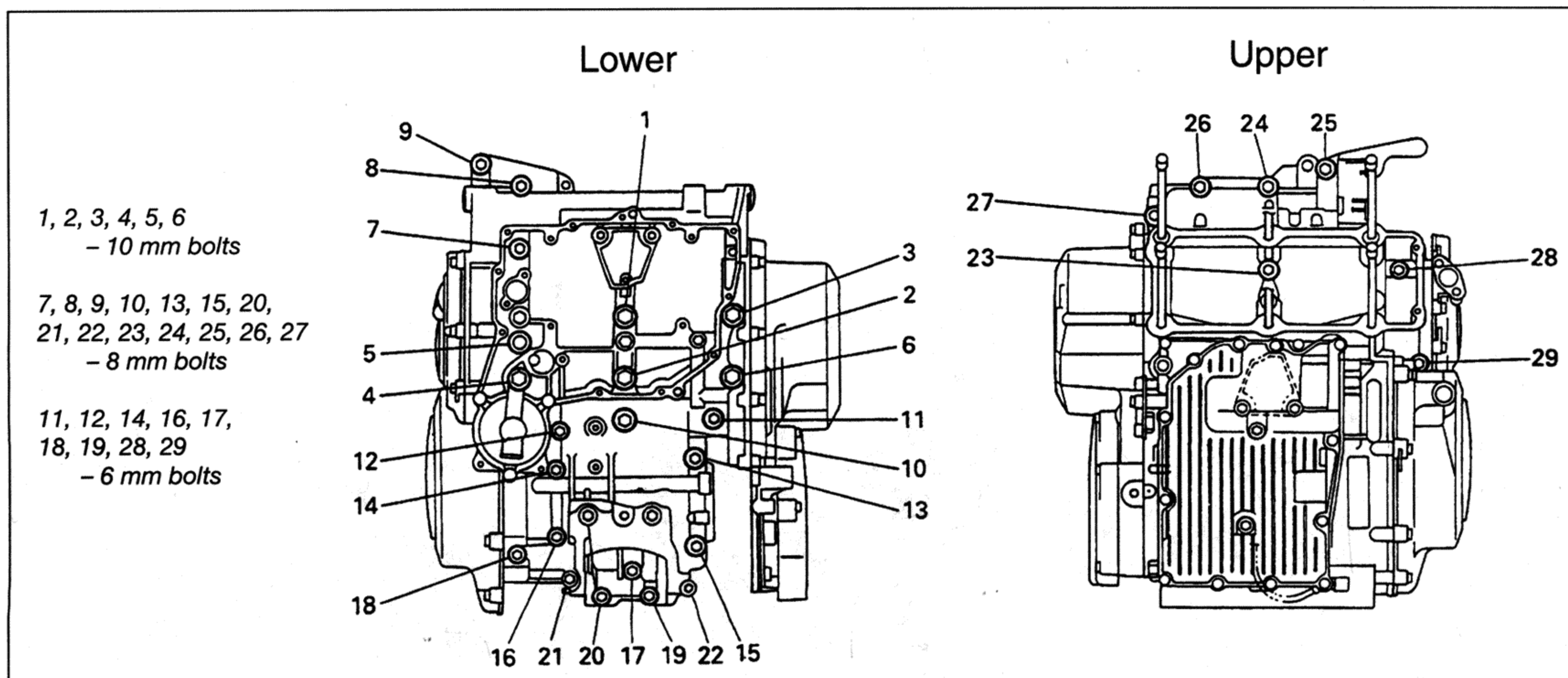
4 Unscrew the 6 mm and 8 mm upper crankcase bolts (see illustrations). Unscrew the bolts evenly, a little at a time in a reverse of the numerical sequence until they are finger-tight, then remove them. The number of each bolt is cast into the crankcase. Note the copper washers fitted with some of the bolts. **Note:** As each bolt is removed, store it in its relative position, with its washer where applicable, in a cardboard template of the crankcase halves. This will ensure all bolts are installed in the correct location on reassembly.

5 Turn the engine upside down so that it rests on the cylinder head studs.

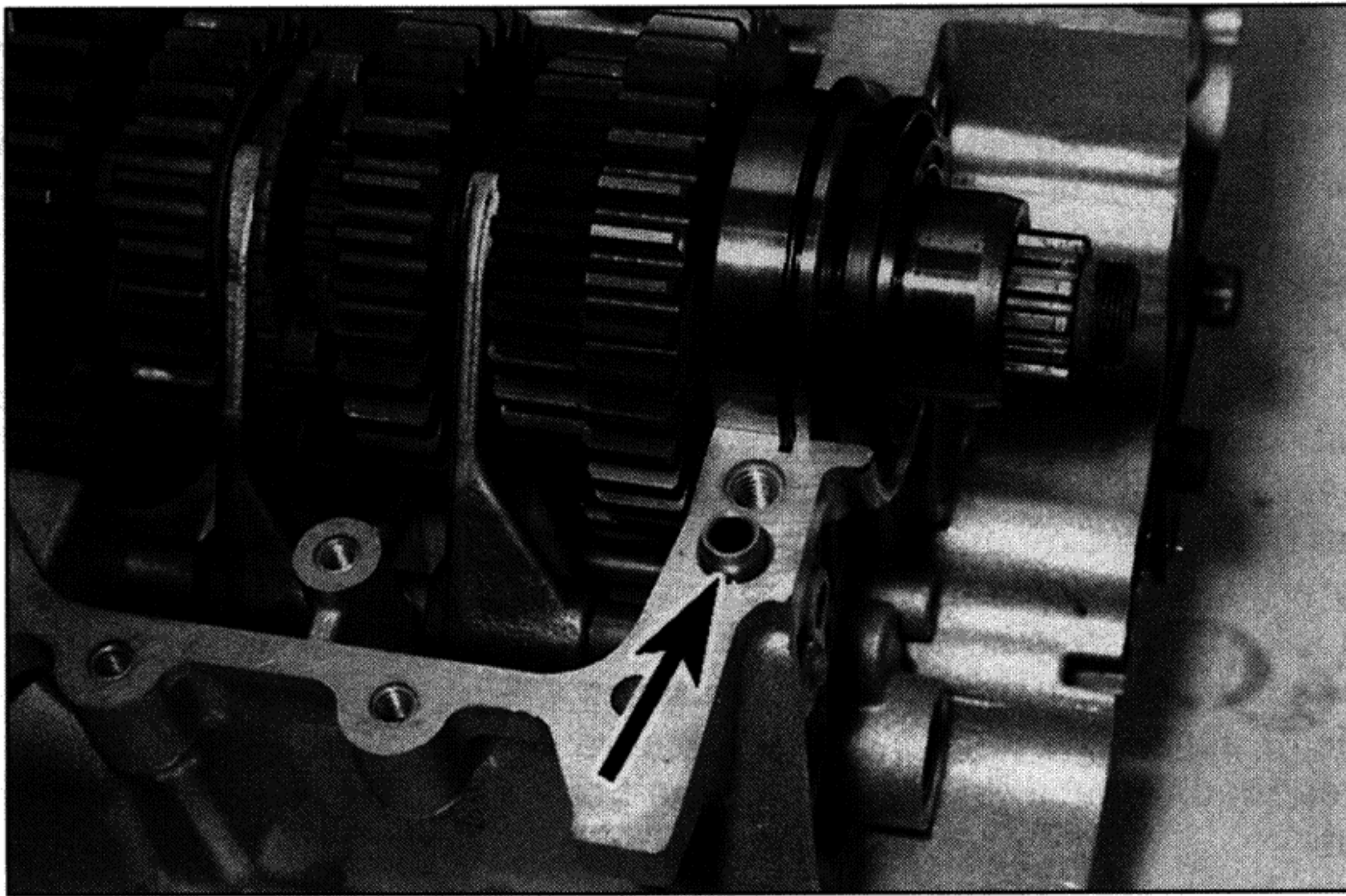
6 Unscrew the 6 mm lower crankcase bolts, the 8 mm bolts, and the 10 mm bolts (see illustrations 25.4a and b). Unscrew the bolts evenly, a little at a time in a reverse of the numerical sequence until they are finger-tight, then remove them. The number of each bolt is cast into the crankcase. Note the copper washers fitted with some of the bolts, and also the cable guide. **Note:** As each bolt is removed, store it in its relative position, with its washer and cable guide where applicable, in a cardboard template of the crankcase halves. This will ensure all bolts are installed in the correct location on reassembly.



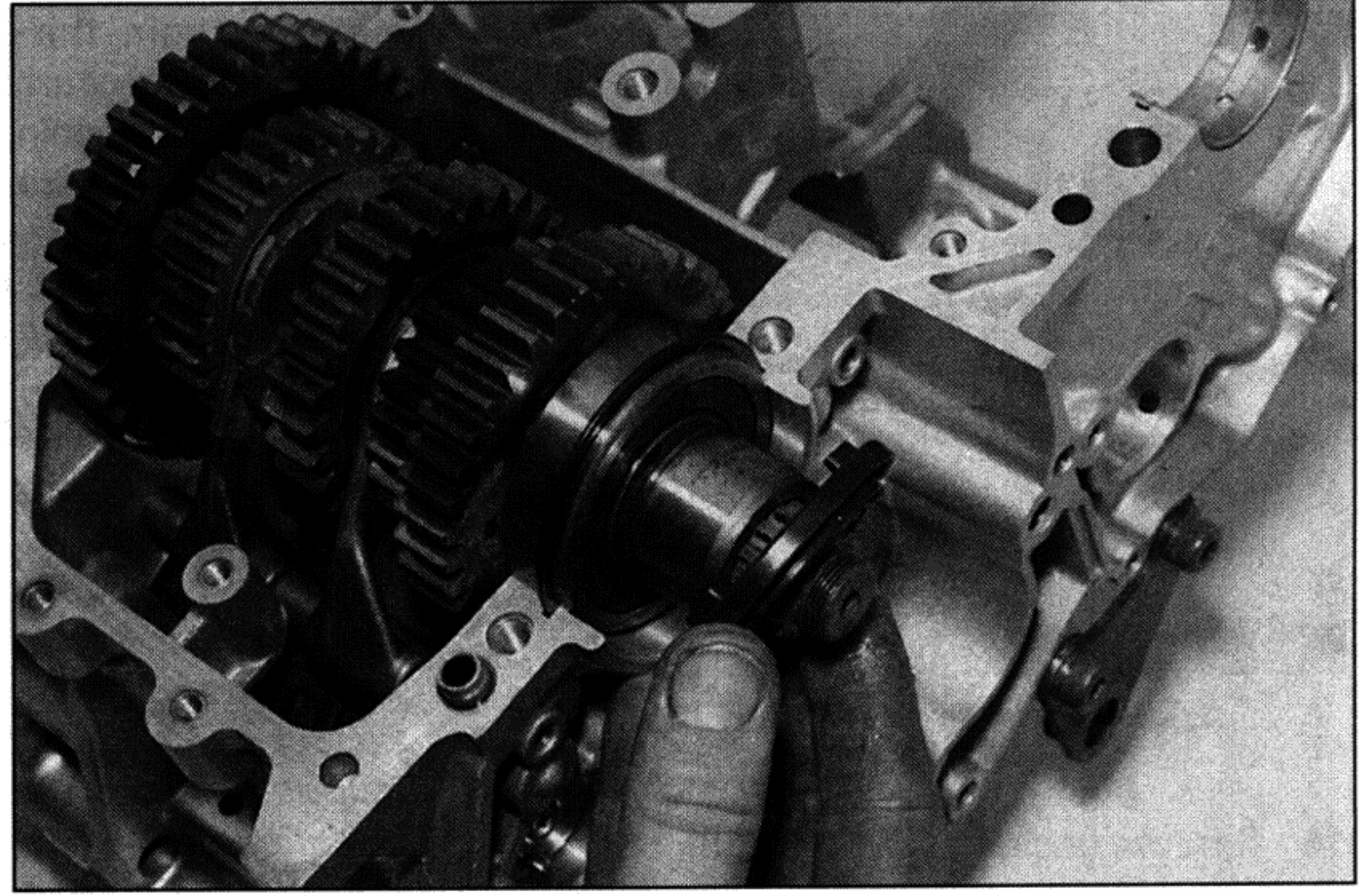
25.4a Crankcase bolts – 1991 to 1995 TDM models and XTZ models



25.4b Crankcase bolts – 1996-on TDM models and TRX models



25.8 Remove the dowel (arrowed) if it is loose



25.11 Use a new output shaft oil seal if required

7 Carefully lift the lower crankcase half off the upper half, using a soft-faced hammer to tap around the joint to initially separate the halves if necessary (**see illustration 25.15**). **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. Tap around the joint faces with a soft-faced mallet.

8 Remove the locating dowel from the crankcase if it is loose (it could be in either crankcase half) (**see illustration**).

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

Reassembly

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

11 Ensure that all components and their bearings are in place in the upper and lower crankcase halves. If the transmission shafts have not been removed, check the condition of the output shaft oil seal on the left-hand

end of the shaft and renew it if it is damaged or deteriorated (**see illustration**).

12 Generously lubricate the crankshaft 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.

13 If removed, install the locating dowel in the upper crankcase half (**see illustration 25.8**).

14 Apply a small amount of suitable sealant (such as Yamaha Bond 1215) to the outer mating surface of one crankcase half (**see illustration**).

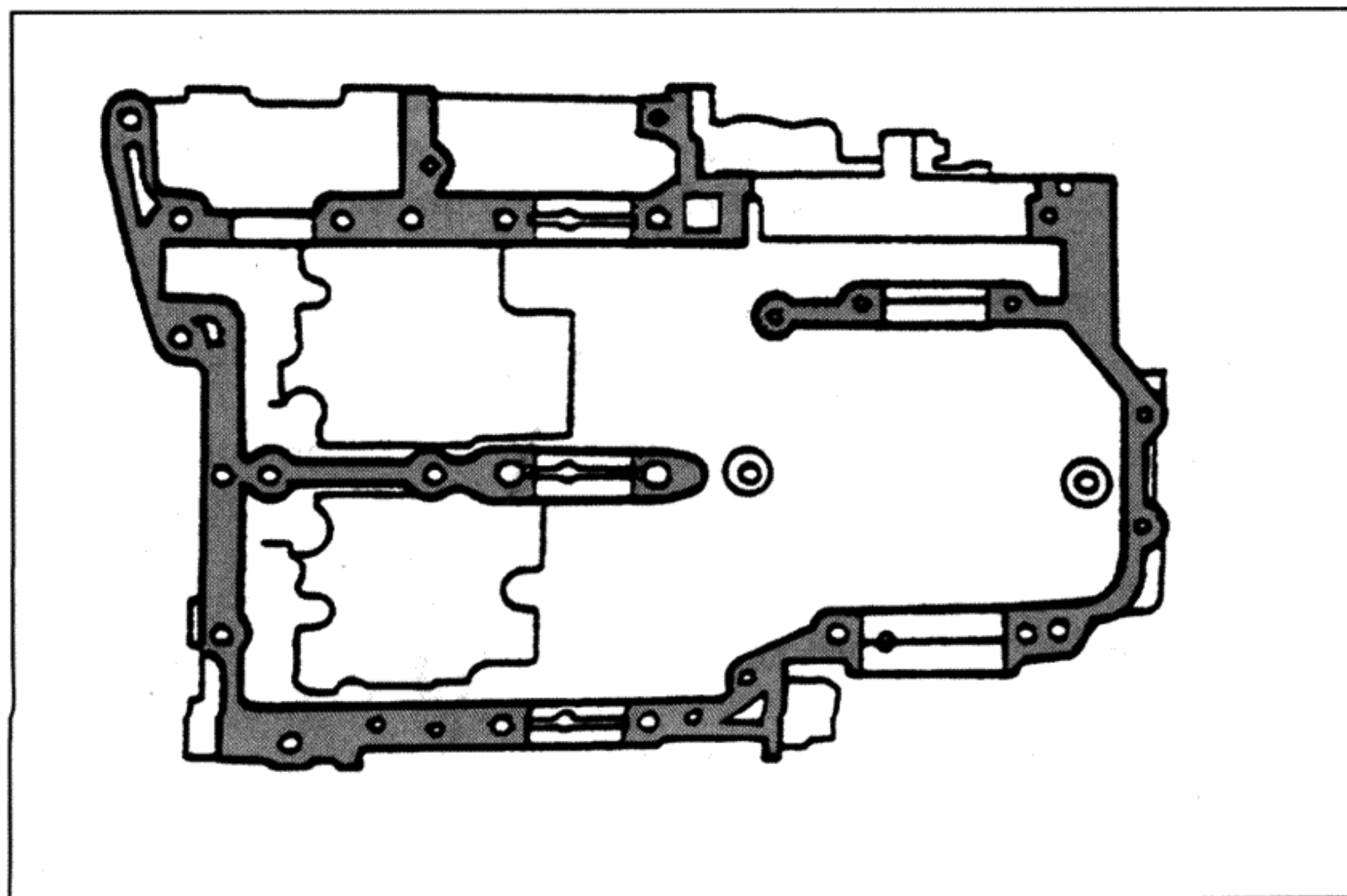
Caution: Do not apply an excessive amount of sealant as it will ooze out when the case halves are assembled and may obstruct oil passages. Do not apply the sealant on or too close (within 2 to 3 mm) to any of the bearing inserts or surfaces.

15 Check again that all components are in position, particularly that the bearing shells are still correctly located in the lower crankcase half. Carefully install the lower crankcase half down onto the upper

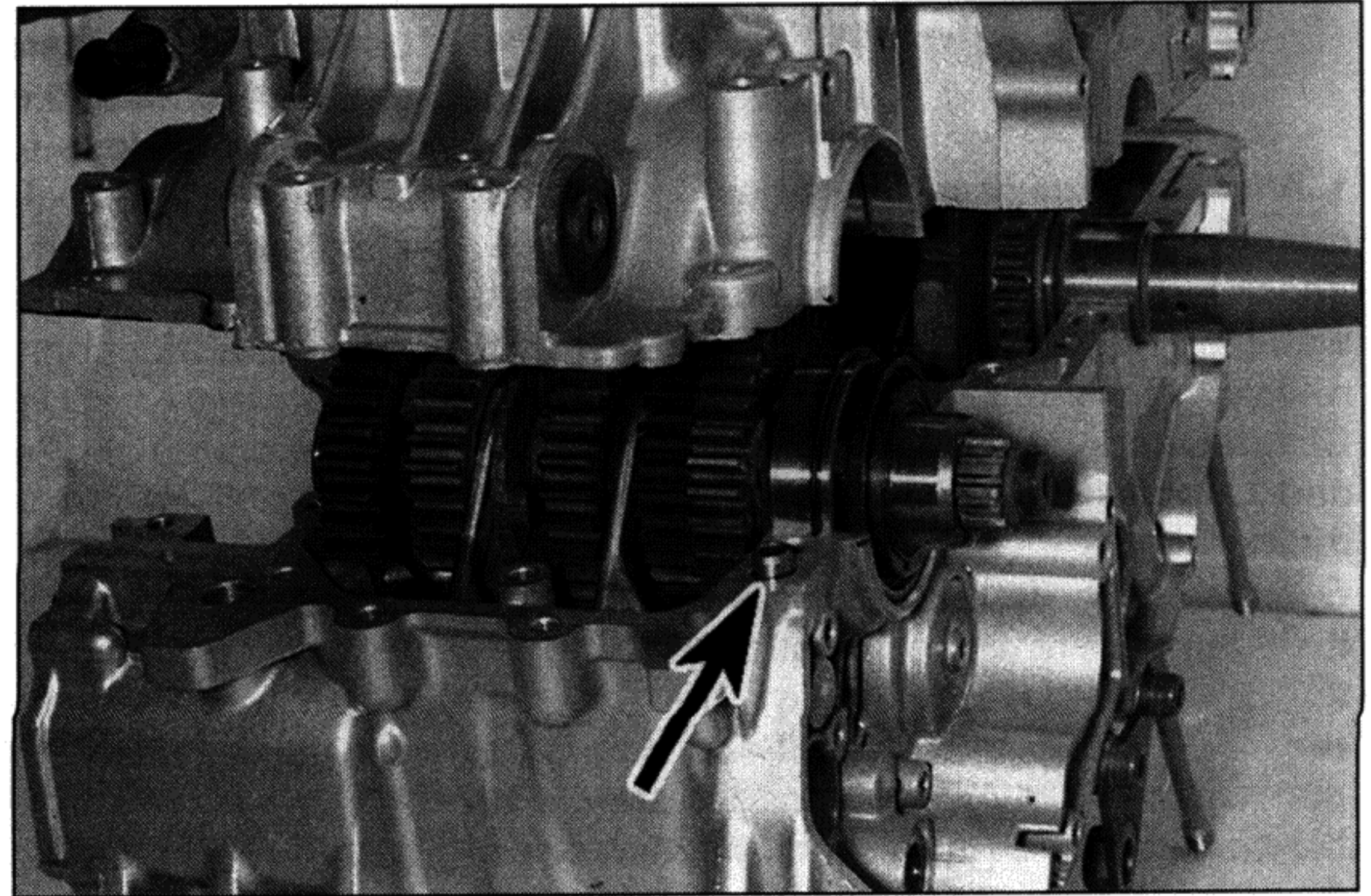
crankcase half, making sure the dowel locates correctly into the lower crankcase half (**see illustration**).

16 Check that the lower crankcase half is correctly seated. **Note:** The crankcase halves should fit together without being forced. If the casings are not correctly seated, remove the lower 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.

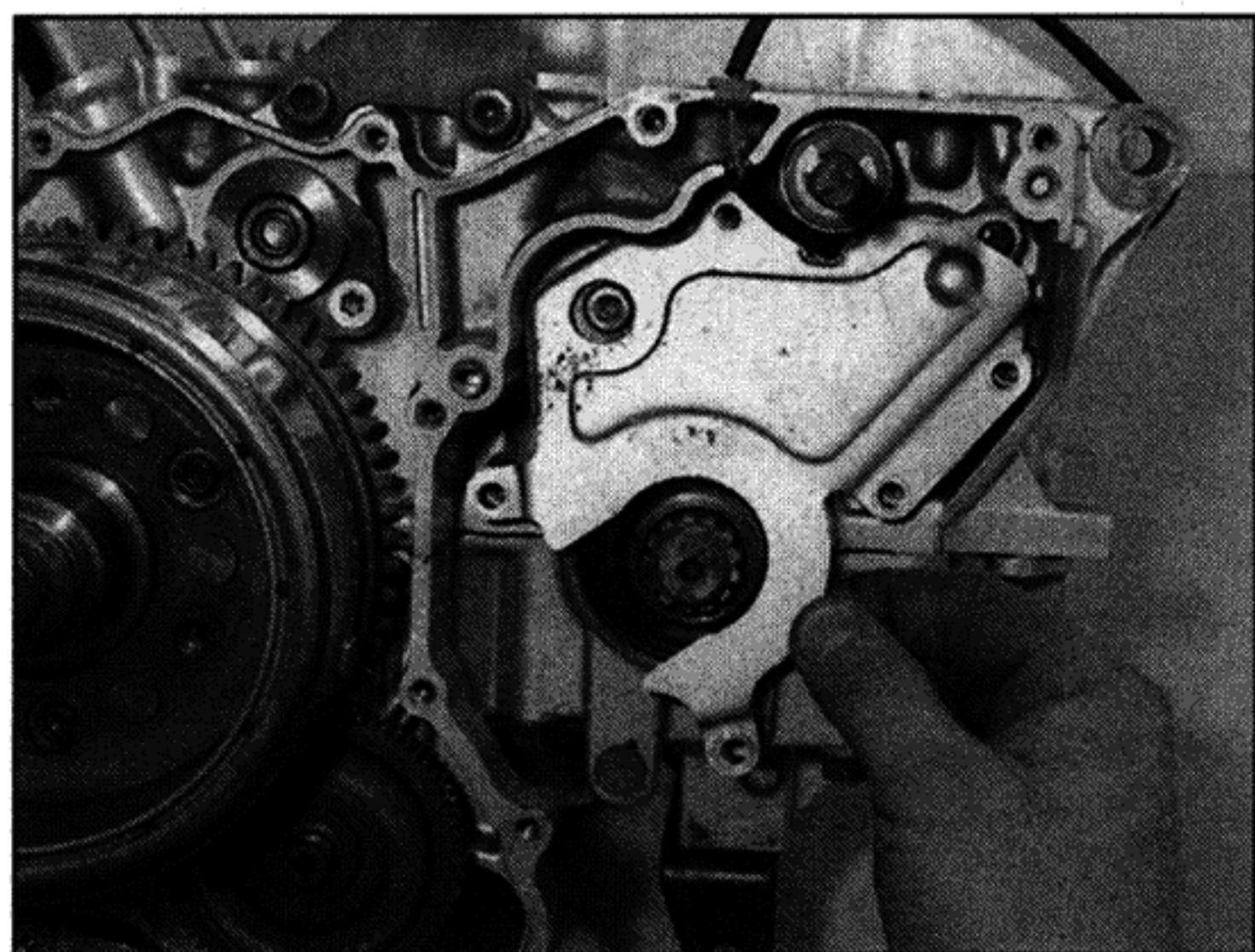
17 Clean the threads of the 10 mm lower crankcase bolts and apply molybdenum disulphide oil (a 50/50 mixture of molybdenum disulphide grease and new engine oil) to their threads. Insert them with their washers in their original locations. Clean the threads of the 8 mm and 6 mm lower crankcase bolts and apply new engine oil to their threads. Insert them (with their washers where fitted, and not forgetting the cable guide) in their original locations. Secure all bolts finger-tight at first, then tighten them evenly and a little at a time in the correct numerical sequence to the torque settings specified at the beginning of the Chapter (**see illustrations 25.4a or b**).



25.14 Apply the sealant to the shaded areas



25.15 Fit the lower half onto the upper half, making sure it locates onto the dowel (arrowed)



25.20 Install the retainer plate

18 Turn the engine over. Clean the threads of the 8 and 6 mm upper crankcase bolts and apply new engine oil to their threads. Insert them (with their washers where fitted) in their original locations. Secure all bolts finger-tight at first, then tighten them evenly and a little at a time in the correct numerical sequence to the torque settings specified at the beginning of the Chapter (see illustrations 25.4a or b).

19 With all crankcase fasteners tightened, check that the crankshaft 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.

20 Install the transmission output shaft retainer plate onto the left-hand side of the crankcase (see illustration). Apply a suitable non-permanent thread locking compound to the threads of the bolts and tighten them to the specified torque setting.

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

26 Crankcase halves – inspection and servicing



1 After the crankcases have been separated, remove the crankshaft, connecting rods, transmission shafts, selector drum and forks, water pump drive gear, and neutral switch, referring to the relevant Sections of this Chapter, and to Chapter 3 for the water pump and Chapter 9 for the neutral switch. Also remove the oil passage collars and their O-rings (see illustration 22.9). Discard the O-rings as new ones must be used.

2 The crankcases should be cleaned thoroughly with new solvent and dried with compressed air. All oil passages should be blown out with compressed air. Also check that the oil nozzles are securely screwed into their bores and have not worked loose.

3 All traces of old gasket sealant should be

removed from the mating surfaces. Minor damage to the surfaces can be cleaned up 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.

4 Small cracks or holes in aluminium castings may be repaired with an epoxy resin adhesive as a temporary measure. Permanent repairs can only be effected 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.

5 Damaged threads can be economically reclaimed by using a diamond section wire insert, of the Heli-Coil type, which is easily fitted after drilling and re-tapping the affected thread.

6 Sheared studs or screws can usually be removed with screw extractors, which consist of a tapered, left thread screw of very hard steel. These are inserted into a pre-drilled hole in the stud, and usually succeed in dislodging the most stubborn stud or screw.



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

7 Install all components and assemblies, referring to the relevant Sections of this Chapter and to Chapters 3 and 9, before reassembling the crankcase halves. Do not forget to install the oil passage collars using new O-rings.

27 Main and connecting rod bearings – general information

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

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

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

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

5 Lack of lubrication or lubrication breakdown has a number of interrelated causes. Excessive heat (which thins the oil), overloading (which squeezes the oil from the bearing face) and oil leakage or throw off (from excessive bearing clearances, worn oil pumps 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.

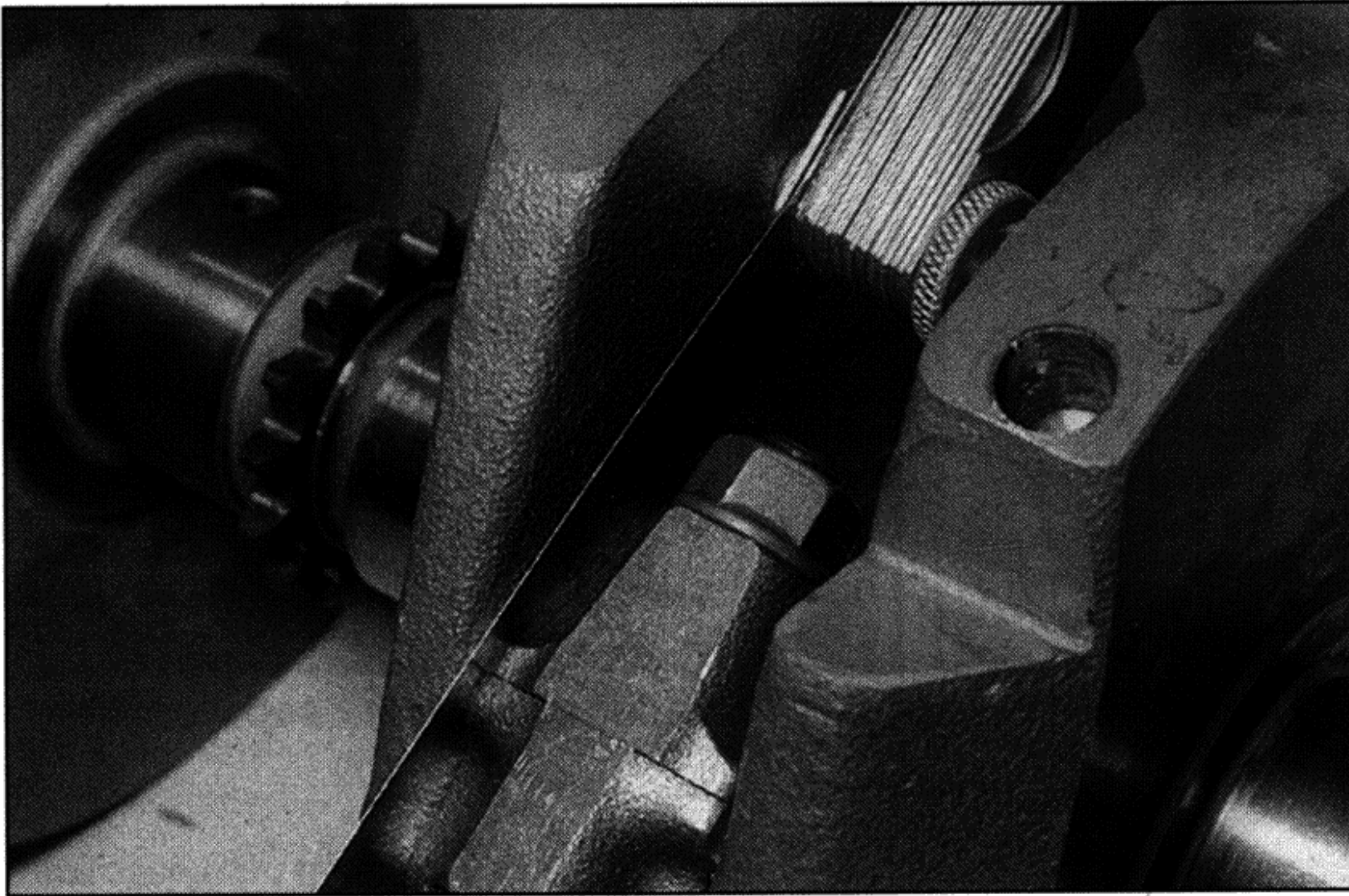


Refer to Tools and Workshop Tips for bearing fault finding.

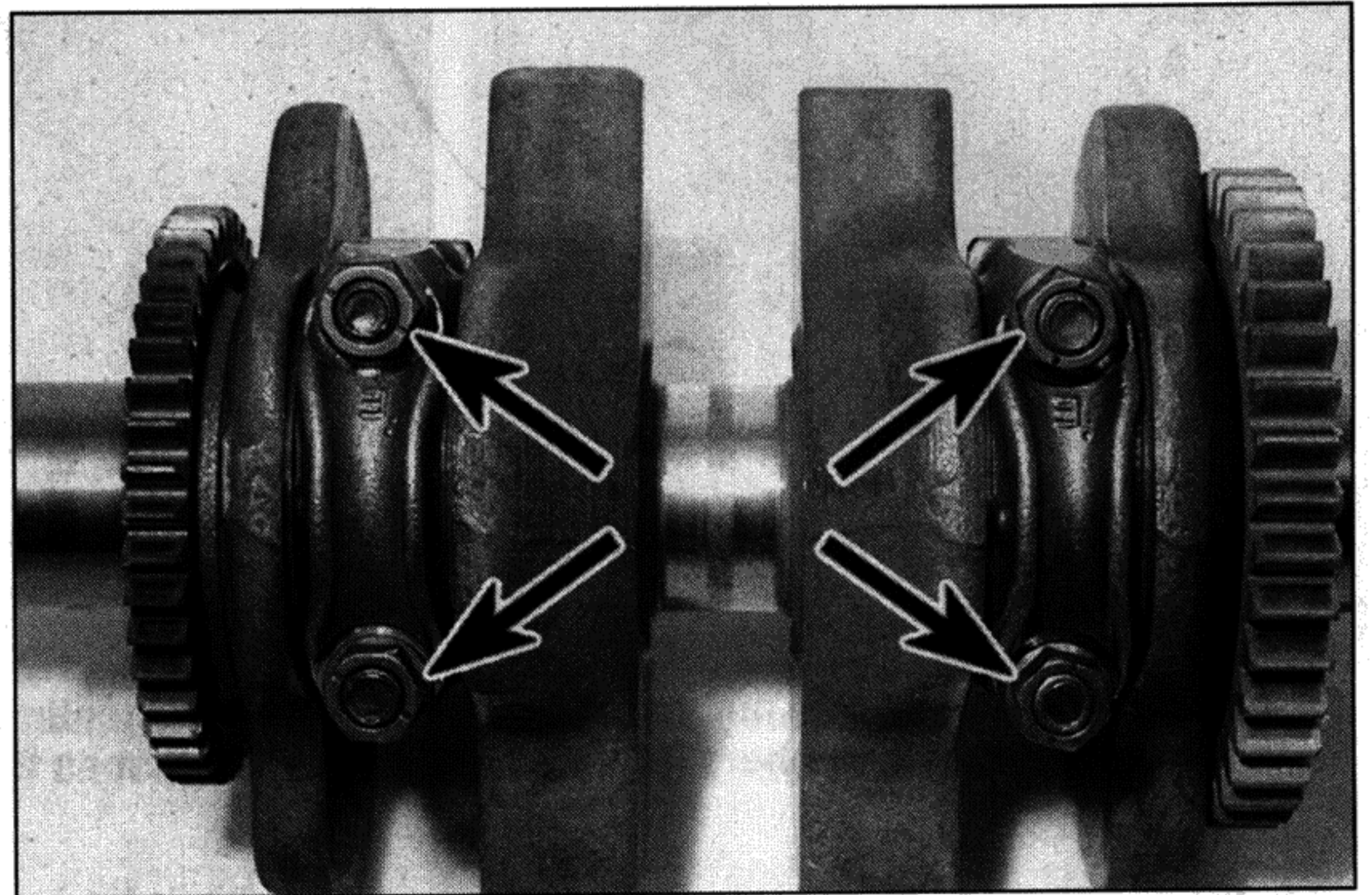
6 Riding habits can have a definite effect on bearing life. Full throttle low speed operation, or labouring the engine, puts very high loads on bearings, which tend to squeeze out the oil film. These loads cause the bearings to flex, which produces fine cracks in the bearing face (fatigue failure). Eventually 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. 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.



28.2 Measure the connecting rod side clearance using a feeler gauge



28.4 Unscrew the nuts (arrowed) and remove the connecting rods

28 Connecting rods – removal, inspection and installation



Note: To remove the connecting rods the engine must be removed from the frame and the crankcases separated.

Removal

- 1 Remove the engine from the frame (see Section 5) and separate the crankcase halves (see Section 25).
- 2 Before removing the rods from the crankshaft, measure the side clearance on each rod with a feeler gauge (see illustration). If the clearance between any rod is greater than the service limit listed in this Chapter's Specifications, replace that rod 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 the Y mark on each connecting rod which must face to the left-hand side of the engine to ensure that the cap and rod are fitted the correct way around on reassembly. Note that the number etched

across the rod and cap indicates rod size grade, not cylinder number.

- 4 Unscrew the big-end cap nuts and separate the cap from the crankpin (see illustration). Do not remove the bolts from the connecting rods. 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 to ensure correct installation.

Inspection

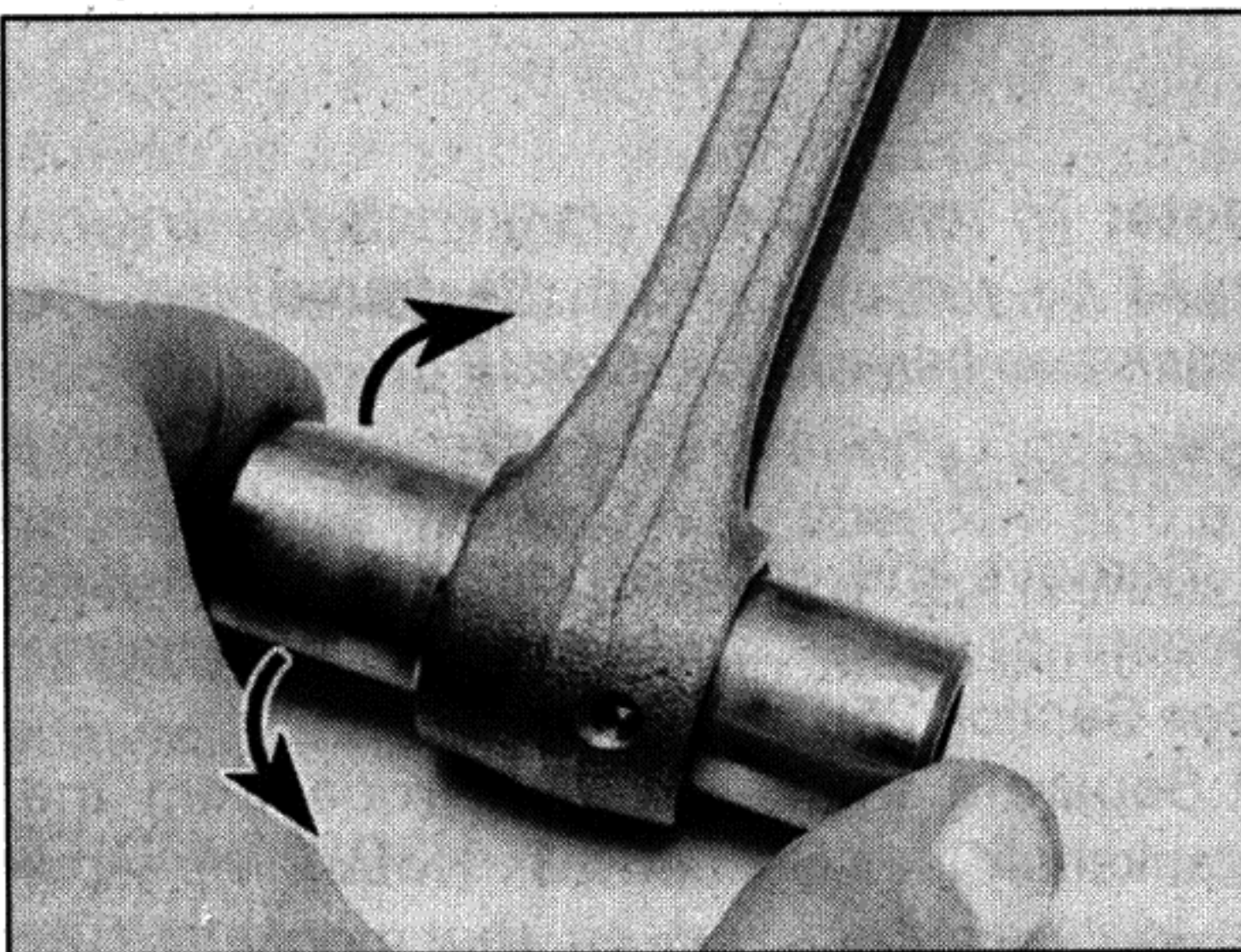
- 5 Check the connecting rods for cracks and other obvious damage.
- 6 Apply clean engine oil to the piston pin, insert it into the connecting rod small-end and check for any freeplay between the two (see illustration). Measure the pin external and compare the result to the specifications at the beginning of the Chapter (see illustration). If the piston pin is worn below the service limit it should be renewed.
- 7 Refer to Section 27 and examine the connecting rod bearing shells. If they are scored, badly scuffed or appear to have seized, new shells must be installed. Always renew 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.

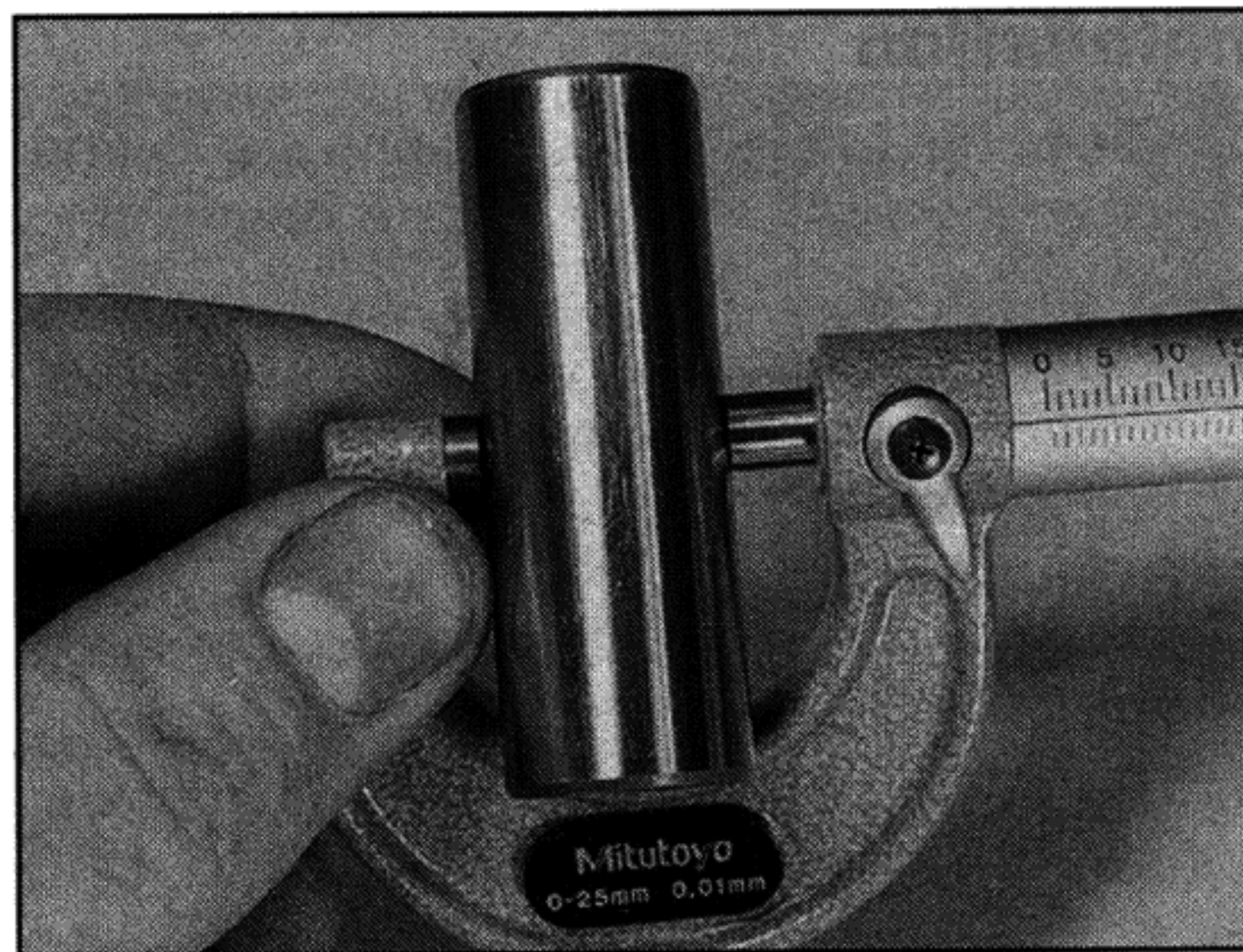
- 8 Have the rods checked for twist and bend by a Yamaha dealer or engineer if you are in doubt about their straightness.

Oil clearance check

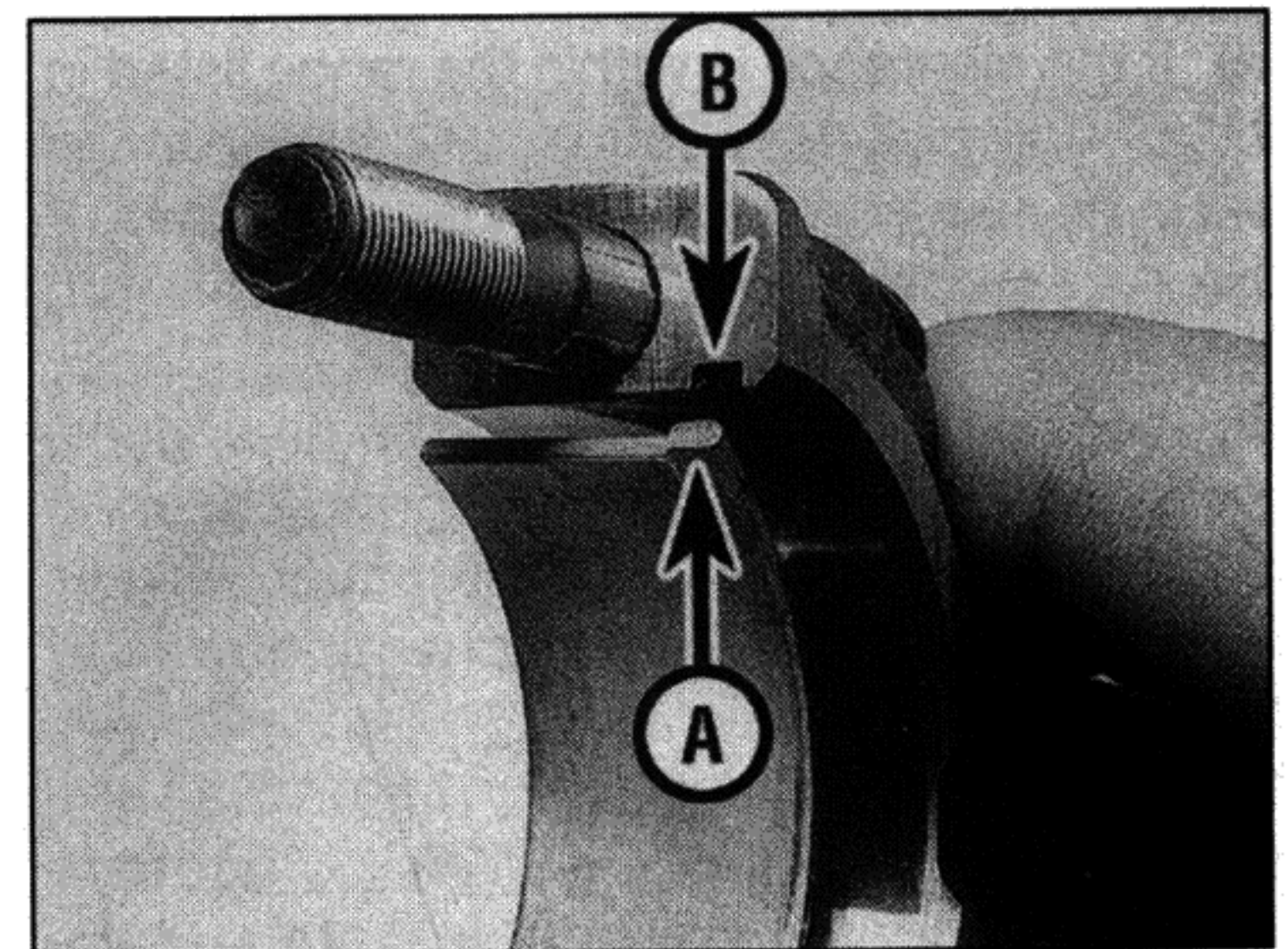
- 9 Whether new bearing shells are being fitted or the original ones are being re-used, the connecting rod bearing oil clearance should be checked prior to reassembly.
- 10 Clean the backs of the bearing shells and the bearing locations in both the connecting rod and cap.
- 11 Press the bearing shells 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.
- 12 Cut a length of the appropriate size Plastigauge (it should be slightly shorter than the width of the crankpin). Place a strand of Plastigauge on the (cleaned) crankpin journal.
- 13 Apply molybdenum disulphide grease to



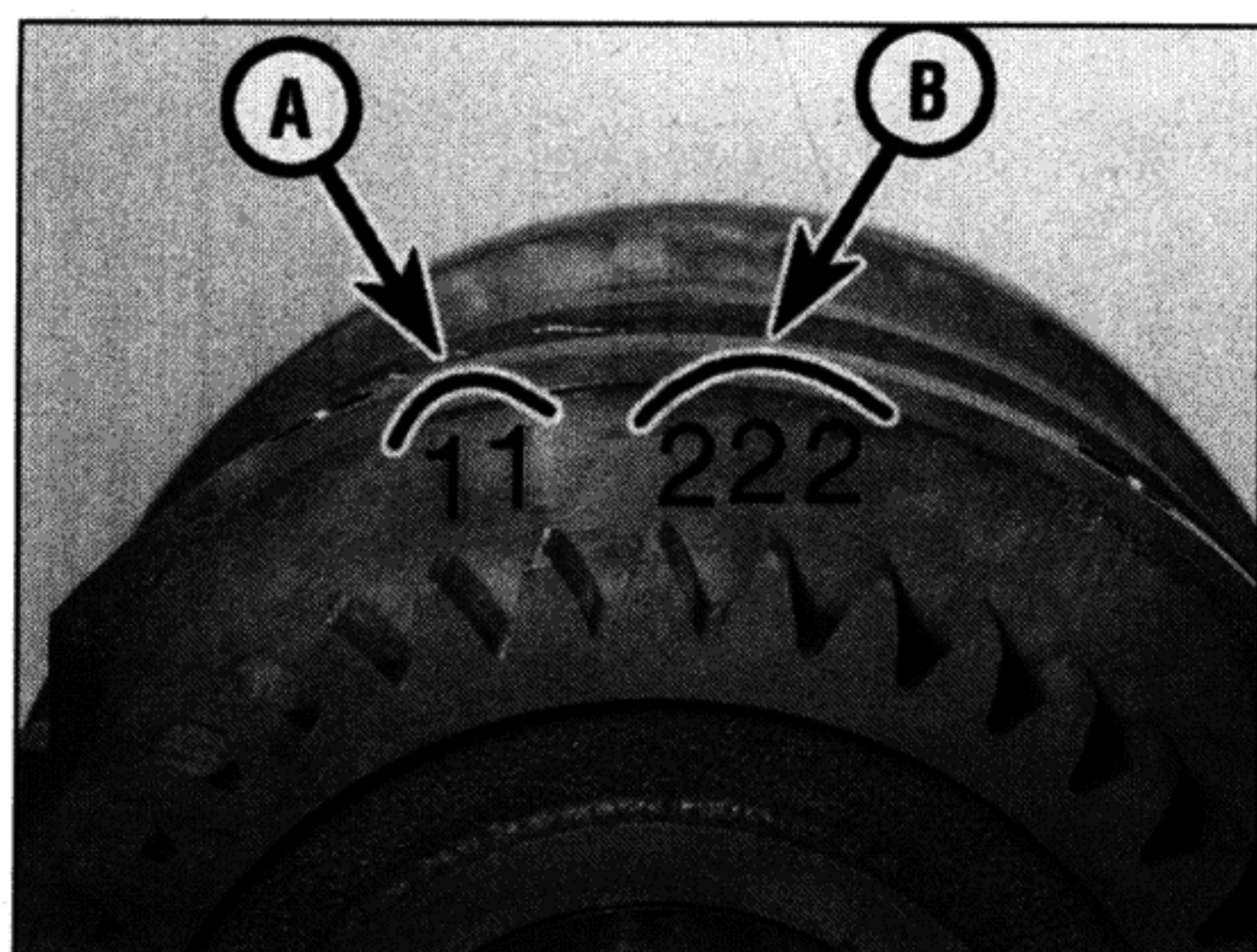
28.6a Slip the piston pin into the rod's small-end and rock it back and forth to check for looseness



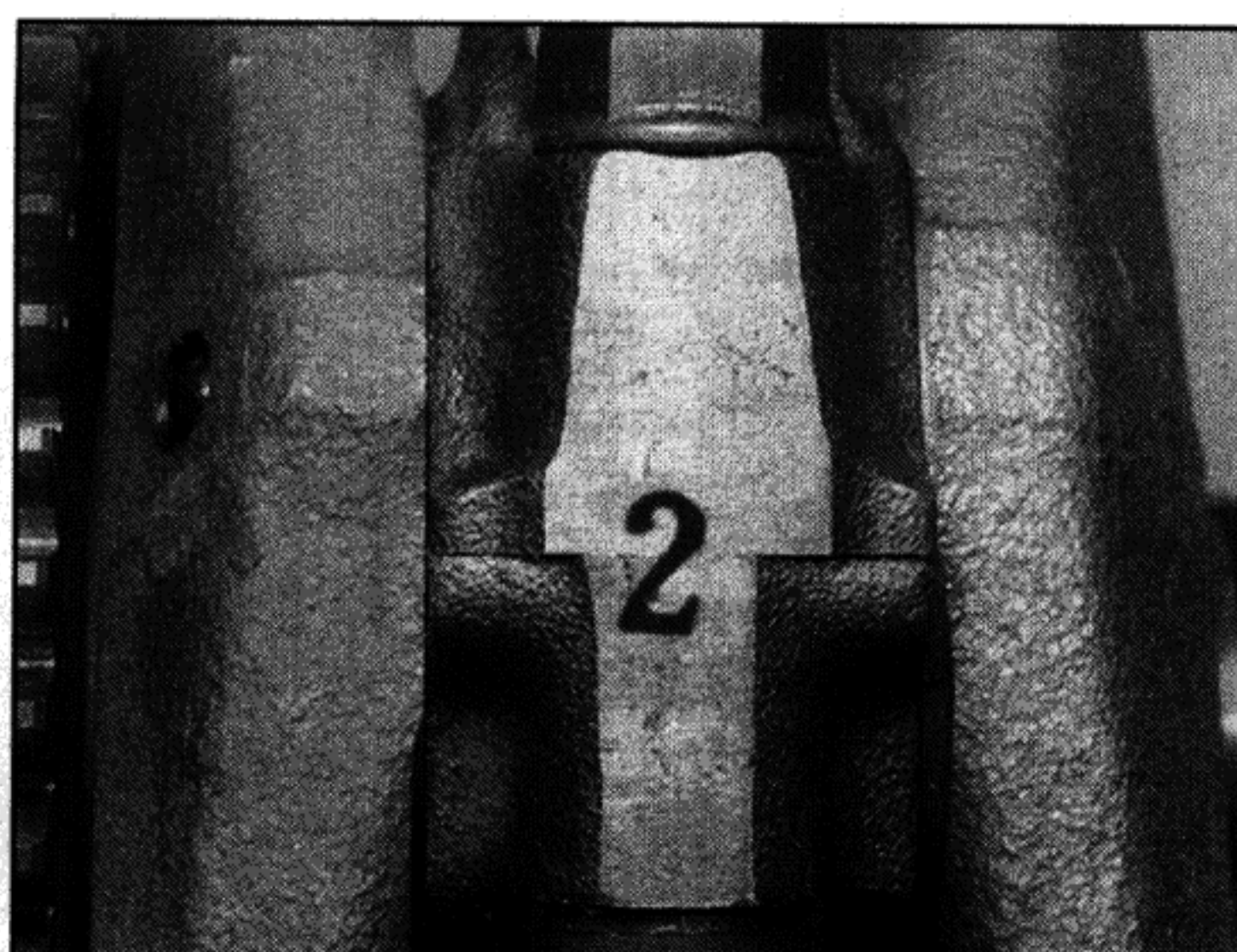
28.6b Measure the external diameter of the pin



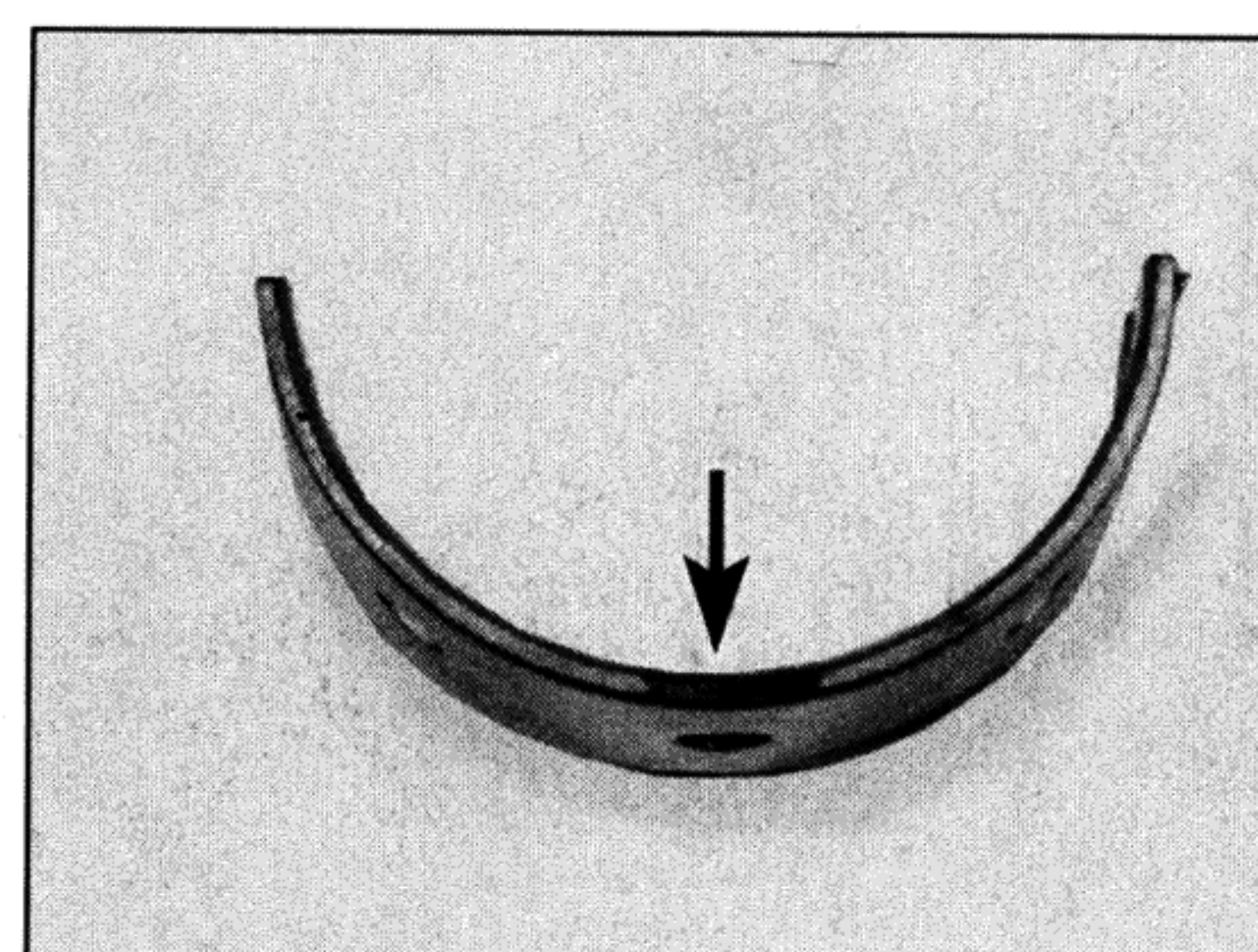
28.11 Make sure the tab (A) locates in the notch (B)



28.21a Big-end journal size numbers (A), main journal size numbers (B)



28.21b Connecting rod size number is marked across the cap and rod join



28.22 Bearing shell colour code location

the bolt shanks and threads and to the seats of the nuts. Install the (clean) connecting rod, shells and cap. Make sure the cap is fitted the correct way around so the previously made markings align, and that the rod is facing the right way (see Step 3). Tighten the nuts finger-tight, making sure the connecting rod does not rotate on the crankshaft.

14 Tighten the bearing cap nuts evenly, in two or three stages, to the initial torque setting specified at the beginning of the Chapter, making sure the connecting rod does not rotate on the crankshaft. Now tighten each nut in turn and in one continuous movement to the final torque setting specified. If the tightening is interrupted between the initial and final torque settings, slacken the nuts and begin the procedure again.

15 Slacken the cap nuts and remove the connecting rod, again taking great care not to rotate the rod or crankshaft.

16 Compare the width of the crushed Plastigauge on the crankpin to the scale printed on the Plastigauge envelope to obtain the connecting rod bearing oil clearance (see illustration 29.20). 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 crankpin and bearing shells using a fingernail or other object which is unlikely to score the shells.

18 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, renew the shells (see Steps 21 and 22). Check the oil clearance once again (the new shells may be thick enough to bring bearing clearance within the specified range). Always renew the shells in both connecting rods at the same time.

19 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 renewed.

20 Repeat the bearing selection procedure for other connecting rod.

Bearing shell selection

21 New bearing shells for the big-end bearings are supplied on a selected fit basis. Code numbers stamped on various components are used to identify the correct parts. The crankshaft journal size numbers are stamped on the outside of the crankshaft web on the right-hand end (see illustration). The block of two numbers are for the big-end bearing journals (the block of three numbers are for the main bearing journals). The left-hand number is for the left-hand (No. 1 cylinder) journal. The connecting rod numbers are marked in ink on the flat face of the connecting rod and cap (see illustration).

22 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). Compare the bearing number calculated with the table below to find the colour coding of the new bearing required. The bearing shell colour code is marked on the side of the shell (see illustration).

Number	Colour
1	Blue
2	Black
3	Brown
4	Green

Installation

23 Clean the backs of the bearing shells and the bearing locations in both the connecting rod and cap.

24 Press the bearing shells into their locations, making sure the tab on each shell locates in the notch in the connecting rod/cap (see illustration 28.11). Make sure the bearings are fitted in their correct locations and take care not to touch any shell's bearing surface with your fingers. Lubricate the shells with clean engine oil.

25 Apply molybdenum disulphide grease to the bolt shanks and threads and to the seats of the nuts. Assemble the connecting rod and cap on the crankpin. Make sure the cap is

fitted the correct way around so the previously made markings align, and that the rod is facing the right way (see Step 3). Tighten the nuts finger-tight, making sure the connecting rod does not rotate on the crankshaft. Check again to make sure all components have been returned to their original locations using the marks made on disassembly.

26 Tighten the bearing cap nuts evenly, in two or three stages, to the initial torque setting specified at the beginning of the Chapter, making sure the connecting rod does not rotate on the crankshaft. Now tighten each nut in turn and in one continuous movement to the final torque setting specified. If the tightening is interrupted between the initial and final torque settings, slacken the nuts and begin the procedure again.

27 Check that the rods rotate smoothly and freely on the crankpin. If there are any signs of roughness or tightness, remove the rods and re-check the bearing clearance. Sometimes tapping the bottom of the connecting rod cap will relieve tightness, but if in doubt, recheck the clearances.

28 Reassemble the crankcase halves (see Section 25).

29 Crankshaft and main bearings – removal, inspection and installation



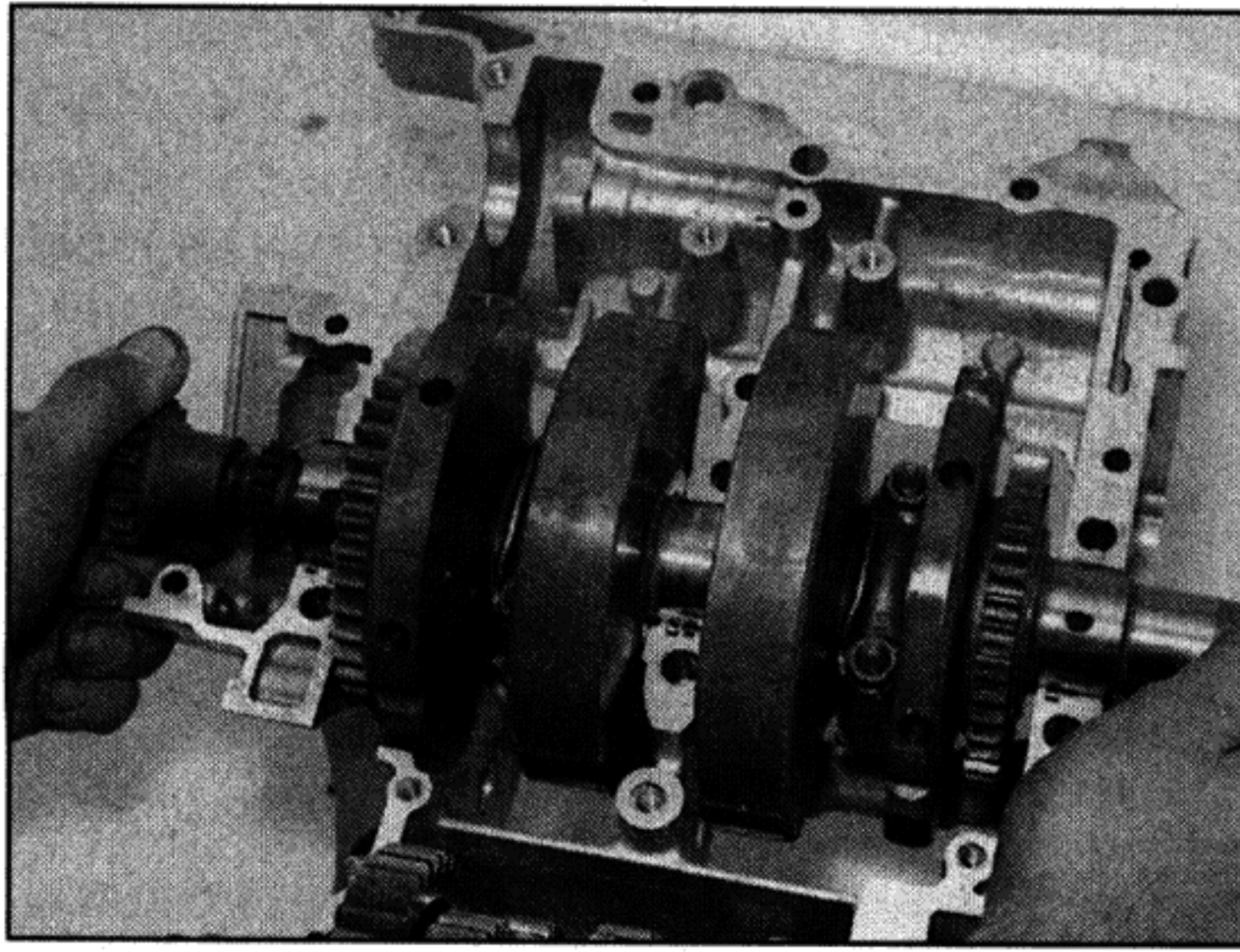
Note: To remove the crankshaft the engine must be removed from the frame and the crankcase halves separated.

Removal

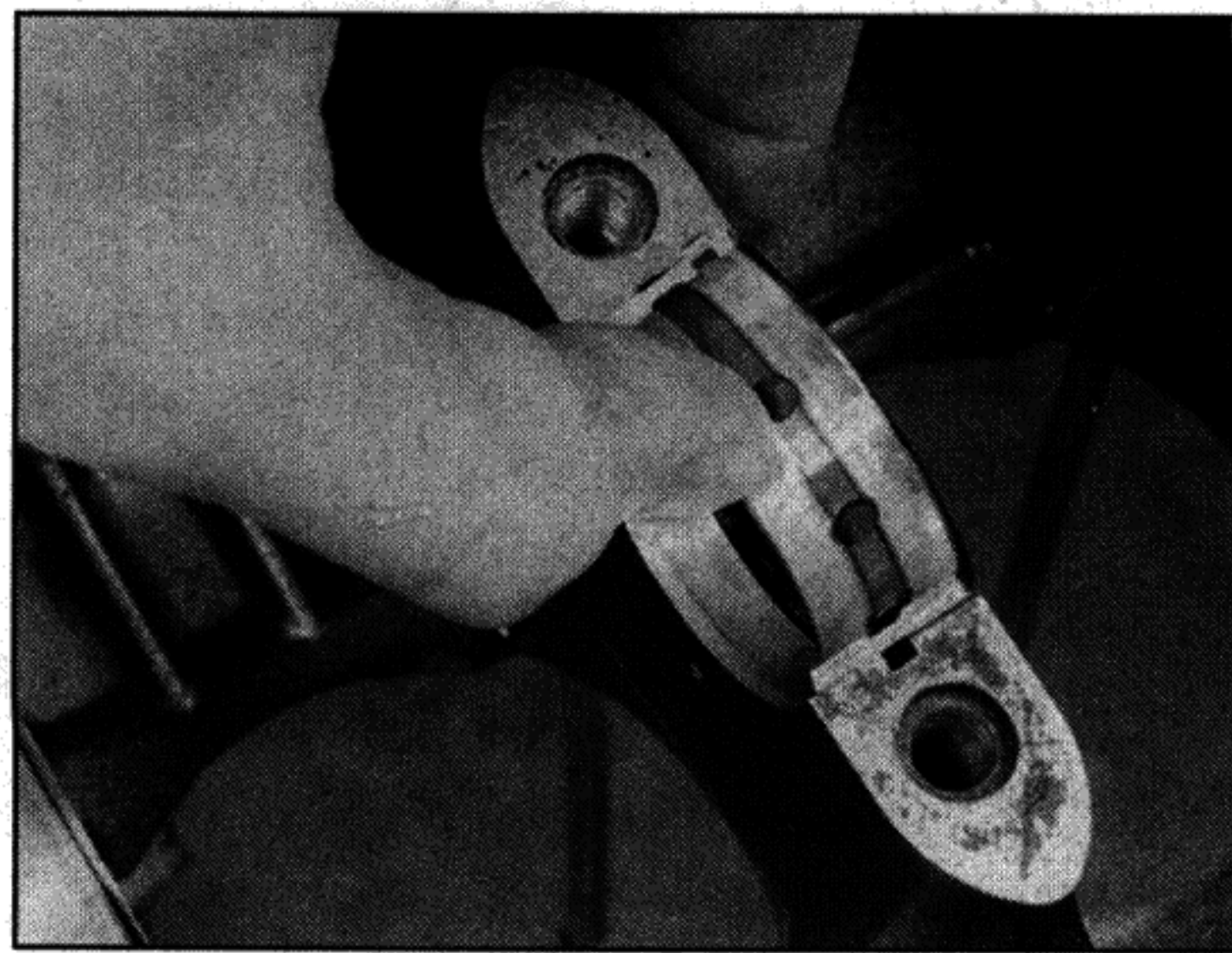
1 Remove the engine from the frame (see Section 5) and separate the crankcase halves (see Section 25).

2 Separate the connecting rods from the crankshaft (see Section 28). **Note:** If no work is to be carried out on the crankshaft or connecting rod assemblies, there is no need to separate them.

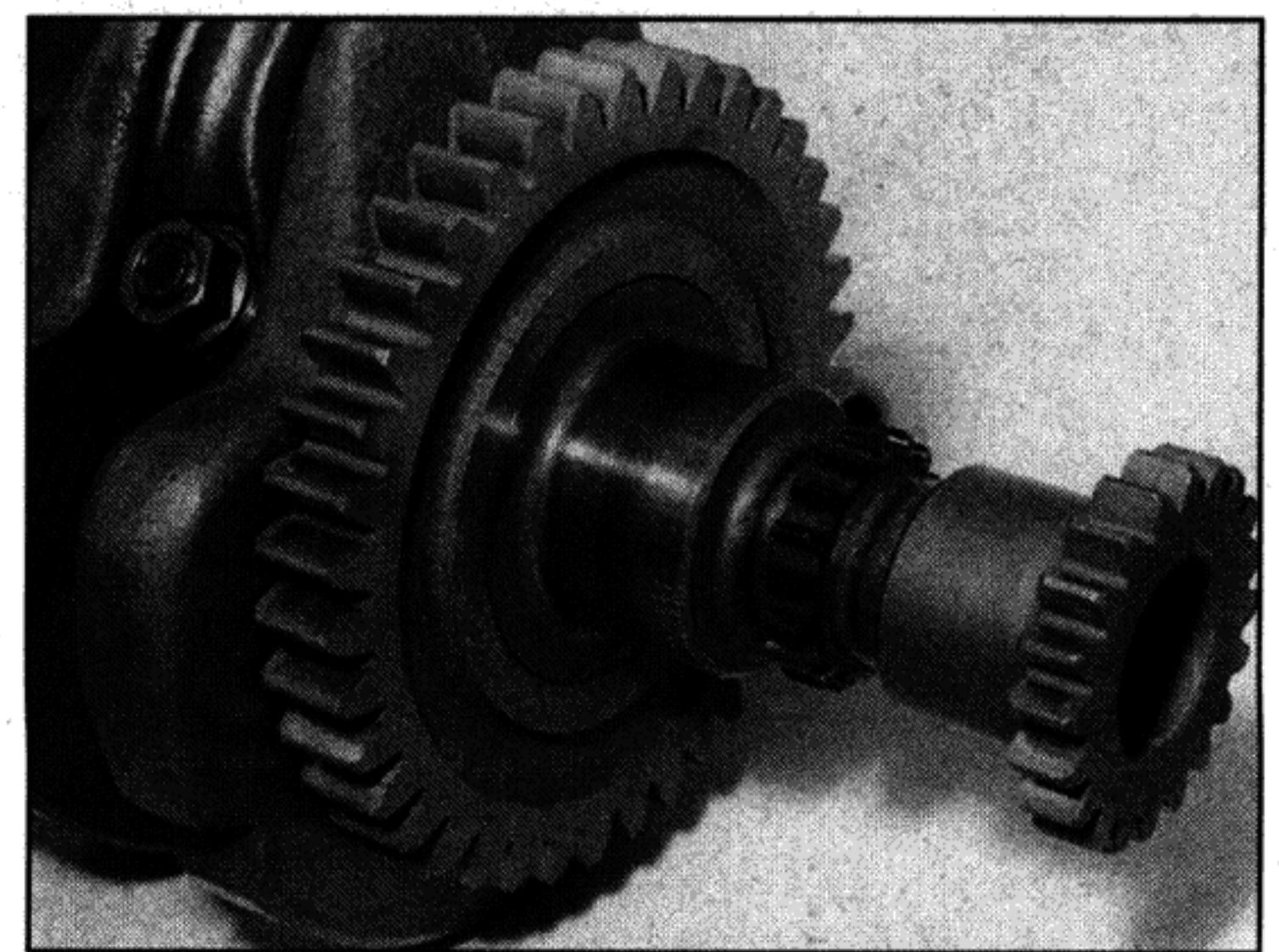
3 Lift the crankshaft out of the upper



29.3 Carefully lift the crankshaft out of the crankcase



29.4 To remove a main bearing shell, push it sideways and lift it out



29.5 Check the condition of the gear and sprocket teeth

crankcase half, taking care not to dislodge the main bearing shells (**see illustration**).

4 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

5 Clean the crankshaft with solvent, using a rifle-cleaning brush to scrub out the oil passages. If available, blow the crank dry with compressed air, and also blow through the oil passages. Check the drive gears for wear or damage (**see illustration**). If any of the gear teeth are excessively worn, chipped or broken, the crankshaft must be renewed. If wear or damage is found, check the driven gears on the balancer shafts, oil pumps, water pump and clutch housing.

6 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.

7 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.

8 Place the crankshaft on V-blocks and check the runout at the main bearing journals using a dial gauge (**see illustration**). Compare the reading to the maximum specified at the beginning of the Chapter. If the runout exceeds the limit, the crankshaft must be renewed.

Oil clearance check

9 Whether new bearing shells are being fitted or the original ones are being re-used, the main bearing oil clearance should be checked before the engine is reassembled. Main

bearing oil clearance is measured with a product known as Plastigauge.

10 Clean the backs of the bearing shells and the bearing housings in both crankcase halves.

11 Press the bearing shells into their cut-outs, ensuring that the tab on each shell engages in the notch in the crankcase (**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.

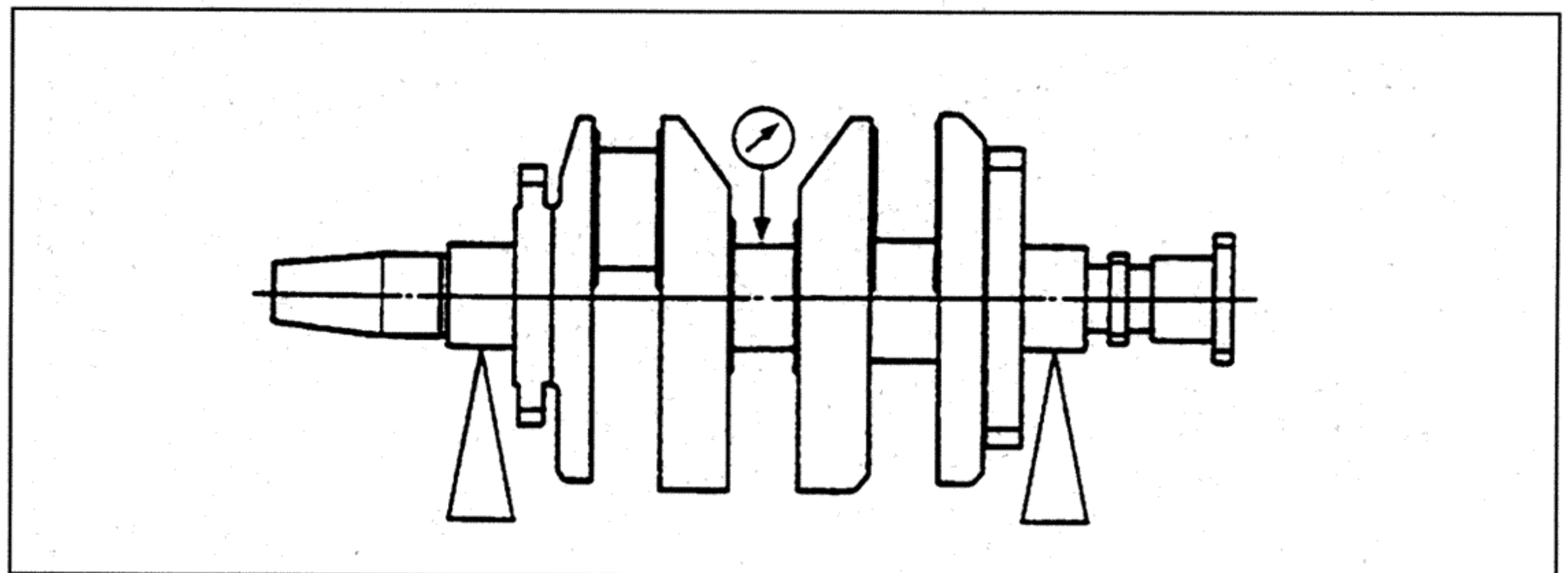
12 Ensure the shells and crankshaft are clean and dry. Lay the crankshaft in position in the upper crankcase.

13 Cut several lengths of the appropriate size Plastigauge (they should be slightly shorter than the width of the crankshaft journals).

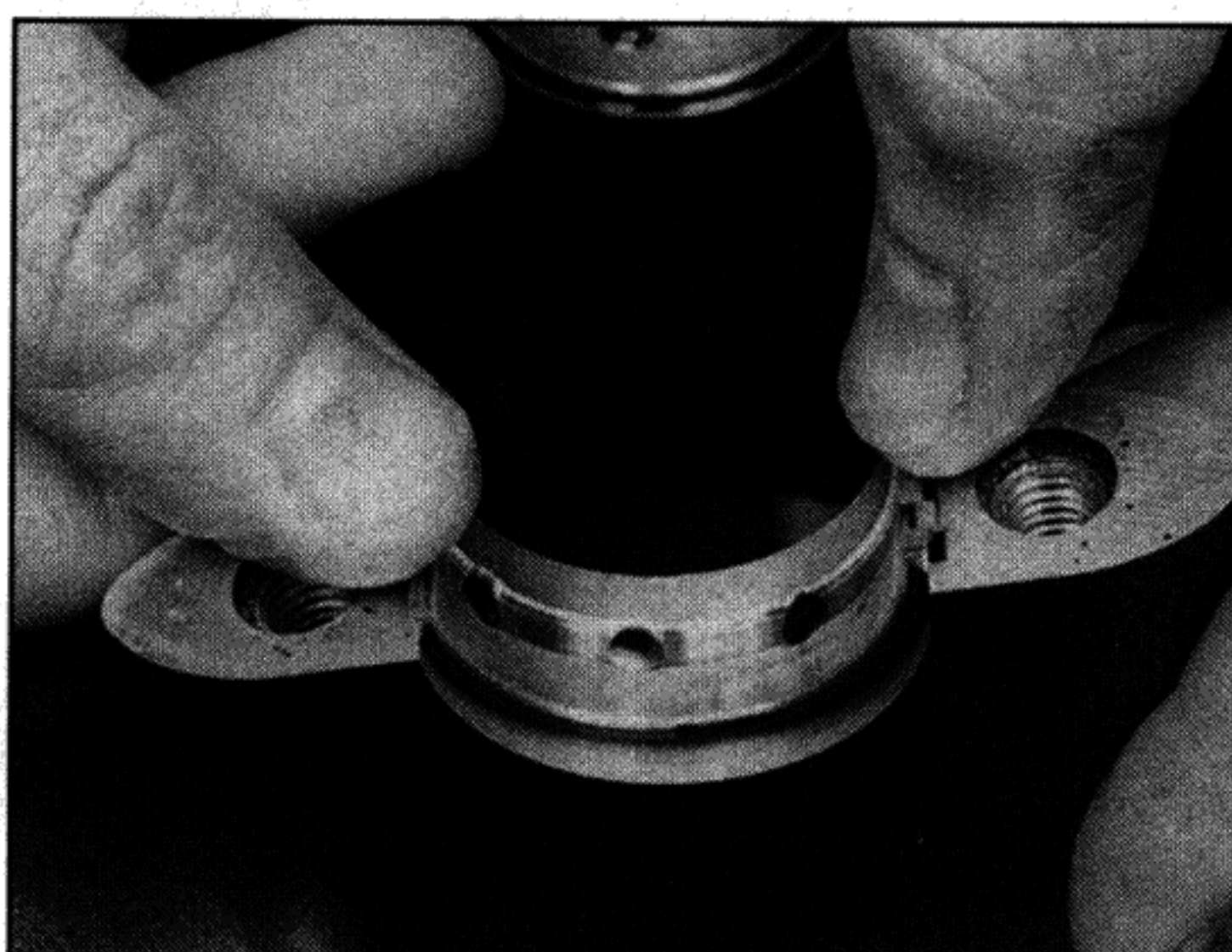
Place a strand of Plastigauge on each (cleaned) journal (**see illustration**). Make sure the crankshaft is not rotated.

14 If removed, install the locating dowel in the upper crankcase half (**see illustration 25.8**). Carefully install the lower crankcase half on to the upper half, making sure the dowel locates correctly into the lower crankcase half (**see illustration 25.15**). Check that the lower crankcase half is correctly seated. **Note:** Do not tighten the crankcase bolts if the casing is not correctly seated.

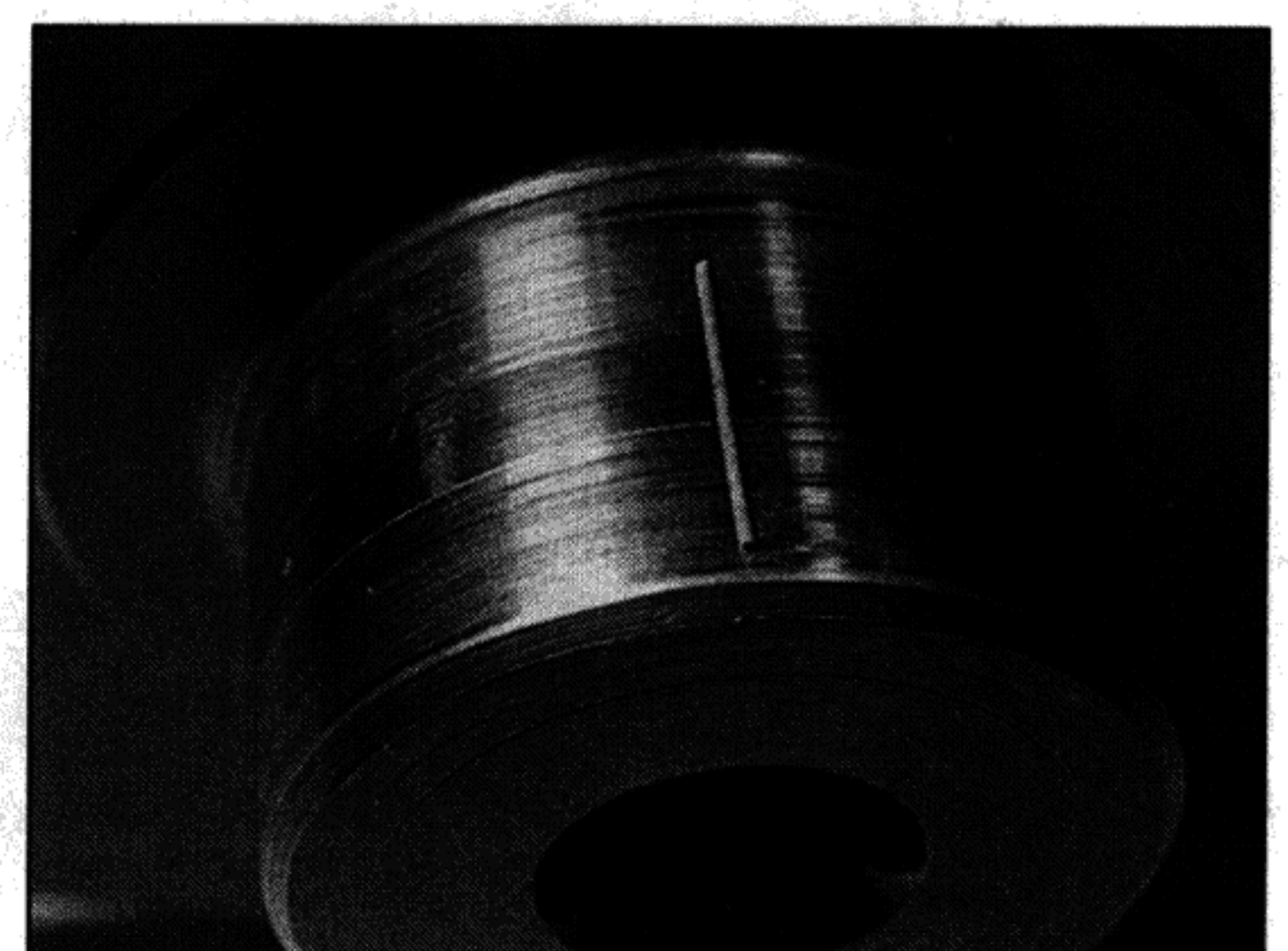
15 Clean the threads of the 10 mm lower crankcase bolts and apply molybdenum disulphide oil (a 50/50 mixture of molybdenum disulphide grease and new engine oil) to their threads. Insert them with their washers in their original locations. Clean the threads of the



29.8 Measuring crankshaft runout



29.11 Make sure the tab on the shell locates in the notch in the rod



29.13 Lay a strip of Plastigauge on each journal parallel to the crankshaft centreline



29.20 Measure the width of the crushed Plastigauge (be sure to use the correct scale – metric and imperial are included)

8 and 6 mm lower crankcase bolts and apply new engine oil to their threads. Insert them (with their washers where fitted) in their original locations. Secure all bolts finger-tight at first, then tighten them evenly and a little at a time in the correct numerical sequence to the torque settings specified at the beginning of the Chapter (**see illustrations 25.4a or b**). Make sure that the crankshaft is not rotated as the bolts are tightened.

16 Turn the engine over. Clean the threads of the 8 and 6 mm upper crankcase bolts and apply new engine oil to their threads. Insert them (with their washers where fitted) in their original locations. Secure all bolts finger-tight at first, then tighten them evenly and a little at a time in the correct numerical sequence to the torque settings specified at the beginning of the Chapter (**see illustrations 25.4a or b**). Make sure that the crankshaft is not rotated as the bolts are tightened.

17 Unscrew the 6 mm and 8 mm upper crankcase bolts evenly, a little at a time in a **reverse** of the numerical sequence until they are finger-tight, then remove them (**see illustrations 25.4a or b**). The number of each bolt is cast into the crankcase. Note the copper washers fitted with some of the bolts. **Note:** As each bolt is removed, store it in its relative position, with its washer where applicable, in a cardboard template of the

crankcase halves. This will ensure all bolts are installed in the correct location on reassembly. **18** Turn the engine upside down so that it rests on the cylinder head studs.

19 Unscrew the 6 mm lower crankcase bolts, the 8 mm bolts, and the 10 mm bolts evenly, a little at a time in a **reverse** of the numerical sequence until they are finger-tight, then remove them (**see illustrations 25.4a or b**). The number of each bolt is cast into the crankcase. Carefully lift off the lower crankcase half, making sure the Plastigauge is not disturbed.

20 Compare the width of the crushed Plastigauge on each crankshaft journal to the scale printed on the Plastigauge envelope to obtain the main bearing oil clearance (**see illustration**). Compare the reading to the specifications at the beginning of the Chapter.

21 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.

22 If the oil clearance falls into the specified range, new bearing shells are not required (provided they are in good condition). If the clearance is beyond the service limit, refer to the marks on the case and the marks on the crankshaft and select new bearing shells (**see Steps 24 and 25**). Install the new shells and check the oil clearance once again (the new shells may bring bearing clearance within the specified range). Always renew all of the main bearing shells at the same time.

23 If the clearance is still greater than the service limit listed in this Chapter's Specifications (even with new shells), the crankshaft journal is worn and the crankshaft should be renewed.

Main bearing shell selection

24 New bearing shells for the main bearings are supplied on a selected fit basis. Code numbers stamped on various components are used to identify the correct size bearings. The crankshaft journal size numbers are stamped on the outside of the crankshaft web on the

right-hand end (**see illustration 28.21a**). The block of three numbers are for the main bearing journals (the block of two numbers are for the big-end bearing journals). The main bearing housing numbers are stamped into the upper crankcase half (**see illustration**). Note that if there is only one number stamped into the crankcase, it means that all the journals are the same number.

25 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). Compare the bearing number calculated with the table below to find the colour coding of the new bearings required. The bearing shell colour code is marked on the side of the shell (**see illustration 28.22**).

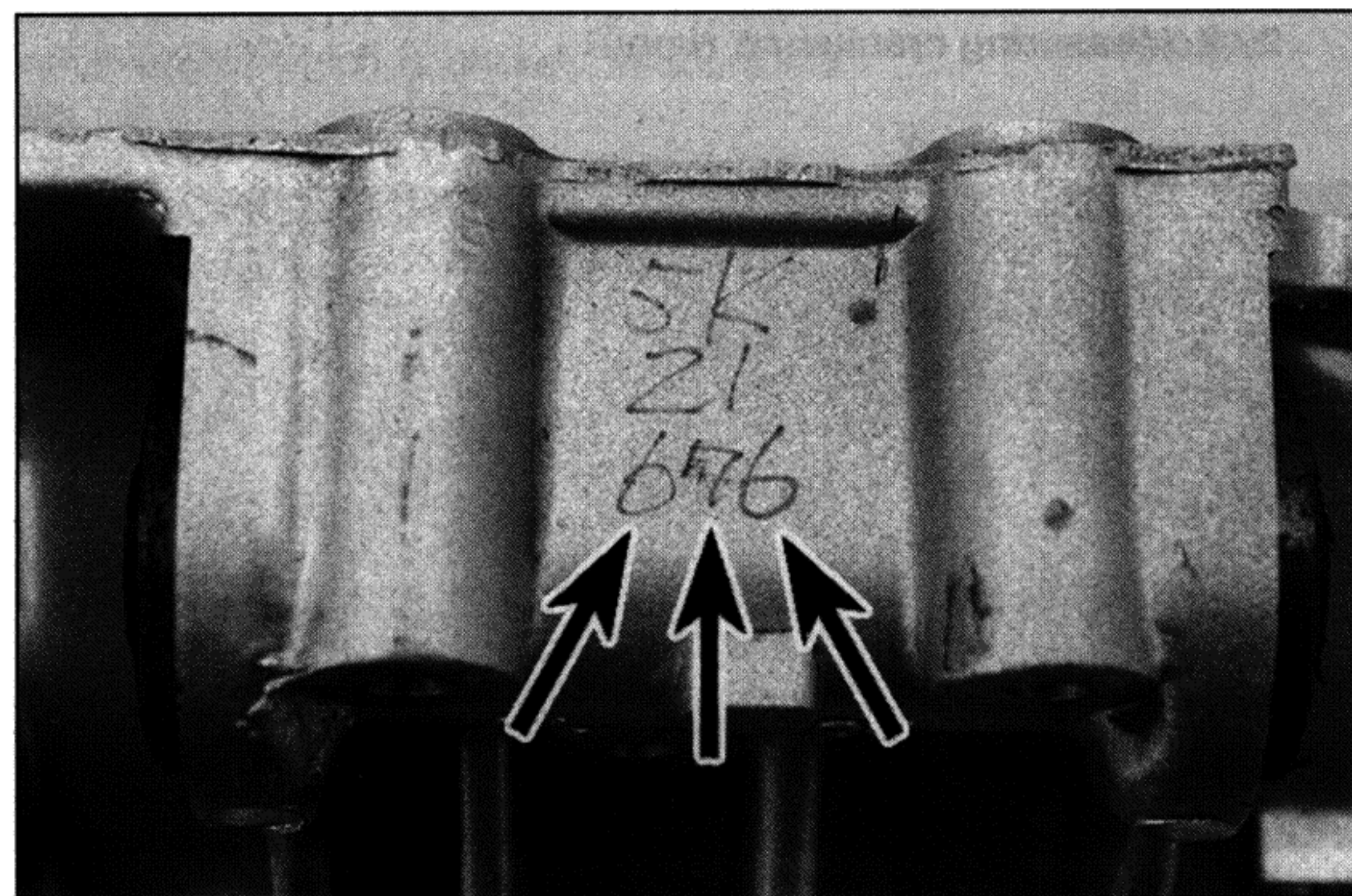
Number	Colour
1	Blue
2	Black
3	Brown
4	Green
5	Yellow
6	Pink
7	Red

Installation

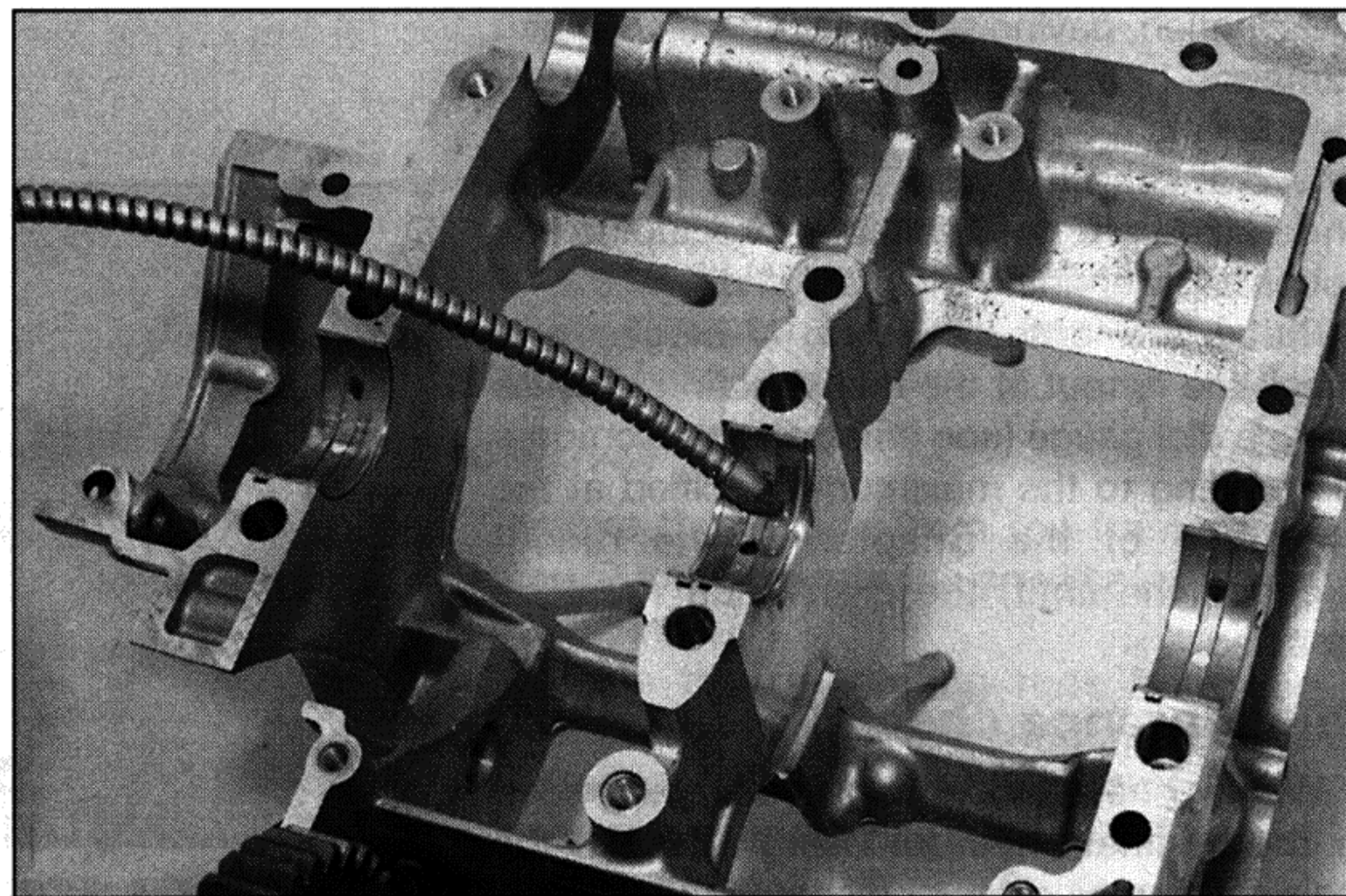
26 Clean the backs of the bearing shells and the bearing cut-outs in both crankcase halves. If new shells are being fitted, ensure that all traces of the protective grease are cleaned off using paraffin (kerosene). Wipe dry the shells and crankcase halves with a lint-free cloth. Make sure all the oil passages and holes are clear, and blow them through with compressed air if it is available.

27 Press the bearing shells into their locations. Make sure the tab on each shell engages in the notch in the casing (**see illustration 29.11**). Make sure the bearings are fitted in the correct locations and take care not to touch any shell's bearing surface with your fingers. Lubricate each shell with clean engine oil (**see illustration**).

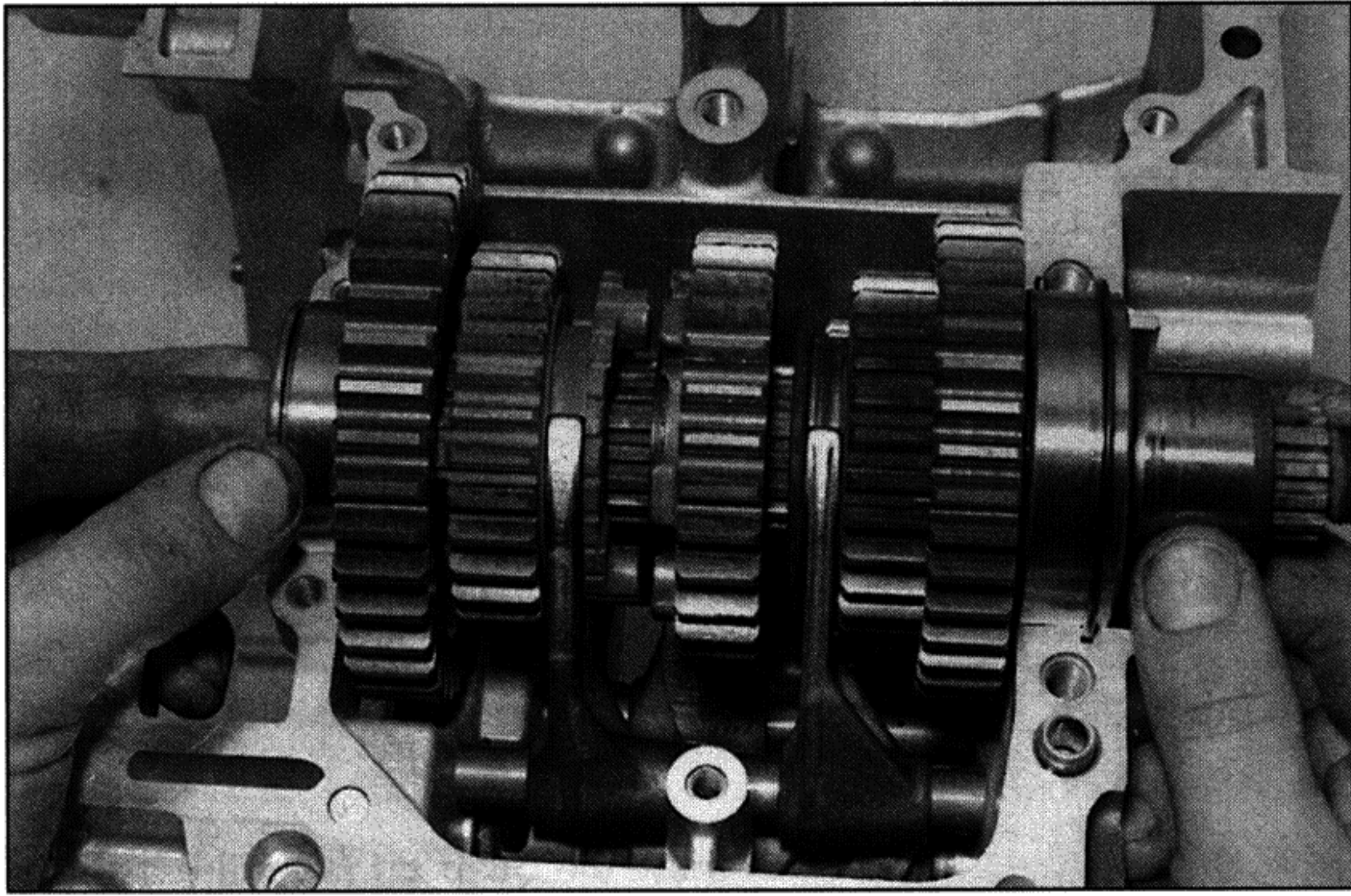
28 Lower the crankshaft into position in the



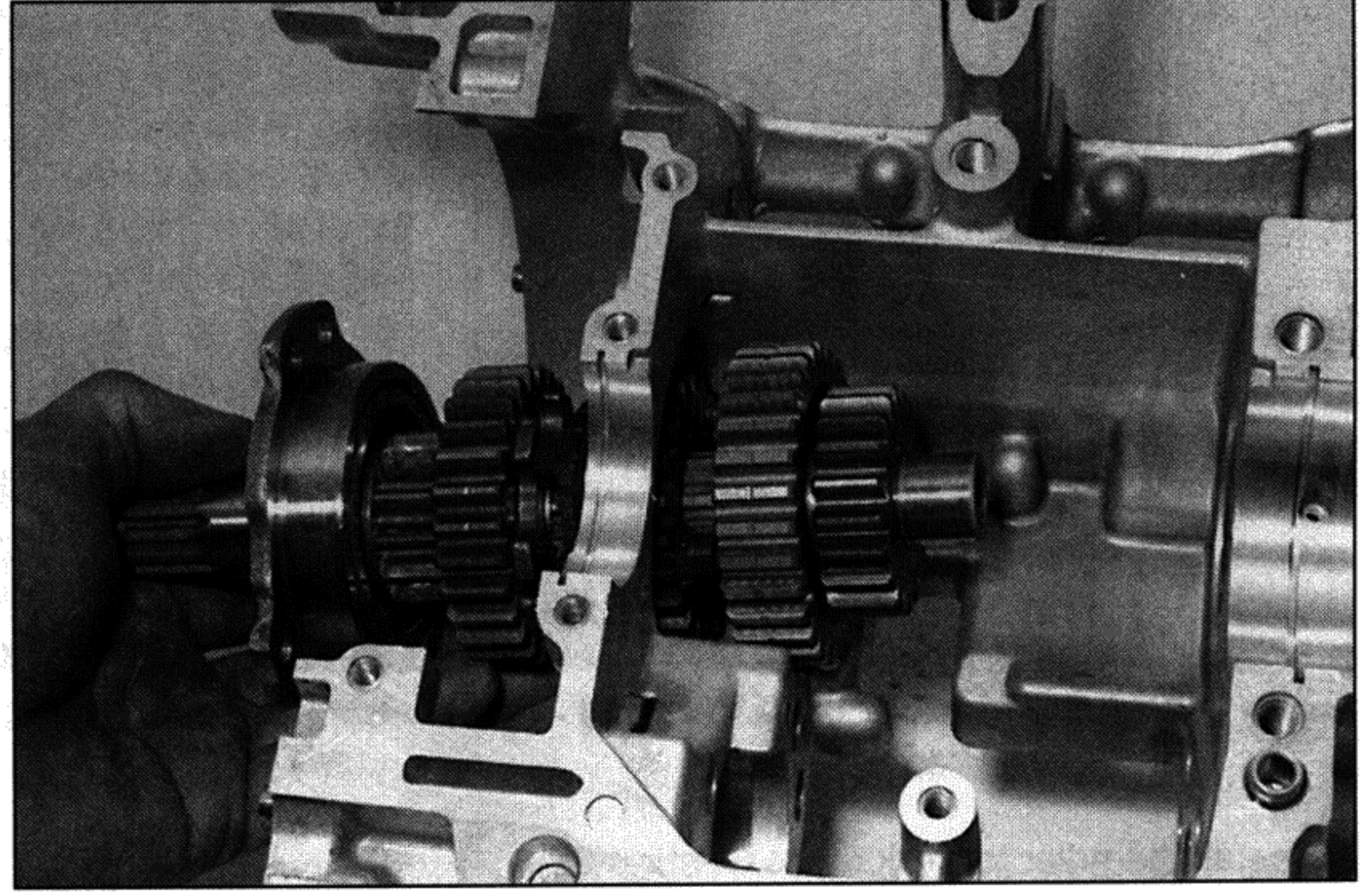
29.24 Main bearing housing numbers (arrowed)



29.27 Generously lubricate all the bearing shells



30.2 Lift out the output shaft



30.4a Draw out the shaft once the retainer screws have been removed

upper crankcase, making sure all bearings remain in place (see illustration 29.3).

29 Fit the connecting rods onto the crankshaft (see Section 28).

30 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 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 output shaft out of the casing, noting how the selector forks locate in the grooves (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 right-hand end of the output shaft and note how the locating pin on each bearing fits into the cutouts in the crankcase (see illustration 30.11). If the half-ring retainer is not in the slot in the crankcase, remove it from the slot in the bearing.

3 Remove the selector forks (see Section 32).

4 Remove the three Torx screws securing the input shaft bearing retainer on the right-hand end of the shaft (see illustration 30.7c). Draw the shaft out of the crankcase from the right-hand side (see illustration). If it is stuck, thread a 6 mm bolt into the centre of the blanking plug on the left-hand end of the shaft and remove the plug by pulling on the bolt (see illustration). Discard the plug O-ring as a new one must be used. Once the plug is removed, tap on the end of the shaft using a soft-faced mallet to free it from the crankcase.

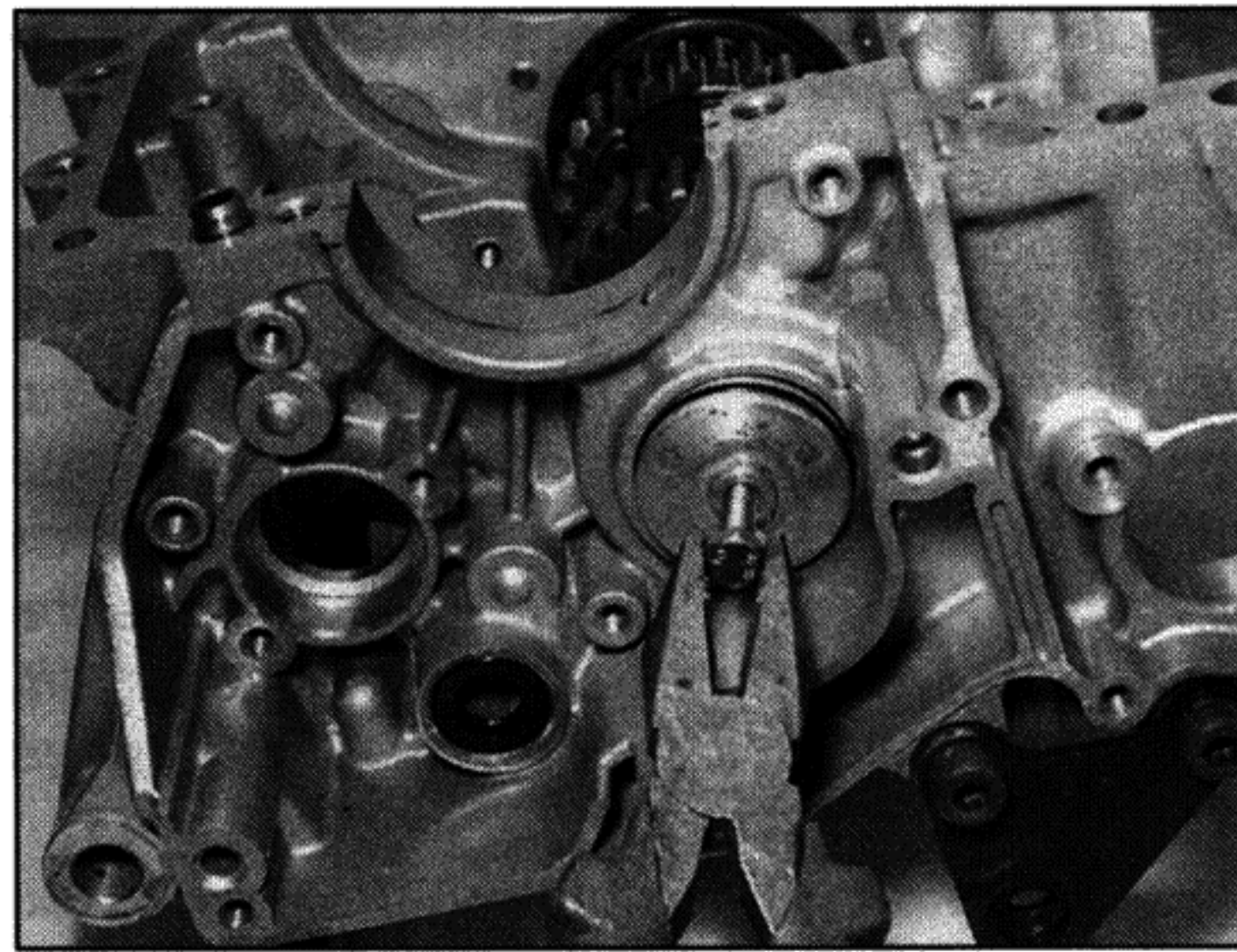
5 If necessary, the input shaft and output shaft can be disassembled and inspected for wear or damage (see Section 31).

6 Referring to *Tools and Workshop Tips* (Section 5) in the Reference Section, check the bearings on the transmission shafts or in the bearing housings in the crankcase. Renew the bearings if necessary. Also check the condition of the output shaft oil seal and renew it if it is worn or damaged (see illustration 25.11).

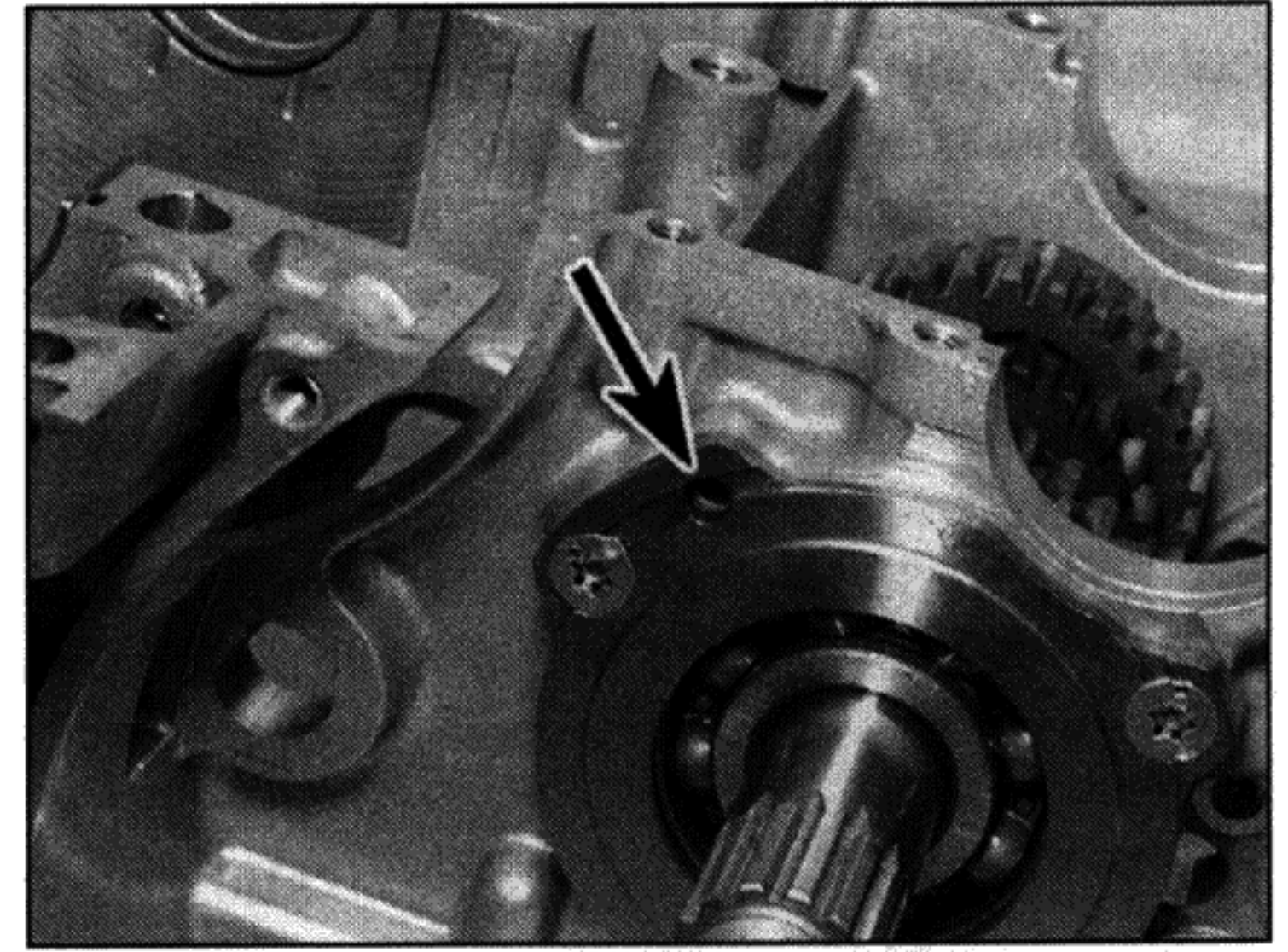
Installation

7 Slide the input shaft into the crankcase, aligning the four holes in the bearing retainer with those in the crankcase (see illustration and 30.4b). Use the screws, a long bolt or a

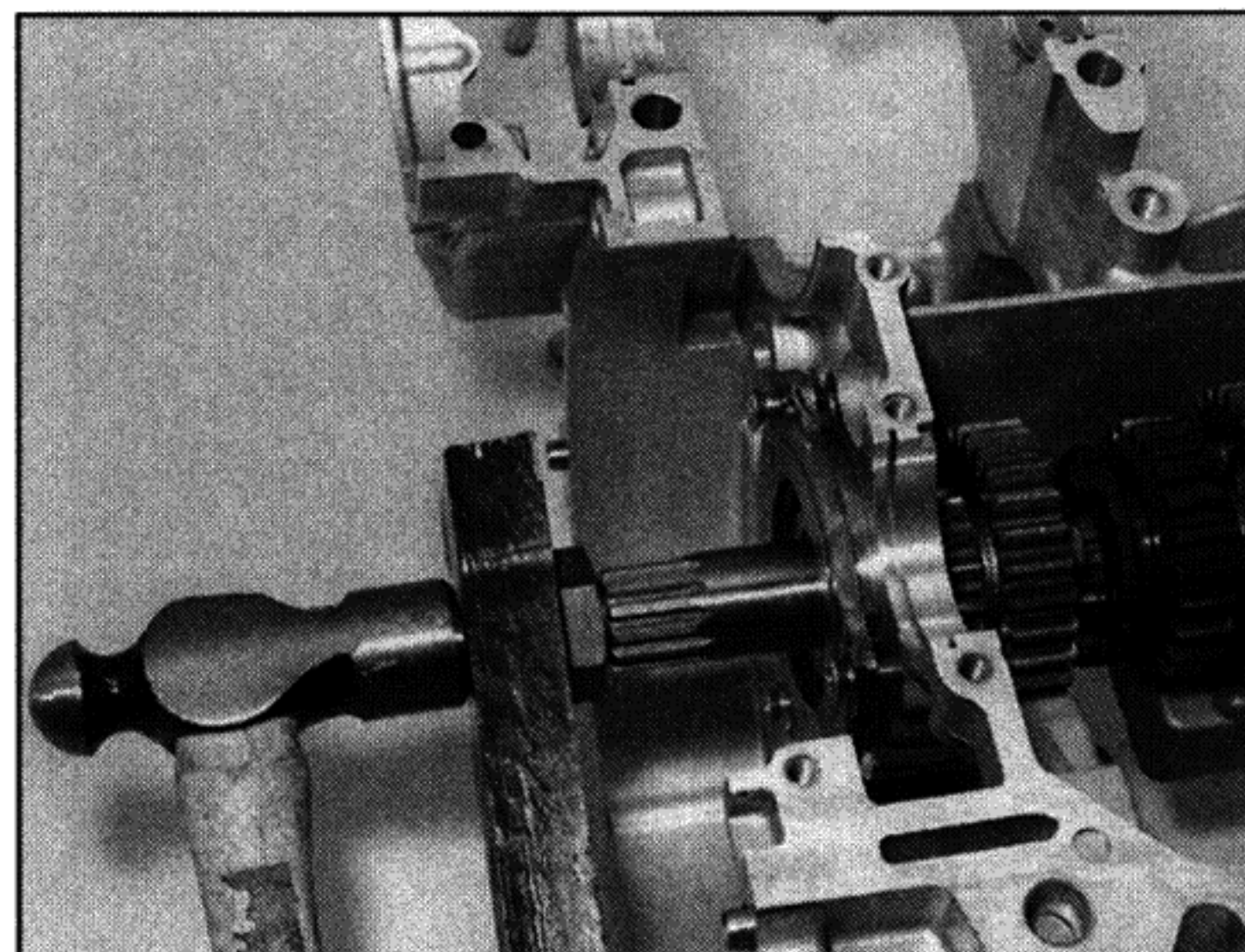
rod as a guide to align the holes, as once the retainer is in the housing it will be difficult to turn. Use a hammer and block of wood to drive the shaft fully home (see illustration). Apply a suitable non-permanent thread locking compound to the Torx screws and tighten them to the torque setting specified at the beginning of the Chapter. **Note:** It is advisable to renew the Torx screws because the originals are likely to have been damaged by previous staking. Using a suitable punch, stake the screws against the retainer (see illustration). If it was removed, fit the blanking plug with a new O-ring and press it home (see illustrations).



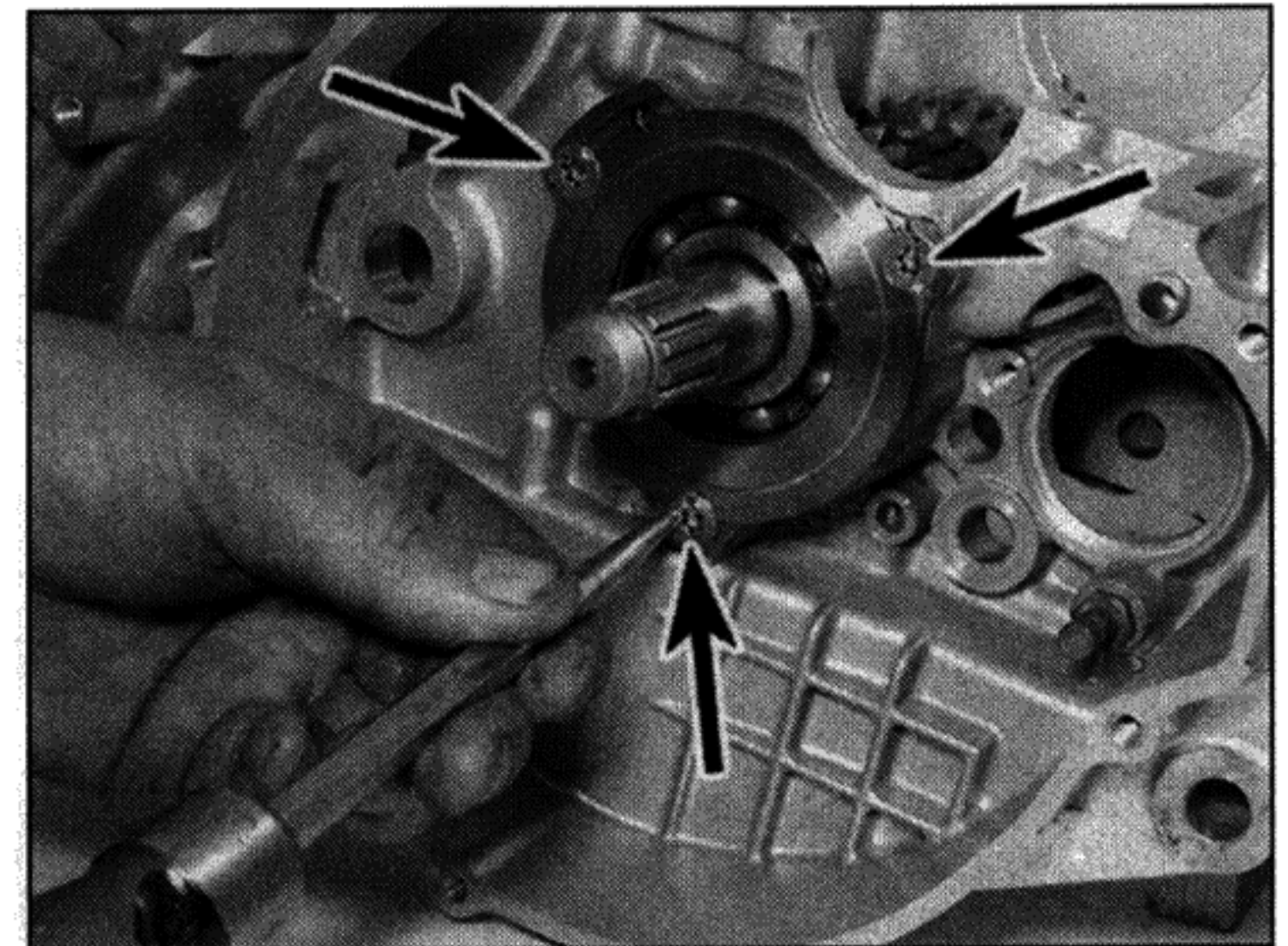
30.4b Thread a suitable bolt into the plug and pull it out



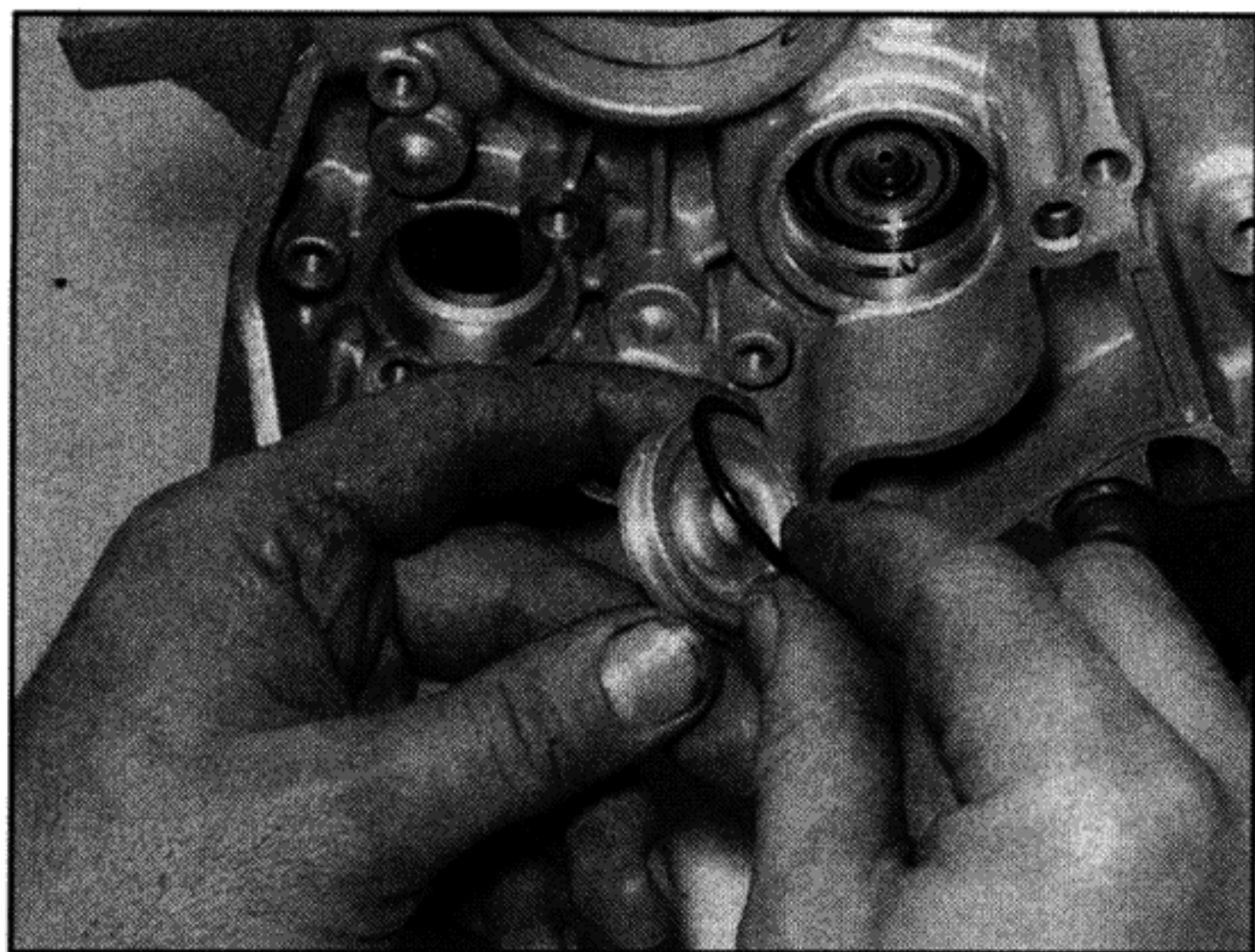
30.7a Note how the holes must align (arrow)



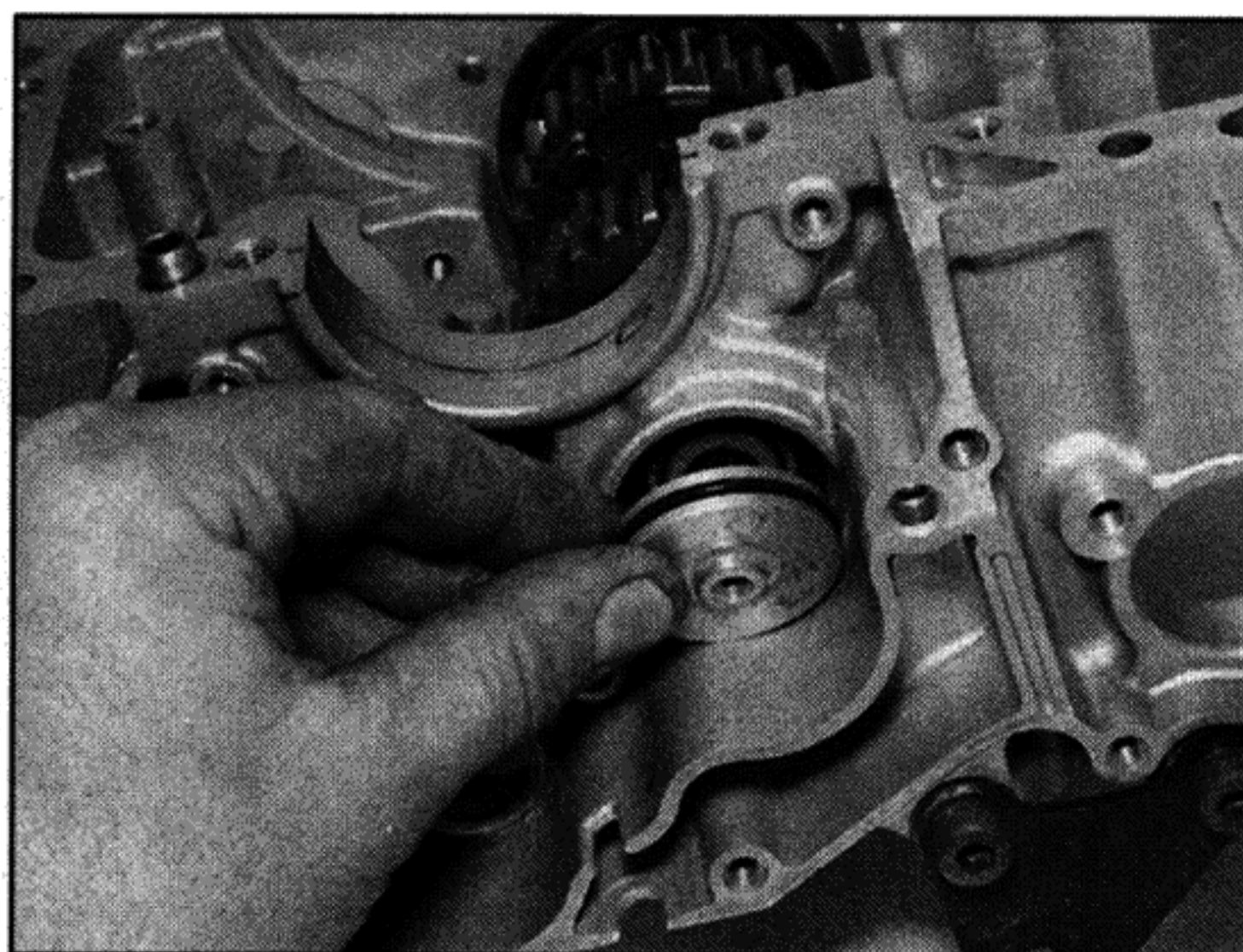
30.7b Tap the shaft into place as shown



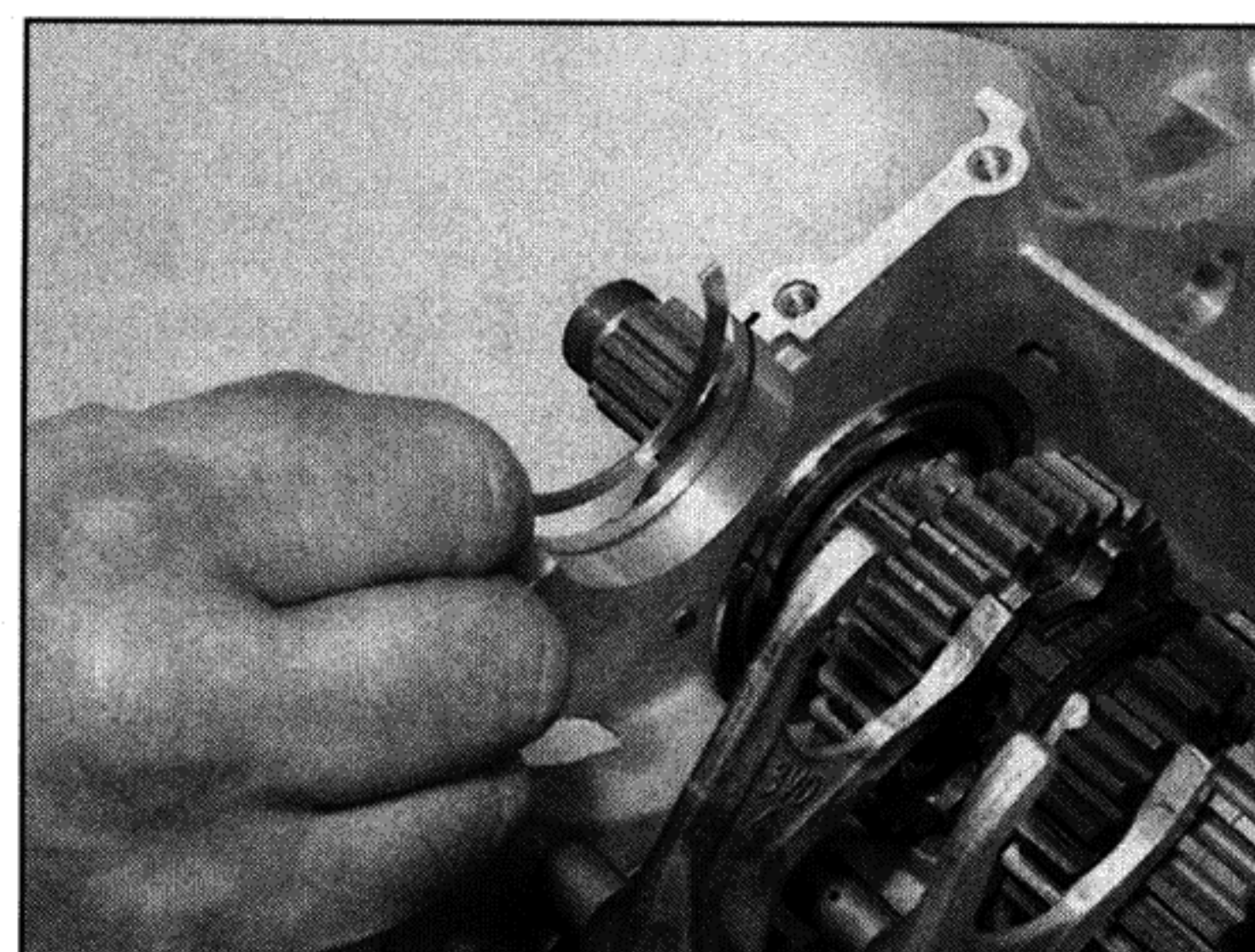
30.7c Install the Torx screws (arrowed) and stake them in place



30.7d Fit a new O-ring onto the plug . . .



30.7e . . . and press it into place



30.9 Fit the half-ring retainer into the slot

8 Install the selector forks (see Section 32).

9 Install the bearing half-ring retainer for the right-hand end of the output shaft into its slot in the upper crankcase half (see illustration).

10 If it has not been removed, slide the output shaft oil seal off the left-hand end of the shaft (see illustration 25.11); the seal must be renewed. Lubricate the shaft and new seal with clean oil and slide it onto the shaft. Smear the seal rim with oil.

11 Lower the output shaft into position in the crankcase half (see illustration 30.2), making sure the selector fork guide pins are engaged with their selector drum groove and the forks themselves fit into the grooves in the pinions, and the slot in the right-hand bearing engages correctly with the bearing half-ring retainer, the circlip on the left-hand bearing fits into its slot, and the bearing locating pins fit into the cutouts in the crankcase (see illustration).

12 Make sure both transmission shafts are correctly seated and their related pinions are correctly engaged.

Caution: If the bearing half-ring retainer, circlip and locating pins are not correctly engaged, the crankcase halves will not seat correctly.

13 Position the gears in the neutral position and check the shafts are free to rotate easily and independently (ie the input shaft can turn whilst the output shaft is held stationary) before proceeding further.

14 Reassemble the crankcase halves (see Section 25).

31 Transmission shafts – disassembly, inspection and reassembly



1 Remove the transmission shafts from the casing (see Section 30). Always disassemble the transmission shafts separately to avoid mixing up the components.

Input shaft disassembly



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 2nd gear pinion from the left-hand end of the shaft using a puller, referring to *Tools and Workshop Tips* (Section 5) in the Reference Section if required (see illustration). If a legged puller is being used, it will be easier to set it up with the legs behind the 5th gear pinion, and draw the 2nd and 5th pinions off together. **Note:** In our experience an hydraulic press was needed to remove the 2nd gear pinion as it was so tight on the shaft. Take the shaft to a properly equipped workshop if necessary.

3 Slide the 5th gear pinion off the shaft (see illustration 31.17d).

4 To remove the 5th gear pinion bush, set up a puller behind the 3rd gear pinion and use

that to draw the bush off (see illustration). Remove the thrust washer and the 3rd gear pinion (see illustration 31.17a and 31.16).

5 Remove the circlip securing the 4th gear pinion, then slide the splined washer and the pinion off the shaft (see illustrations 31.15c, b and a). The 4th gear pinion bush is a press fit. Do not remove it unless it needs to be renewed. Remove it using a puller.

6 The 1st gear pinion is integral with the shaft.

Input shaft inspection

7 Wash all of the components in clean solvent and dry them off.

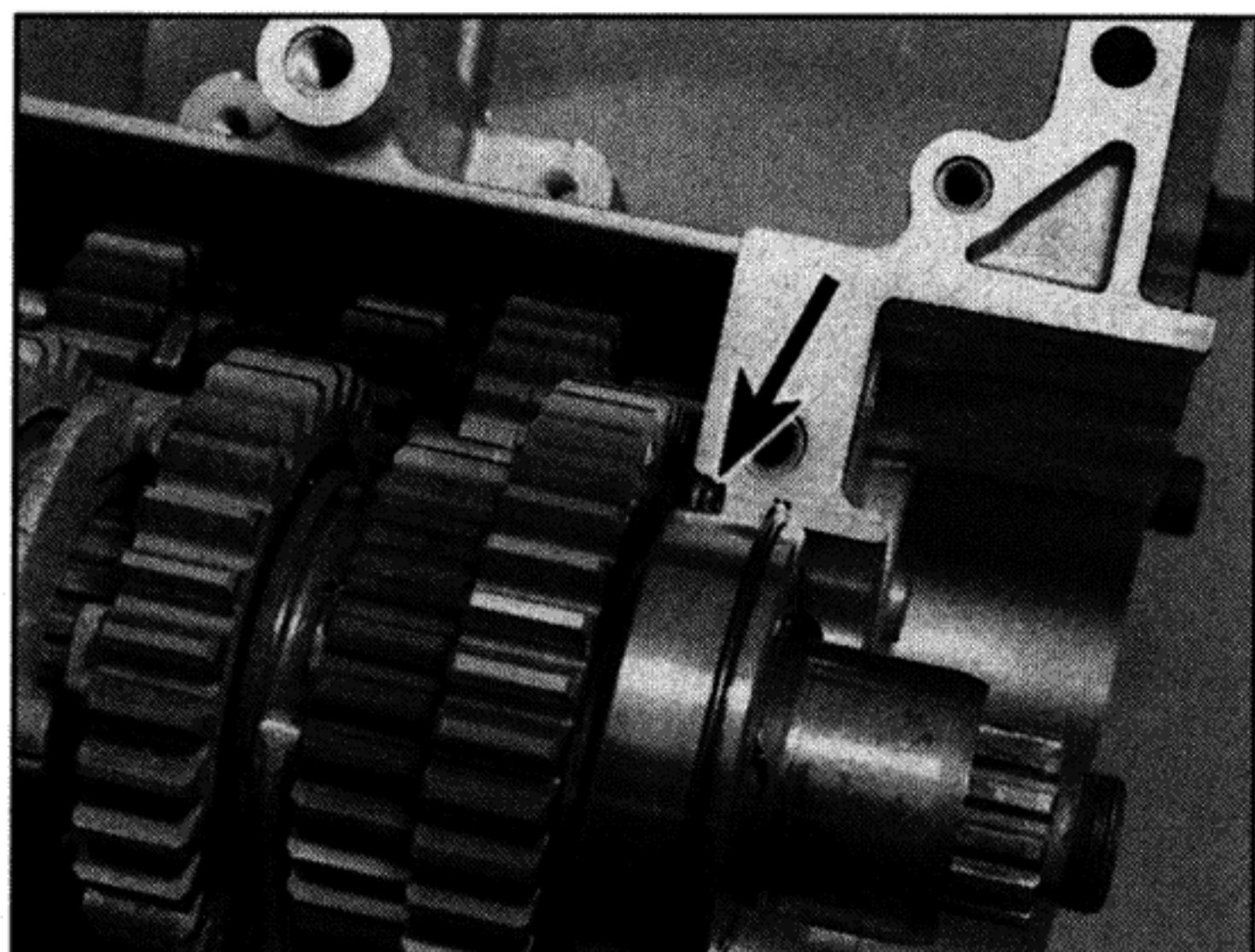
8 Check the gear teeth for cracking, chipping, pitting and other obvious wear or damage. Any pinion that is damaged as such must be renewed.

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. Renew the paired gears as a set if necessary.

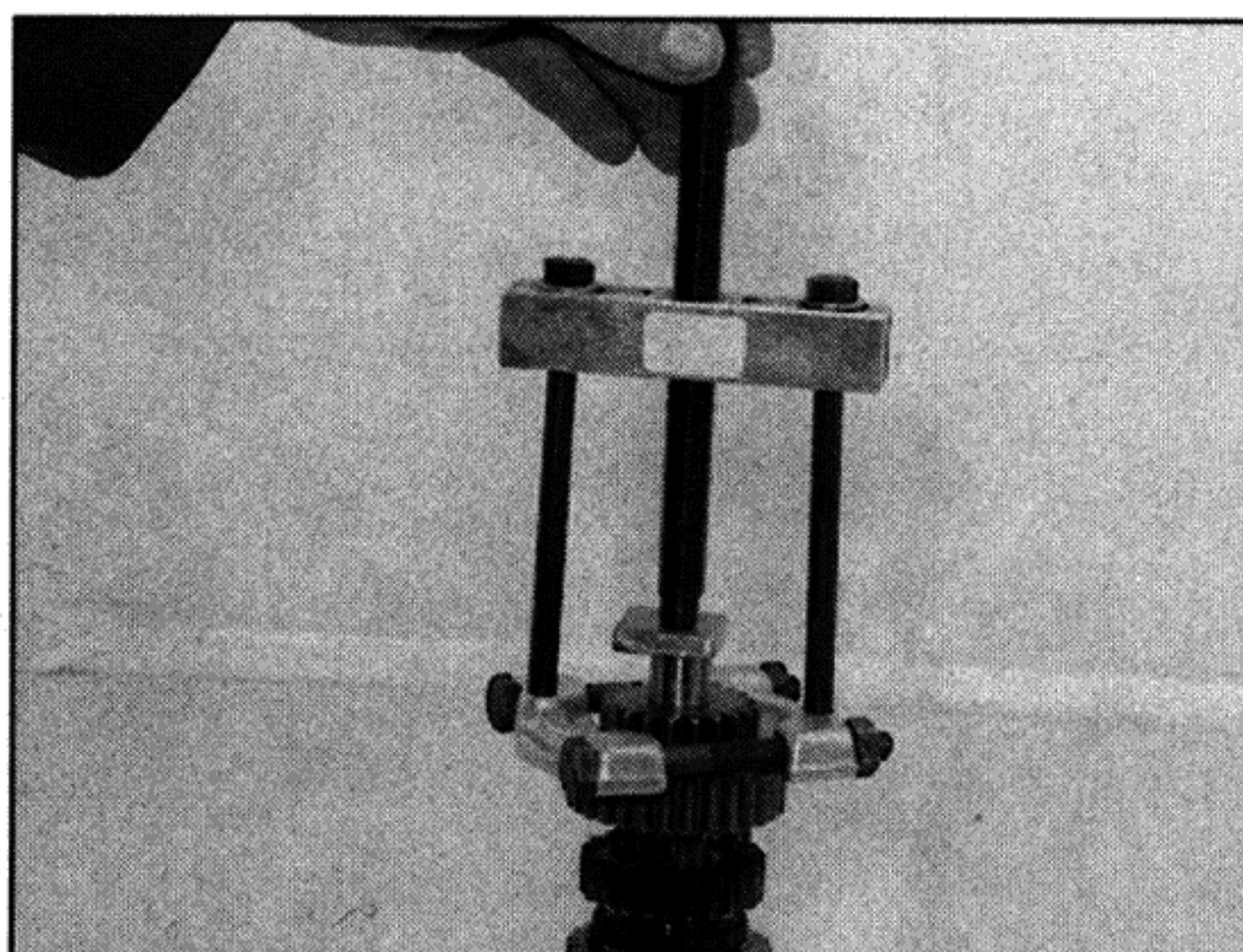
10 Check for signs of scoring or bluing on the pinions, bushes and shaft. This could be caused by overheating due to inadequate lubrication. Check that all the oil holes and passages are clear. Renew any damaged pinions or bushes.

11 Check that each mobile pinion moves freely on the shaft or bush but without undue freeplay.

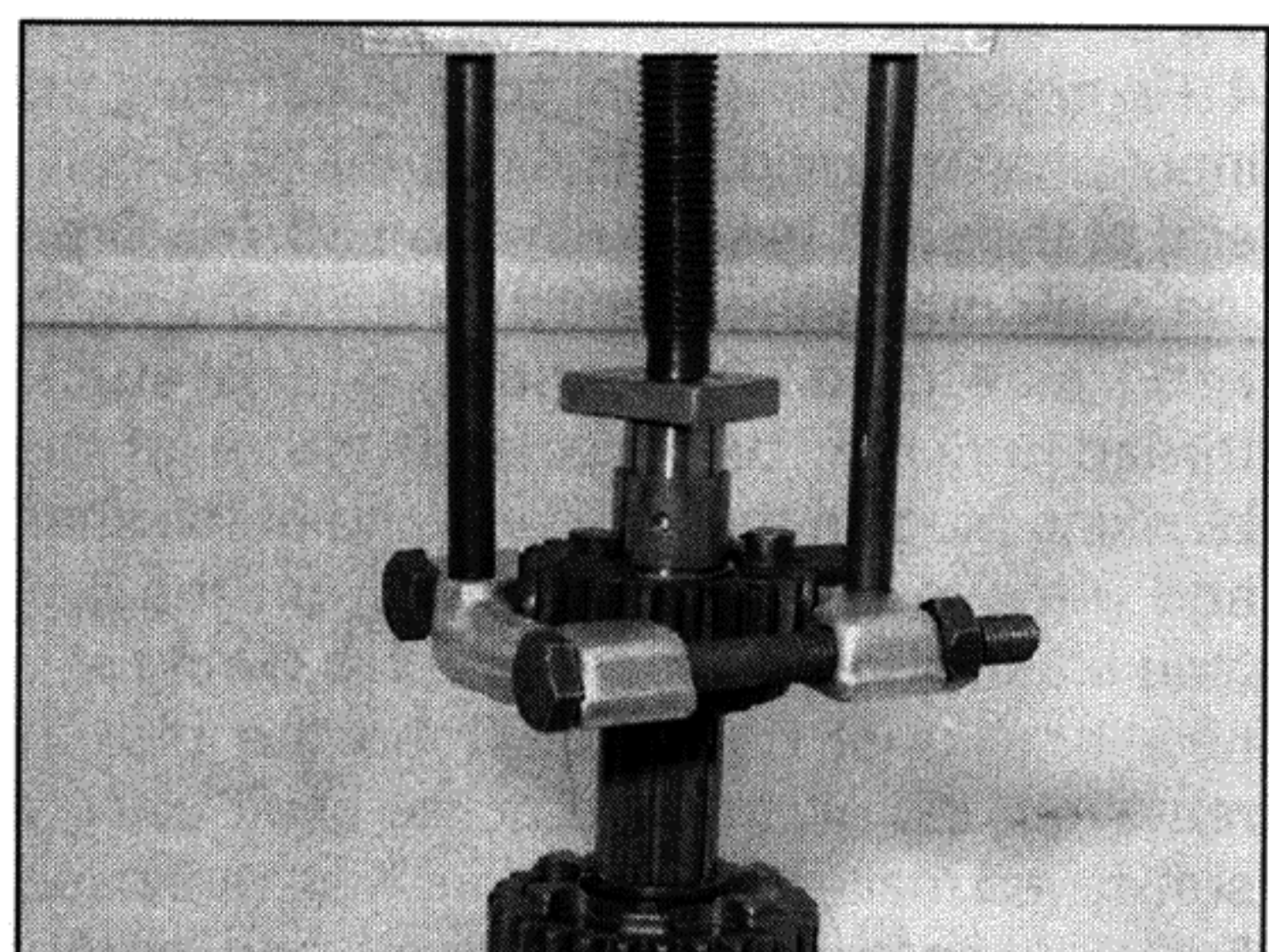
12 The shaft is unlikely to sustain damage unless the engine has seized, placing an



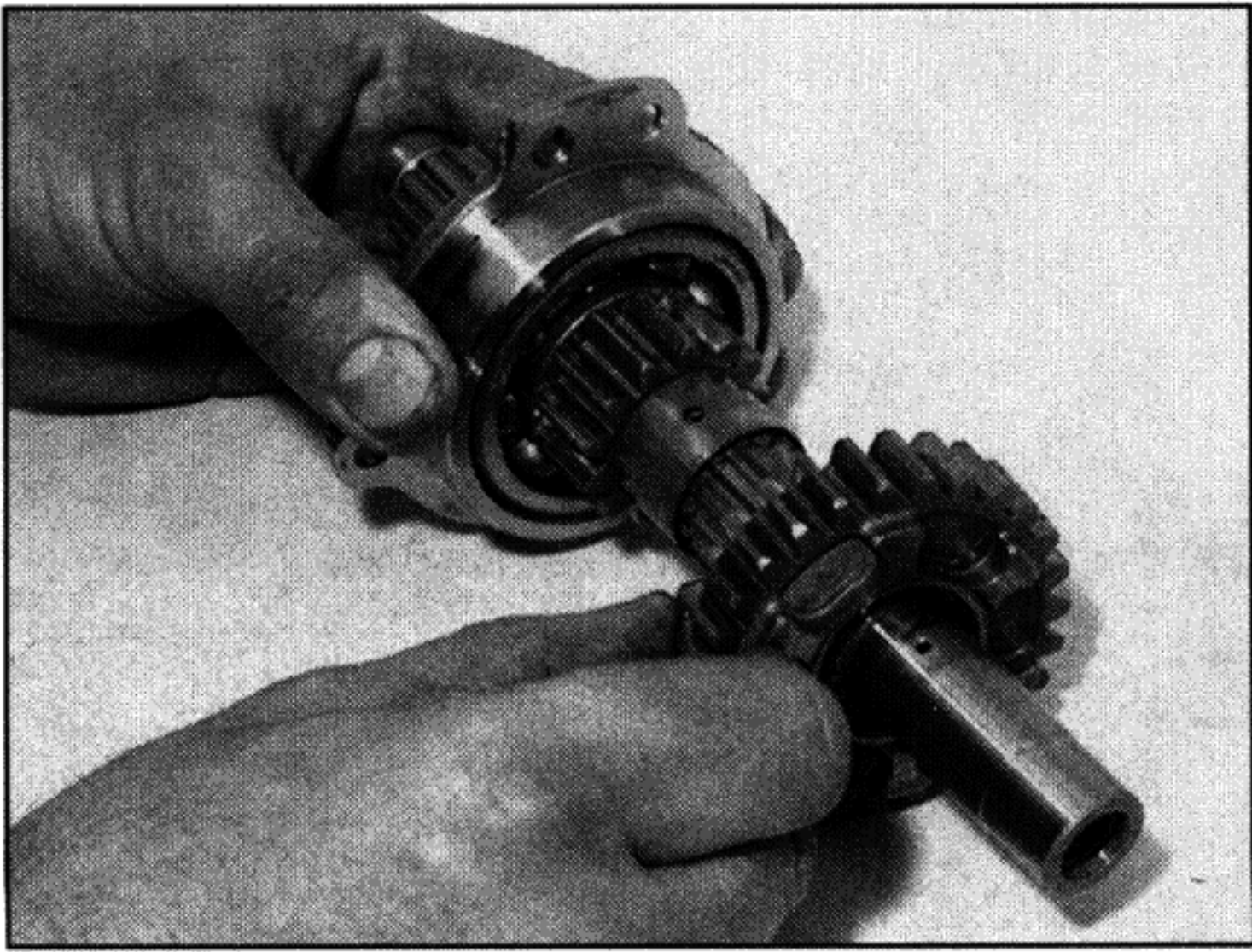
30.11 Make sure that each pin (arrowed) locates in its cutout



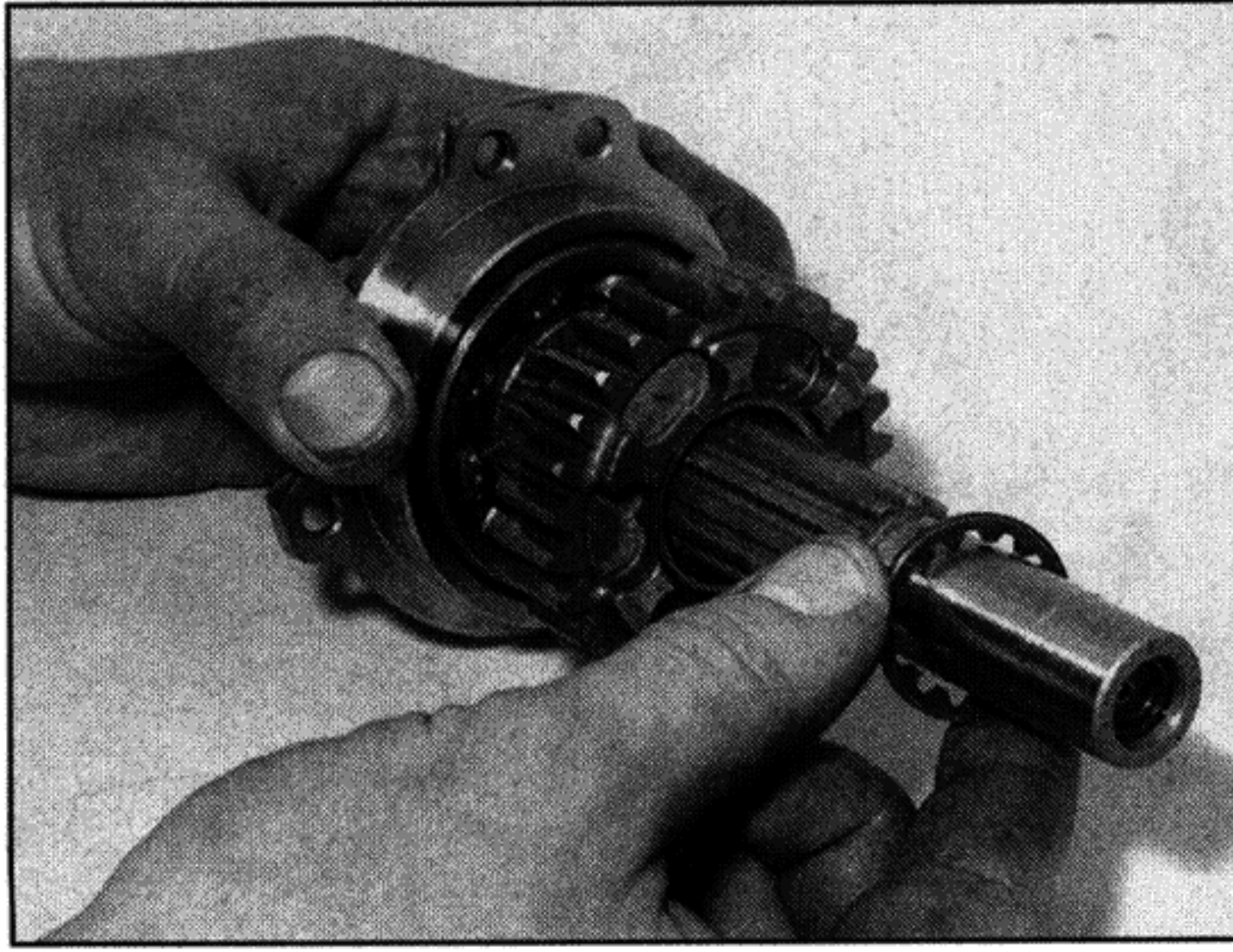
31.2 Use a puller or press to remove the 2nd gear pinion



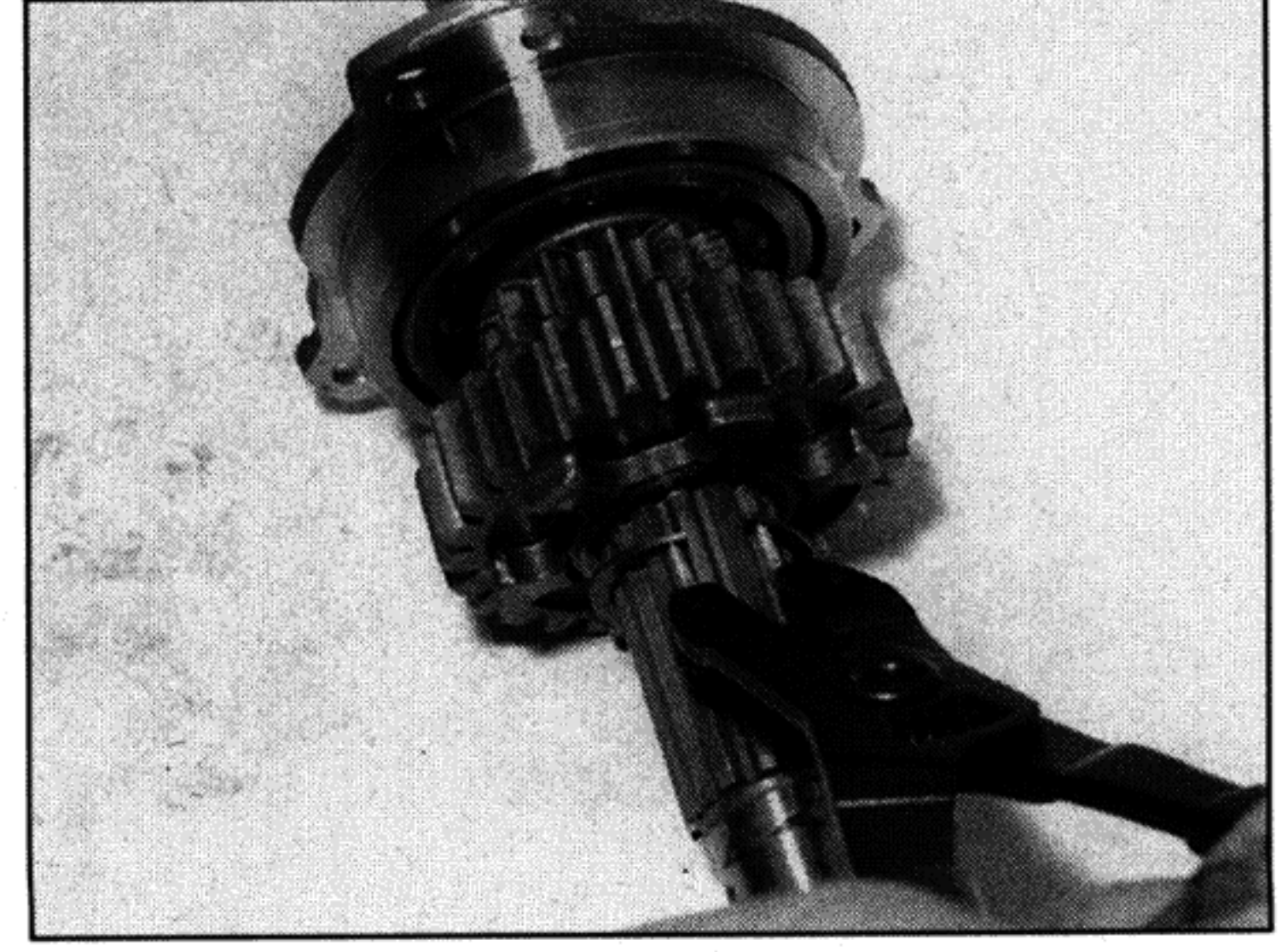
31.4 Draw off the bush using a puller behind the 3rd gear pinion



31.15a Slide the 4th gear pinion onto the bush . . .



31.15b . . . then slide on the splined washer . . .



31.15c . . . and secure them with the circlip

unusually high loading on the transmission, or the machine has covered a very high mileage. Check the surface of the shaft, especially where a pinion turns on it, and renew the shaft if it has scored or picked up, or if there are any cracks. Damage of any kind can only be cured by renewal. Check the shaft runout using V-blocks and a dial gauge and renew the shaft if the runout exceeds the limit specified at the beginning of the Chapter.

13 Check the washers and circlips and renew any that are bent or appear weakened or worn. It is a good policy to renew all circlips and washers as a matter of course during a gearshaft overhaul.

Input shaft reassembly

14 During reassembly, apply 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 so that their chamfered side faces the pinion it secures and the sharp edged sides faces the direction of thrust load (see 'correct fitting of a stamped circlip illustration' in *Tools and Workshop Tips* in the Reference section).

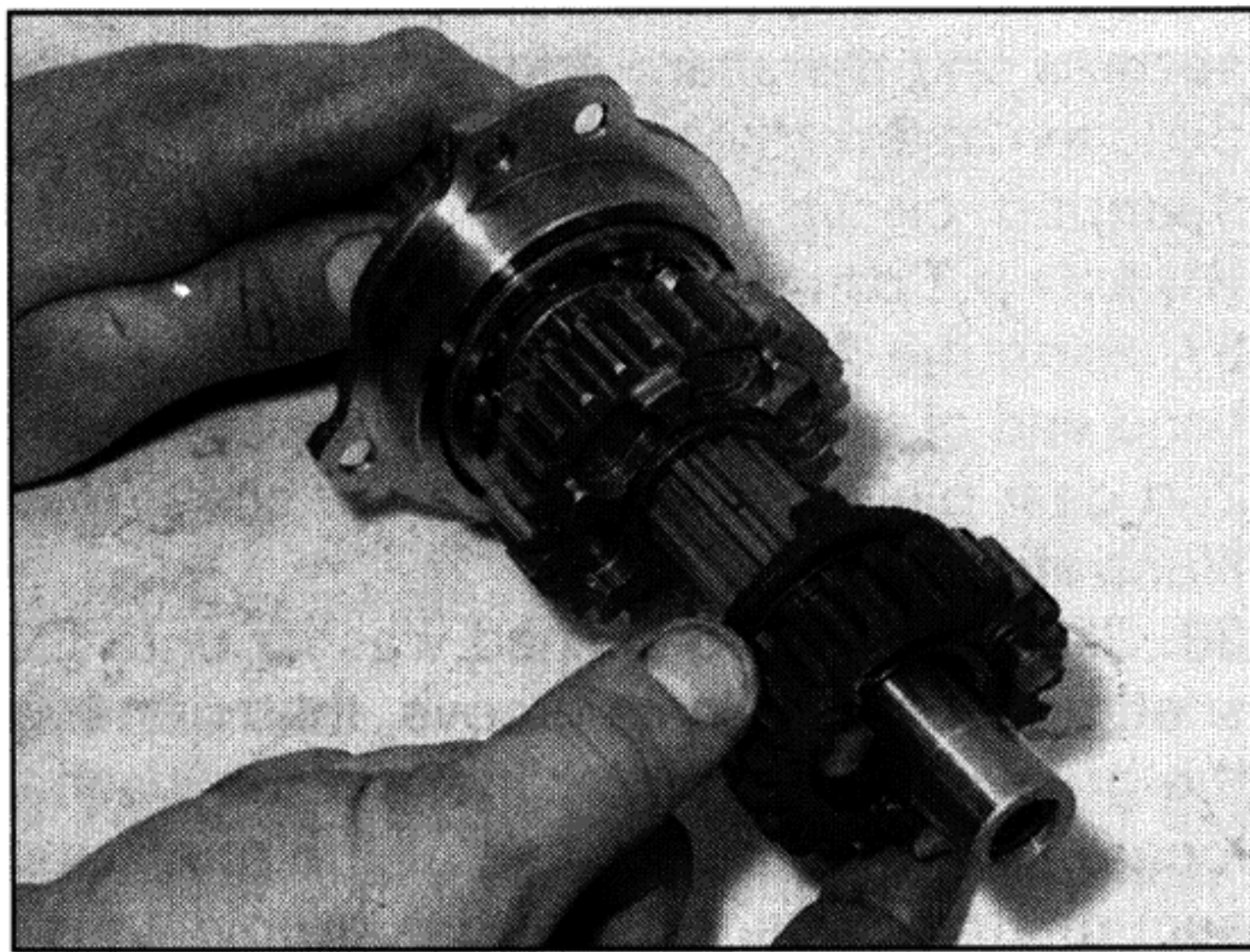
15 If removed, drive or press the 4th gear pinion bush onto the shaft, aligning the oil hole in the bush with the hole in the shaft. Slide the 4th gear pinion, with the pinion dog holes facing away from the integral 1st gear onto the bush (**see illustration**). Slide the splined washer onto the shaft, then fit the circlip, making sure that it locates

correctly in the groove in the shaft (**see illustrations**).

16 Slide the 3rd gear pinion onto the shaft with the selector fork groove facing the 4th gear pinion (**see illustration**).

17 Slide the thrust washer onto the shaft, then drive or press the 5th gear pinion bush into place, aligning the oil hole in the bush with the hole in the shaft (**see illustrations**). Slide the 5th gear pinion onto the bush (**see illustration**).

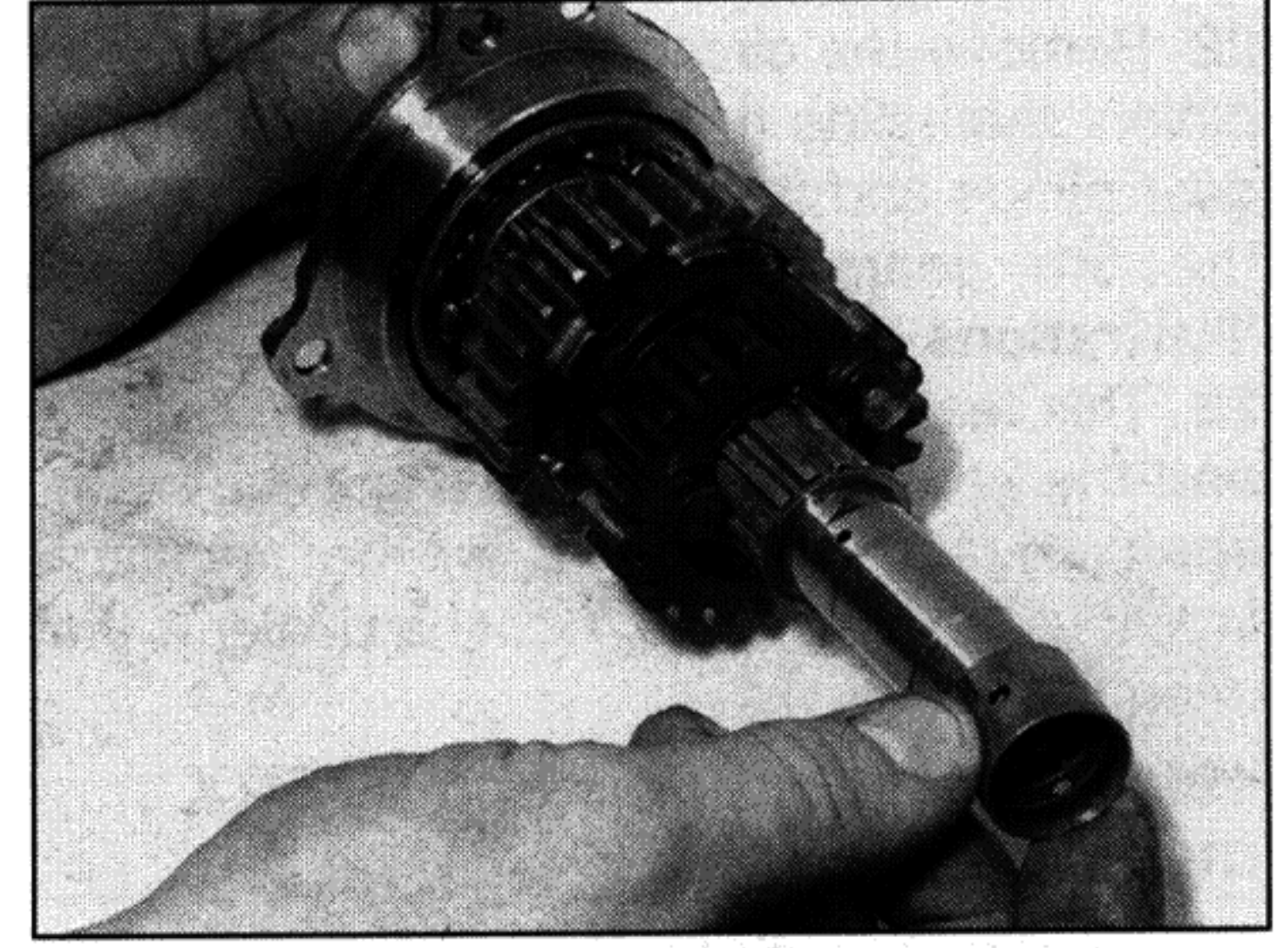
18 Press the 2nd gear pinion onto the left-hand end of the shaft using a press or tubular drift, referring to *Tools and Workshop Tips* (Section 5) in the Reference Section if required (**see illustration**). Set the pinion so that the distance between the outside edge of the 2nd gear pinion and the outside edge of



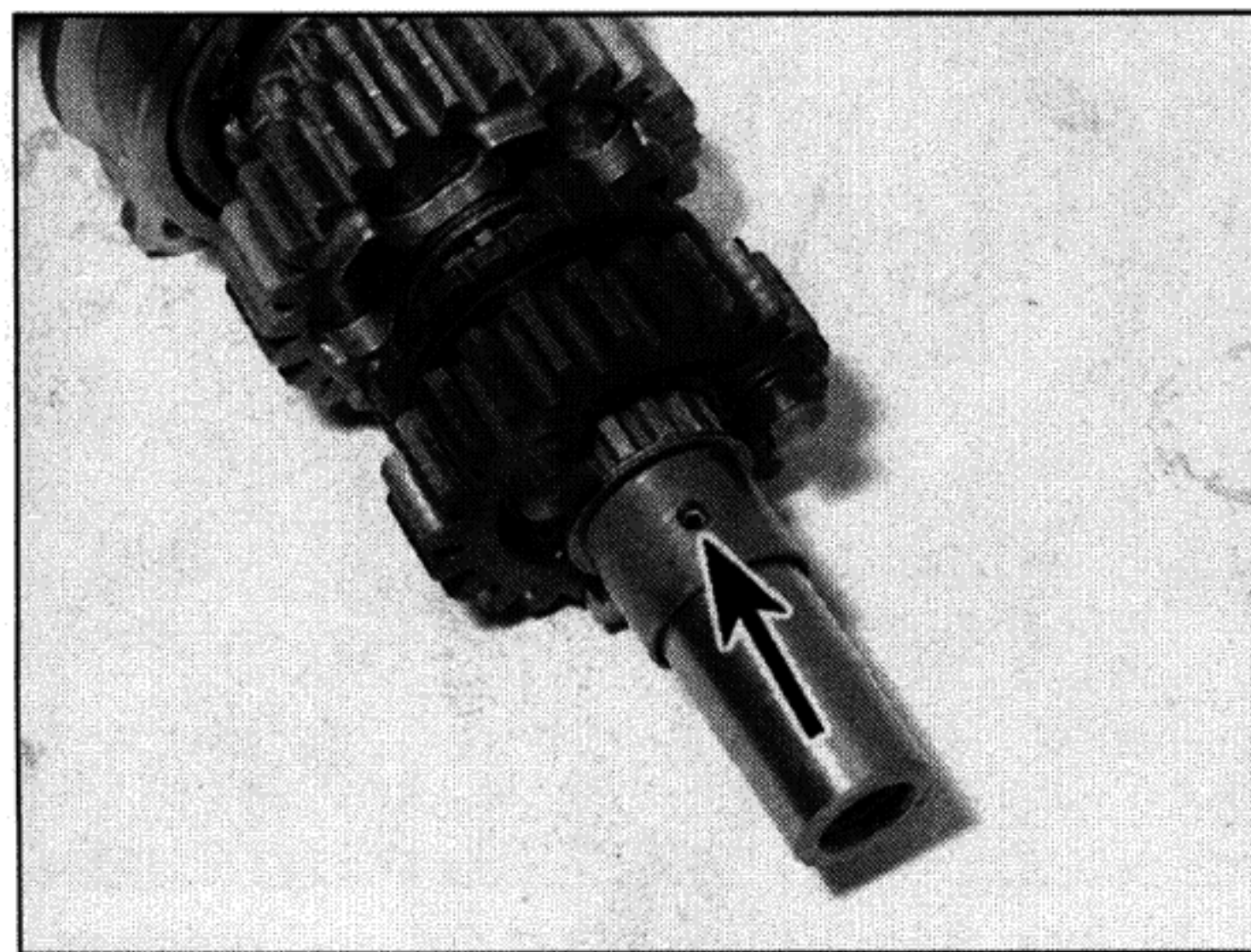
31.16 Slide the 3rd gear pinion onto the shaft, making sure it is the correct way round



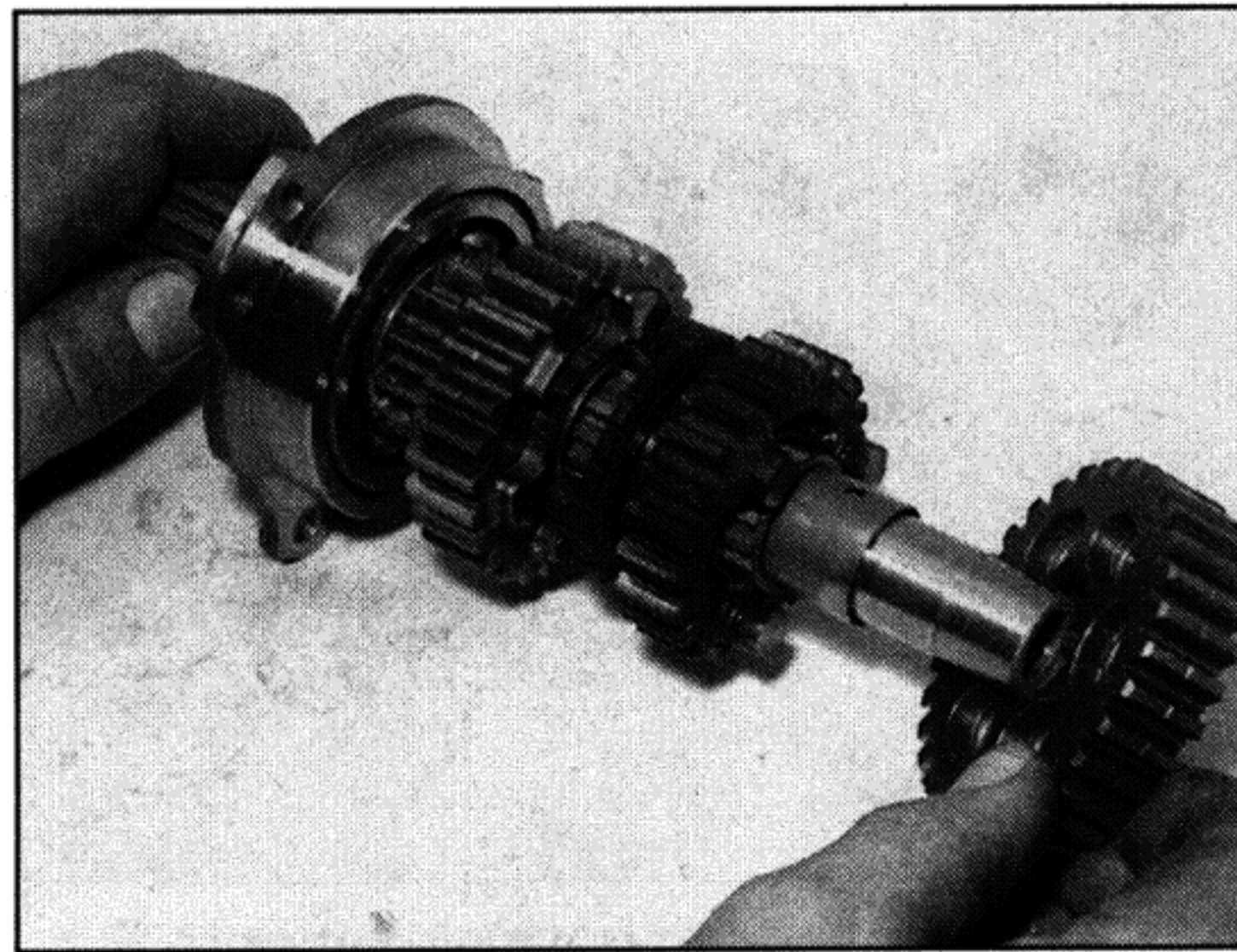
31.17a Slide on the thrust washer . . .



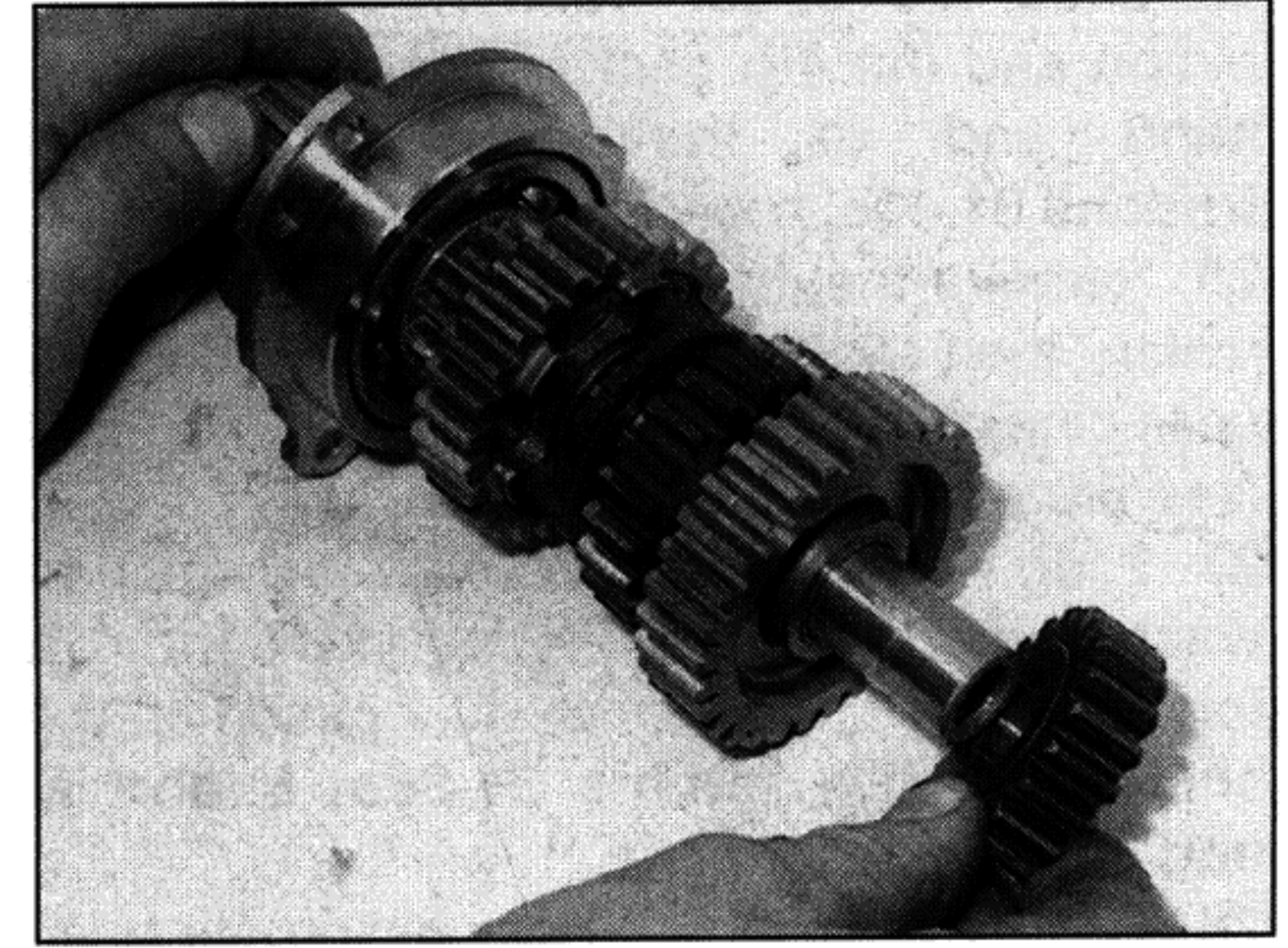
31.17b . . . then fit the bush . . .



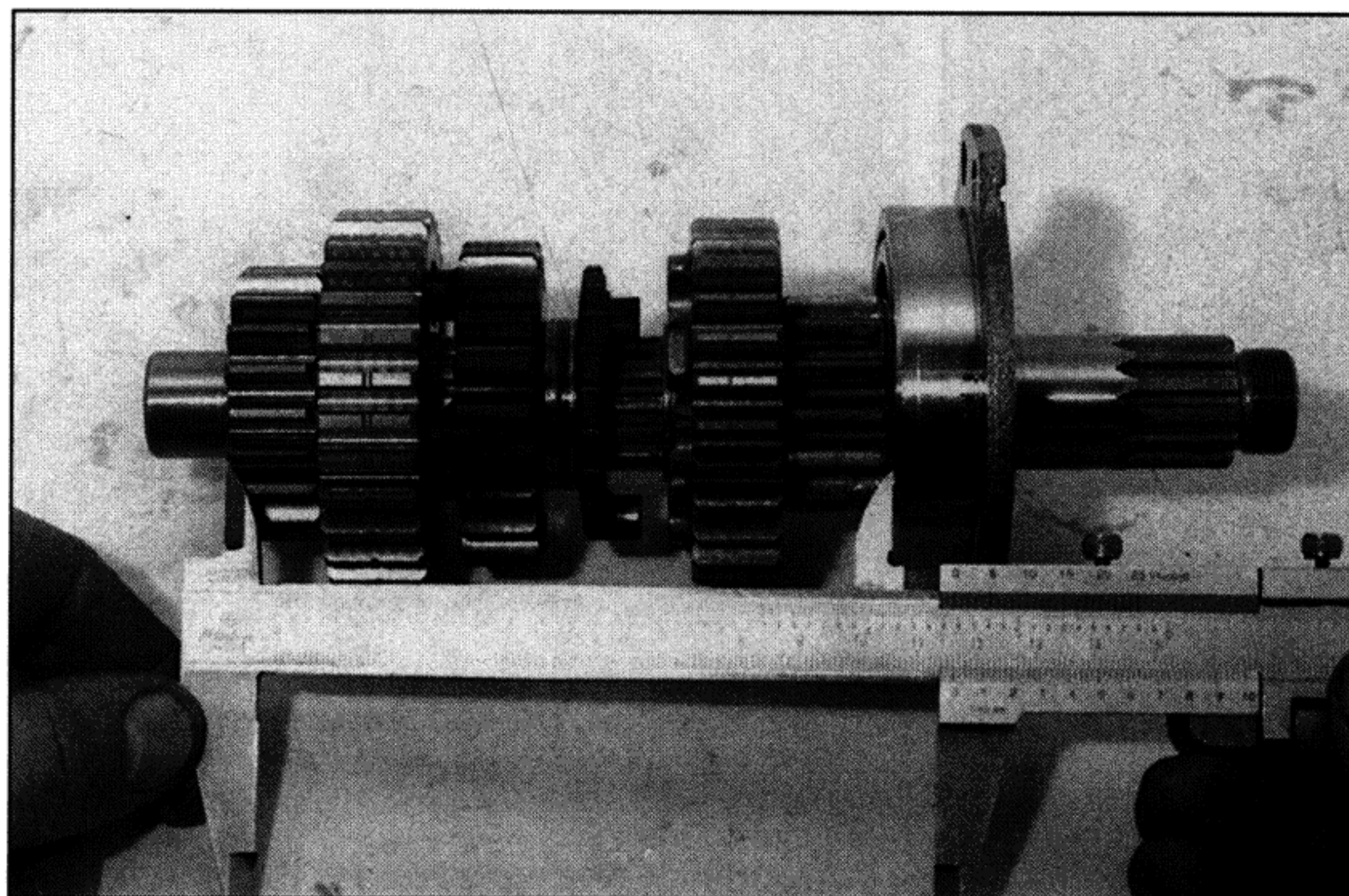
31.17c . . . aligning the oil holes (arrowed)



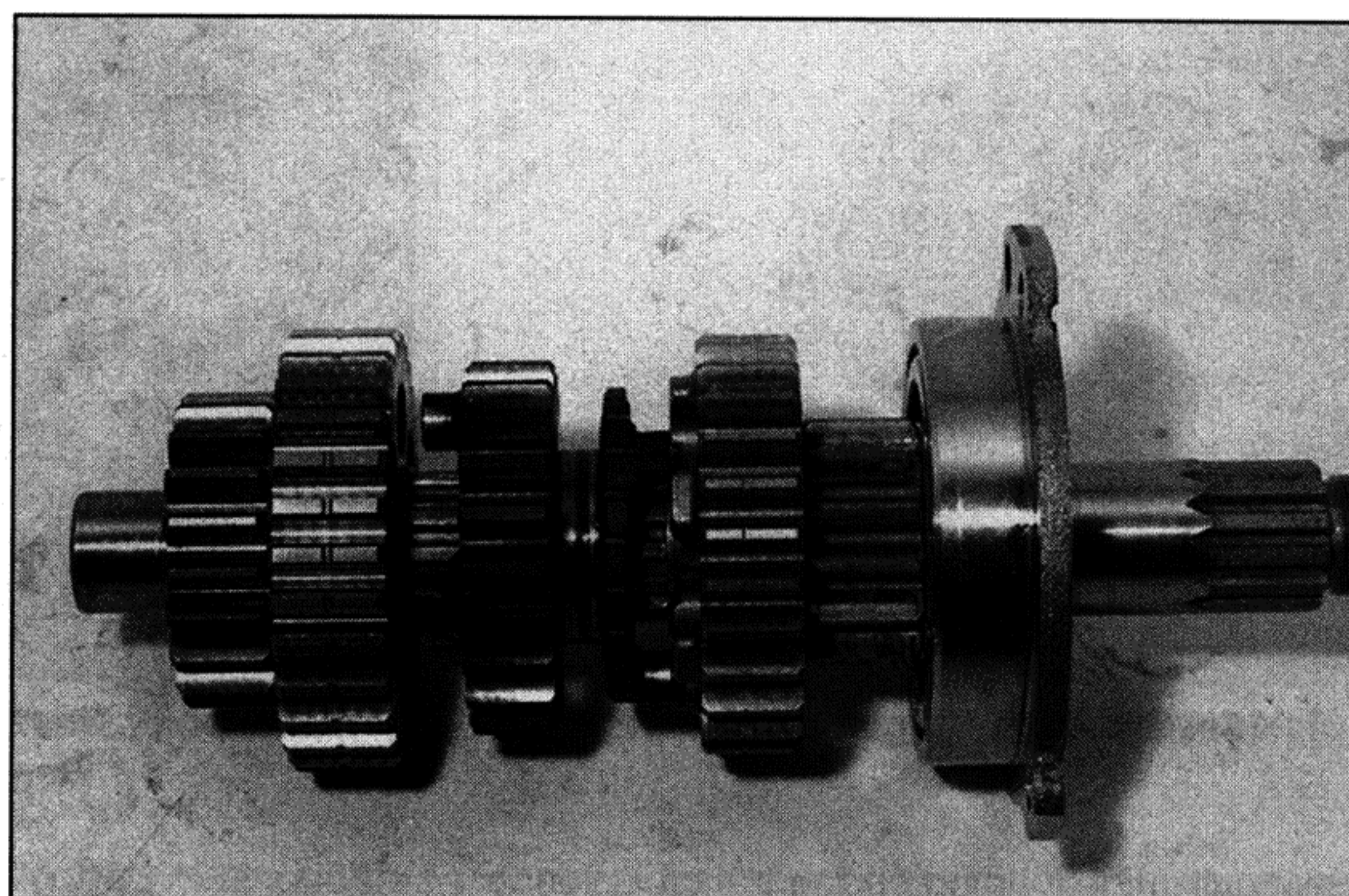
31.17d Install the 5th gear pinion over the bush



31.18a Fit the 2nd gear pinion . . .



31.18b . . . and set the distance as specified



31.19 The assembled input shaft should be as shown

the 1st gear pinion (which is integral with the shaft) is 116.6 mm to 116.8 mm (see illustration).

19 Check that all components have been correctly installed (see illustration).

Output shaft disassembly

1991 to 1994 TDM models and all XTZ models

20 Remove the caged ball bearing from the right-hand end of the shaft (see illustration 31.41).

21 Slide the 1st gear pinion and the 4th gear pinion off the right-hand end of the shaft (see illustrations 34.40b and a).

22 Remove the circlip securing the 3rd gear pinion, then slide the splined washer, the 3rd gear pinion and its splined bush, followed by the 5th gear pinion off the shaft (see illustrations 31.39d, c, b and a, and 31.37).

23 This leaves the 2nd gear pinion, its bush and the bearing on the left-hand end of the shaft; these components are not available individually – refer to a Yamaha dealer if they need renewing.

1995-on TDM models and all TRX models

24 Remove the caged ball bearing from the right-hand end of the shaft (see illustration 31.41).

25 Slide the thrust washer, the 1st gear pinion and the 4th gear pinion off the right-hand end of the shaft (see illustrations 31.40c, b and a).

26 Remove the circlip securing the 3rd gear pinion, then slide the splined washer, the 3rd gear pinion and its splined bush off the shaft (see illustrations 31.39d, c, b and a).

27 Slide the lockwasher and the splined washer off the shaft, noting how they fit together, then slide the 5th gear pinion off the shaft (see illustrations 31.38c, b and a, and 31.37).

28 This leaves the 2nd gear pinion, its bush and the bearing on the left-hand end of the shaft; these components are not available

individually – refer to a Yamaha dealer if they need renewing.

Output shaft inspection

29 Refer to Steps 7 to 13 above.

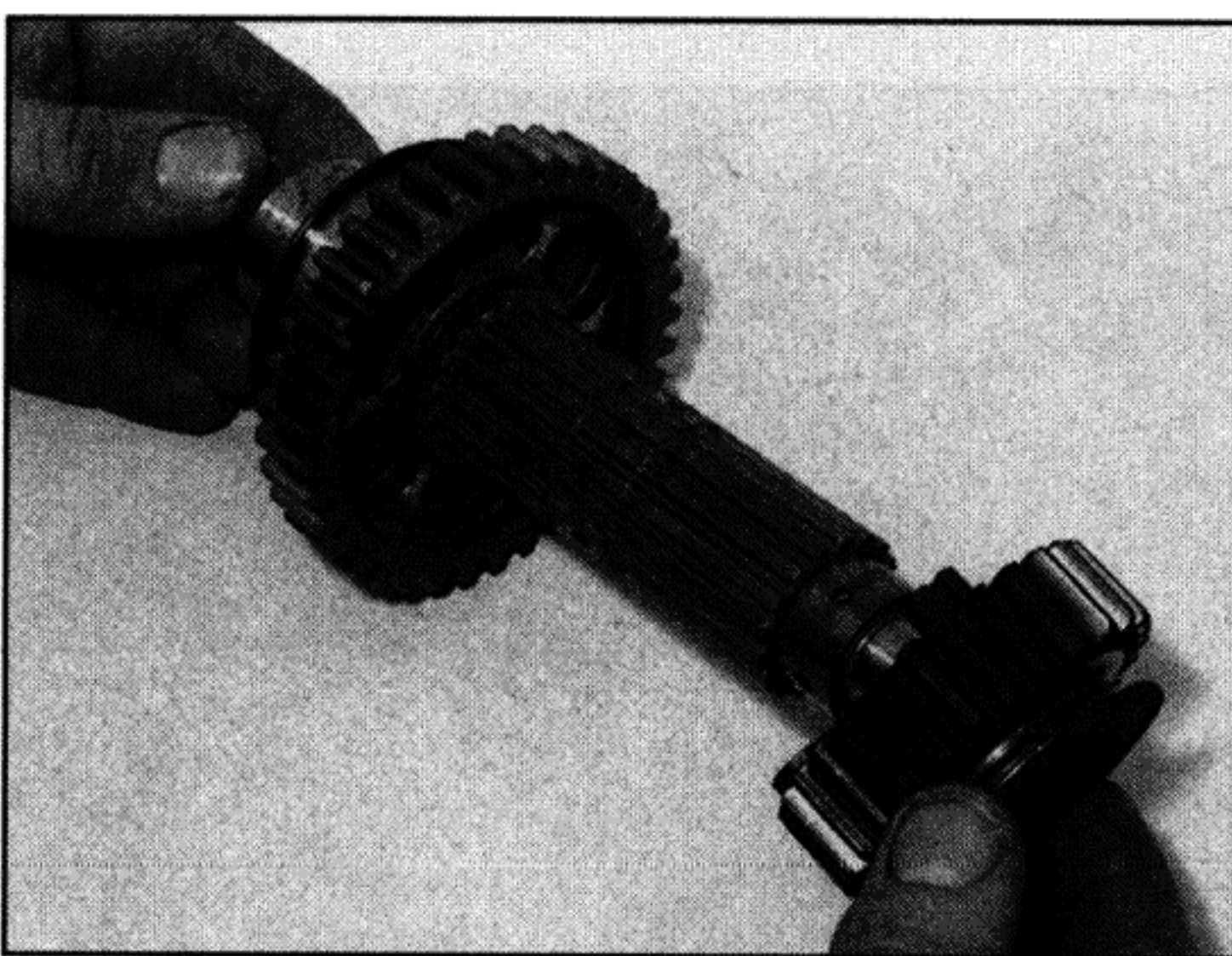
Output shaft reassembly

1991 to 1994 TDM models and XTZ models

30 During reassembly, apply 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 so that their chamfered side faces the pinion it secures and the sharp edged sides faces the direction of thrust load (see 'correct fitting of a stamped circlip illustration' in *Tools and Workshop Tips* in the Reference section).

31 Slide the 5th gear pinion onto the right-hand end of the shaft, with its dogs facing the 2nd gear pinion (integral with the shaft) (see illustration 31.37).

32 Slide the 3rd gear pinion splined bush onto the shaft, followed by the 3rd gear pinion, and the splined washer, and secure them with the circlip, making sure it locates correctly in its groove in the shaft (see illustrations 31.39a, b, c and d).



31.37 Slide the 5th gear pinion onto the shaft, making sure it is the correct way round

33 Slide the 4th gear pinion onto the shaft, with its selector fork groove facing the 3rd gear pinion, followed by the 1st gear pinion (see illustrations 31.40a and b).

34 Fit the caged ball bearing onto the right-hand end of the shaft (see illustration 31.41).

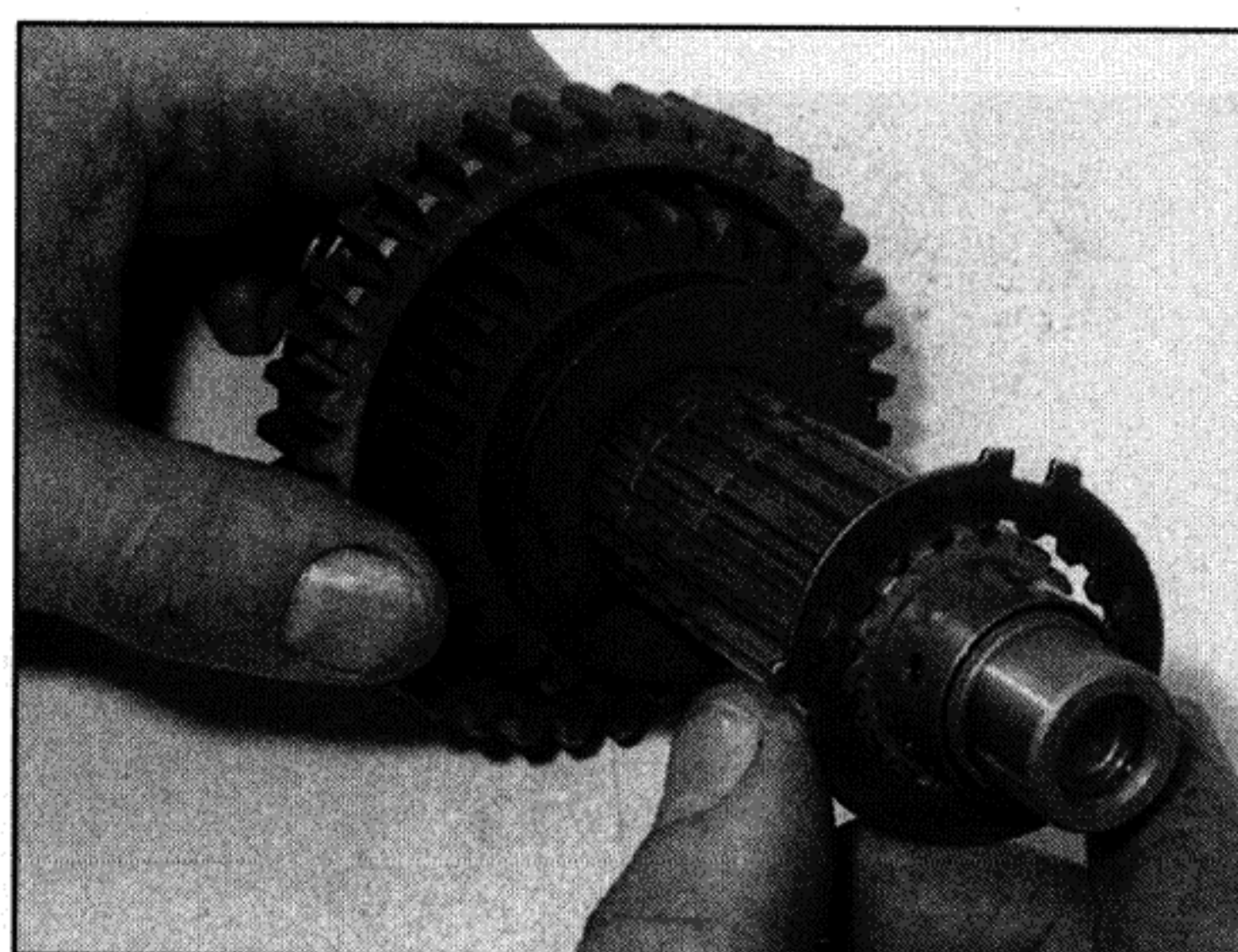
35 Check that all components have been correctly installed.

1995-on TDM models and TRX models

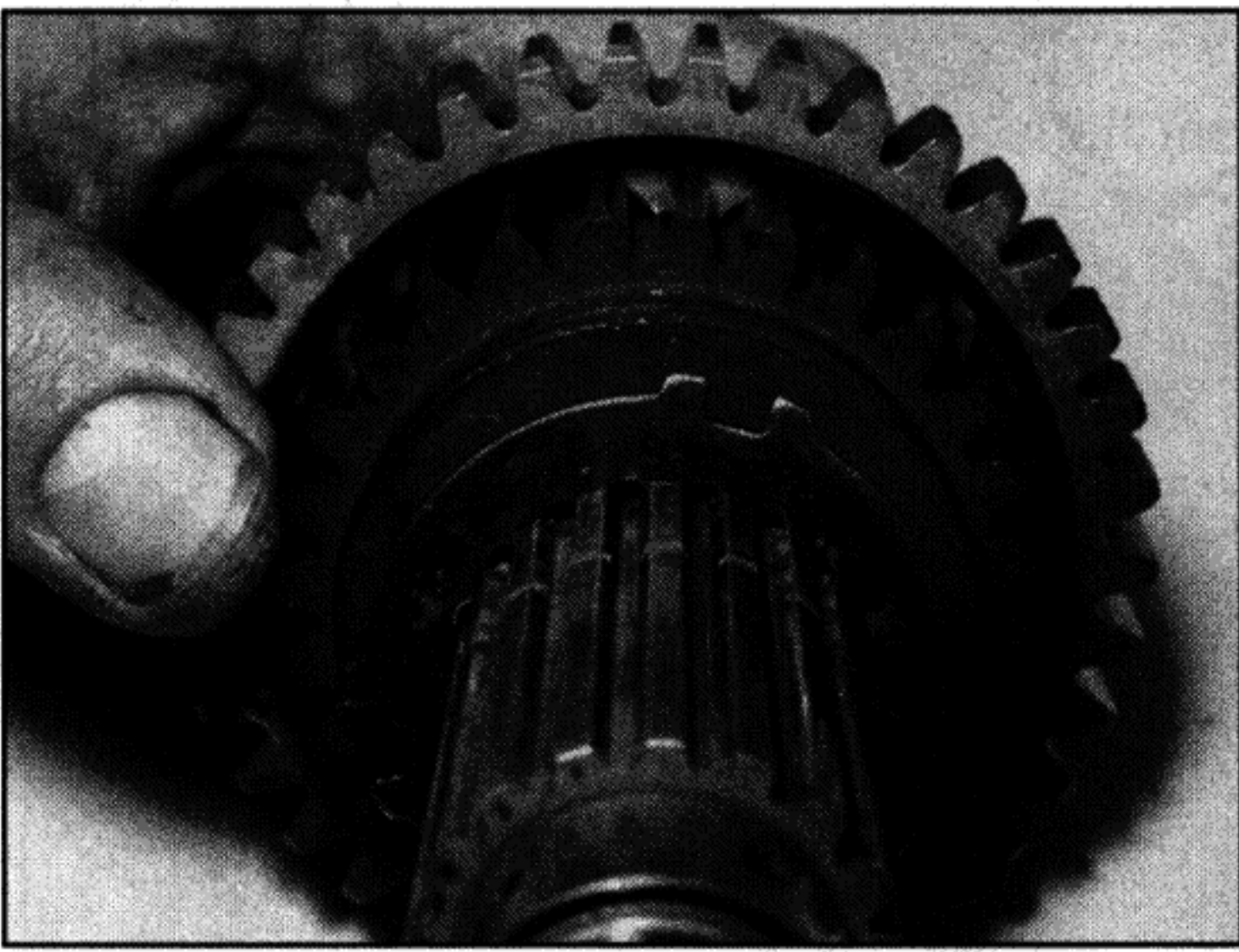
36 During reassembly, apply engine oil to the mating surfaces of the shaft, pinions and bushes. When installing the circlips, do not expand their ends any further than is necessary. Install the stamped circlips so that their chamfered side faces the pinion it secures and the sharp edged sides faces the direction of thrust load (see 'correct fitting of a stamped circlip illustration' in *Tools and Workshop Tips* in the Reference section).

37 Slide the 5th gear pinion onto the right-hand end of the shaft, with its dogs facing the 2nd gear pinion (integral with the shaft) (see illustration).

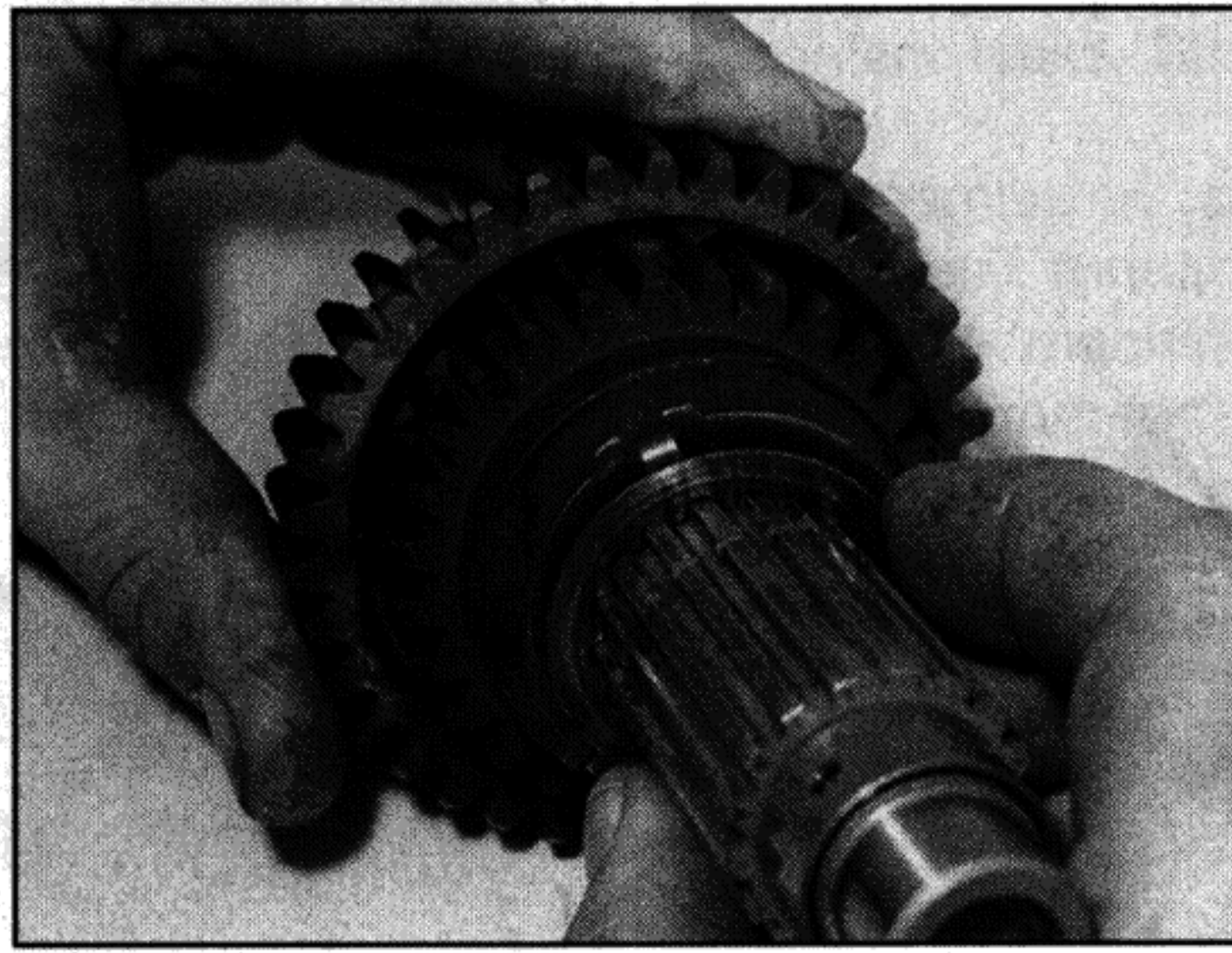
38 Slide the slotted splined washer onto the shaft and locate it in its groove, then turn it in the groove so that the splines on the washer locate between the splines of the shaft and secure the washer in the groove (see illustrations). Slide the lockwasher onto the



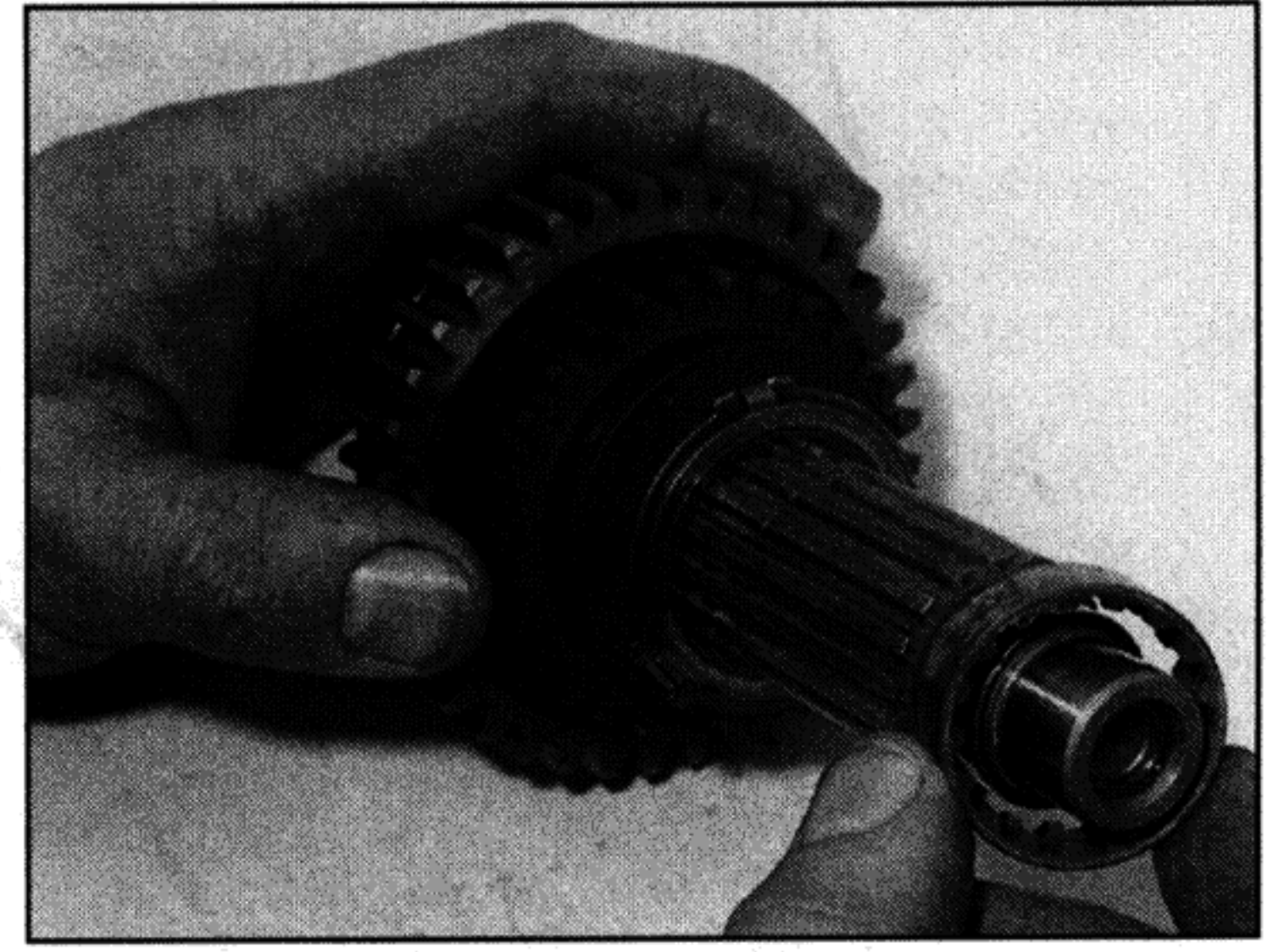
31.38a Slide the slotted splined washer on . . .



31.38b ... and align it as shown ...



31.38c ... then slide the lockwasher on, fitting the tabs into the slots



31.39a Slide on the splined bush ...

shaft, so that the tabs on the lockwasher face the left-hand end of the shaft and locate into the slots in the outer rim of the splined washer (see illustration).

39 Slide the 3rd gear pinion splined bush onto the shaft, followed by the 3rd gear pinion, and the splined washer, and secure them with the circlip, making sure it locates correctly in its groove in the shaft (see illustrations).

40 Slide the 4th gear pinion onto the shaft, with its selector fork groove facing the 3rd gear pinion, followed by the 1st gear pinion, and the thrust washer (see illustrations).

41 Fit the caged ball bearing onto the right-hand end of the shaft (see illustration).

42 Check that all components have been correctly installed.

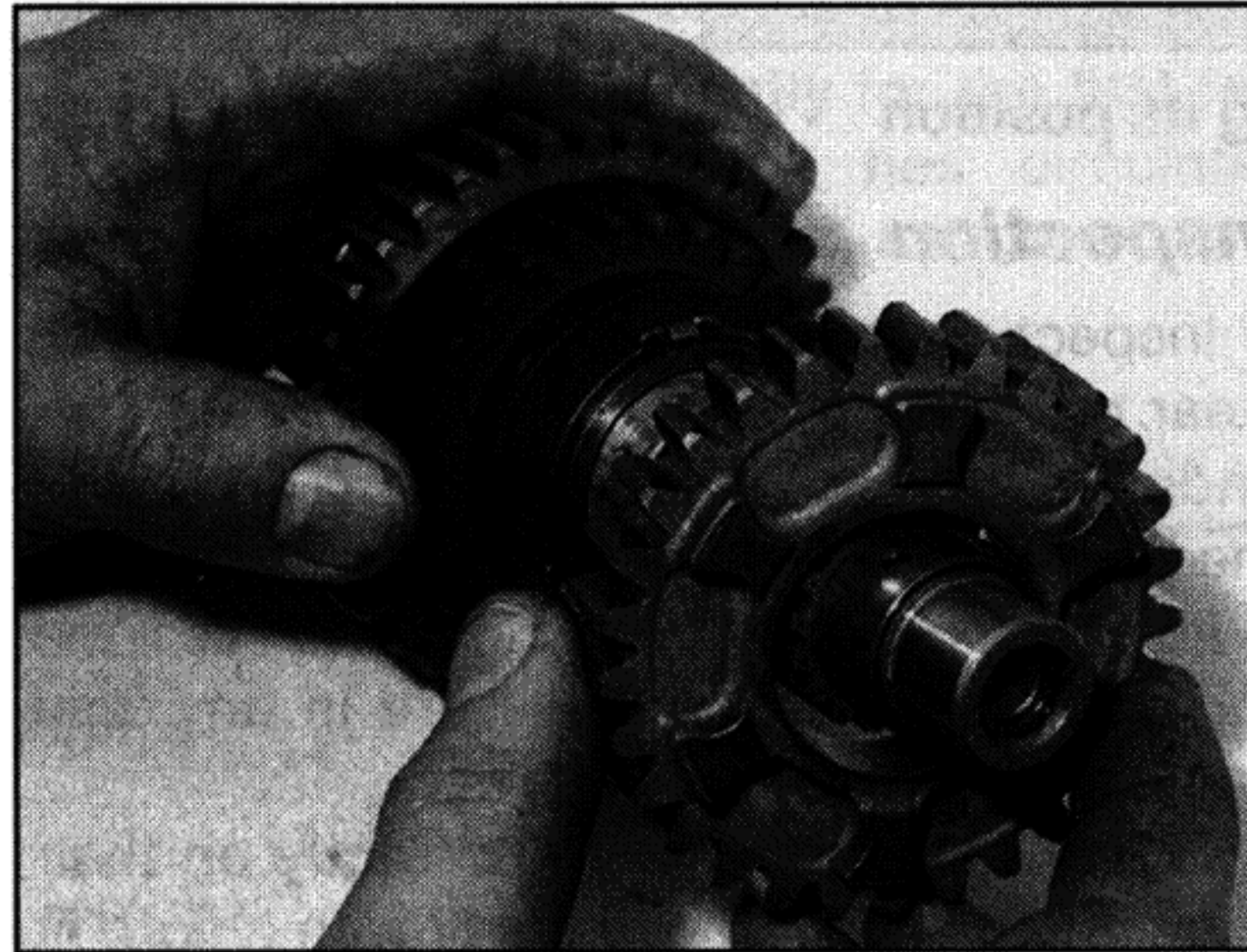
32 Selector drum and forks – removal, inspection and installation



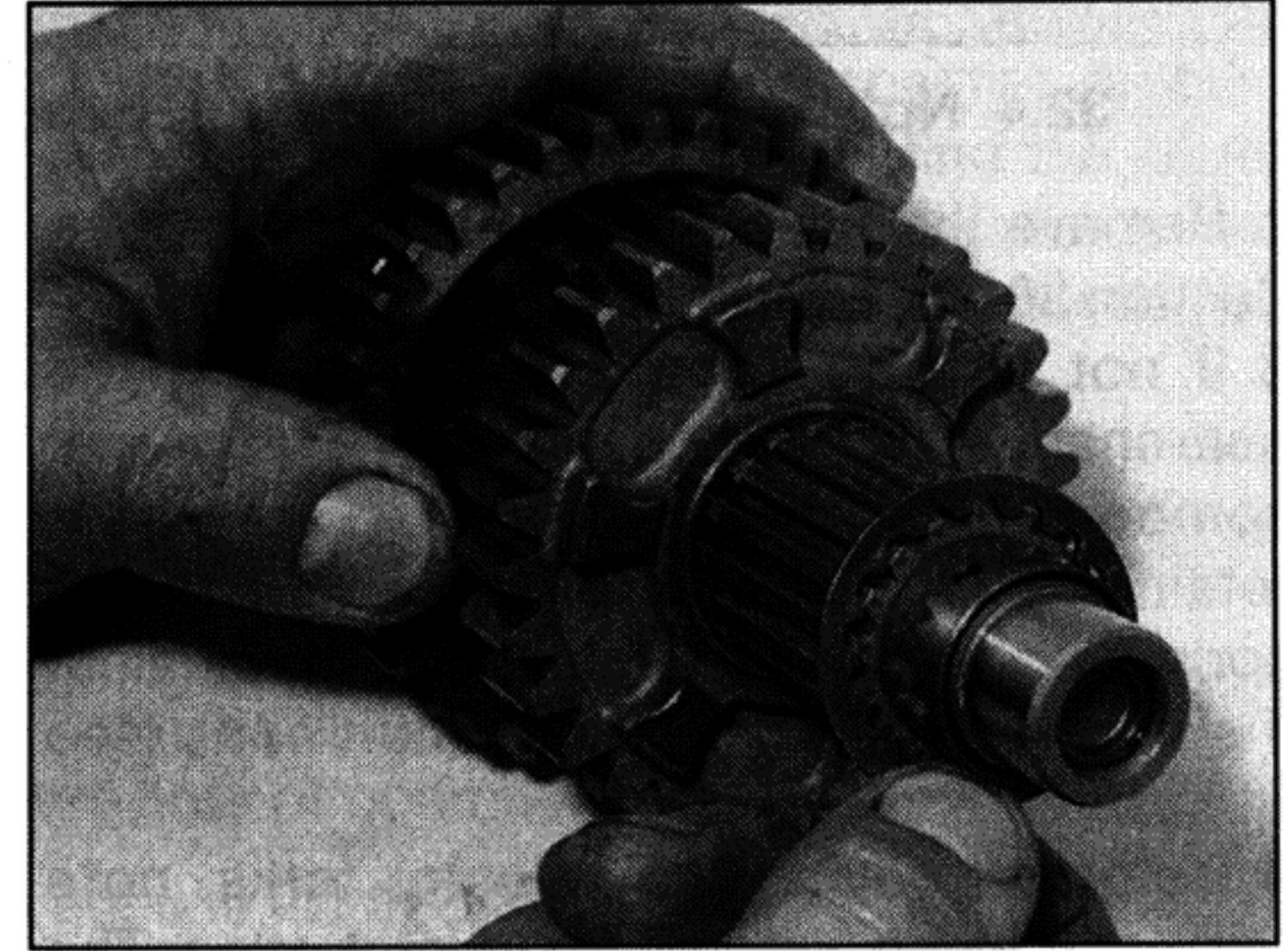
Note: To remove the selector drum and forks the engine must be removed from the frame and the crankcase halves separated.

Removal

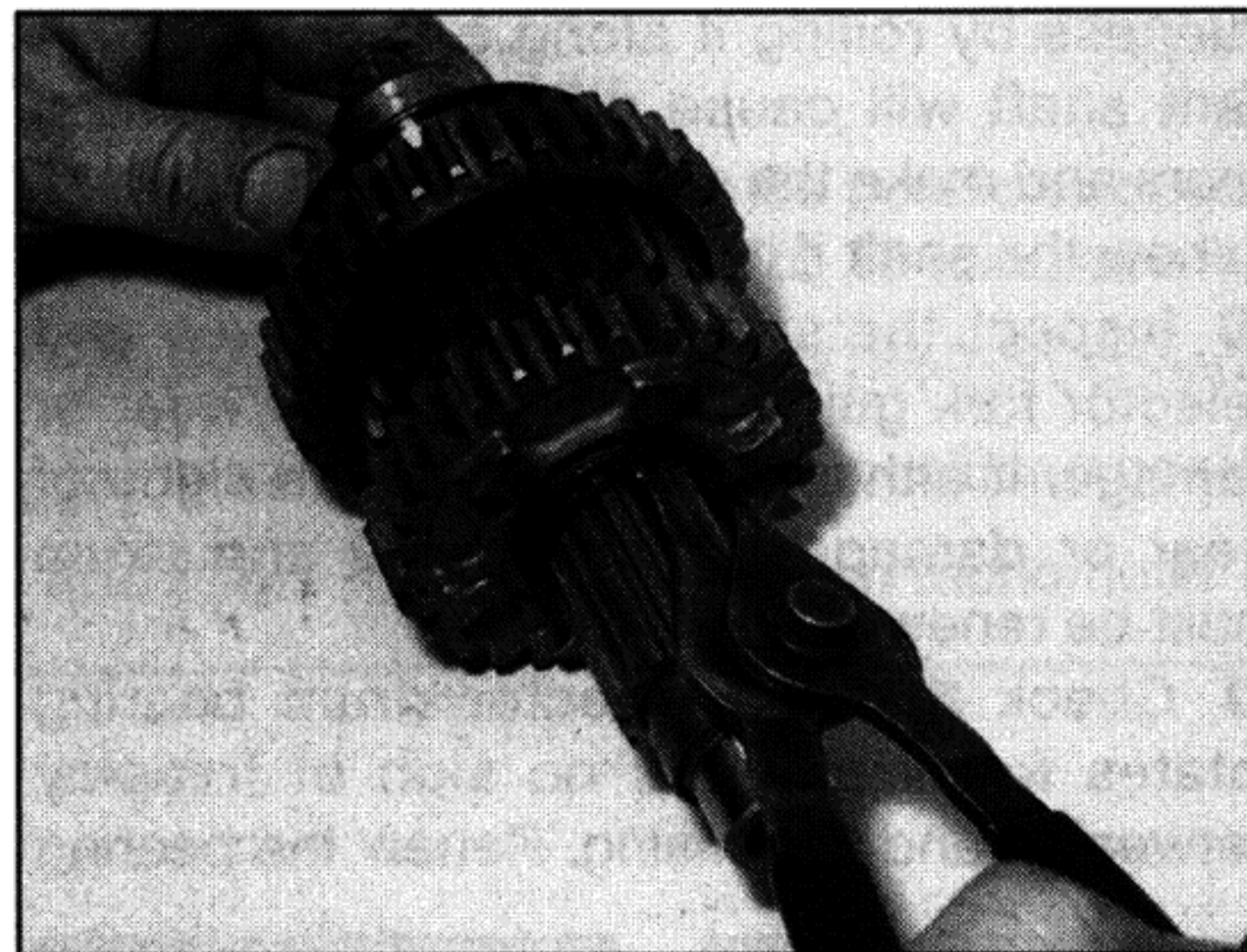
1 Remove the engine (see Section 5) and separate the crankcase halves (see Section 25). The selector drum and forks are located in the upper crankcase half.



31.39b ... the 3rd gear pinion ...



31.39c ... and the splined washer ...



31.39d ... and secure them with the circlip



31.40a Slide on the 4th gear pinion, making sure it is the correct way round ...



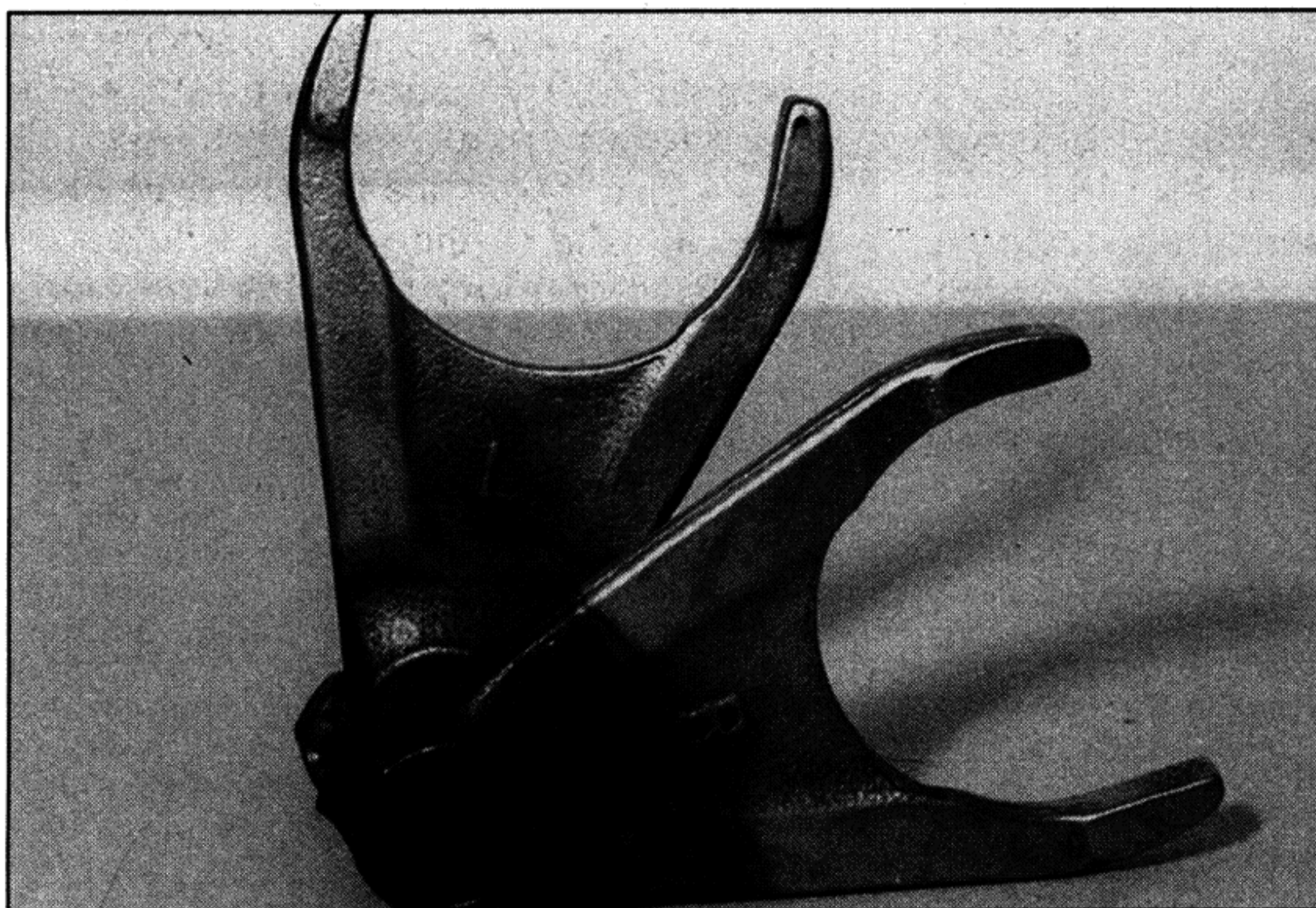
31.40b ... followed by the 1st gear pinion ...



31.40c ... the thrust washer ...



31.41 ... and the bearing



32.4 Note the letter on each fork denoting its position

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

3 If not already done when removing the gearchange mechanism (external components), remove the selector drum retainer plate and the stopper arm return spring, noting how the plate locates against the flats on the selector fork shaft ends (see Section 19).

4 Before removing the selector forks, note that each fork is lettered for identification. The right-hand fork has an 'R', the centre fork a 'C', and the left-hand fork an 'L' (see illustration). These letters face the right-hand side of the engine. If no letters are visible, mark them yourself using a felt pen.

5 Support the selector forks and withdraw the shafts from the casing, then remove the forks (see illustrations 32.13b and a). Once removed from the case, slide the forks back onto their shafts in their correct order and way round. On 1991 to 1995 TDM models and XTZ models, note the spring fitted on the outside of the left-hand fork.

6 Withdraw the selector drum from the right-hand side of the casing (see illustration 32.12).

Inspection

7 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. 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 renewed.

8 Check that the forks fit correctly on their shaft. 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.

9 The selector fork shaft can be checked for trueness by rolling it along a flat surface. A bent shaft will cause difficulty in selecting gears and make the gearchange action heavy. Renew the shaft if it is bent.

10 Inspect the selector drum grooves and selector fork guide pins for signs of wear or damage. If either component shows signs of wear or damage the selector(s) and drum must be renewed.

11 Check that the selector drum bearing rotates freely and has no sign of freeplay between it and the casing. Renew the bearing

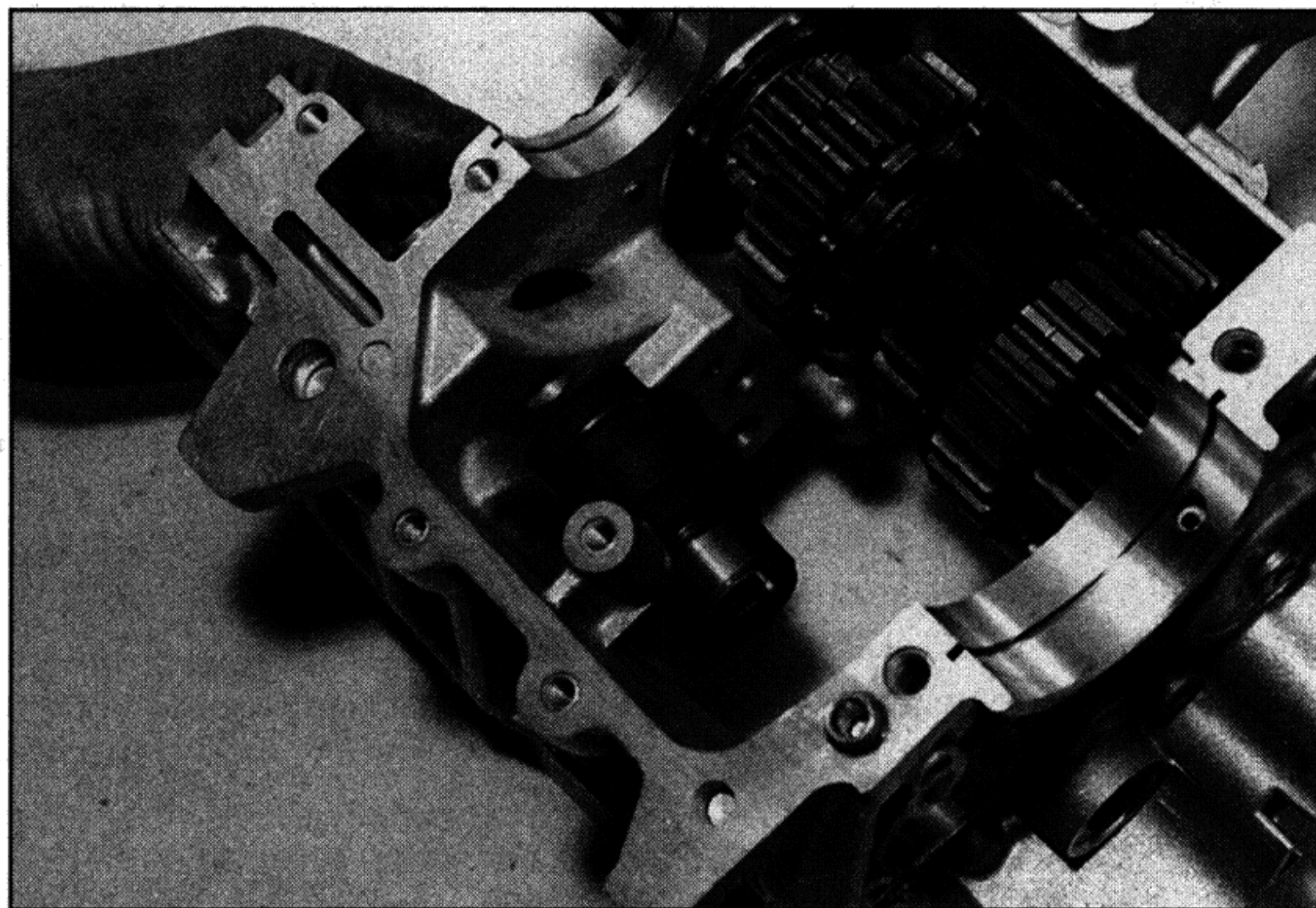
if necessary (see *Tools and Workshop Tips* (Section 5) in the Reference Section). Also check that the neutral switch contact plunger in the other end of the drum is free to move in and out under spring pressure. If required, remove the screw securing the contact plate and remove the plunger and spring for inspection or renewal (see Chapter 9).

Installation

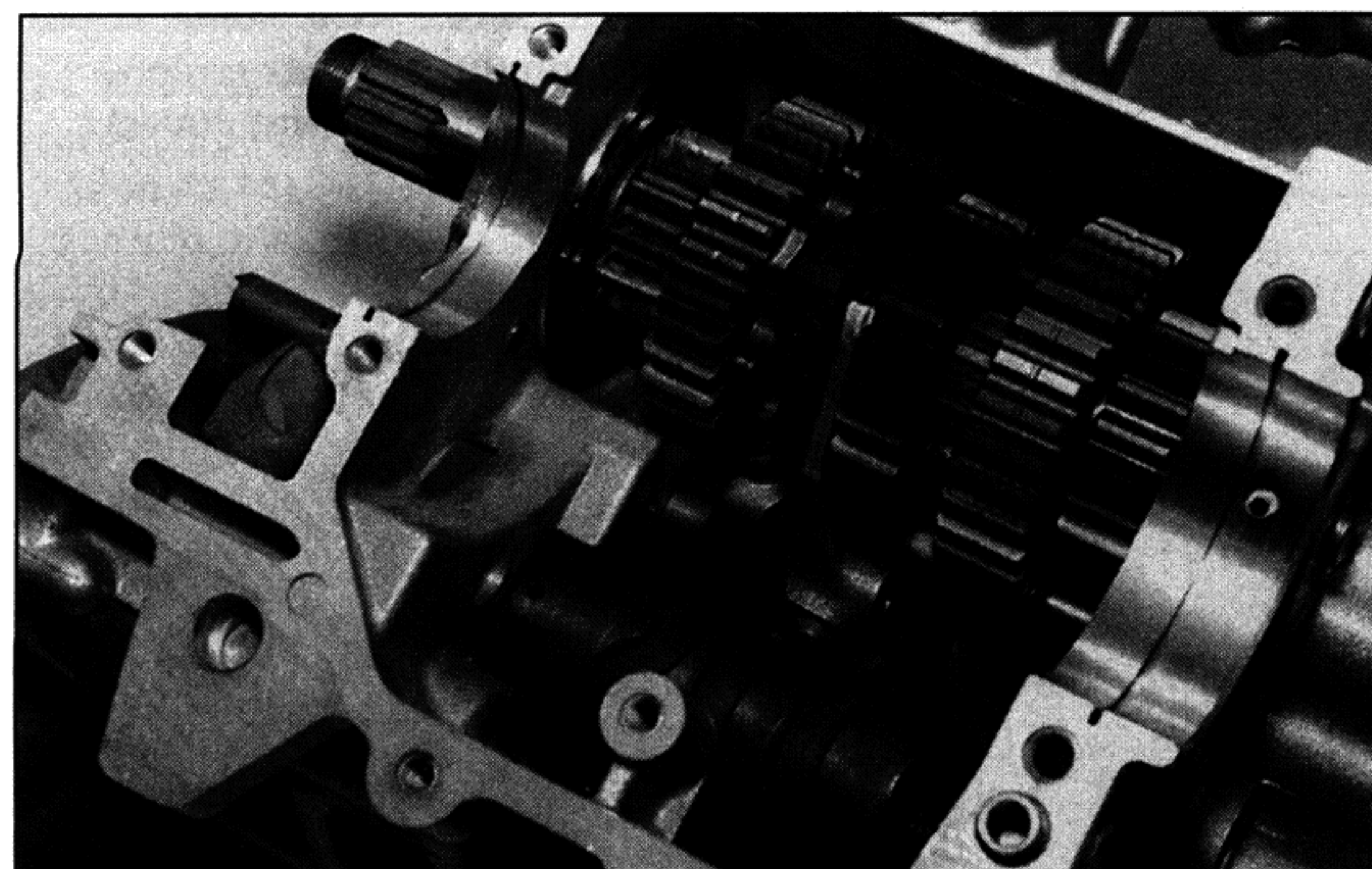
12 Slide the selector drum into position in the crankcase and position it so that the neutral contact is against the neutral switch (see illustration).

13 Refer to Step 4 for the correct location of each fork (see illustration 32.4). Lubricate the selector fork shafts with clean engine oil and slide them into the crankcase, with the cut end of the upper (single fork) shaft facing the right-hand side, and the spring (where fitted) in the lower shaft end facing the left-hand side. Slide each shaft through its fork(s) and into its bore, locating the guide pin on the end of each fork into its groove in the drum as you do (see illustrations).

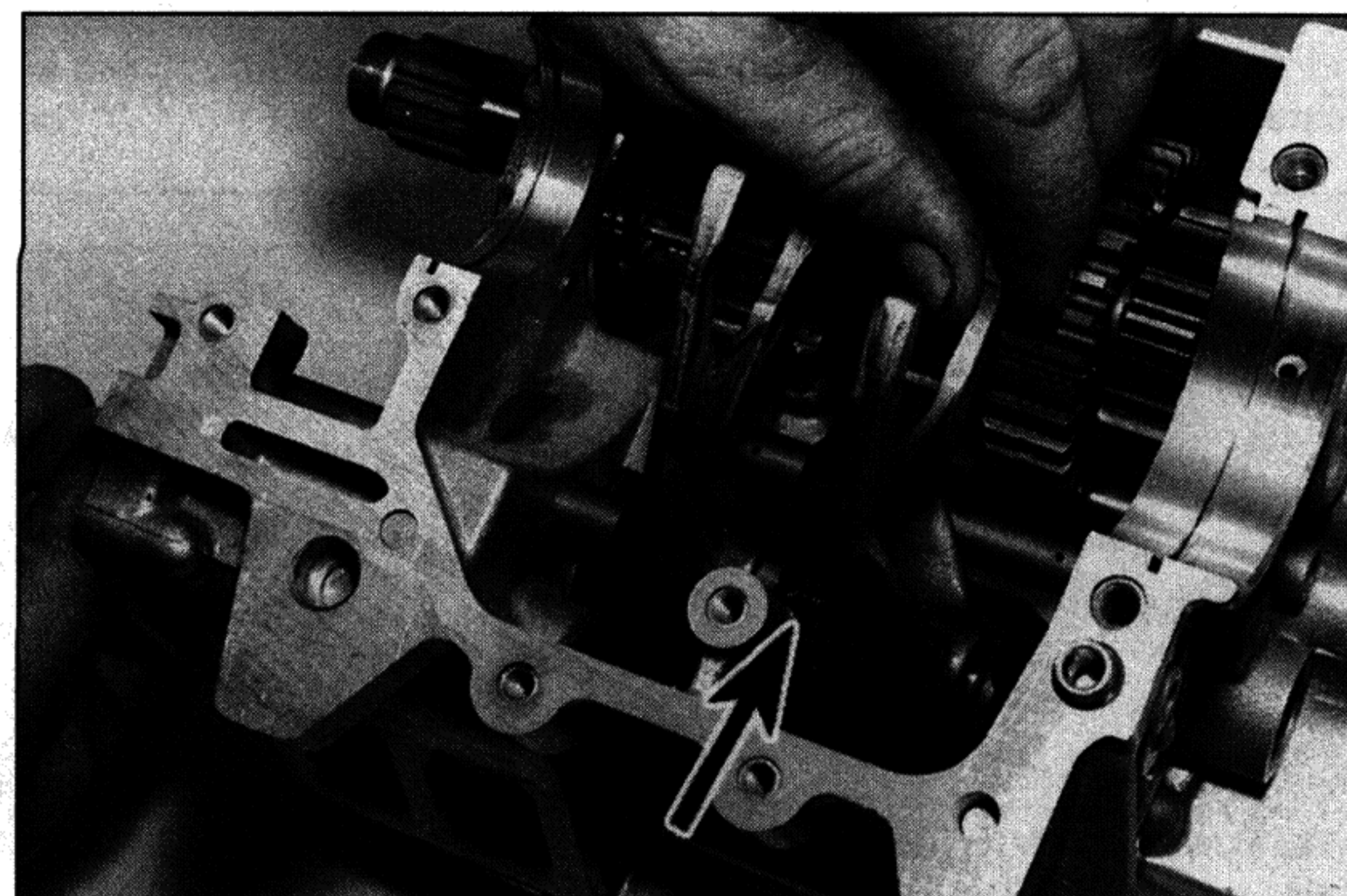
14 Locate the stopper arm spring, then install the selector drum retainer plate, making sure



32.12 Slide the drum into the casing



32.13a Fit the centre fork (C) into the groove in the input shaft pinion and locate the guide pin in its groove in the drum, then slide in the shaft



32.13b Slide the shaft into the casing and through each fork in turn – note the spring (arrowed)

it locates correctly against the flat in the end of the fork shaft (see Section 19).
15 Install the transmission output shaft (see Section 30, Step 11).
16 Reassemble the crankcase halves (see Section 25).

33 Initial start-up after overhaul

- 1** Make sure the engine oil level and coolant level are correct (see *Daily (pre-ride) checks*).
- 2** Make sure there is fuel in the tank, then turn the fuel tap to the ON or RES position as required, and set the choke on.
- 3** As there isn't an oil pressure warning light fitted, an oil pressure check must be carried out. Follow the procedure in Chapter 1, Section 32.
- 4** If the oil pressure test is satisfactory, allow the engine to run at a moderately fast idle until

it reaches operating temperature and check that there are no oil and coolant leaks. Stop the engine.
5 Check carefully that 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 rebored or a new crankshaft has been installed. In the case of a rebore, the bike will have to be run in as when new. This means greater use of the transmission and a restraining hand on the throttle until at least 600 miles (1000 km) have been covered. There's no point in keeping to any set speed limit – the main idea is to keep from labouring the engine and to gradually increase performance up to the 600 mile (1000 km) mark. These recommendations can be lessened to an extent when only a new crankshaft is installed. Experience is the best guide, since it's easy to tell when an engine is running freely. The accompanying table indicates 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.

1991 to 1995 TDM models and all XTZ models		
Up to 100 miles (150 km)	4000 rpm max	Vary throttle position/speed. Do not use full throttle. Stop the engine and let it cool for 5 to 10 minutes after every hour of operation.
100 to 300 miles (150 to 500 km)	5000 rpm max	Vary throttle position/speed. Do not use full throttle
300 to 600 miles (500 to 1000 km)	6000 rpm max	Vary throttle position/speed. Use full throttle for short bursts
Over 600 miles (1000 km)	8000 rpm max	Do not exceed tachometer red line
1996-on TDM models and all TRX models		
Up to 100 miles (150 km)	5000 rpm max	Vary throttle position/speed. Do not use full throttle. Stop the engine and let it cool for 5 to 10 minutes after every hour of operation.
100 to 300 miles (150 to 500 km)	6000 rpm max	Vary throttle position/speed. Do not use full throttle
300 to 600 miles (500 to 1000 km)	7000 rpm max	Vary throttle position/speed. Use full throttle for short bursts
Over 600 miles (1000 km)	8000 rpm max	Do not exceed tachometer red line