

# VOLVO

## Service Manual

### Reconditioning

Section 2 (21)

B 28 Engine

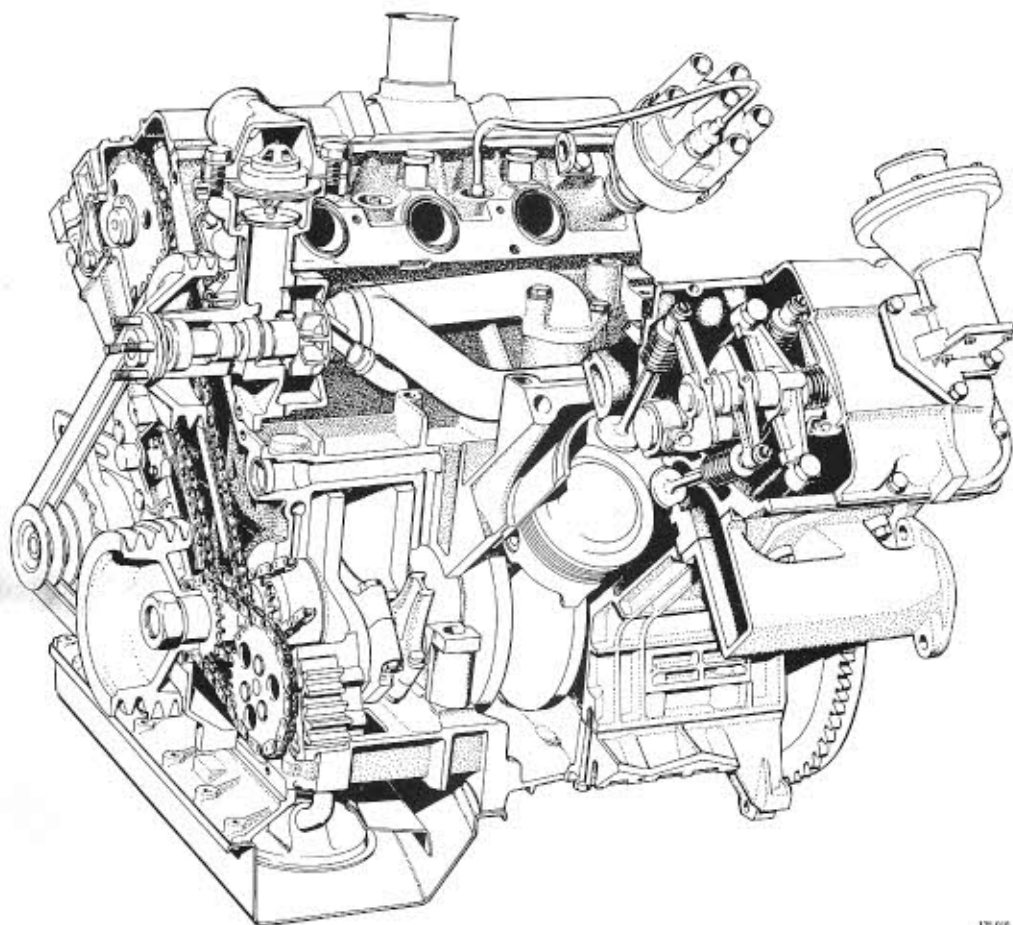
760 GLE  
1982-19 ..

230-27-9192

C. EVANS



## B 28 A – B 28 E – B 28 F



12-08

### What do these designations mean?

**B 28 E**  
↓  
A = carburetted engine  
E = fuel injected engine  
F = fuel injected engine "USA models"  
↓  
28 = displacement  
↓  
B = petrol (gasoline)

This manual covers the following engine types:

| Engine type | Model year |
|-------------|------------|
| B 28 A      | 1982–      |
| B 28 E      | 1982–      |
| B 28 F      | 1983–      |

Volvos are sold in versions adapted for different markets. These adaptations depend on many factors including legal, taxation and market requirements.

This manual may therefore show illustrations and text which do not apply to cars in your country.

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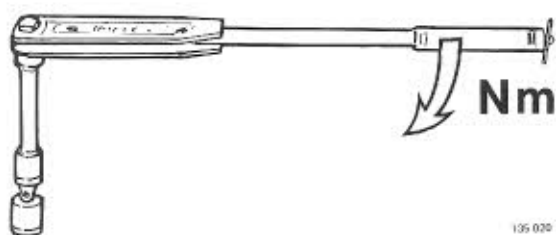
**Index page 58**

This manual deals exclusively with the overhaul of the engine.  
For work carried out on an engine installed in the car, and for engine removal and installation, please refer to the appropriate manual in section 2.

**Order number: TP 30703/1**

We reserve the right to make alterations without prior notification.

## Important information



135 020

### Tightening torques

Nearly all of the B 28 engine is made of aluminium alloy. The threads are tapped directly into the alloy. For this reason it is extremely important that all of the bolts are tightened to specified torque.

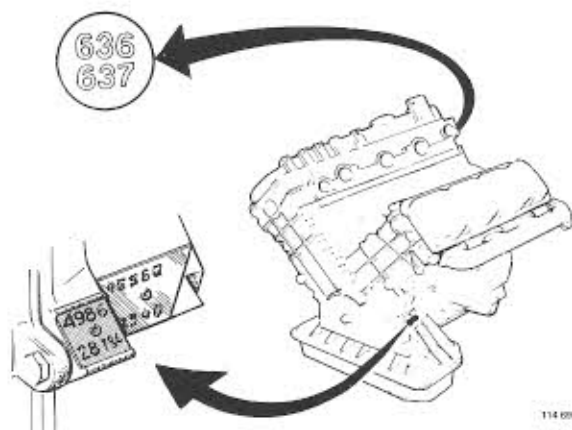
Two types of tightening torques are used in this manual:

- I. Tightening torque **40 Nm** (30 ft.lbs) = a torque wrench must be used.
- II. Tightening torque **40 Nm** (30ft.lbs) = correct value, however it is not necessary to use a torque wrench.

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## Specifications

### Group 20 General



114 020

### Engine serial number and part number

Located on a plate in front of the oil filter.

B 28 E/F models: An additional decal at the rear of the right-hand cylinder head, shows the last three digits of the part number.

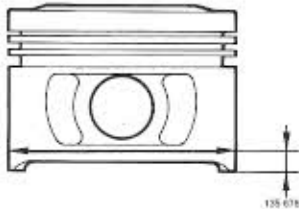


Specifications

**PISTONS**

Pistons and liners are matched sets.

|  |                                     |
|--|-------------------------------------|
| Weight .....   | 455±3 grams (16.25±0.1 oz)          |
| Max weight difference between pistons in same engine ..... | 6 grams (0.2 oz)                    |
| Height, overall A- and F-engines .....                     | 62.8 mm (2.4724 in)                 |
| E-engine .....   | 65.3 mm (2.5709 in)                 |
| from gudgeon pin centre to piston crown                    |                                     |
| A- and F-engines .....                                     | 38.8 mm (1.5276 in)                 |
| E-engine .....   | 41.3 mm (1.6260 in)                 |
| Piston float .....   | 0.020–0.040 mm (0.0007–0.0015 in)   |
| Piston diameter, A-marked pistons .....                    | 90.970–90.980 mm (3.5814–3.5818 in) |
| B-marked pistons .....                                     | 90.980–90.990 mm (3.5818–3.5822 in) |
| C-marked pistons .....                                     | 90.990–91.000 mm (3.5822–3.5826 in) |

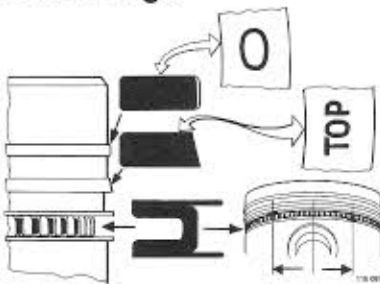


Piston diameter is measured at right-angles to gudgeon pin bore, **8 mm (0.31 in)** from bottom edge.

Diameter, gudgeon pin bore:

| Marking, piston | Marking, gudgeon pin |                                     |
|-----------------|----------------------|-------------------------------------|
| Blue            | Blue                 | 23.510–23.513 mm (0.9255–0.9257 in) |
| White           | White                | 23.507–23.510 mm (0.9254–0.9255 in) |
| Red             | Red                  | 23.504–23.507 mm (0.9253–0.9254 in) |

**Piston rings**



Ring gap measured 15 mm (0.6 in) from lower edge of cylinder.

|   | Upper compression ring | Lower compression ring | Oil ring         |
|---|------------------------|------------------------|------------------|
| Height .....  | mm 1.478–1.490         | mm 1.978–1.990         | mm 2.629–2.731   |
|   | in 9.0582–0.0587       | in 0.0779–0.0783       | in 0.1035–0.1075 |
| Side clearance (measured with ring on piston) .....                       | mm 0.045–0.074         | mm 0.025–0.054         | mm 0.009–0.233   |
|   | in 0.0017–0.0029       | in 0.0009–0.0212       | in 0.0003–0.0091 |
| Ring gap when checked in 91 mm (3.5826 in) cylinder (B 28), see fig. .... | mm 0.40–0.60           | mm 0.40–0.60           | mm 0.38–1.45     |
|   | in 0.0157–0.0236       | in 0.0157–0.0236       | in 0.0150–0.0570 |

**Gudgeon (piston) pins**

Diameter

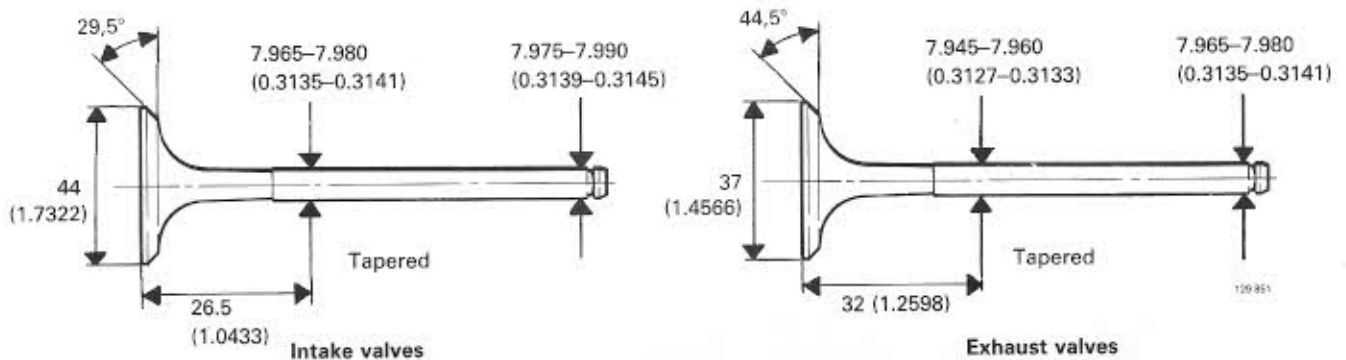
| Marking, gudgeon pin              | Marking, piston |                                     |
|-----------------------------------|-----------------|-------------------------------------|
| Blue                              | Blue (1)        | 23.500–23.497 mm (0.9251–0.9250 in) |
| White                             | White (2)       | 23.497–23.494 mm (0.9250–0.9249 in) |
| Red                               | Red (3)         | 23.494–23.491 mm (0.9249–0.9248 in) |
| Clearance in connecting rod ..... |                 | 0.020–0.041 mm (0.0007–0.0016 in)   |
| Clearance in piston .....         |                 | 0.014–0.020 mm (0.0006–0.0008 in)   |

## VALVE SYSTEM

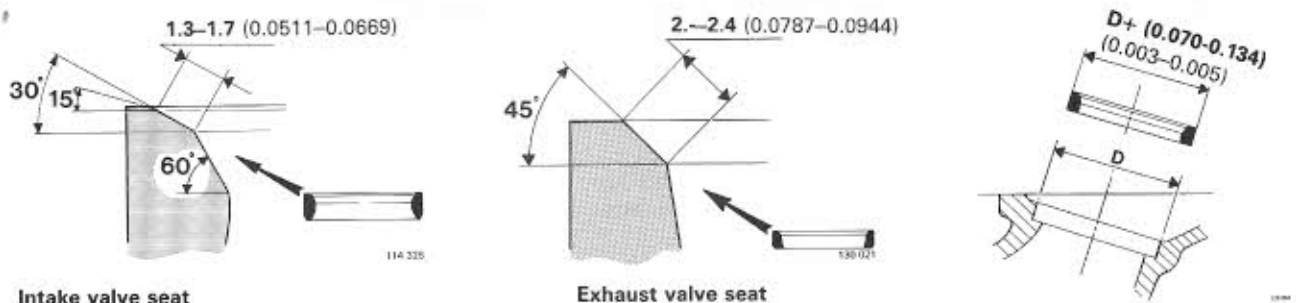
### Valve clearances

|                      |  |  |
|----------------------|--|--|
| Intake valves .....  | <b>Cold engine</b><br>0.10–0.15 mm<br>(0.004–0.006 in) | <b>Warm engine</b><br>0.15–0.20 mm<br>(0.006–0.008 in) |
| Exhaust valves ..... | 0.25–0.30 mm<br>(0.010–0.012 in)                       | 0.30–0.35 mm<br>(0.012–0.014 in)                       |

### Valves mm (in)



### Valve seats mm (in)



Intake valve seat

Exhaust valve seat

Venturi seat: 15° and 60° angles can be used to reduce seat width.

**Note!** When replacing valve seats: the interference between the valve seat and its bore in the cylinder head must be 0.070–0.134 mm (0.0027–0.0052 in), i.e. the valve seat diameter must be 0.070–0.134 mm greater than the diameter of the bore in the cylinder head.

Valve seats are available in three oversizes.

### Valve guides mm (in)

|  |                             |
|--|-----------------------------|
| Length .....   | 50.1–51.3 (1.2725–1.3030)   |
| Inner diameter .....   | 8.000–8.022 (0.3149–0.3158) |
| Press-in measurement to cylinder head contact surface against block: |                             |
| intake .....   | 39.5–40.5 (1.5551–1.5944)   |
| exhaust .....  | 36.9–37.9 (1.4527–1.4921)   |

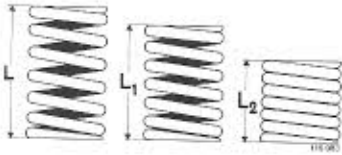


Valve guides are available in three oversizes, and are marked with grooves.

|            | Marking   | Reamer for seat |
|------------|-----------|-----------------|
| Standard   | No groove | –               |
| Oversize 1 | 1 groove  | 5166            |
| 2          | 2 grooves | 5167            |
| 3          | 3 grooves | 5168            |

Specifications

**Valve springs**



Springs are green.

Length under different loads:

| Length<br>mm | in   | Load    |         |
|--------------|------|---------|---------|
|              |      | N       | lbs.    |
| 47.1         | 1.85 | 0       | 0       |
| 40.0         | 1.57 | 230-266 | 51-59   |
| 30.0         | 1.18 | 613-689 | 137-154 |

**Rocker arm mechanism**

The rocker arm tips are surface hardened and must not be ground.

|                                   |                                     |
|-----------------------------------|-------------------------------------|
| Diameter, rocker arm shaft .....  | 19.959-19.980 mm (0.7857-0.7866 in) |
| Hole diameter, rocker arm .....   | 19.992-20.013 mm (0.7870-0.7879 in) |
| Clearance, shaft-rocker arm ..... | 0.012-0.054 mm (0.0005-0.0021 in)   |

**TIMING GEARS**

**Camshaft**



Camshaft type varies with engine type. Identification number/letter is stamped in end.

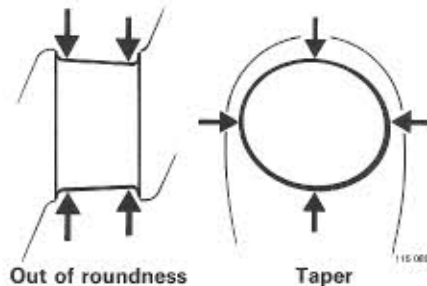
|   |                               |                     |
|---|-------------------------------|---------------------|
| Identification, part number/letter, left .....        | <b>B 28 A &amp; E</b>         | <b>B 28 F</b>       |
| right .....   | 74 01 269 615/F               | 74 01 269 486/G     |
| Max lobe lifting height, left and right, inlet .....  | 74 01 269 616/F               | 74 01 269 487/G     |
| exhaust .....   | 5.96 mm (0.2348 in)           | 5.44 mm (0.2142 in) |
| Checking camshaft settings (cold engine):             | 5.96 mm (0.2348 in)           | 5.94 mm (0.2339 in) |
| adjust valve clearance on 1st and 6th inlet valves to | 0.7 mm (0.0275 in)            | 0.7 mm (0.0275 in)  |
| The inlet valves should then open at:                 |                               |                     |
| 1st .....   | 8±3° b.t.d.c.                 | 1±3° b.t.d.c.       |
| 6th .....   | 8±3° b.t.d.c.                 | 1±3° b.t.d.c.       |
| Journal diameter, mm (in):                            |                               |                     |
| 1st .....   | 40.440-40.465 (1.5921-1.5931) |                     |
| 2nd .....   | 41.040-41.065 (1.6157-1.6167) |                     |
| 3rd .....   | 41.640-41.665 (1.6393-1.6403) |                     |
| 4th .....   | 42.240-42.265 (1.6629-1.6639) |                     |
| Radial play .....                                     | 0.035-0.085 (0.0013-0.0033)   |                     |
| End float, new .....                                  | 0.070-0.144 (0.0027-0.0056)   |                     |
| max. ....   | 0.5 (0.0196)                  |                     |

**CRANK MECHANISM****Crankshaft**

|   |                  |                    |
|---|------------------|--------------------|
| Max. run-out (measured on two centre main bearing journals) . . . | 0.02 mm          | (0.0007 in)        |
| Crankshaft, end float . . . . .                                   | 0.070–0.270 mm   | (0.0027–0.0106 in) |
| clearance (main bearings) . . . . .                               | 0.038–0.088 mm   | (0.0014–0.0034 in) |
| Crank journals, side clearance . . . . .                          | 0.20–0.38 mm     | (0.0078–0.0149 in) |
| clearance . . . . .   | 0.030–0.080 mm   | (0.0011–0.0031 in) |
| Rear sealing ring diameter, standard . . . . .                    | 79.926–80.000 mm | (3.1466–3.1496 in) |
| undersized . . . . .  | 79.726–79.800 mm | (3.1388–3.1417 in) |

**Main bearing journals**

|  |                  |                    |
|--|------------------|--------------------|
| Out of roundness, max. . . . .   | 0.007 mm         | (0.0002 in)        |
| Taper, max. . . . .  | 0.01 mm          | (0.0003 in)        |
| Diameter, standard . . . . .   | 70.043–70.062 mm | (2.7575–2.7583 in) |
| undersized . . . . .   | 69.743–69.762 mm | (2.7457–2.7465 in) |
| Main bearing shells, thickness, standard . . . . .                             | 1.961–1.967 mm   | (0.0772–0.0774 in) |
| oversized . . . . .  | 2.111–2.117 mm   | (0.0831–0.0833 in) |
| Width of crankshaft journal for thrust bearing<br>(rear main bearing journal): |                  |                    |
| standard . . . . .   | 29.20–29.25 mm   | (1.1496–1.1515 in) |
| oversized 1 . . . . .  | 29.40–29.45 mm   | (1.1574–1.1594 in) |
| 2 . . . . .  | 29.50–29.55 mm   | (1.1614–1.1633 in) |
| 3 . . . . .  | 29.60–29.65 mm   | (1.1653–1.1673 in) |
| Thrust bearing washer, thickness, standard . . . . .                           | 2.30–2.35 mm     | (0.0905–0.0925 in) |
| oversized 1 . . . . .  | 2.40–2.45 mm     | (0.0944–0.0964 in) |
| 2 . . . . .  | 2.45–2.50 mm     | (0.0964–0.0984 in) |
| 3 . . . . .  | 2.50–2.55 mm     | (0.0984–0.1003 in) |

**Connecting rod bearing journals**

|  |                  |                    |
|--|------------------|--------------------|
| Out of roundness, max. . . . .                               | 0.007 mm         | (0.0002 in)        |
| Taper, max. . . . .  | 0.01 mm          | (0.0003 in)        |
| Diameter, standard . . . . .                                 | 52.267–52.286 mm | (2.0577–2.0585 in) |
| undersized . . . . .   | 51.967–51.986 mm | (2.0456–2.0466 in) |
| Connecting rod bearing shells, thickness, standard . . . . . | 1.842–1.848 mm   | (0.0725–0.0727 in) |
| undersized . . . . .   | 1.992–1.998 mm   | (0.0784–0.0788 in) |
| Bearing journal width . . . . .                              | 39.99–40.09 mm   | (1.5744–1.5783 in) |

**Connecting rods**

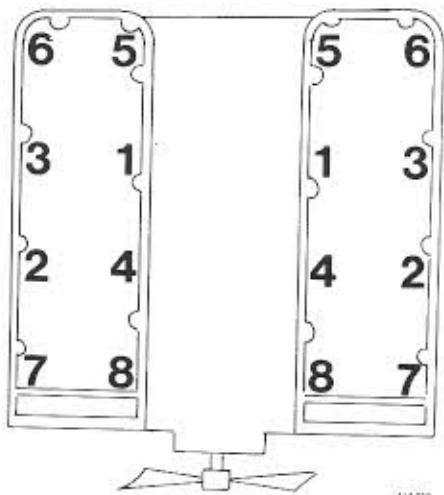
|  |              |                    |
|--|--------------|--------------------|
| End float on crankshaft (all con rods installed) . . . . .       | 0.20–0.38 mm | (0.0078–0.0149 in) |
| Length between centres . . . . .                                 | 146.15 mm    | (5.7539 in)        |
| Max. weight difference between con rods in same engine . . . . . | ±2.5 grams   | ±0.09 oz           |

**Flywheel**

|   |         |             |
|---|---------|-------------|
| Axial throw, max. . . . .                                     | 0.05 mm | (0.0019 in) |
| Radial throw, max. (measured at diameter 282.4 mm = 11.12 in) | 0.15 mm | (0.0059 in) |

## TIGHTENING TORQUES

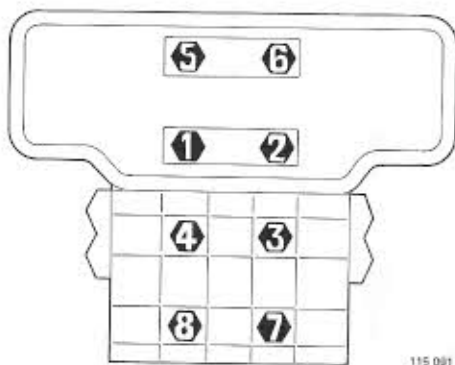
The tightening torques shown below apply to oiled nuts and bolts. Degreased (washed) parts must be oiled prior to assembly.



Tightening sequence for cylinder head bolts

Tighten all bolts in stages according to below:

- 1 = 10 Nm (7 ft. lbs)
- 2 = 30 Nm (22 ft. lbs)
- 3 = 60 Nm (44 ft. lbs)
- 4 = Wait 10–15 minutes
- 5 = Slacken bolts
- 6 = 15–20 Nm (11–15 ft. lbs)
- 7 = Angle-tighten to 113–117°
- 8 = Warm-up engine to operating temperature
- 9 = Cool block 30 minutes
- 10 = Slacken and then retighten bolts one at a time in specified tightening order.  
Retighten according to stages 6 and 7.



Tightening sequence for main bearings  
(via lower crankcase)

### Main bearings

Tighten all nuts in stages:

- 1 = 30 Nm (22 ft. lbs)
- 2 = Slacken nut 1
- 3 = Tighten nut 1 to 30–35 Nm (22–26 ft. lbs.)
- 4 = Angle-tighten nut 1 73°–77°
- 5 = Slacken and retighten the other nuts in the order specified in stages 2–4.

|                                       | Nm      | ft. lbs |
|---------------------------------------|---------|---------|
| Connecting rod bearings .....         | 45–50   | 33–37   |
| Crankshaft pulley .....               | 240–280 | 174–203 |
| Camshaft sprocket .....               | 70–90   | 52–66   |
| Flywheel (always use new bolts) ..... | 45–50   | 33–37   |
| Spark plugs (do not oil) .....        | 12±2    | 9±1.5   |
| Valve cover .....                     | 15      | 11      |

## Group 22 Lubricating system

### GENERAL

|   |            |            |
|---|------------|------------|
| Oil capacity, excl. oil filter .....      | 6.0 litres | 6.3 US qts |
| incl. oil filter .....                    | 6.5 litres | 6.9 US qts |
| Volume difference, max. – min. ....       | 1.0 litres | 1.1 US qts |
| Oil pressure, warm engine new oil filter: |            |            |
| at 15 r/s (900 r/min), minimum .....      | 0.1 MPa    | (14.2 psi) |
| 50 r/s (3,000 r/min) .....                | 0.4 MPa    | (57 psi)   |

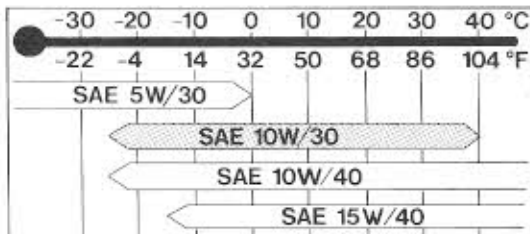
#### Petrol (gasoline) engines, USA, Canada & Japan Oil quality

According to API ..... min. SF\*

\* Oils with designations SF/CC and SF/CD fulfil this requirement.

Supplementary engine oil additives are not recommended because of potential damage to engine.

#### Viscosity (stable ambient temperatures)



137 644

#### Other markets Oil quality

According to API-1983 ..... min. SE\*  
1984– ..... min. SF\*\*

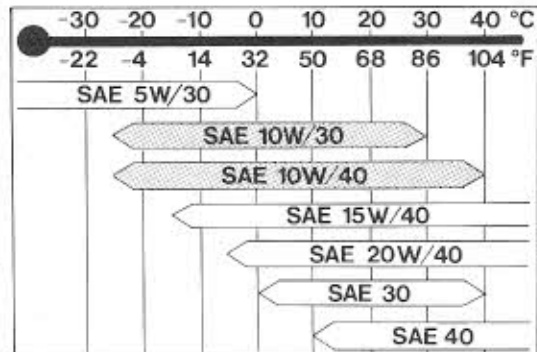
\* Oils with designations SE, SF, SE/CC, SF/CC and SF/CD fulfil this requirement.

**Note that SE/CD oils must not be used.**

\*\* Oils with designations SF/CC and SF/CD fulfil this requirement.

Supplementary engine oil additives are not recommended because of potential damage to engine.

#### Viscosity (stable ambient temperatures)



137 642

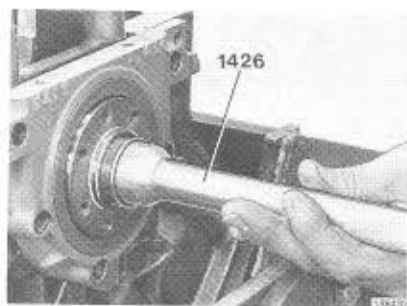
**Note!** SAE 15W/40 (SAE 20W/40) oils are recommended for use in extreme driving conditions which involve high oil consumption e.g. mountain driving with frequent deceleration or fast motorway driving. (Note, however, the lower temperature limits.)

### OIL PUMP

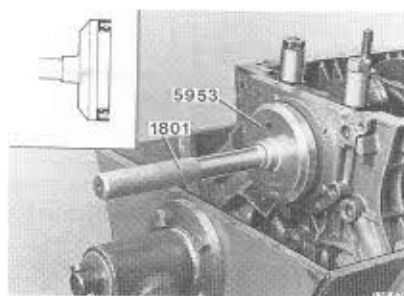
|   |                |                  |
|---|----------------|------------------|
| End float .....   | 0.025–0.084 mm | 0.0009–0.0033 in |
| Clearance between tooth tip and pump housing wall (excl. bearing clearance) ..... | 0.110–0.185 mm | 0.0043–0.0072 in |
| Backlash (excl. bearing clearance) .....  | 0.17–0.27 mm   | 0.0066–0.0106 in |
| Bearing clearance, driveshaft .....   | 0.015–0.053 mm | 0.0006–0.0021 in |
| idler shaft .....   | 0.15–0.051 mm  | 0.0006–0.0020 in |
| Relief valve spring, length under various loads:                                  |                |                  |
| unloaded .....  | 89.5 mm        | 3.52 in          |
| loaded to 88.3 N (19.4 lbs) .....   | 56.5–60.5 mm   | 2.22–2.38 in     |

## Special tools

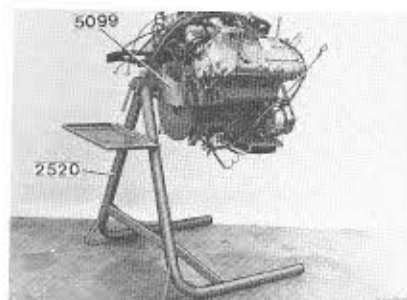
| 999    | Description – use  |
|--------|--|
| 1426-9 | <b>Drift:</b> fitting pilot bearing in crankshaft  |
| 1801-3 | <b>Standard handle:</b> used with 5953   |
| 2520-8 | <b>Stand:</b> used with fixture 5099   |
| 4090-0 | <b>Extractor:</b> pilot bearing  |
| 5029-7 | <b>Drift:</b> fitting intake valve seat  |
| 5092-5 | <b>Combined tools:</b> (6 parts) removing – fitting gudgeon (piston) pins. Used with 5128 and 5129           |
| 5093-3 | <b>Retainer:</b> (4x) for cylinder liners  |
| 5096-6 | <b>Spacer sleeve:</b> main bearings  |
| 5098-2 | <b>Protractor:</b> for angle-tightening cylinder head bolts and main bearing nuts                            |
| 5099-0 | <b>Fixture:</b> for engine. Used with 2520   |
| 5103-0 | <b>Drift:</b> fitting crankshaft front oil seal  |
| 5108-9 | <b>Drift:</b> fitting valve guide – intake   |
| 5109-7 | <b>Drift:</b> fitting valve guide – exhaust  |
| 5111-3 | <b>Centering drift:</b> clutch, manual gearboxes   |
| 5112-1 | <b>Locking sector:</b> locking flywheel  |
| 5128-7 | <b>Piston support:</b> removing gudgeon pin. Used with 5092  |
| 5129-5 | <b>Piston support:</b> fitting gudgeon pin. Used with 5092   |
| 5165-9 | <b>Reamer kit:</b> valve guides: contains 5164 (early type), 5224 (late type), 5166, 5167 and 5168           |
| 5166-7 | <b>Reamer:</b> valve guide seat oversize 1   |
| 5167-5 | <b>Reamer:</b> valve guide seat oversize 2   |
| 5168-3 | <b>Reamer:</b> valve guide seat oversize 3   |
| 5192-3 | <b>Support:</b> for dial indicator. Measuring cylinder liner height and piston height. Also 5094 can be used |
| 5218-6 | <b>Drift:</b> removing valve guides. Fitting oil seal on valve guide   |
| 5220-2 | <b>Drift:</b> fitting valve seat – exhaust   |
| 5224-4 | <b>Reamer:</b> cleaning valve guides. Also 5164 can be used  |
| 5953-8 | <b>Drift:</b> fitting crankshaft rear oil seal. Used with 1801   |



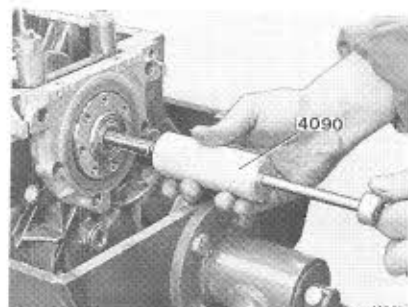
1426



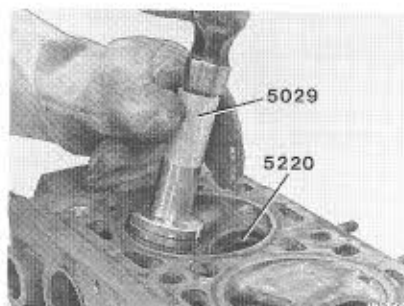
1801



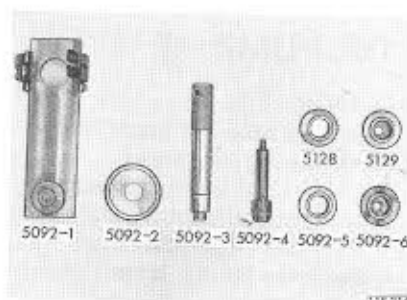
2520



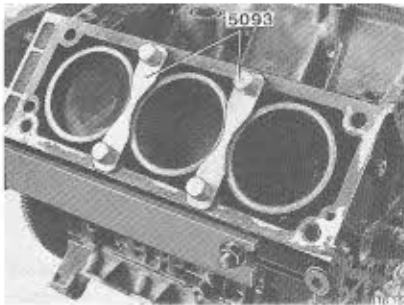
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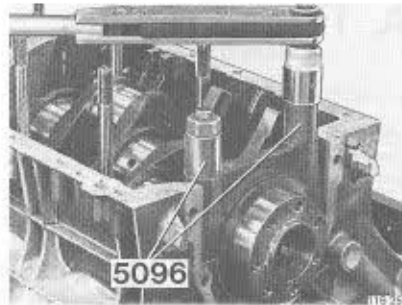
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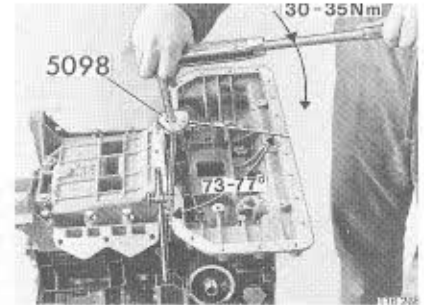
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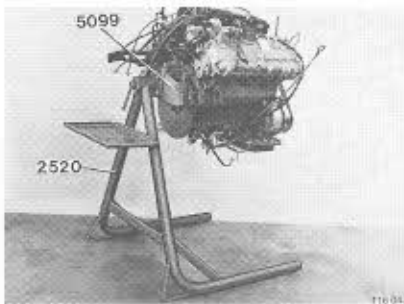
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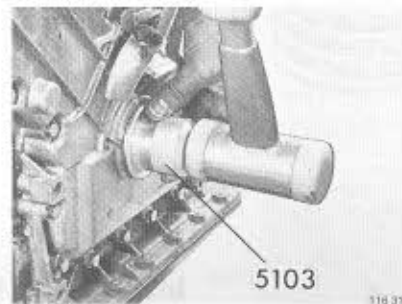
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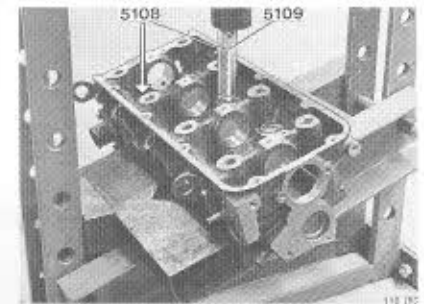
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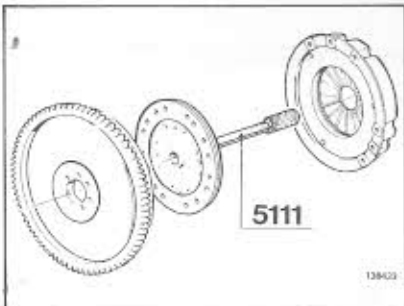
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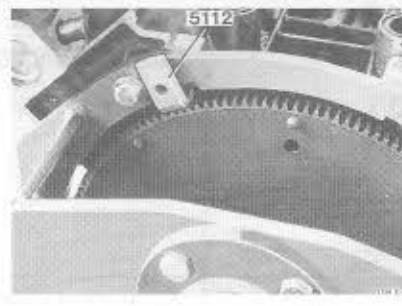
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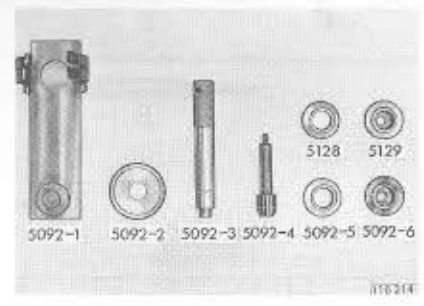
5108, 5109



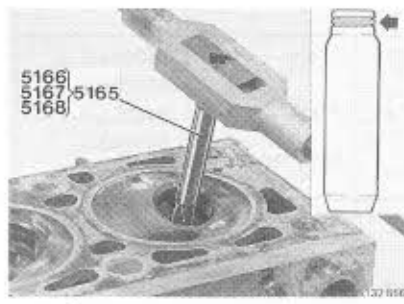
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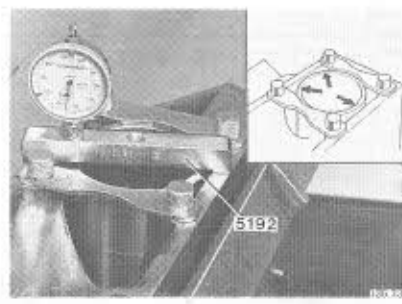
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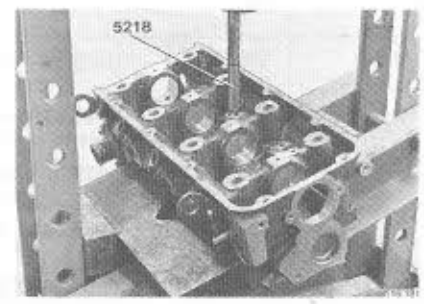
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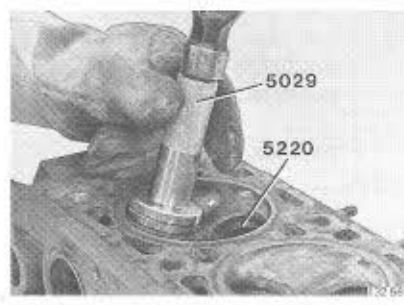
5165 (5166, 5167, 5168)



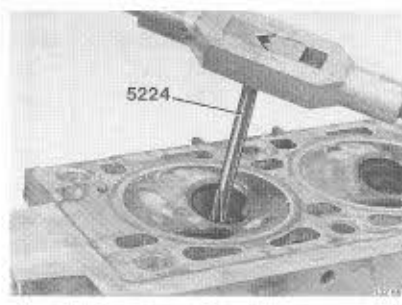
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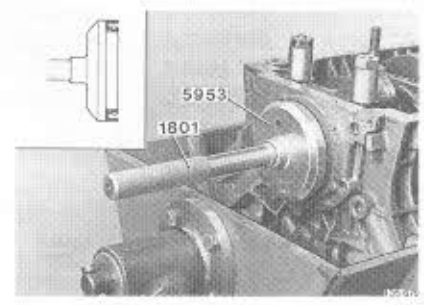
5218



5220

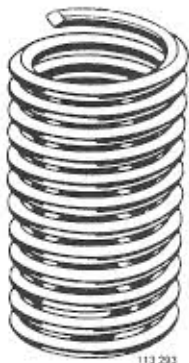
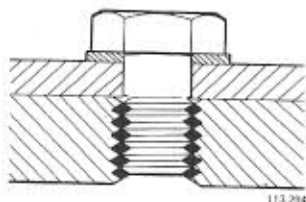


5224



5953

## A. Thread repairs

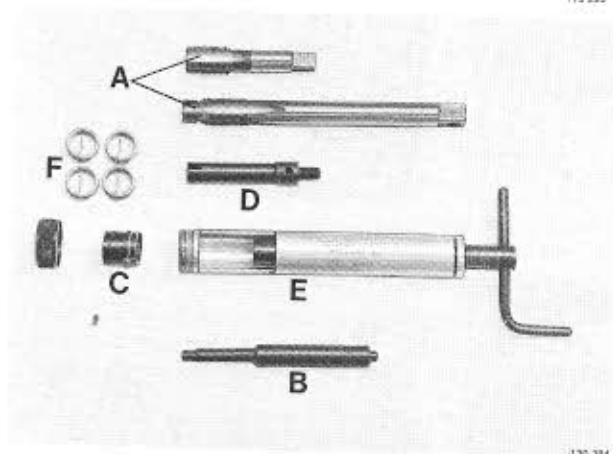


A1

### General

A damaged thread can usually be repaired with a thread insert. Thread inserts and installation tools are available from Volvo Parts.

Note! Some threads can/may not be repaired with thread inserts, see next page.



A2

### Installation tools

Tools to install thread repair inserts are supplied in kits. Some thread inserts are also included in the kits. See the table below.

Each tool can be ordered separately.

| Thread    | Complete kit            | Contents of complete kit |            |            |            |            |                         |
|-----------|-------------------------|--------------------------|------------|------------|------------|------------|-------------------------|
|           |                         | Tap A                    | Tang B     | Mandrel C  | Crank D    | Tool E     | Thread inserts (10 x) F |
| M 6x1     | 998 5840-9              | 998 5802-0               | 998 5803-7 | 998 5804-5 | 998 5805-2 | 4)         | 956014-5 +              |
| M 7x1     | 998 5841-7              | 998 5806-0               | 998 5807-8 | 998 5808-6 | 998 5809-4 | 4)         | 956015-2                |
| M 8x1.25  | 998 5842-5              | 998 5810-2               | 998 5811-0 | 998 5812-8 | 998 5813-6 | 4)         | 948015-3 +              |
| M 10x1.5  | 998 5843-3              | 998 5814-4               | 998 5815-1 | 998 5816-9 | 998 5817-7 | 4)         | 941843-5                |
| M 12x1.5  | 998 5844-1              | 998 5818-5               | 998 5819-3 | 998 5820-1 | 998 5821-9 | 4)         | 956018-6 +              |
| M 14x1.25 | 998 5845-8 <sup>1</sup> | 998 5823-5               | 2)         | 998 5824-3 | 998 5825-0 | 4)         | 956019-4                |
| M 14x1.25 | 998 5846-6              | 998 5826-8               | 2)         | 998 5824-3 | 998 5825-0 | 4)         | 956022-8 +              |
| M 14x1.5  | 998 5847-4              | 998 5827-6               | 2)         | 998 5828-4 | 998 5829-2 | 4)         | 956023-6                |
| M 16x1.5  | 998 5848-2              | 998 5831-8               | 2)         | 3)         | 3)         | 998 5832-6 | 948094-8 +              |
| M 18x1.5  | 998 5849-0              | 998 5833-4               | 2)         | 3)         | 3)         | 998 5834-2 | 948095-5                |
| 5/8"-     |                         |                          |            |            |            |            | 948756-2                |
| 18 UNF    | 998 5850-8              | 998 5860-7               | 2)         | 3)         | 3)         | 998 5861-5 | 948756-2                |
|           |                         |                          |            |            |            |            | 948758-8                |
|           |                         |                          |            |            |            |            | 947847-0                |
|           |                         |                          |            |            |            |            | 947843-9                |
|           |                         |                          |            |            |            |            | 948755-4                |

<sup>1</sup> Designed especially for spark plug threads (do not drill).

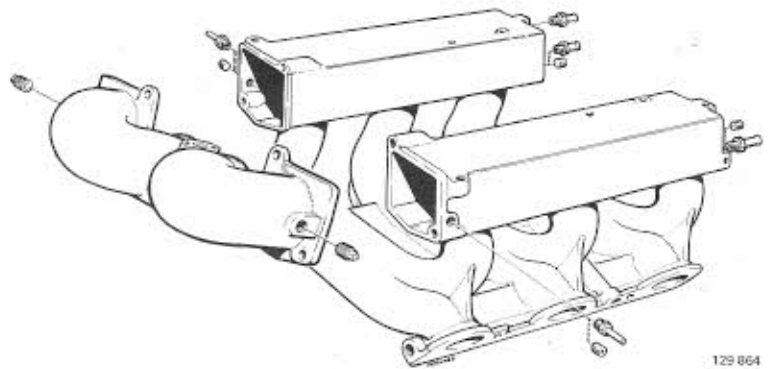
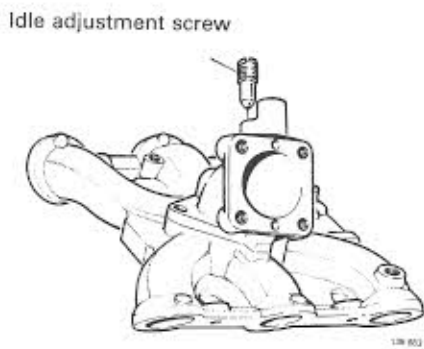
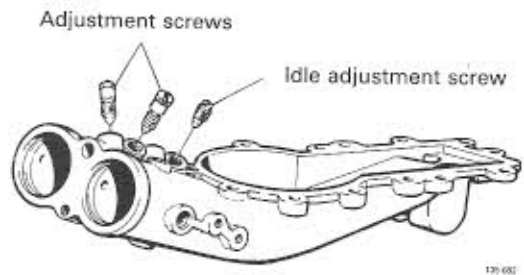
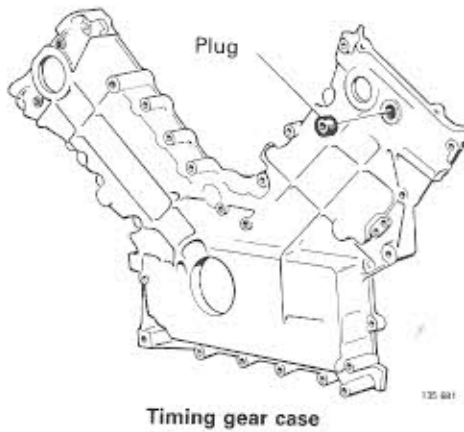
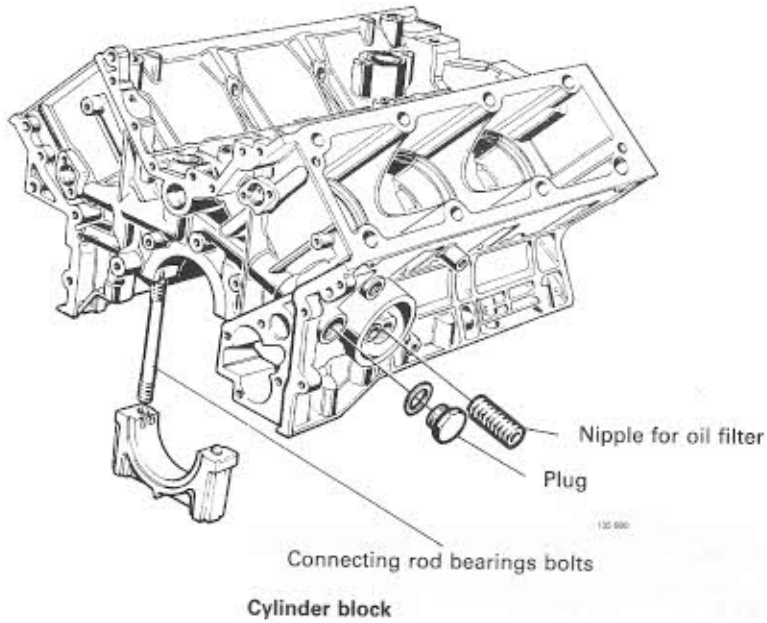
<sup>2</sup> Use flat nosed pliers or similar tool.

<sup>3</sup> Supplied with set.

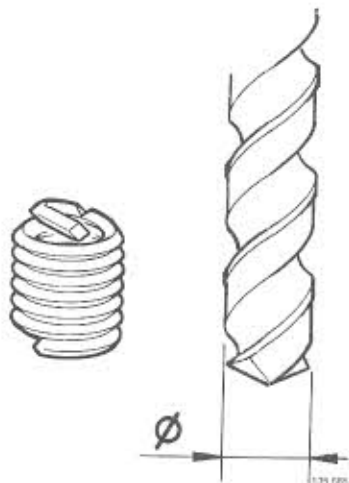
<sup>4</sup> Tool 998 5830-0 is not supplied with complete kit, but may be ordered separately.

**Do not repair these threads**

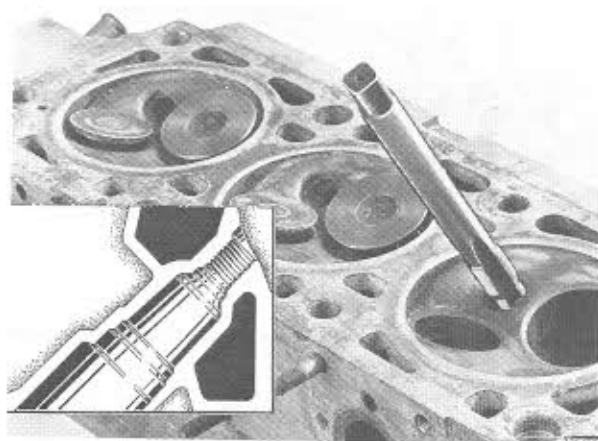
(Threads shown below cannot or must not be repaired)



**Thread repair insert, drill diameter**



| Thread      | Length mm | P/N      | Drill dia mm |
|-------------|-----------|----------|--------------|
| M 6x1       | 9.0       | 956014-5 | 6.3          |
|             | 12.0      | 956015-2 | 6.3          |
| M 7x1       | 10.5      | 948015-3 | 7.3          |
|             | 14.0      | 941843-5 | 7.3          |
| M 8x1.25    | 8.0       | 956017-8 | 8.4          |
|             | 11.4      | 956018-6 | 8.4          |
|             | 16.0      | 956019-4 | 8.4          |
| M 10x1.5    | 10.0      | 956021-0 | 10.5         |
|             | 15.0      | 956022-8 | 10.5         |
|             | 20.0      | 956023-6 | 10.5         |
|             | 25.0      | 956024-4 | 10.5         |
| M 12x1.5    | 12.0      | 948094-8 | 12.5         |
|             | 24.0      | 948095-5 | 12.5         |
|             | 30.0      | 956028-5 | 12.5         |
| M 14x1.25   | 14.5      | 948756-2 | 14.3         |
| M 14x1.5    | 10.0      | 948758-8 | 14.5         |
| M 16x1.5    | 12.0      | 947847-0 | 16.5         |
| M 18x1.5    | 13.5      | 947843-9 | 18.5         |
| 5/8"x18 UNF | 8.0       | 948755-4 | 16.4         |



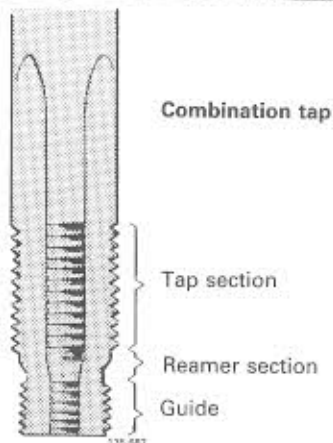
**Repairing spark plug threads**

Cylinder head must be removed first. Tap hole from inside to avoid damaging seat for spark plug.

Do not drill the hole. Use tap 998 5823-5.

Re-cut old threads only. Do not cut further into cylinder block. Spark plug bore must not be threaded along entire length.

Screw in thread insert (P/N 948756-2)

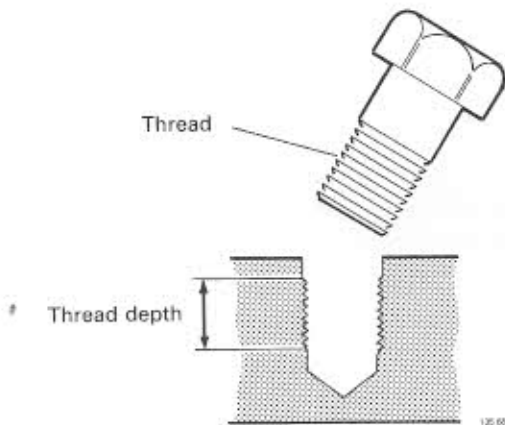


## Installing thread inserts

A6

### Select drill size, tap and insert

Measure length and thread of old hole.



A7

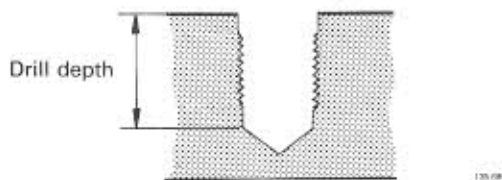
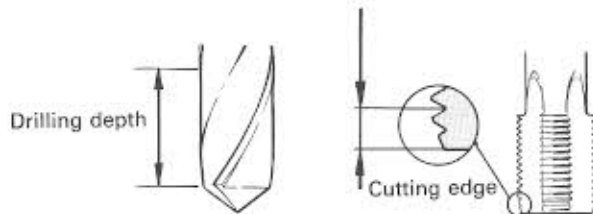
### Tap hole

**NOTE!** Special instructions for spark plug holes, see page 16.

Measure depth of hole. Drill out hole to this depth.

Cut the screw thread to such a depth that the thread insert makes contact with fully cut screw thread along its entire length.

Clean the hole.



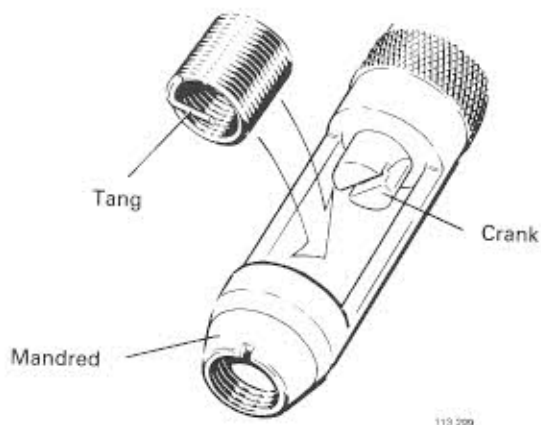
A8

### Assemble installation tool

**M6-M14 threads:** fit correct mandrel and crank in installation tool 998 5830-0.

**M16 and coarser threads:** use the prescribed complete installation tool.





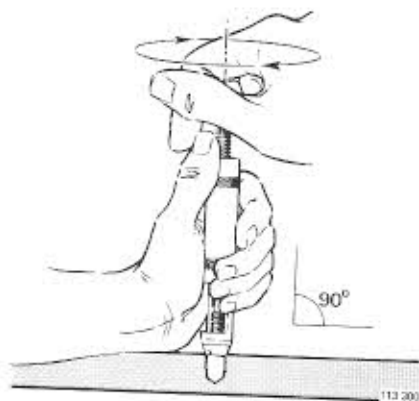
A9

#### Fit thread insert in installation tool

Fit the thread insert in the tool with the tang facing downwards.

Turn the crank clockwise until the tang of the thread insert engages the slot in the crank.

**Without pressing**, screw the thread insert into the mandrel until the first thread of the insert is flush with the opening of the mandrel.

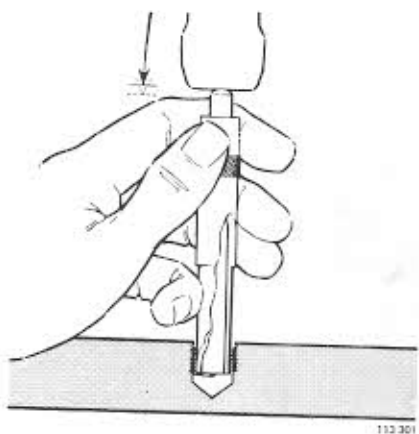


A10

#### Install thread insert

Hold the tool vertically above the centre of the hole.

**Without pressing**, screw in the thread insert until the top thread of the insert is at least 1/2 a thread below the working surface (0.5 x pitch). The insert must not be screwed in to the bottom otherwise it will not be possible to break off the tang.



A11

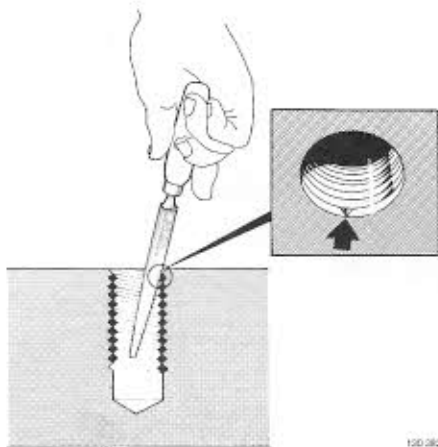
#### Break off tang

**M16–M12 threads:** use the tang breaker in the installation kit.

**M14 and coarser threads:** use a pair of flat nosed pliers to break off the tang downwards.

Remove the tang from the hole.

## Removing thread repair inserts



A12

### File groove in thread insert

Using a triangular file make a groove in the top thread of the insert, approx. 1/4 of a thread from the end. Take care not to damage the thread holding the insert.



A13

### Remove thread insert

Insert a sharp edge of a triangular scraper in the groove. Press downwards and rotate anti-clockwise until the insert is removed.



A14

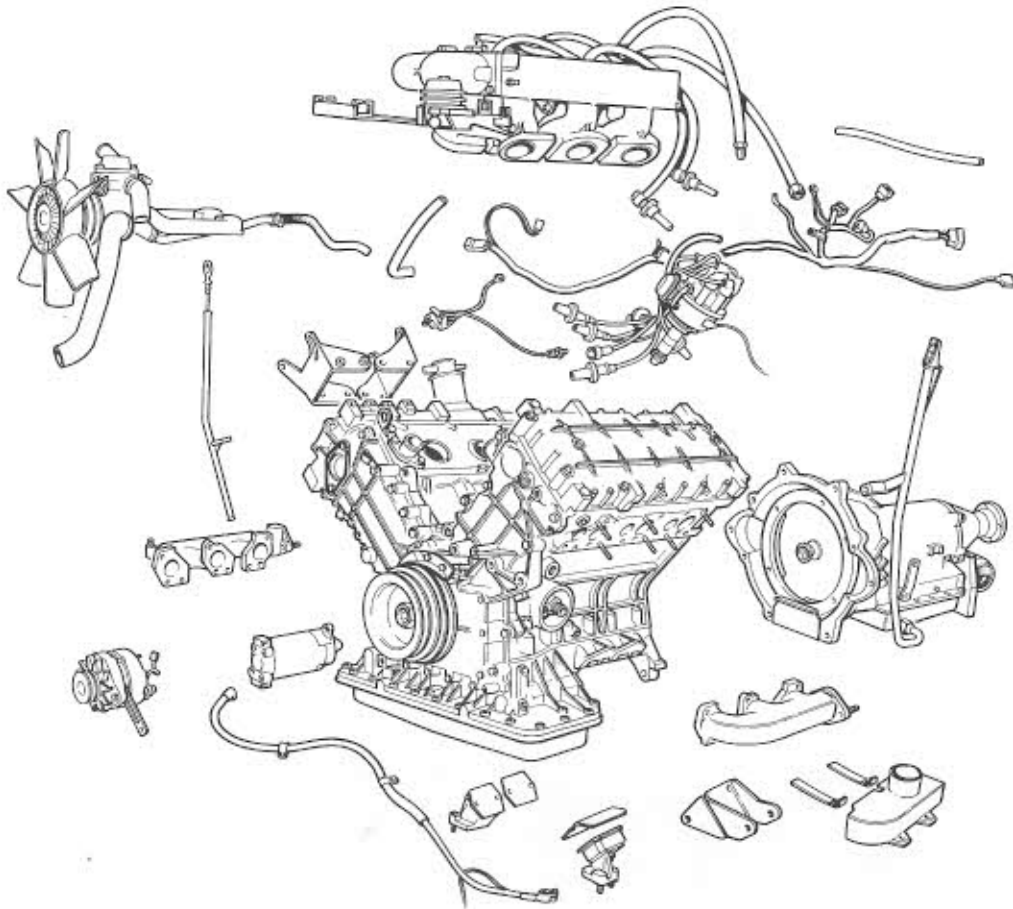
### Fit new thread insert

Clean the hole with a tap and fit a new insert.

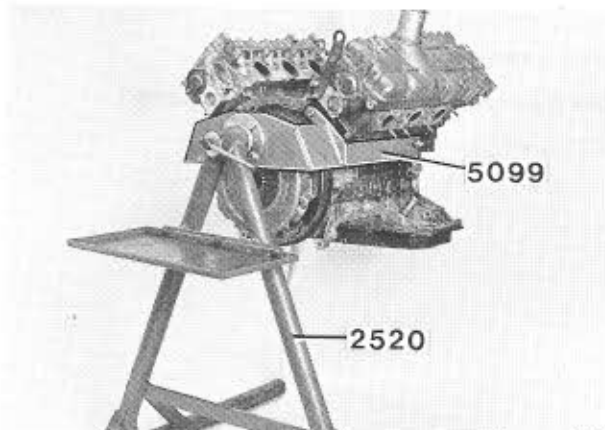
## Reconditioning engine

Special tools: 1426, 1801, 2520, 4090, 5029, 5092, 5093, 5096, 5098, 5099, 5103, 5108, 5109, 5111, 5112, 5128, 5129, 5165, 5192, 5218, 5220, 5953

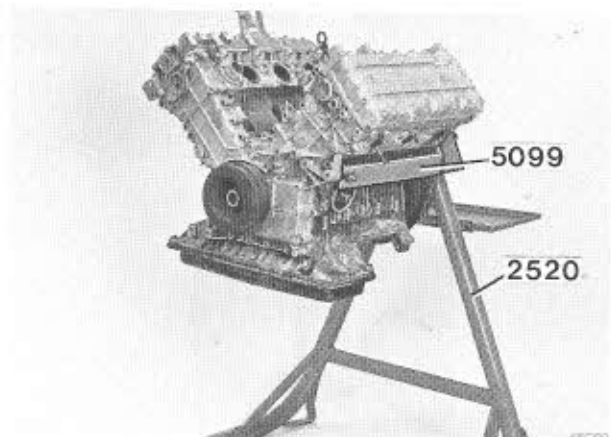
For the overhaul of the engine it is presumed that the components shown in the illustration below have already been removed. Also that the engine is mounted on universal stand **2520** with support **5099**.



135 600

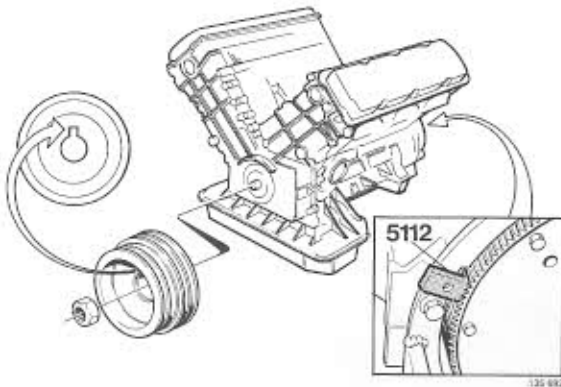


135 600



135 601

## B. Engine, disassembly



### TIMING GEARS

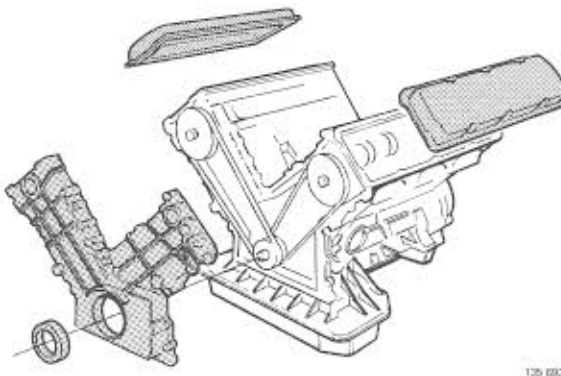
B1

#### Remove crankshaft pulley

36 mm socket.

Use locking sector **5112** to prevent engine from rotating.

Pulley key must point upwards when pulley is removed otherwise it will drop into crankcase.

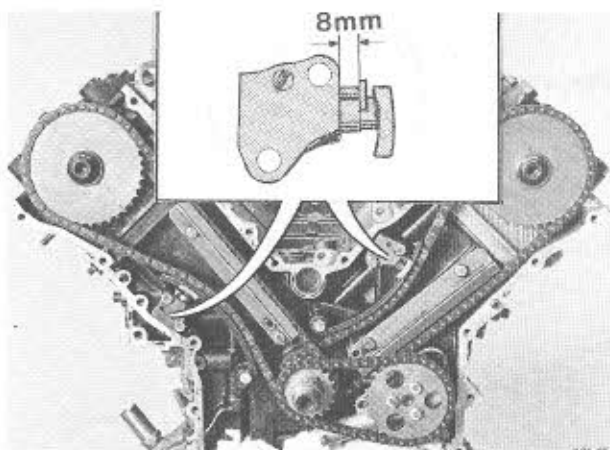


B2

#### Remove:

- valve covers
- timing gear case
- seal from timing gear case.

Cover holes in crankcase with e.g. paper to prevent dirt from entering.

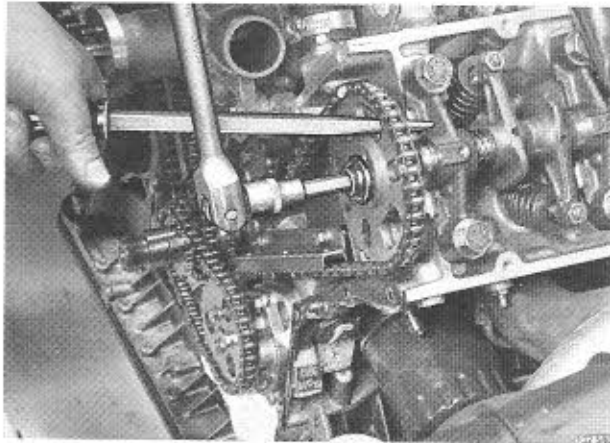


B3

#### Check chain wear

Check position of belt tensioners. If tensioner pin protrudes by 4 or more notches (8 mm = 0.32") chains should be replaced.

**IMPORTANT!** If chains are replaced, sprockets and oil strainers must also be replaced.

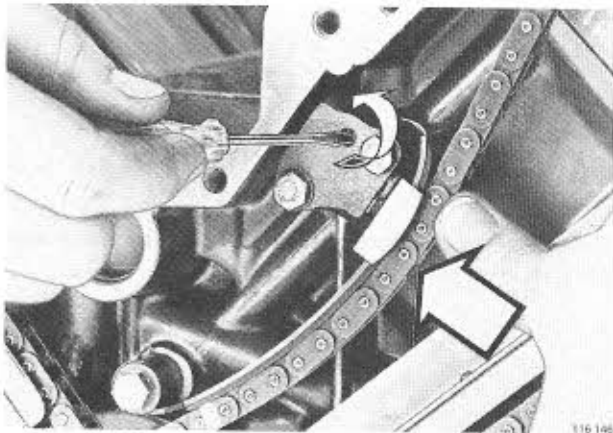


B4

**Slacken camshafts centre bolts**

Allen key 10 mm.

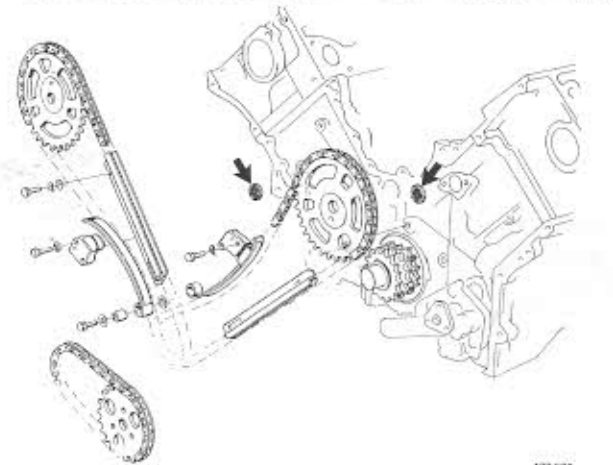
If necessary prevent sprocket from rotating with a screwdriver.



B5

**Slacken timing gear chains**

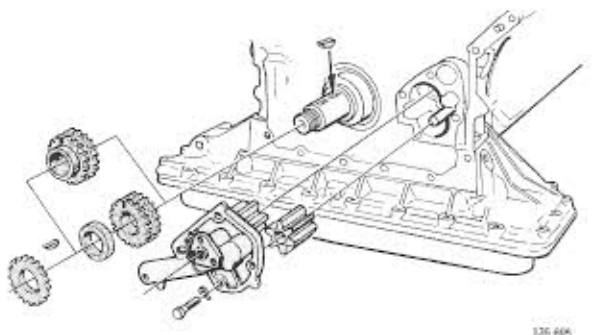
Turn each lock 1/4 turn anti-clockwise and push in piston.



B6

**Remove:**

- oil pump sprocket and chain
- chain tensioners and oil strainers (see arrows)
- bent and straight chain dampers
- camshaft sprockets and chains.

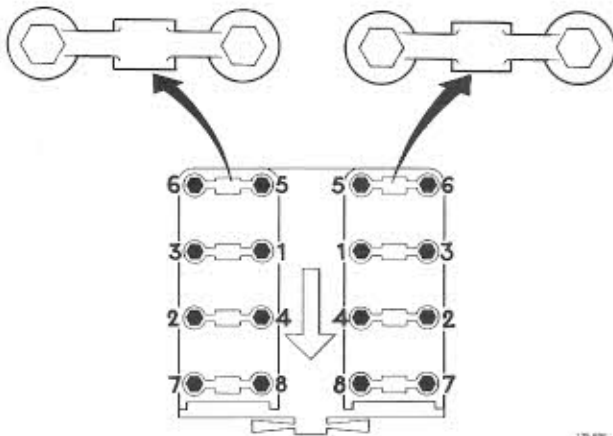


B7

**Remove:**

- oil pump with sprocket
- outer sprocket
- spacer sleeve (late type) and key
- inner sprocket and key.

If necessary use a puller to remove sprockets.

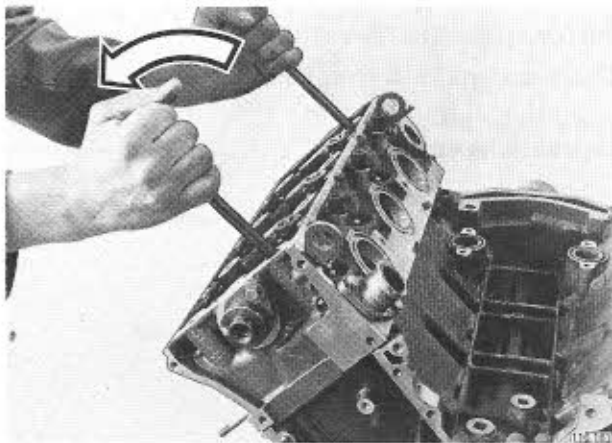


**CYLINDER HEAD**

B8

**Remove rocker arms**

Mark left and right rocker arms.  
Slacken bolts in sequence shown adjacent.



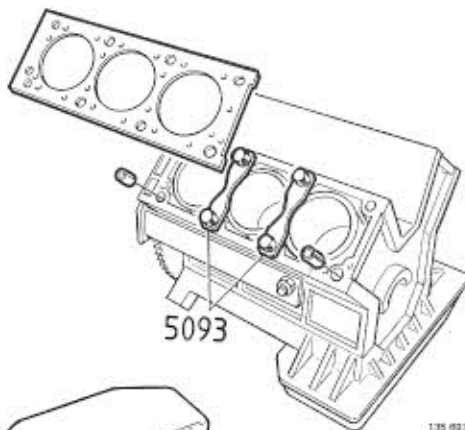
B9

**Remove cylinder heads**

Do not lift cylinder head directly up otherwise cylinder liners may lift as well.

Use two bars (Ø 12 mm, length 300 mm) and lift off cylinder head as illustrated.

Place cylinder heads on wooden blocks to prevent damage.



B10

**Remove:**

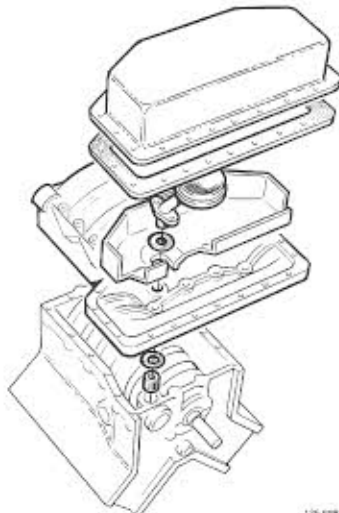
- cylinder head gaskets
- guide sleeves, use a pair of pliers.

B11

**Fit liner holders 5093**

Two per side.

Liner holders must always be used when cylinder head is removed.

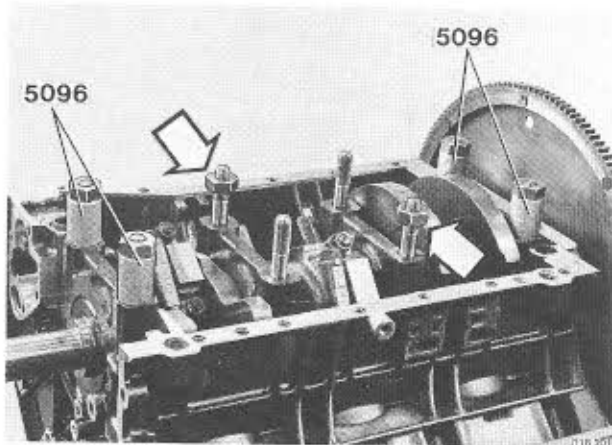


**OIL SUMP, LOWER CRANKCASE**

B12

**Remove:**

- oil sump with gasket
- oil strainer with O-ring
- splash panel
- lower crankcase
- O-ring for oil channels and guide sleeve.

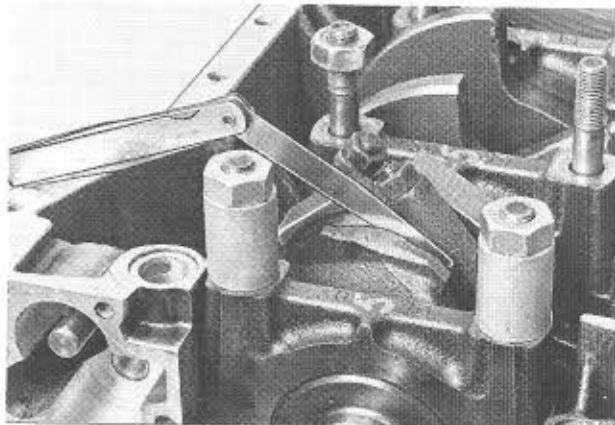


B13

**Install:**

- main bearing holder **5096** for two outer bearings
- a nut for the two centre main bearings.

This is to prevent the crankshaft/main bearings from falling out when the engine is turned.



**PISTONS, CONNECTING RODS**

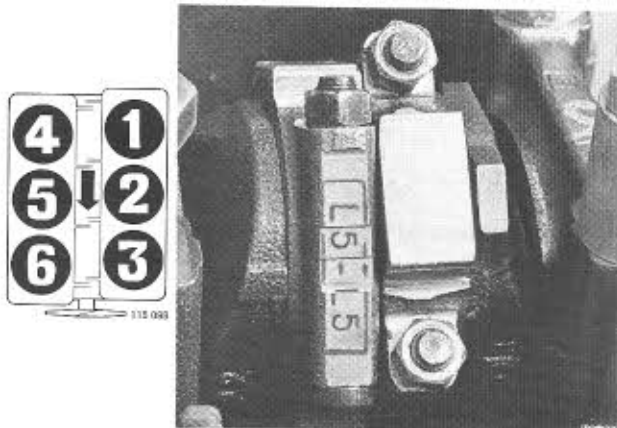
B14

**Check con rod side clearance**

Use a feeler gauge.

Clearance, new parts ..... **0.20-0.38 mm**  
(0.008-0.015")

If clearance is too large, con rods must be replaced.

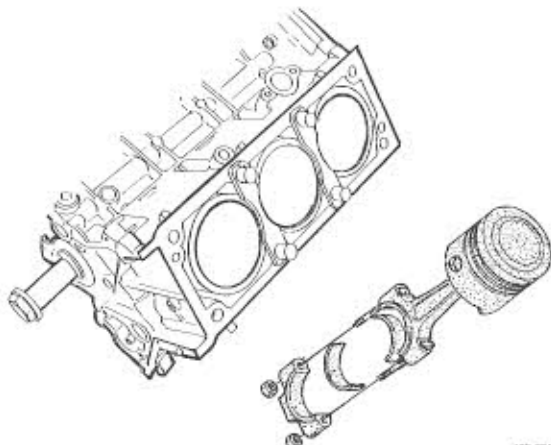


B15

**Check marking of con rod and cap**

If necessary mark as follows:

|                            |   |   |   |   |   |   |
|----------------------------|---|---|---|---|---|---|
| Cylinder                   | 1 | 4 | 2 | 5 | 3 | 6 |
| Marking of con rod and cap | 1 | 2 | 3 | 4 | 5 | 6 |
| Crank webs (from rear)     | 1 |   | 2 |   | 3 |   |

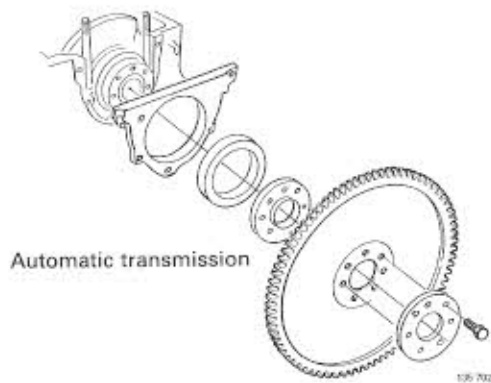


B16

**Remove pistons with con rods and bearings**

Clean cylinder liners.

Assemble con rod, cap and bearing shells to prevent interchange of parts.



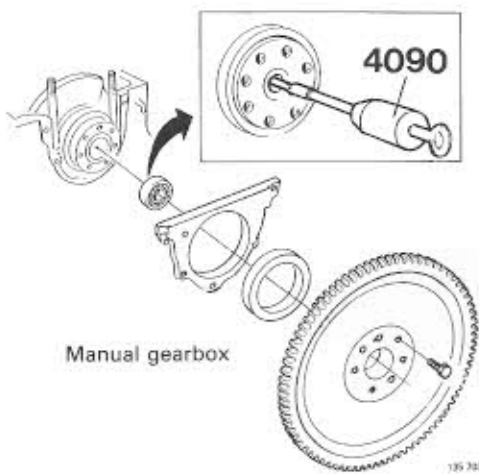
**FLYWHEEL, CRANKSHAFT**

*Automatic transmission*

**B17**

**Remove:**

- carrier plate. Use locking sector **5112** to lock flywheel when bolts are removed
- rear sealing flange. Tap out seal from flange.

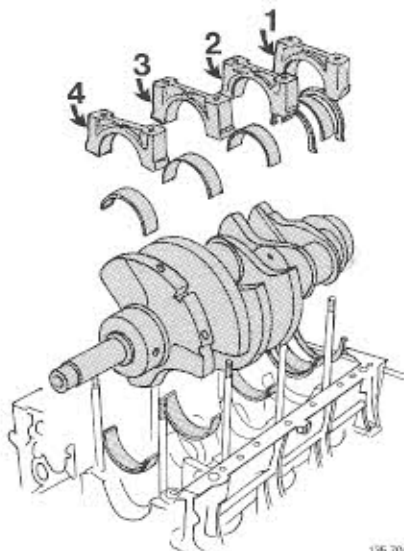


*Manual gearbox*

**B18**

**Remove:**

- pressure plate and clutch disc. Slacken pressure plate bolts crosswise, a few turns at a time to prevent warp.
- flywheel. Use locking sector **5112** to prevent engine from rotating
- rear sealing flange. Tap out bearing from flange
- pilot bearing from crankshaft. Use puller **4090**.



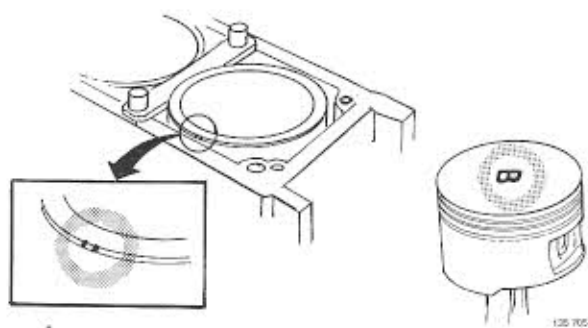
**B19**

**Remove crankshaft, main bearings and thrust bearings**

Check marking of bearing caps, mark if necessary. Caps are marked 1-4, counting from rear.

**IMPORTANT!** Do not interchange bearing shells and caps.

## C. Cleaning, checking

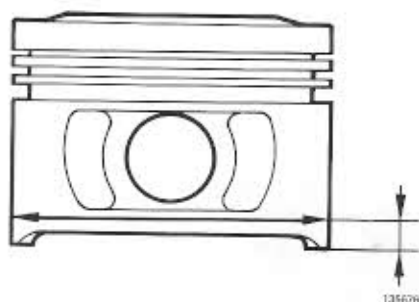


C1

### Check type of piston and cylinder liner

Pistons and liners are matched sets, based on diameter. Three types are available as follows.

| Liner, marking | Piston, marking |
|----------------|-----------------|
| 1 notch        | A               |
| 2 notches      | B               |
| 3 notches      | C               |

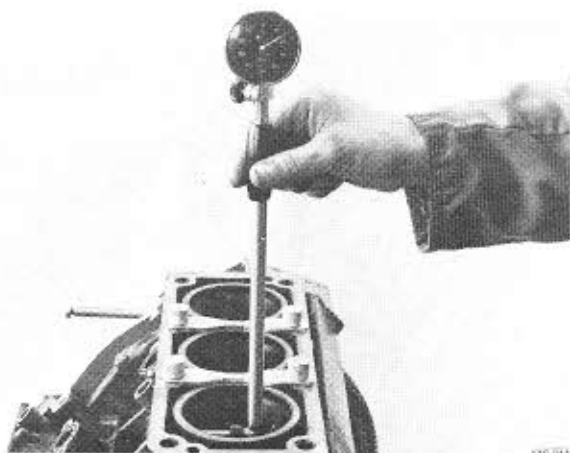


C2

### Measure piston diameter

Measure at **right angles to gudgeon (piston) pin bore and 8 mm (0.3 in) from lower edge.**

| Piston diameter (new pistons) |                                     |
|-------------------------------|-------------------------------------|
| A-marked                      | 90.970–90.980 mm (3.5842–3.5846 in) |
| B-marked                      | 90.980–90.990 mm (3.5846–3.5850 in) |
| C-marked                      | 90.990–91.000 mm (2.5850–3.5840 in) |



C3

### Measure cylinder diameter

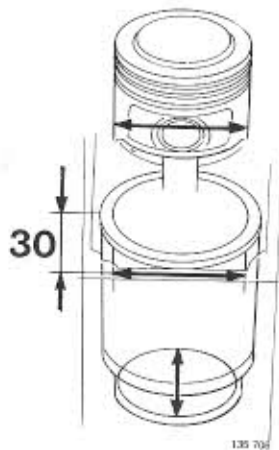
Use a dial indicator (50–100 mm = 1.97–3.94 in).

Measure **max. wear** 30 mm (1.18 in) from block surface.

Measure **min. wear** at lower turning point of piston.

| Cylinder diameter (new liners) |                                   |
|--------------------------------|-----------------------------------|
| liners with 1 cut              | 91.00–91.01 mm (3.5854–3.5858 in) |
| 2 cuts                         | 91.01–91.02 mm (3.5858–3.5862 in) |
| 3 cuts                         | 91.02–91.03 mm (3.5862–3.5866 in) |

C4



**Calculate piston clearance**

Example:

|                                  |                               |                               |
|----------------------------------|-------------------------------|-------------------------------|
| Cylinder bore, measured diameter | min. 91.010 mm<br>(3.5831 in) | max. 91.035 mm<br>(3.5841 in) |
| Piston diameter measured         | 90.985 mm<br>(3.5821 in)      | 90.985 mm<br>(3.5821 in)      |
| Piston clearance                 | min. 0.025 mm<br>(0.0010 in)  | max. 0.050 mm<br>(0.0020 in)  |



Piston clearance for new parts: . . . . . **0.020–0.040 mm**  
(0.0008–0.0016 in)

If clearance is too large replace liners, piston and gudgeon pin. These parts are matched and can only be purchased in kits of six.

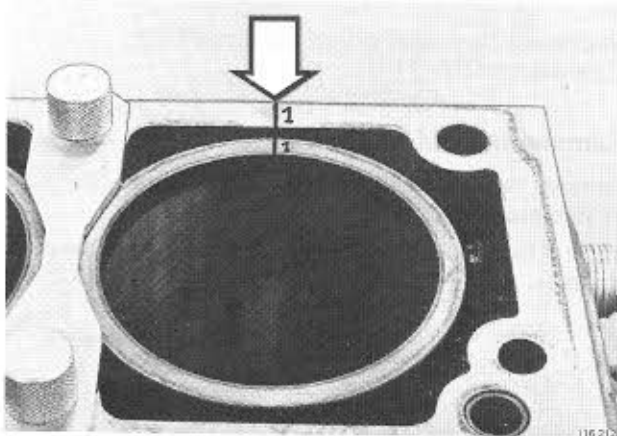
Remove liner if piston/liner is to be replaced.  
Proceed to



C5

**Clean mating surface on cylinder block and liner**

Use a plastic putty knife to avoid damage.



C6

**Mark position of cylinder liner before removing liner**

Mark position and number of each liner. Do not scratch surface.

C7

**Clean and check cylinder liners, piston and con rods**

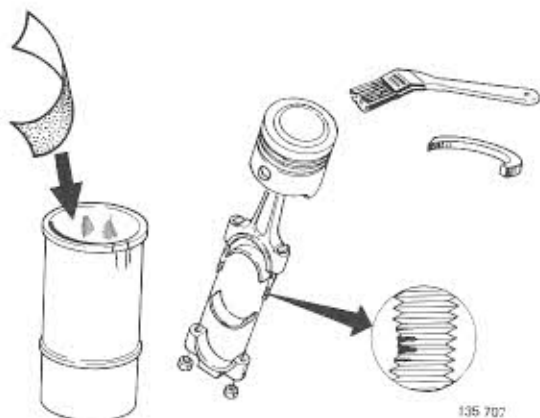
Clean cylinder bores to remove bright surfaces.

Remove piston rings with piston ring pliers.

Scrape out piston ring grooves.

Check for:

- damage, wear, cracks
- out-of-round gudgeon pin bores
- threads on connecting rod bolts.



C8



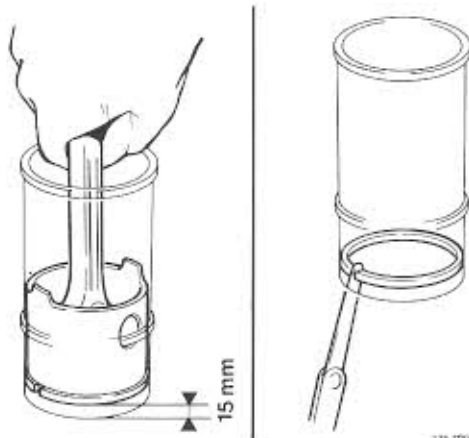
135 708

**Measure axial play of piston rings**

Use a feeler gauge

Axial clearance, new rings:

- upper compression ring ..... **0.045–0.074 mm**  
(0.0018–0.0029 in)
- lower compression ring ..... **0.025–0.054 mm**  
(0.0010–0.0021 in)
- oil scraper ring (fitted) ..... **0.009–0.233 mm**  
(0.0004–0.0092 in)



135 700

C9

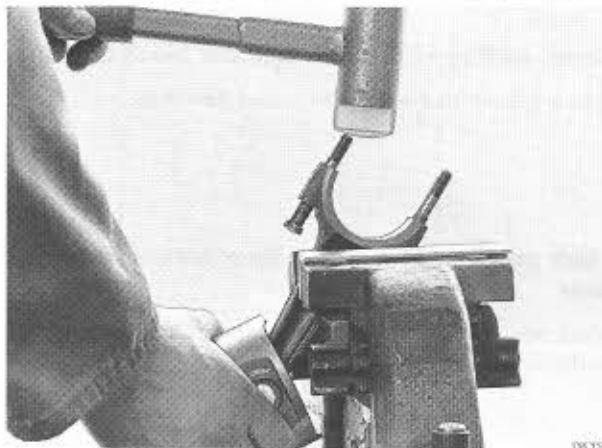
**Measure piston ring gap**

Insert piston ring in bore, one at a time. Use an inverted piston to ensure that rings take up correct position.

Measure gap with ring **15 mm** (0.6 in) from lower edge. Use a feeler gauge.

Piston ring gap, new parts measured in 91 mm (3.5826 in) B 28 cylinder

- upper and lower compression rings . . . **0.40–0.58 mm**  
(0.0157–0.0228 in)
- oil scraper ring ..... **0.38–1.43 mm**  
(0.0150–0.0563 in)



135 712

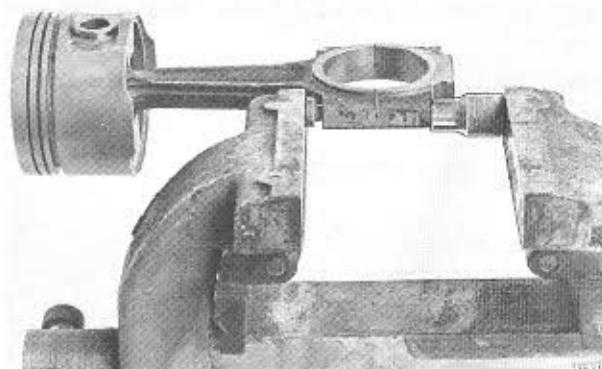
**Replacing damaged connecting rod bolt**  
*Operations C10–11*

C10

**Hammer out old bolt**

Remove bearing cap and shells. Mount connecting rod in vice protected by soft jaws.

Tap out bolt with a plastic mallet. Hold piston to prevent damage.



135 711

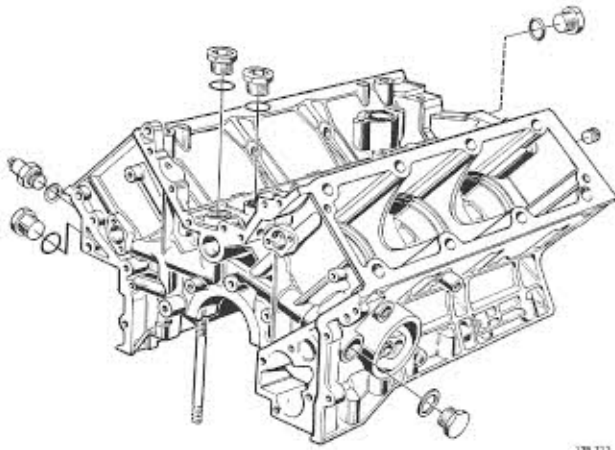
C11

**Press in new bolt**

Position bearing cap, observe identification marks.

Place a 12 mm socket beneath cap.

Press in bolt.



139 712

**Tightening torque:**

- M12 bolts ..... 15-20 Nm (11-15 ft.lbs)
- M18 plugs ..... 30-40 Nm (22-30 ft.lbs)
- M25 plugs ..... 40-45 Nm (29-33 ft.lbs)
- oil pressure sender ..... 30-40 Nm (22-30 ft.lbs)
- adapter for oil dipstick ..... 20-30 Nm (15-22 ft.lbs)

**Clean and inspect cylinder block**

Remove all plugs before cleaning block. Do not remove identification marks for cylinder liners when cleaning.

Clean:

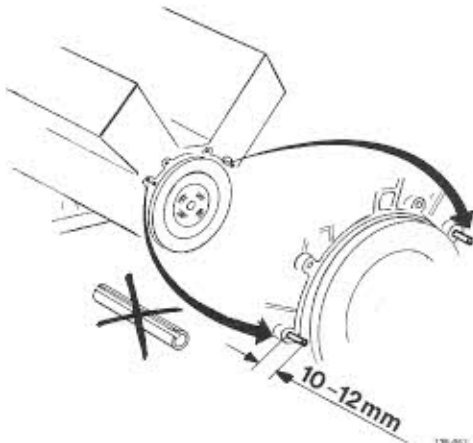
- sealing surfaces. Use a plastic putty knife
- bearing seats
- oil and water channels
- cylinder head bolt holes.

Check for damage, cracks and wear. Also check threads on main bearing bolts.

Re-fit plugs using new seals.

Carry out operation C13 before installing block in fixture.

C12



139 057

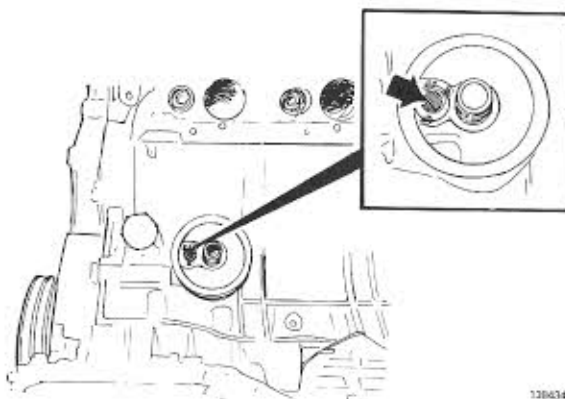
**Check guide pins for gearbox**

Guide pins must protrude **10-12 mm** (0.39-0.47 in) from cylinder block.

If tubular pins are installed, replace these with solid type (P/N 1232544-5).

Secure pins with locking fluid.

C13



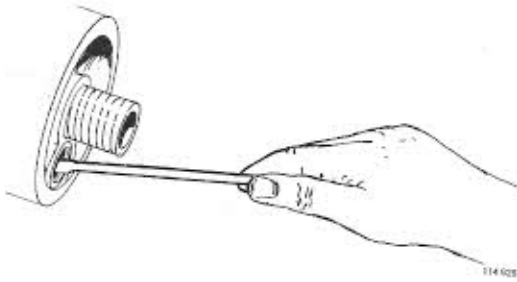
139 634

**Check overflow valve in cylinder block**

Clean filter.

If extremely dirty, replace filter and valve, see next page.

C14



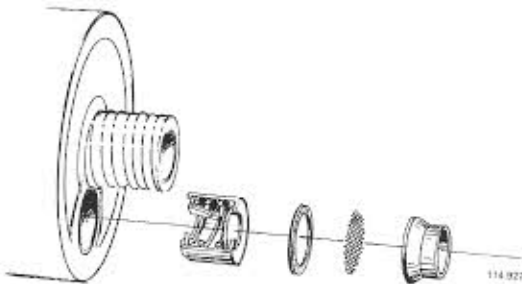
*Overflow valve, replacement  
Operations C15-17*

C15

**Remove old valve and clean seat**

Use a screwdriver.

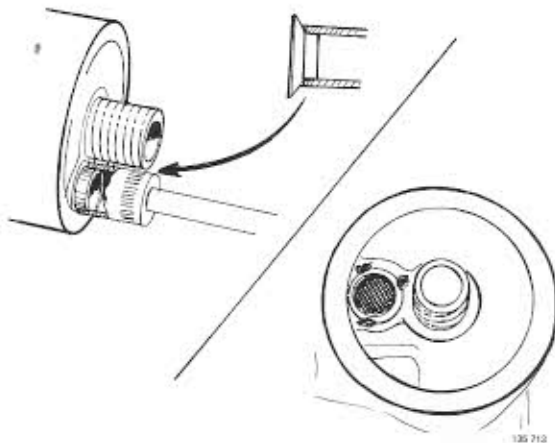
**IMPORTANT!** Take care not to damage the oil filter mating surfaces and make sure that dirt does not enter the oilways.



C16

**Install new parts**

Install valve with spring facing inwards.

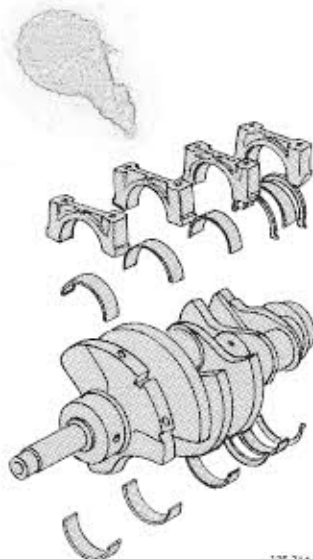


C17

**Tap in washer and secure it**

Use an 11 mm (inner diameter) socket.

Secure washer by making three notches in block with a drift.



C18

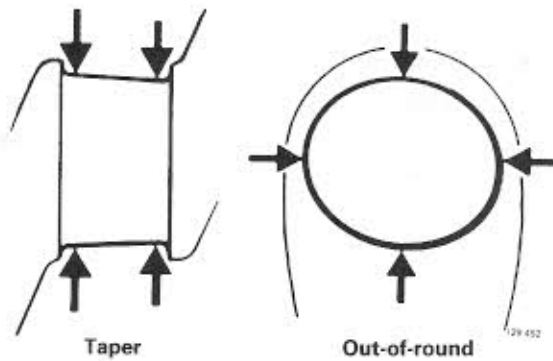
**Clean and check crankshaft, main bearing caps and main bearings**

Clean oilways in crankshaft with a piece of wire and blow clean.

Also check sealing surfaces on crankshaft.

**IMPORTANT!** Do not interchange bearing caps and shells.

C19



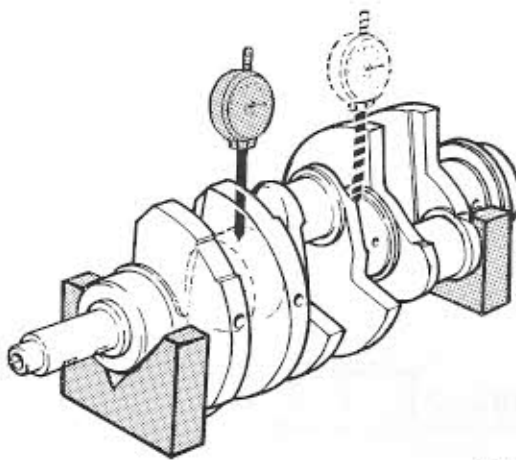
**Measure crankshaft**

Measure out-of-roundness and taper of crank pins. Use a micrometer and take measurements at several different positions.

- Max. out-of-round ..... **0.007 mm** (0.0003 in)
- Max. taper ..... **0.01 mm** (0.0004 in)

Crank pins can be ground to a smaller size, see specifications on page 7.

C20



If crankshaft is thought to have excessive runout, check with a dial indicator.

Support crankshaft by two outer main bearings on a V-block.

Rotate one turn and measure runout for two center crank pins. Max. runout **0.02 mm** (0.0008 in).

**Replacing piston or connecting rod**  
Operations C20-29

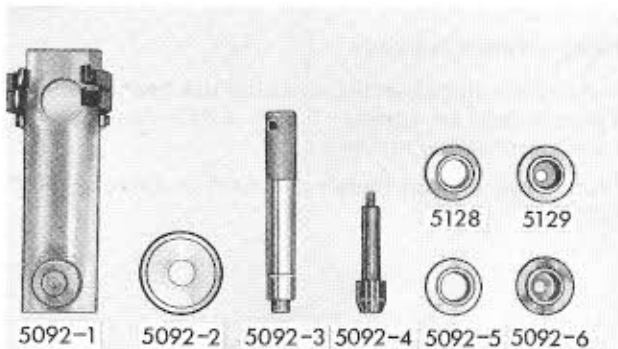
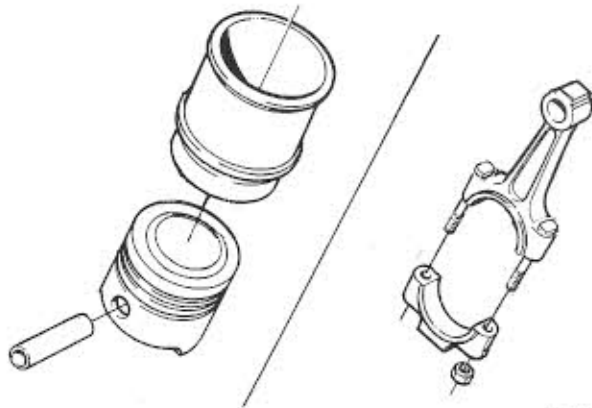
C21

**General**

Pistons – connecting rods should only be disassembled when replacing pistons/liners. Once a piston has been removed it may not be used again. This is because the piston is deformed when the gudgeon (piston) pin is removed.

If a connecting rod is to be removed, it is not necessary to disassemble the piston connecting rod assembly since new connecting rods and pistons must be used.

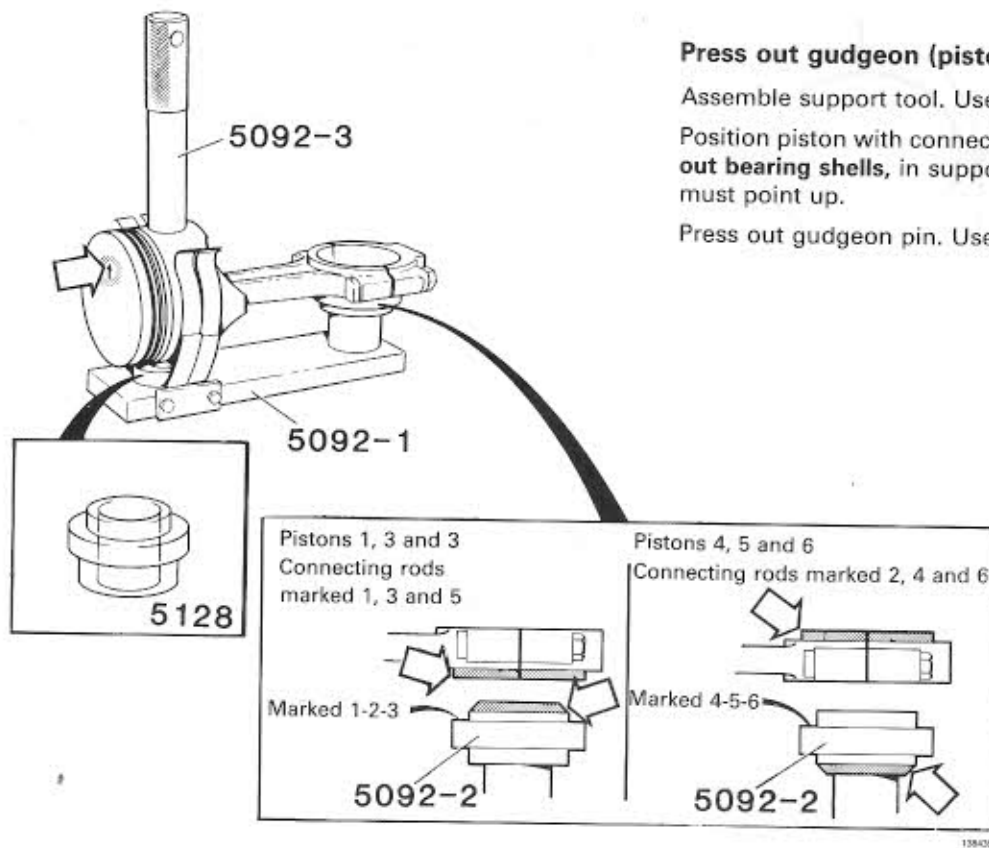
Liner – piston – gudgeon (piston) pin are supplied in matched sets.



**Tools required to replace pistons or connecting rods**

- 5092-1 Holder
- 5092-2 Connecting rod support for big end
- 5092-3 Drift to press out gudgeon (piston) pin, also used as handle to press in pin
- 5092-4 Guide pin, used to press in gudgeon (piston) pin  
(5092-5 & 5092-6 are used on B 27 engines.)
- 5128 Piston support, used when pressing out gudgeon (piston) pin (with large bore)
- 5129 Piston support, used when pressing in gudgeon (piston) pin.

C23

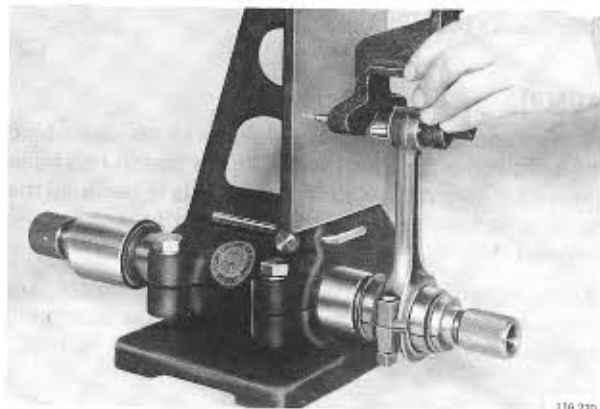


### Press out gudgeon (piston) pin

Assemble support tool. Use 5092-1, 5128 and 5092-2. Position piston with connecting rod and cap, but **without bearing shells**, in support. Arrow on top of piston must point up.

Press out gudgeon pin. Use drift 5092-3.

C24



### Check connecting rods

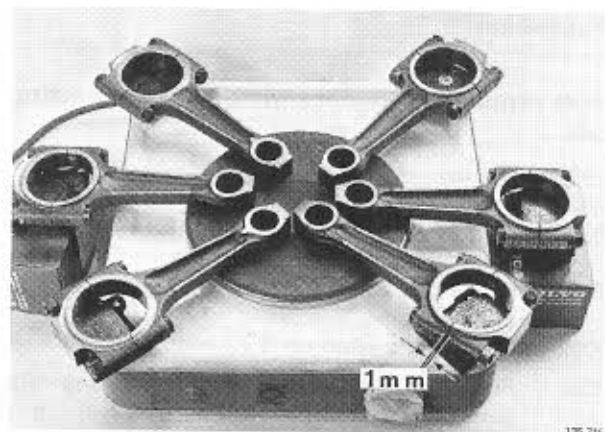
Use an alignment gauge.

Check out-of-true, twist, S-form.

Check bolt threads and replace if necessary, see C10-11.

116 235

C25

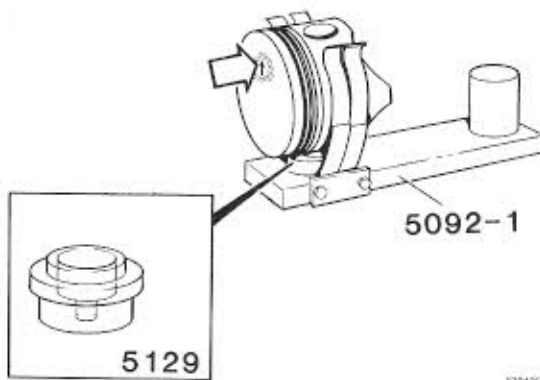


### Heat connecting rods

Install caps on connecting rods but **not bearing shells**. There should be approx. 1 mm (0.04") clearance between connecting rod and cap.

Place small end on heater and heat to approx. 250°C (480°F).

135 716

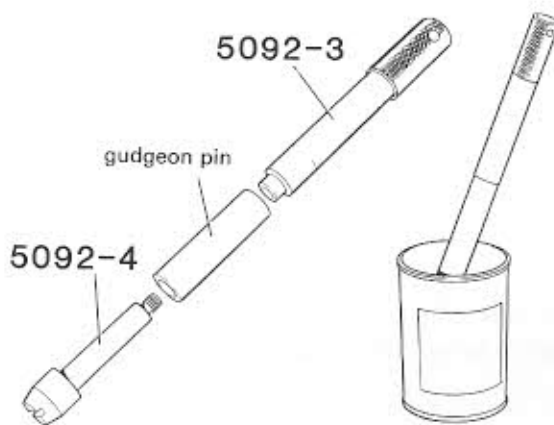


C26

**Place piston support and piston in holder 5092-1**

Use piston support 5129.

Arrow on top of piston must point up.



C27

**Place gudgeon (piston) pin in tool**

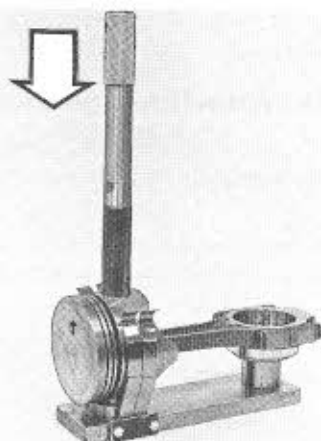
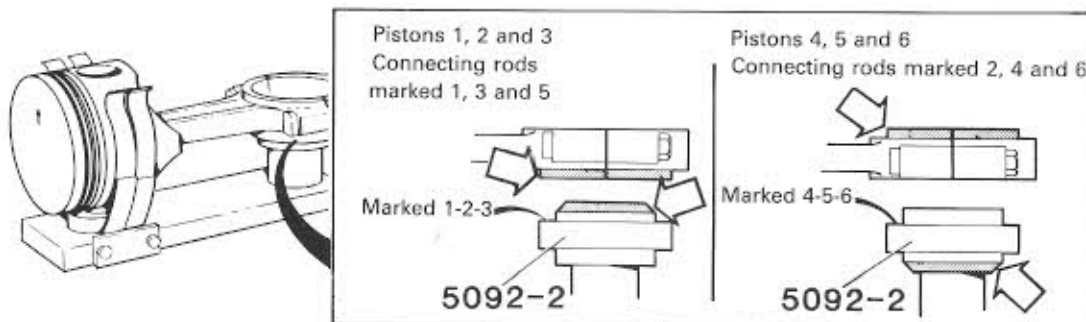
Immerse in oil

C28

**Place connecting rod support and connecting rod in holder**

**IMPORTANT!** Connecting rod support and connecting rod must be turned in different directions for different pistons—connecting rods.

Gudgeon (piston) pin must be pressed in **immediately** (Operation C29), otherwise it may jam halfway.

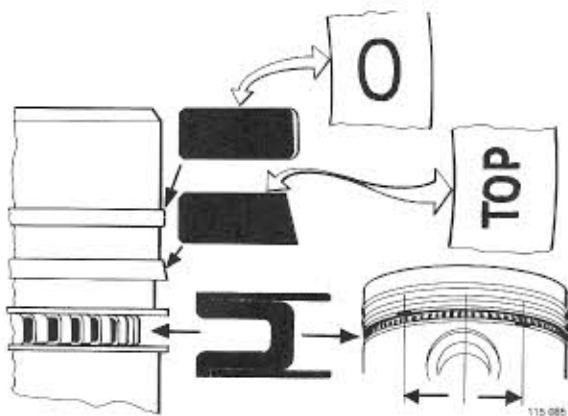


C29

**Press in gudgeon (piston) pin**

Quickly press down drift by hand until it contacts support tool.

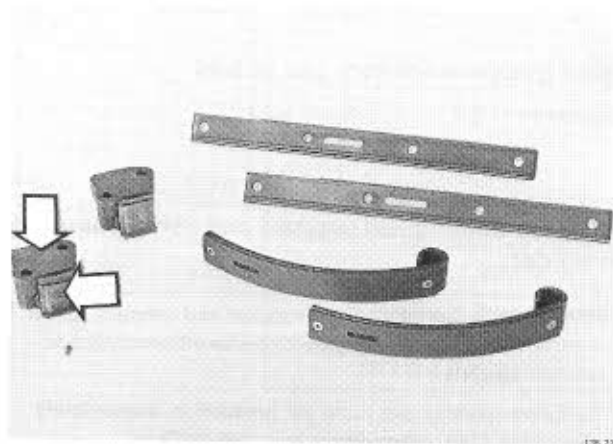
Lift away piston with connecting rod from holder. Remove drift and guide pin from gudgeon pin.



C30

**Install piston rings**

Note position of oil ring gap.



C31

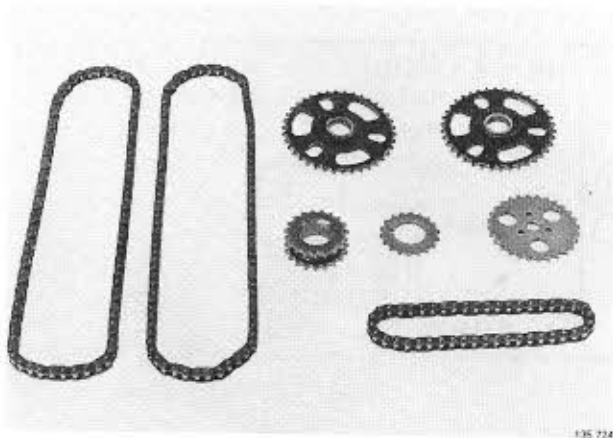
**Clean, check chain tensioners and chain dampers**

**IMPORTANT!** Do not disassemble tensioners. If locking pin falls out, complete tensioner must be replaced.

Check that oilways in chain tensioners do not leak.

Check dampers for damage and wear.

Replace parts as necessary.

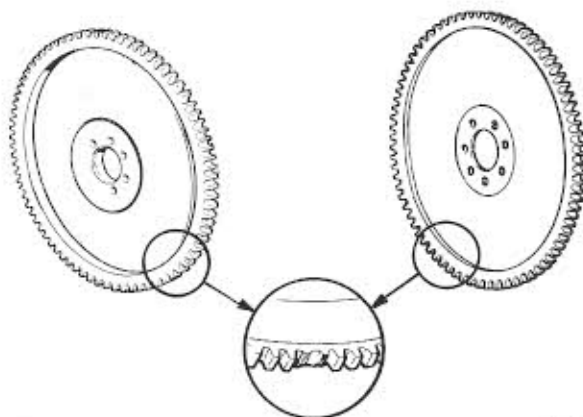


C32

**Clean, check chains and sprockets**

Check for damage and wear.

**IMPORTANT!** If damaged, replace chains and sprockets together. Also replace oil strainers behind tensioners.



C33

**Clean, check flywheel (man. gearbox) and carrier plate (auto.)**

Damaged carrier plate/ring gear must be replaced as one unit.

Damaged or worn flywheel must be replaced with ring gear attached. If necessary, ring gears can be replaced separately.

New flywheels are rustproofed and should be washed (degreased) prior to assembly.

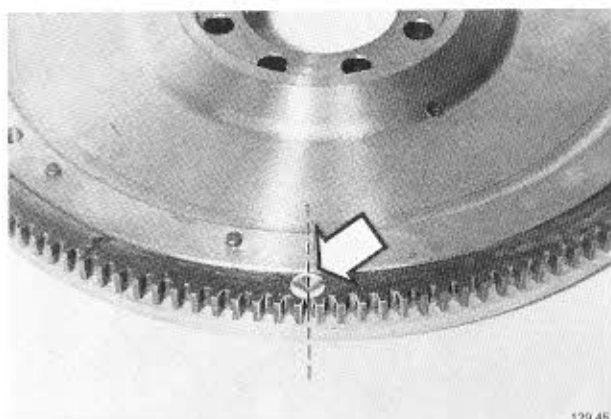
*Replacing ring gear  
Operations C34–38*

C34

**Heat new ring gear to +230°C (446°F)**

Heat in an oven or by oxyacetylene flame.

If oven is to be used begin heating at this time. With oxyacetylene, heat just before installation.



129 451

C35

**Drill hole between two cogs**

Use a 10 mm (0.4 in) drill.

Hole depth = 9 mm (0.35 in).

**IMPORTANT!** Do not drill into flywheel since this may cause an imbalance.



129 452

C36

**Remove ring gear**

Mount the flywheel in a vice protected by soft jaws.

Pry off ring gear with a screwdriver. It may be necessary to split the ring gear above the drilled hole.

Clean contact surfaces on flywheel.

C37

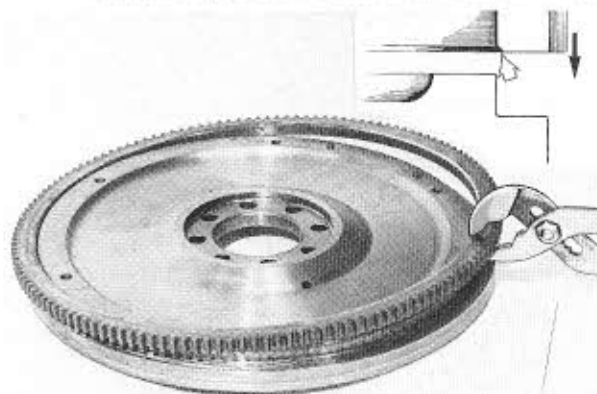
**Heat new ring gear to approx. 230°C (446°F)**

Check temperature with solder (40 % tin, 60 % lead). Solder melts at 220–230°C (428–446°F).

C38

**Install new ring gear**

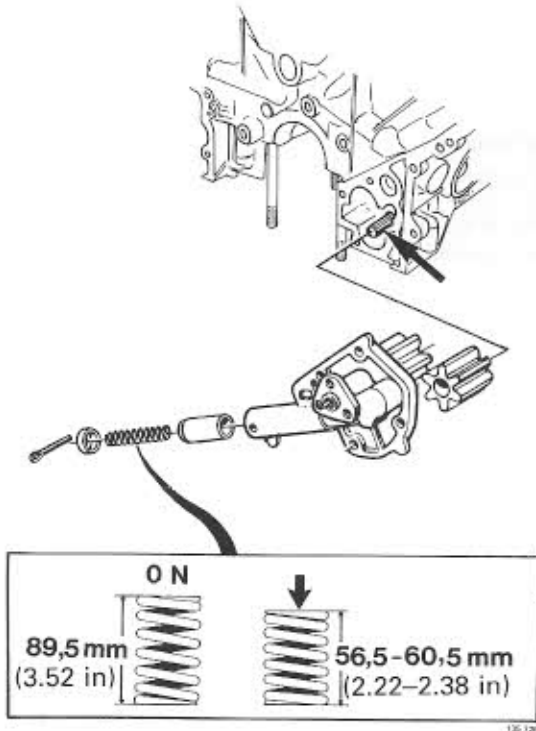
Position ring gear.



129 449

**IMPORTANT!** Bevelled side of ring gear must face flywheel.

If necessary tap ring gear until flush. Use a brass drift. Leave to cool.



C39

### Clean and inspect oil pump

Disassemble and clean oil pump.

Check for damage and wear and also that relief valve plunger operates smoothly.

Check that shaft is firmly secured to cylinder block.

Test relief valve in a spring tester.

Replacement oil pumps are only available as complete units (pump body cover, gears and relief valve). Spare parts for the relief valve are, however, available.

Re-assemble pump.

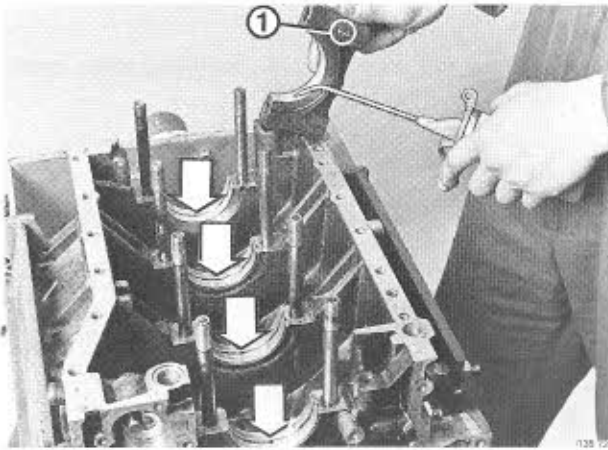
C40

### Clean and check parts

Oil strainer, sump, lower crankcase, valve covers and timing gear case.

## D. Engine assembly

Always use new seals, O-rings and gaskets when assembling the engine.



### CRANKSHAFT

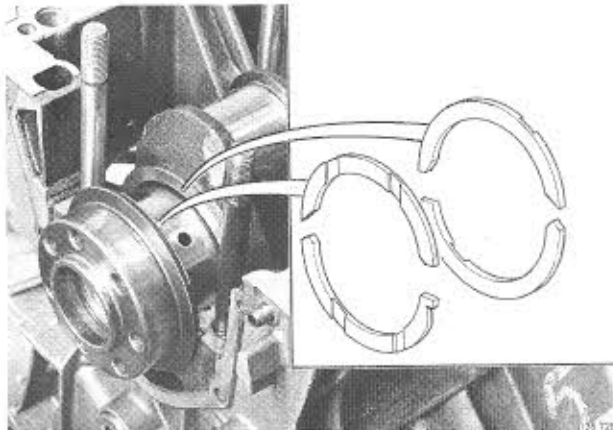
D1

#### Install main bearing shells in engine block and main bearing cap

Make sure that matched pairs are installed together. Bearing cap at flywheel end is marked 1.

Note! The holes in the bearing shells must coincide with the oilways in the engine block.

Lubricate the bearing shells and studs.



D2

#### Position crankshaft

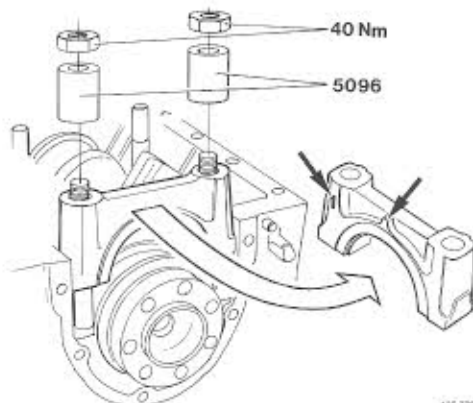
Lubricate bearings.

D3

#### Install thrust washer segments

Lubricate washers.

Note the oilways in the two lower segments.



D4

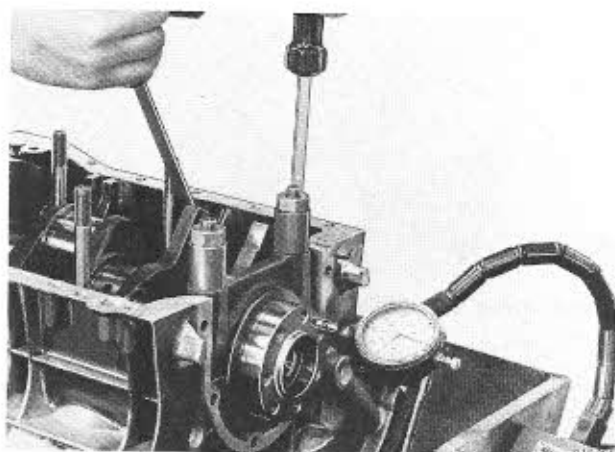
#### Install rear main bearing cap with shells and holder 5096 for main bearing

Rear cap is marked 1.

Identification number and casting lug on the bearing cap should face forwards.

Install cap, holder and nuts.

Torque to **40 Nm** (30 ft.lbs)



D5

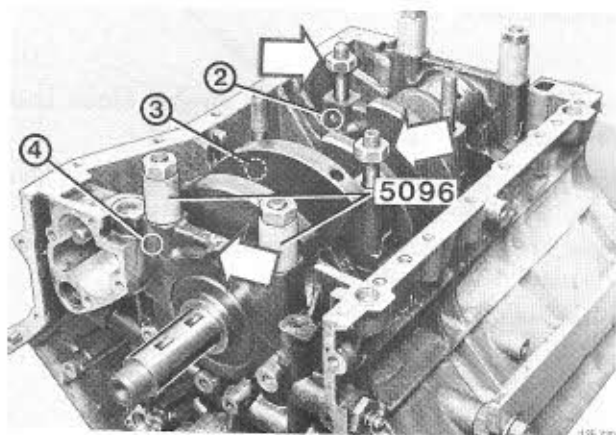
**Check crankshaft end float**

Move the crankshaft lengthwise back and forth and measure the clearance with a dial indicator.

End float ..... **0.070–0.270 mm**  
(0.0027–0.0106 in)

Replace thrust washers if necessary. Washers are available in the following sizes:

- standard ..... 2.30–2.35 mm (0.0905–0.0925 in)
- OS 1 ..... 2.40–2.45 mm (0.0944–0.0964 in)
- OS 2 ..... 2.45–2.50 mm (0.0964–0.0984 in)
- OS 3 ..... 2.50–2.55 mm (0.0984–0.1003 in)

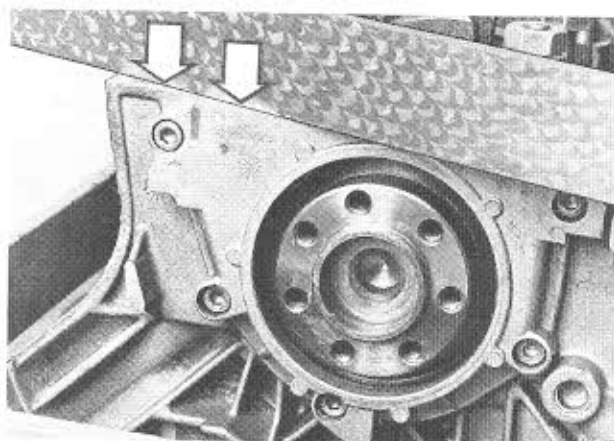


D6

**Install three remaining main bearing caps with shells**

Identification numbers 2, 3 and 4 and the casting lugs on the caps must face forwards.

Secure front bearing cap with holder **5096** and install nuts on each of the two centre caps.



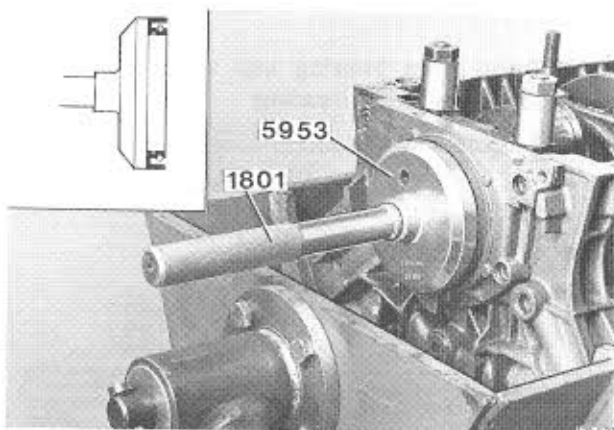
**CRANKSHAFT REAR SEAL, PILOT BEARING**

D7

**Install seal holder**

Use a new seal.

Using a straight edge, make sure that the holder is flush with the cylinder block.



D8

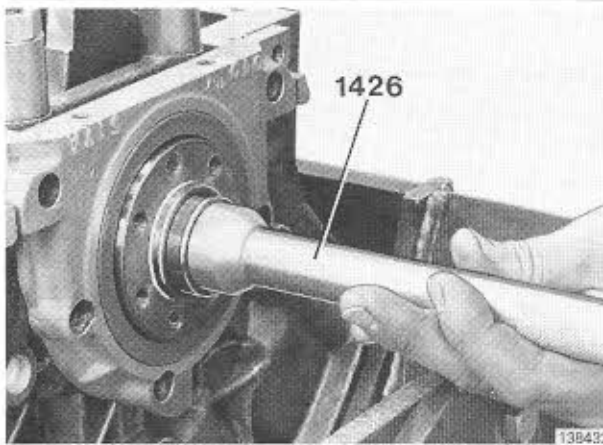
**Install crankshaft seal**

Assemble standard handle **1801** and drift **5953**.

Lubricate the seal and groove. Pack grease between the sealing lips.

Place the seal on the drift, see fig.

Tap in the seal until the drift contacts the crankshaft.

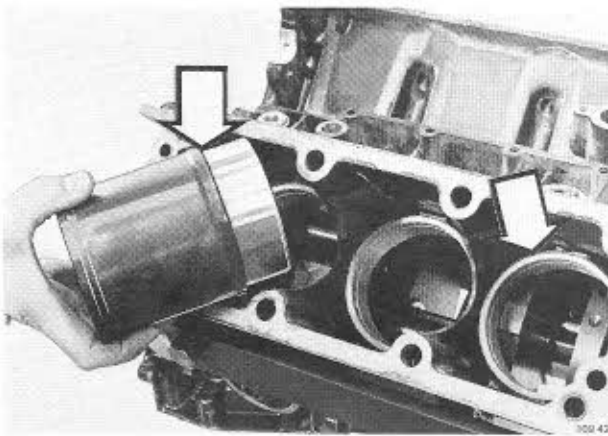


Cars with manual gearbox

D9

**Install new pilot bearing in crankshaft**

Tap in the bearing until it contacts the crankshaft.  
Use drift 1426.



**CYLINDER LINERS**

D10

**Check mating surfaces for shims**

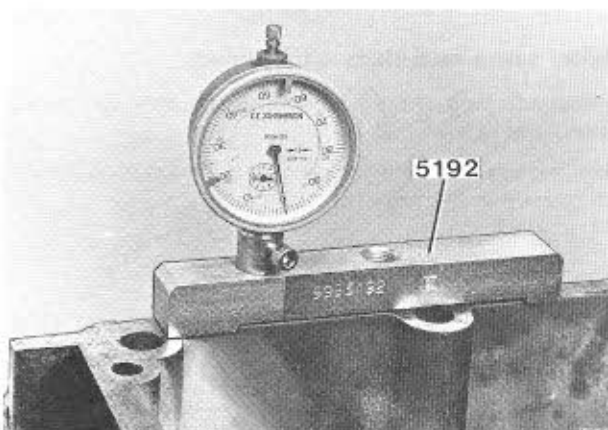
Check that surfaces in liner and block are clean and free from defects.



D11

**Install no. 1 liner without shim**

Check line-up marks and number.  
Install two holders 5093, hand tight.

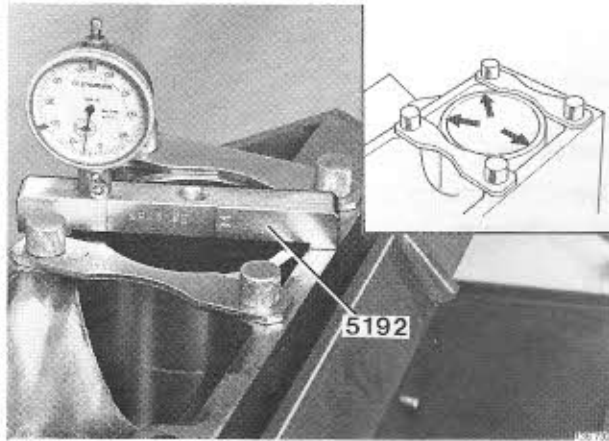


D12

**Set dial indicator zero position**

Place dial indicator in outer hole in holder 5192 (5094 can also be used).

Rest holder on a flat surface (e.g. cylinder block) and set to zero, making sure that there is a preload on the indicator.



D13

**Measure liner height**

Measure at three different positions, as shown in adjacent fig.

Difference between the three measurements must **not exceed 0.05 mm** (0.002 in). If greater, check for dirt, etc.

Use the highest measurements for the calculation.

Example: 1st measurement ..... 0.11 mm (0.004 in)  
 2nd measurement ..... 0.08 mm (0.003 in)  
 3rd measurement ..... 0.09 mm (0.004 in)  
 Difference between measurements does not exceed 0.05 mm (0.002 in) and highest measurement is 0.11 mm (0.004 in).

D14

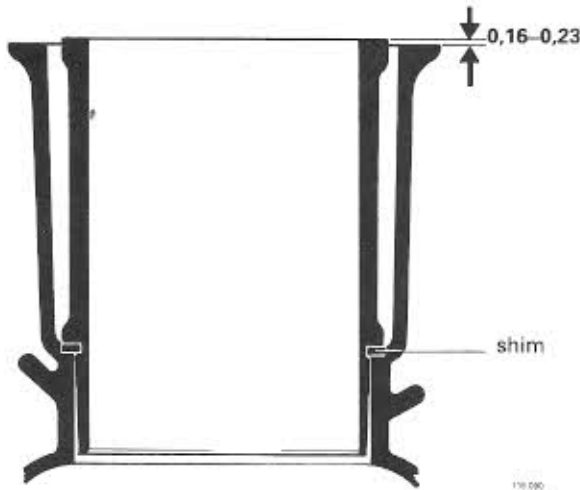
**Select correct size shim**

Distance between top of liner and block should be **0.16–0.23 mm**. Gap should be as near as possible to 0.23 mm.

Select a shim which is the same or just under the calculated thickness.

Shims are available as follows:

| Colour | Thickness                         |
|--------|-----------------------------------|
| Blue   | 0.070–0.105 mm (0.0027–0.0041 in) |
| White  | 0.085–0.120 mm (0.0033–0.0047 in) |
| Red    | 0.105–0.140 mm (0.0041–0.0055 in) |
| Yellow | 0.130–0.165 mm (0.0051–0.0065 in) |



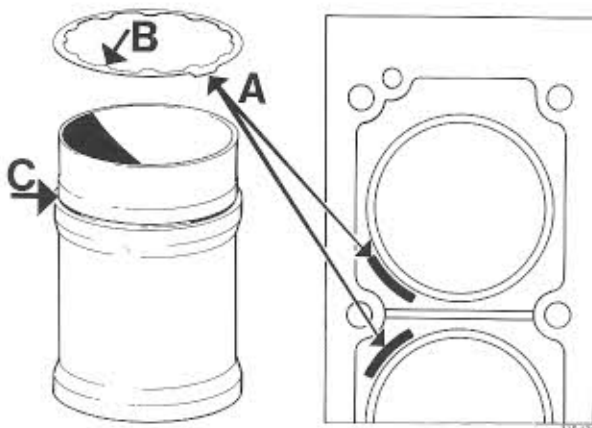
Example:  
 Max. specified gap ..... 0.23 mm (0.009 in)  
 Measured gap (without shim) ..... 0.11 mm (0.004 in)  
 Difference ..... 0.12 mm (0.005 in)  
 Select a white shim.

D15

**Install same size shim on all liners**

Colour marking should face upwards and be visible when liner is installed.

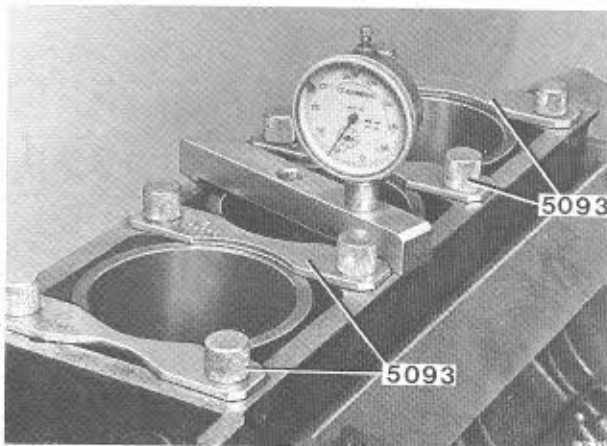
The tongues (B) on the inside of the shim should fit into the groove in the liner (C).



D16

**Install liner in block**

Observe liner identification marks as applicable.



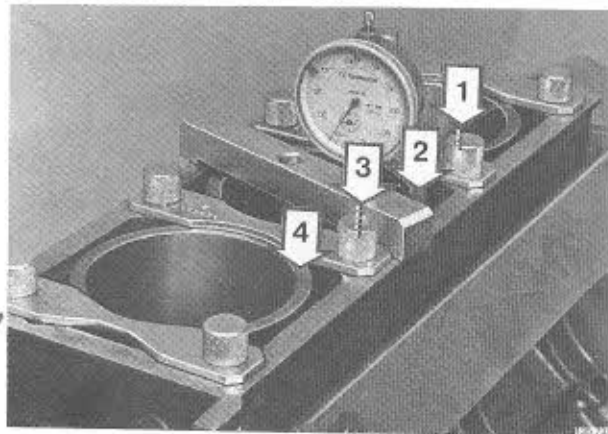
### Check liner/deck height

Install four holders 5093 for one bank of cylinders.  
Measure height at three places. Difference between values must not exceed 0.05 mm (0.0020 in).

Liner height = 0.16–0.23 mm (0.0063–0.009 in).

Replace shims if necessary.

D17



### Measure difference in height between next liner

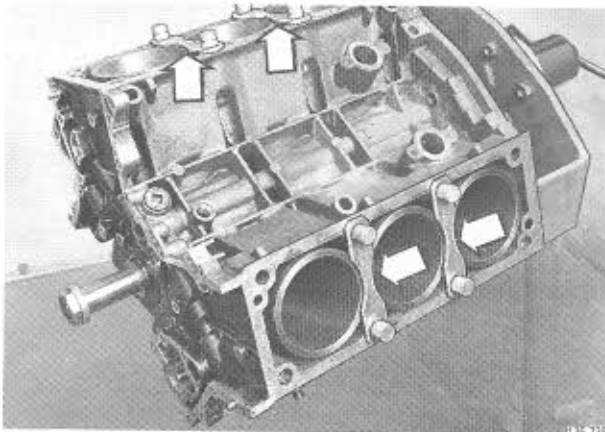
Measure at points 1, 2, 3 and 4 as illustrated.

Difference between 1 and 2 resp. 3 and 4 must not exceed max. 0.04 mm (0.0016 in)

Replace shims if necessary and re-measure according to D17.

If new liners are used and difference is too large, rotate liners or change positions and re-measure.

D18

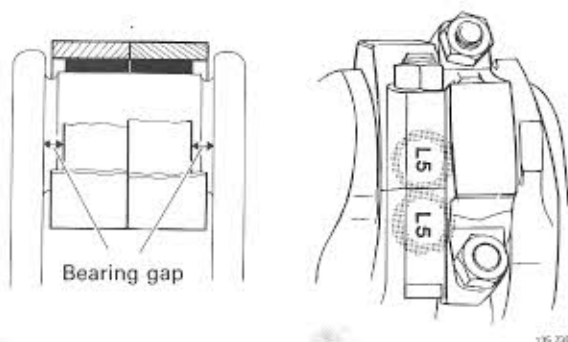
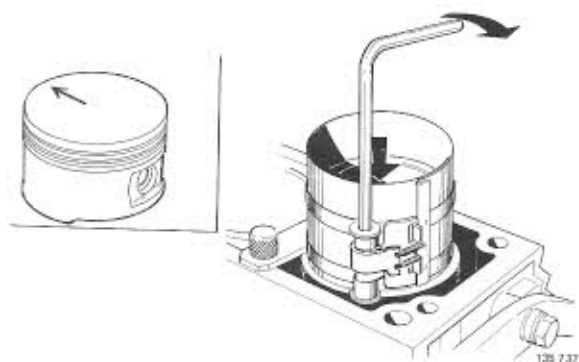
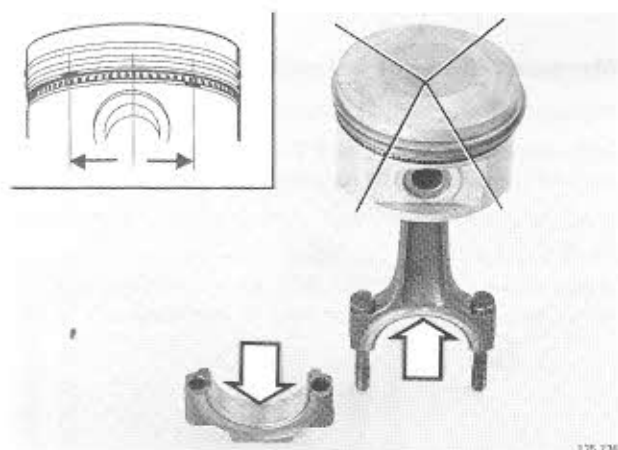


### Measure liner/deck height for 2nd cylinder bank

Follow D17–18.

Then transfer the two outer holders to the 1st cylinder bank.

D19



### PISTONS, CONNECTING RODS

|                                   |   |   |   |   |   |   |
|-----------------------------------|---|---|---|---|---|---|
| Cylinder                          | 1 | 4 | 2 | 5 | 3 | 6 |
| Marking of connecting rod and cap | 1 | 2 | 3 | 4 | 5 | 6 |
| Crank webs, from rear             | 1 | 2 | 3 |   |   |   |

D20

**Install bearing shells in connecting rods and caps**

D21

**Turn piston rings so that gaps are not in line**

Note position of oil ring gap.

D22

**Lubricate:**

- bearing shells
- cylinder bores
- pistons.

D23

**Install piston**

Use a piston ring compressor tool.

**IMPORTANT!** Arrow on top of piston must point forwards.

D24

**Install connecting rod cap**

Use new nuts, lubricate mating surface.

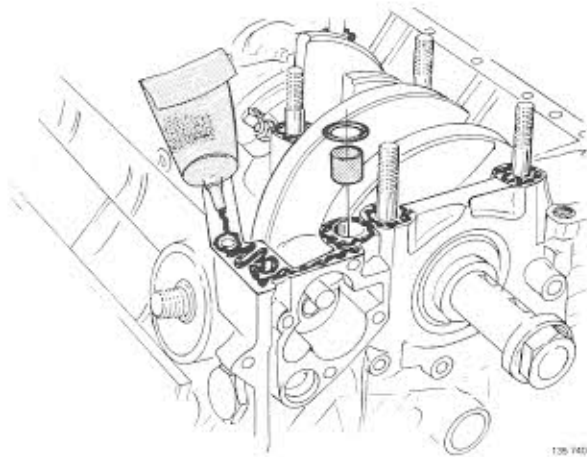
Torque to **45-50 Nm (33-37 ft.lbs)**.

Check that crankshaft can be rotated.

**IMPORTANT!** Marks on connecting rod and cap must match.

Bearing gap should point:

- rearwards for cylinder 1, 2 and 3
- forwards for cylinders 3, 5 and 6.



D25

**Install sleeve and O-ring in oil channel**

D26

**Remove main bearing holders and nuts**

If any of the pin studs is slack torque to 15–20 Nm (11–15 ft.lbs).

D27

**Apply sealer**

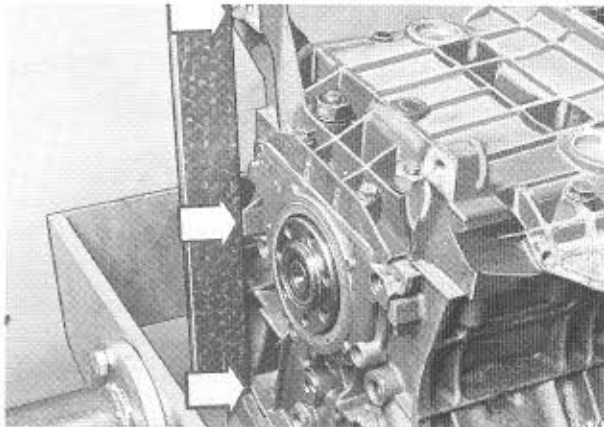
Mating surfaces for lower crankcase as well as main bearing caps should be smeared with sealer P/N 1161058-1.

D28

**Install lower crankcase**

Tighten nuts and bolts by hand.

Align crankcase so that rear edge is flush with cylinder block rear. Use a straight edge. Check both sides.



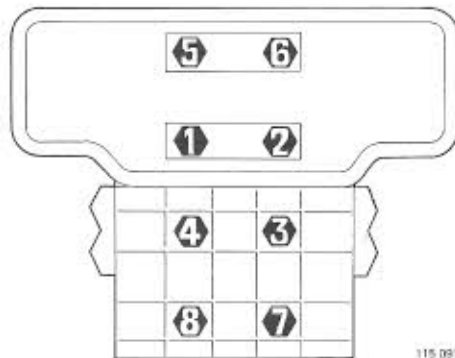
**IMPORTANT!** Crankcase and cylinder block must be flush otherwise distortions may result and cause noise or damage.

D29

**Tighten main bearing nuts**

Tighten in order shown adjacent to 30 Nm (15 ft.lbs).

Re-check that lower crankcase lies flush with the rear of cylinder block, see D28.



115 091

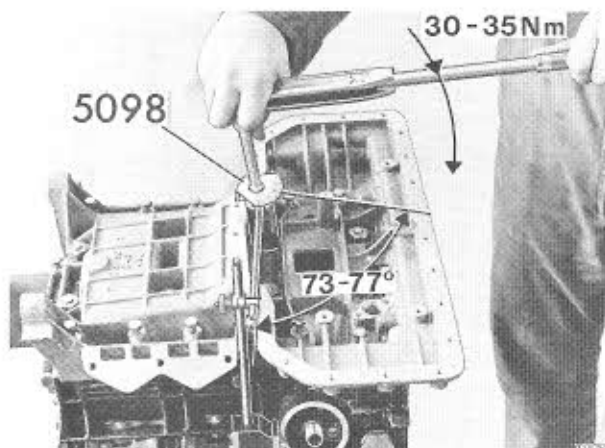
D30

**Angle-tighten main bearing nuts**

Use protractor 5098.

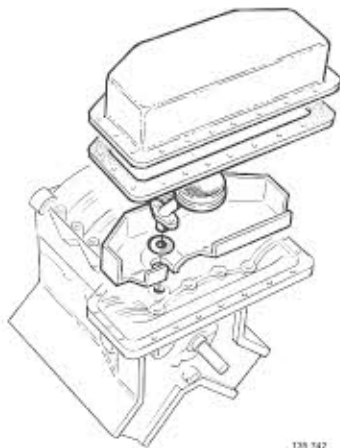
A measuring stand can be used to align the protractor. The magnetic base of the stand should be placed on fixture 5099 and the arm pointed towards the protractor.

- Slacken nut 1
- Tighten nut 1 to 30–35 Nm (15–27 ft.lbs).
- Angle-tighten nut 1 by 73–77°
- Slacken and re-tighten remaining nuts in order specified above.



D31

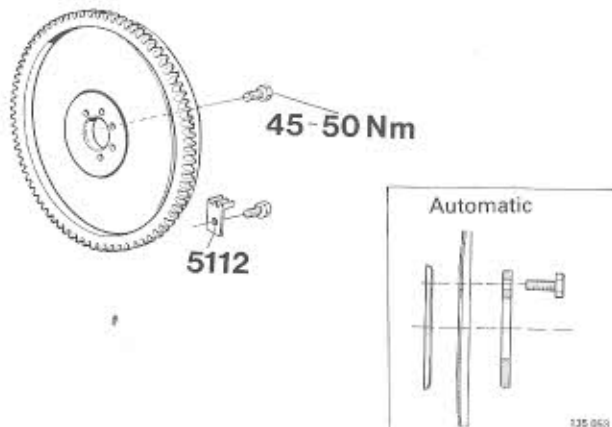
**Check that crankshaft can be rotated**  
**Tighten bolts for lower crankcase**



D32

**Install:**

- splash panel
- oil strainer with O-ring
- oil sump with gasket.



**FLYWHEEL, CLUTCH, CARRIER PLATE**

D33

**Install flywheel (manual)**

**Install carrier plate (automatic)**

Flywheel/carrier plate can only be installed in one position since bolt holes are asymmetrically located.

Use **new** bolts.

Torque to **45-50 Nm** (33-37 ft.lbs). Use locking sector **5112** to lock the flywheel.

**Auto:** Note position of support plates. Inner plate should be turned with bevel forwards.

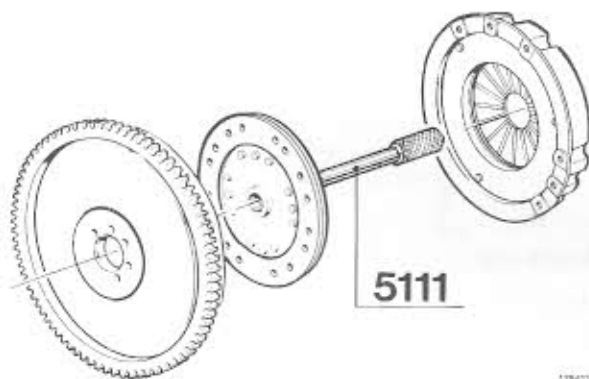
D34

**Install clutch driven plate and pressure plate**

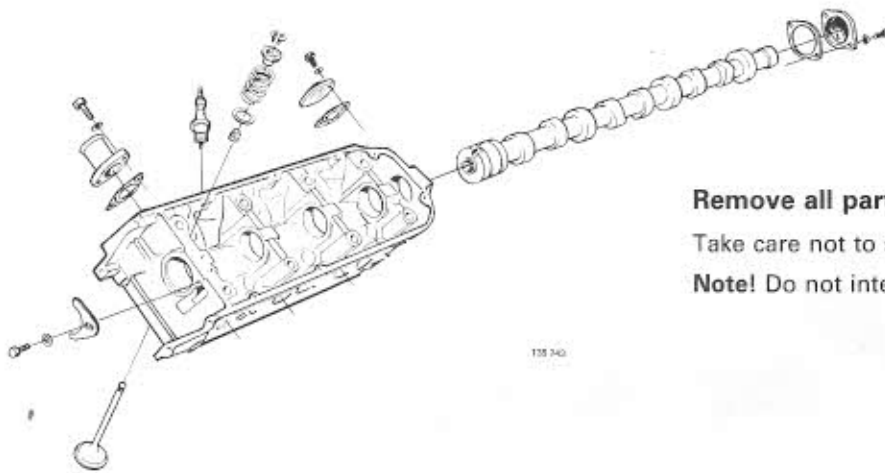
Turn the plate so that the hub faces outwards, away from the flywheel.

Tighten pressure plate retaining screws crosswise, a few turns at a time to avoid distorting the plate.

Use centering drift **5111**.



## E. Cylinder head, reconditioning

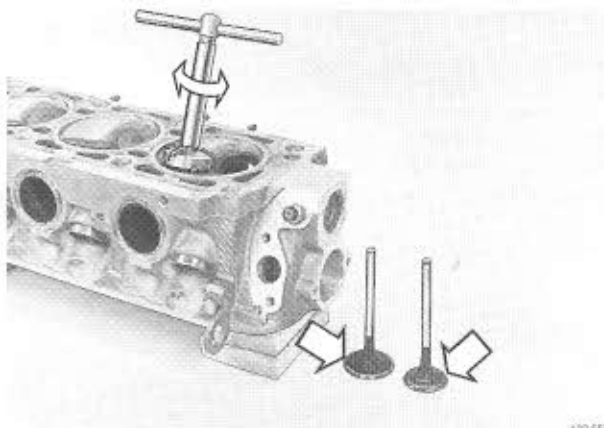


E1

### Remove all parts from cylinder head

Take care not to score/damage the mating surfaces.

**Note!** Do not interchange valve parts.



E2

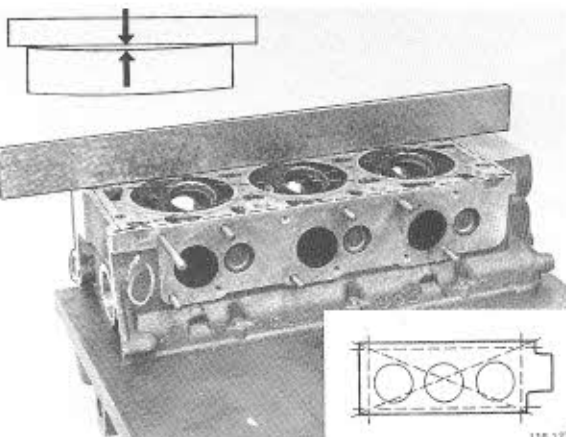
### Clean cylinder head and parts

Remove carbon deposits from the combustion chambers and valves.

Clean valve seats with a grinder (to be able to see cracks, damage, etc.).

Clean gasket mating surfaces.

Use a plastic scraper and, if necessary, a fine grade wet abrasive paper.



E3

### Check all parts

Visible damage, wear, etc.

E4

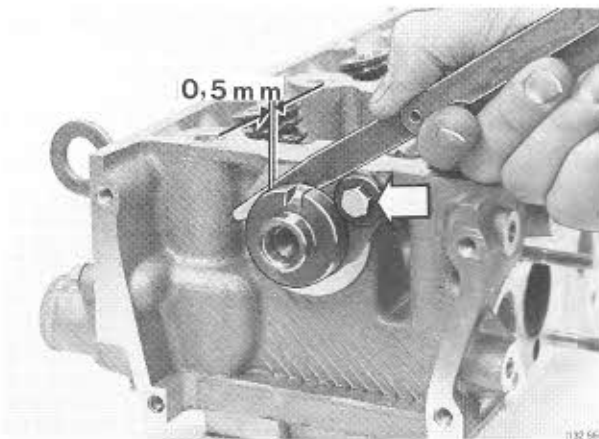
### Check cylinder head for warp

Use a straight edge and feeler gauge.

Warp = max. **0.05 mm (0.002 in)** per 100 mm (3.94 in).

The cylinder head must not be machined but, instead, replaced if the warp is too great.

E5

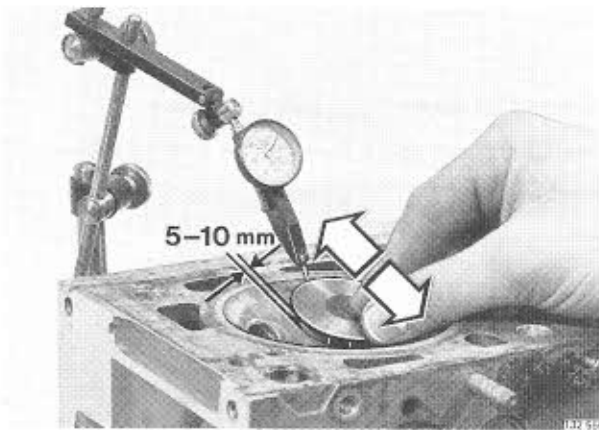


**Check camshaft end float**

Position the camshaft and make sure that it turns easily. Fit the locking fork. Measure the end float with a feeler gauge. The clearance must not exceed max. **0.5 mm (0.020 in)**. Replace the locking fork if the end float is too large.

Remove the locking fork and camshaft.

E6



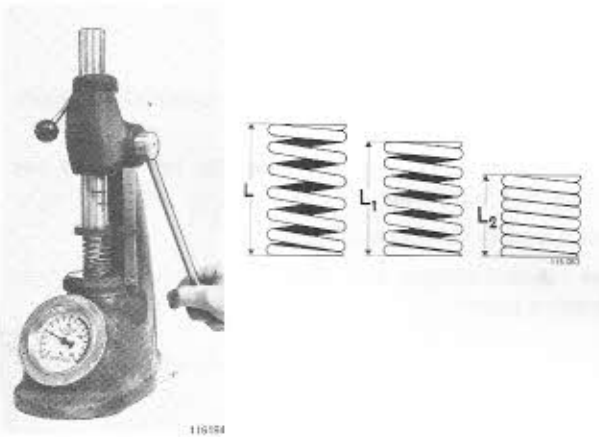
**Check valve guide – valve clearances**

Use a dial indicator.

Use new valves and press up **5–10 mm (0.2–0.4 in)** with finger when measuring.

The clearance must not exceed max. **0.15 mm (0.0059 in)**.

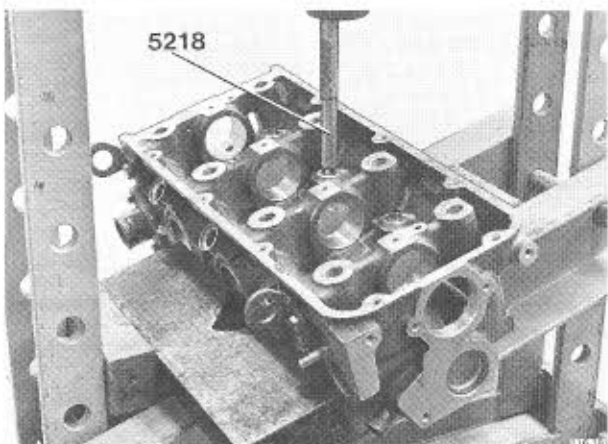
E7



**Check valve springs**

| Color code | Length mm (in) | Load N (lbs)      |   |
|------------|----------------|-------------------|---|
|            |                | 0                 | 0 |
| GREEN      | 47.1 (1.85)    | 0                 | 0 |
|            | 40.0 (1.57)    | 230–266 (51–59)   |   |
|            | 30.0 (1.18)    | 613–689 (137–154) |   |

E8

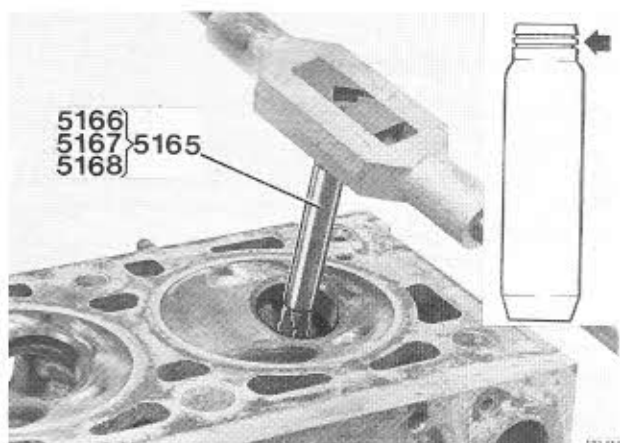


*Valve guide replacement  
Operations E8–11*

**Press out valve guides**

Use drift **5218**.

Place the cylinder head on a sloping surface so that the valve guides are vertical.



E9

**Select a new valve guide, one size larger than old one**

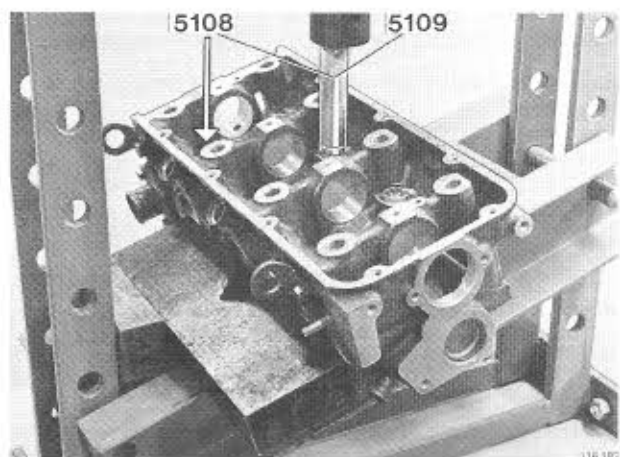
Valve guides are marked with grooves.

Ream seat for guide.

See table.

| Valve guide | Mark      | Reamer |
|-------------|-----------|--------|
| Standard +  | no groove | —      |
| Oversize 1  | 1 groove  | 5166   |
|             | 2 grooves | 5167   |
|             | 3 grooves | 5168   |

E10



**Press in new guide**

Heat cylinder head to approx. 150°C. (300°F).

Cool valve guide to approx. -70°C (-95°F).

Use liquid carbon dioxide or equivalent to cool the valve guides.

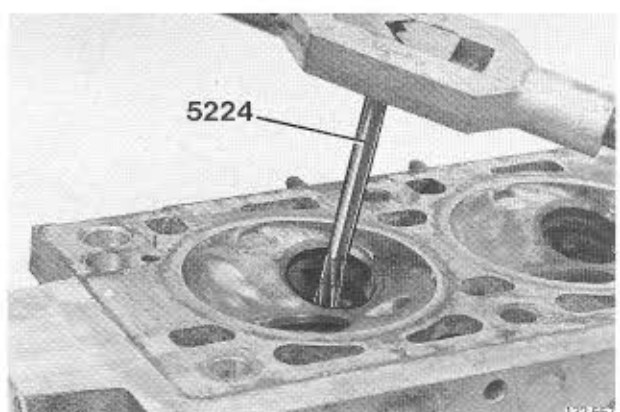
**Warning!** Wear protective gloves and safety glasses.

Place the cylinder head on a sloping surface so that the valve guides are vertical.

Use drift 5108 for intake and 5109 for exhaust valve guides.

**IMPORTANT!** This must be done very quickly, within 3-4 secs.

E11

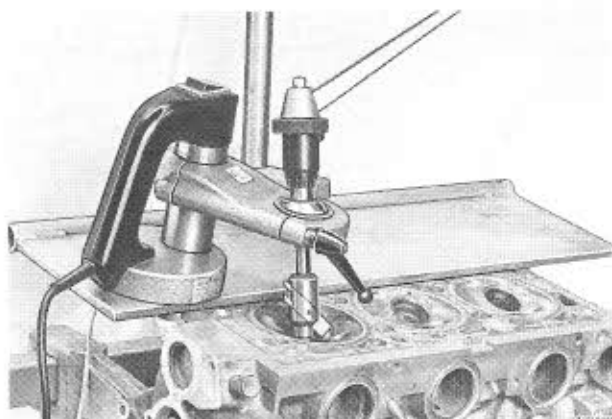


**Clean inner surface of new valve guides**

Use reamer 5224.

Reamer 5164 can also be used.

**IMPORTANT!** Valves and valve seats must be ground-in if guide has been replaced.



## Valve seat replacement

Operations E12–16

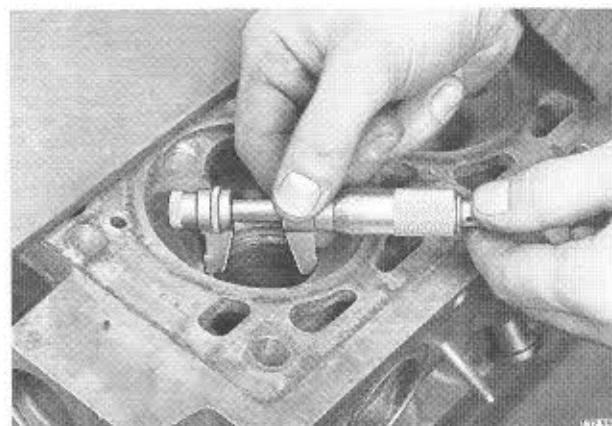
**Note!** Valve guides must always be renewed before replacing seats, see E8–11.

E12

### Clean combustion chambers

Clean the surfaces until the edge of the inserted seat is clearly visible.

E13



### Remove valve seat

Machine the valve seat. Use Mira valve cutter P/N 998 6045-5. Follow the manufacturer's instructions.

Make sure that the cylinder head is not damaged. Clean carefully.

E14

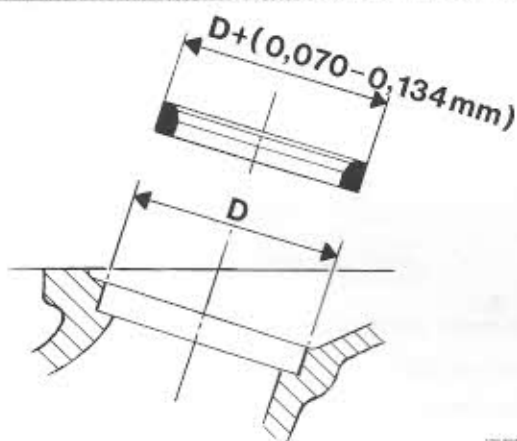
### Measure valve seat diameter in cylinder head and select a new seat of correct size

Use an internal micrometer.

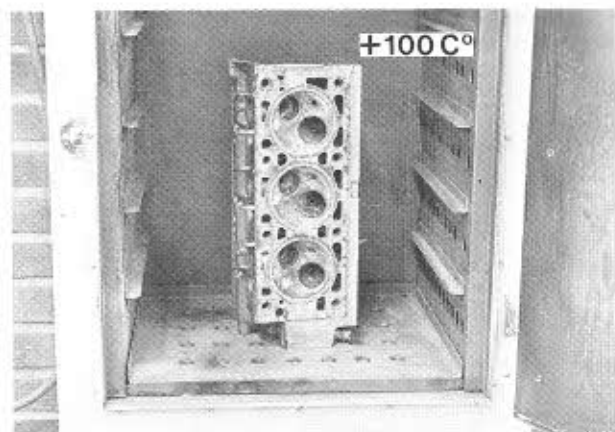
Valve seats are available in three oversizes.

The interference between the valve seat and recess in the cylinder head must be **0.070–0.134 mm** (0.0027–0.0052 in), i.e. the valve seat must be 0.070–0.134 mm larger than the recess in the cylinder head.

If too small, fit a new cylinder head. If too large, mill the valve seat to correct size. Use a valve cutter.



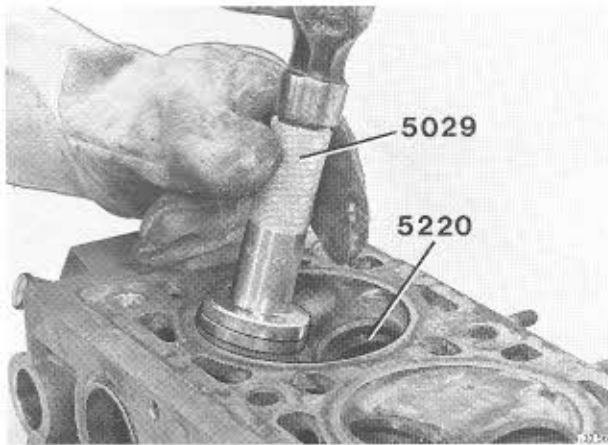
E15



### Heat up cylinder head

Approx. 100°C. (212°F).

E16



### Install new valve seats

Place seat on special tool **5029** (intake valve seats) or **5220** (exhaust valve seats).

Cool valve seat to  $-70^{\circ}\text{C}$  ( $95^{\circ}\text{F}$ ).

Use liquid carbon dioxide or equivalent.

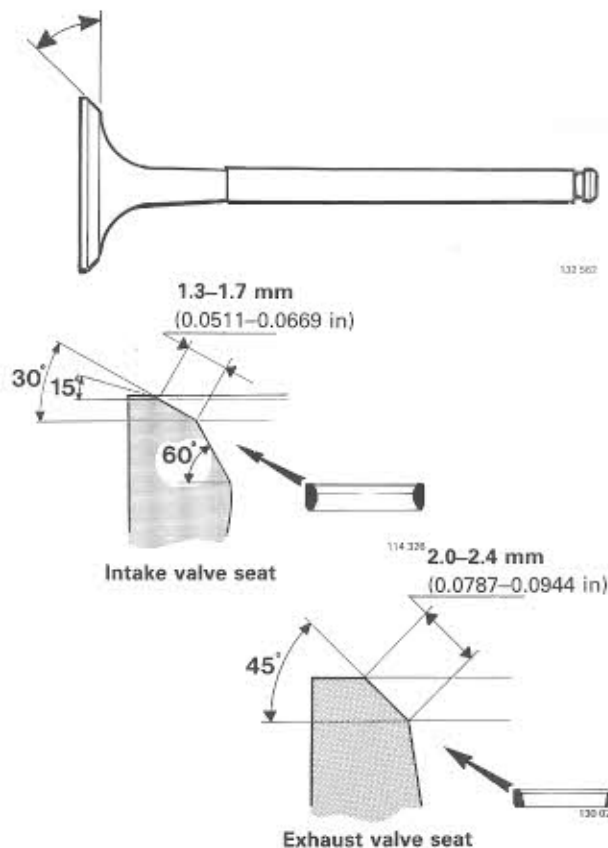
**Warning!** Wear protective gloves and safety glasses.

Tap in valve seat

**IMPORTANT!** This must be done quickly, within **3-4 seconds** to avoid temperature loss.

Check fit of valve seat. Make sure that the seat has bottomed correctly and is secure. If not, fit a larger size.

**IMPORTANT!** After valve seat replacement, valve seats must be milled and valves ground.



### Grinding of valves and valve seats

Operations E17-18

E17

#### Machine grind valves

Intake valves .....  $29.5^{\circ}$

Exhaust valves .....  $44.5^{\circ}$

Also grind flush the end of the valve stem.

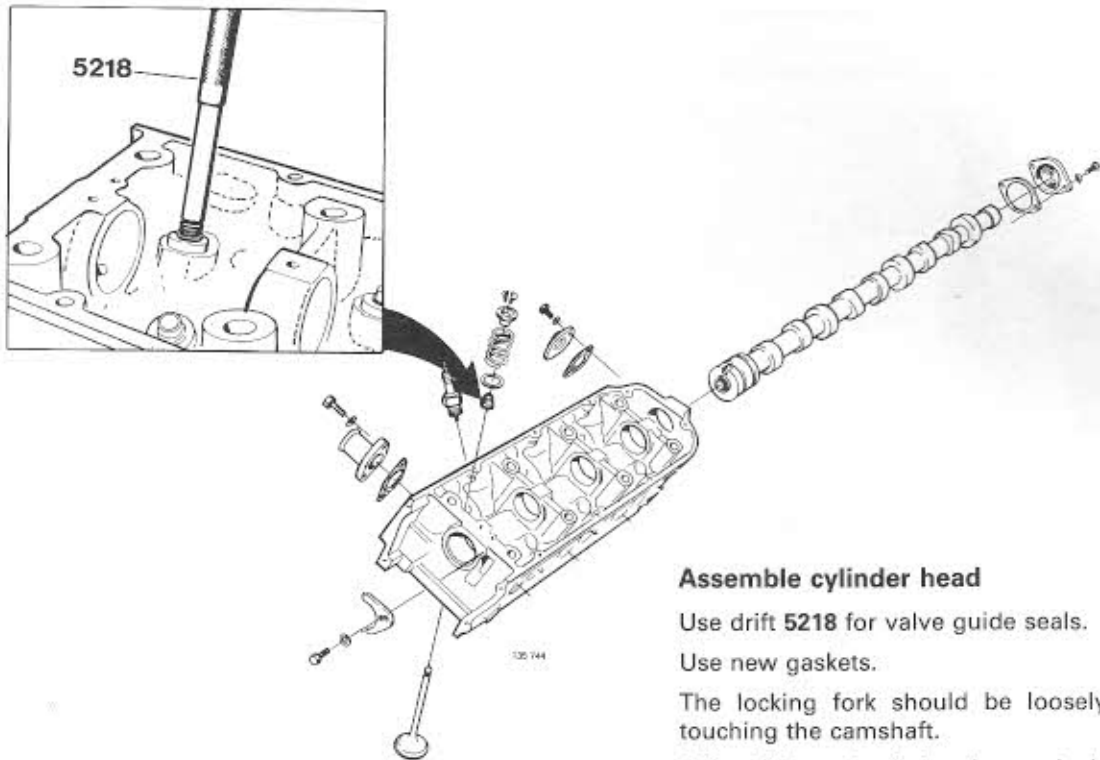
E18

#### Mill or grind valve seats

##### Check valve fit

If necessary grind-in valves with grinding paste.

Venturi seat:  $15^{\circ}$  and  $60^{\circ}$  angles can be used to reduce seat width.



E19

### Assemble cylinder head

Use drift 5218 for valve guide seals.

Use new gaskets.

The locking fork should be loosely fitted and not touching the camshaft.

Before fitting, check that the spark plugs are clean, replace if necessary. Electrode gap = 0.6 mm (0.024 in). Tightening torque 12±2 Nm (9±1.5 ft.lbs).

E20

### Clean and check rocker arm shaft

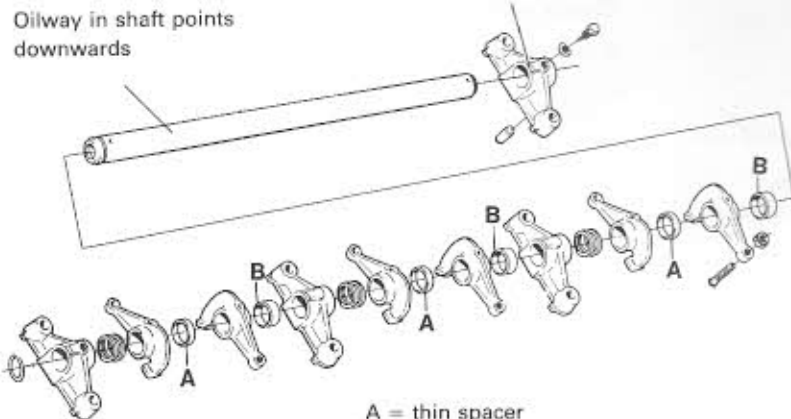
Disassemble only if necessary. (Place parts in order, so that they can be re-assembled in the same position.)

The clearance between the rocker arm and shaft is for new parts 0.012–0.054 mm (0.0005–0.0021 in).

**IMPORTANT!** The rocker arm contact surface on the camshaft is face-hardened and must not be ground.

The flat face must be turned towards the circlip groove. Applies to all four rocker shaft supports

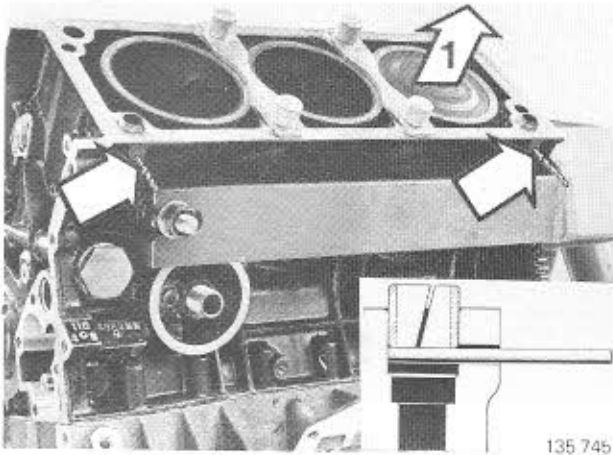
Oilway in shaft points downwards



A = thin spacer  
B = thick spacer

132 564

## F. Engine, assembly



### CYLINDER HEAD

Install cylinder heads one at a time i.e. perform operations F1-7 separately for each cylinder head.

F1

Turn crankshaft to TDC for cyl. 1.

F2

Install guide sleeves in cylinder block

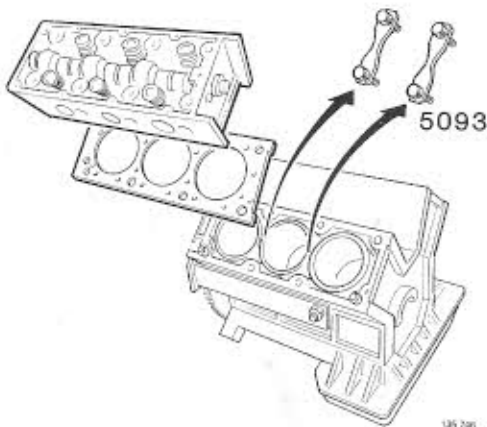
Secure the sleeves with e.g. a 3 mm (0.12 in) drill. This prevents the sleeves from being forced down when the cylinder head is fitted.

F3

Install cylinder head gasket and cylinder head

First remove liner holder 5093 and then the protective paper in the water passages.

Note! Different gaskets for right and left cylinder heads.

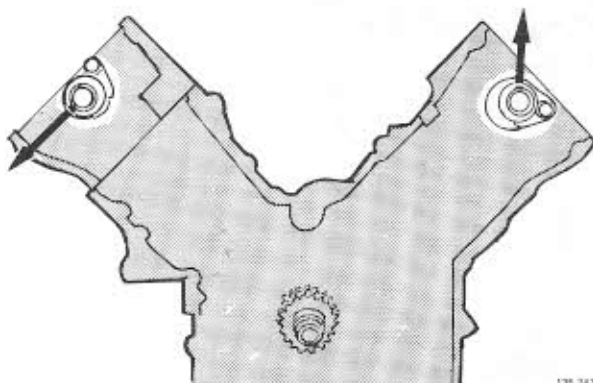


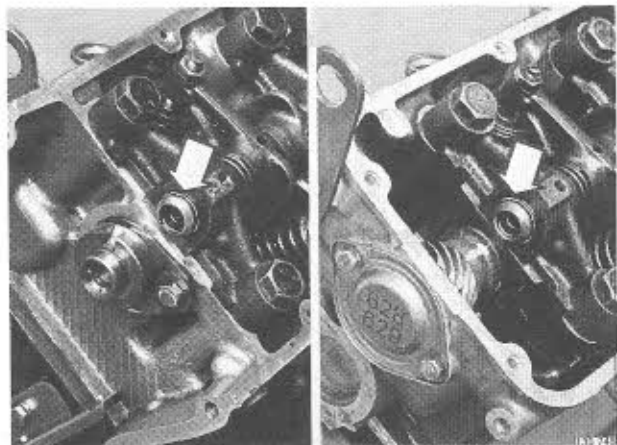
F4

Position camshaft

Left side: groove in camshaft must point up.

Right side: groove in camshaft must point out and down.





F5

**Install rocker arm assembly**

Use the correct bridge on the right and left sides. Bridges are the same but must face different directions.

- left side circlip must face forwards and
- right side circlip must face rearwards.

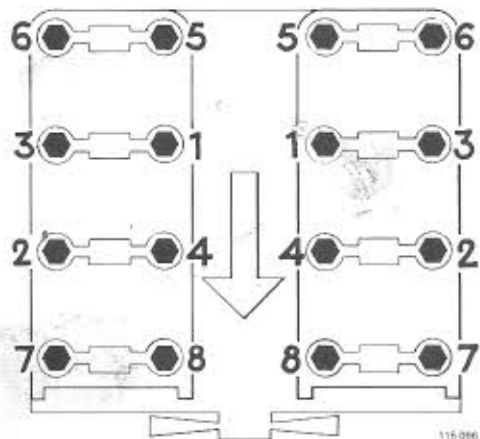
F6

**Clean, lubricate and install cylinder head bolts**

(Remove 3 mm drill beneath guide sleeves.)

Tighten bolts by hand.

F7



**Tighten cylinder bolts**

Tighten to the correct torque in three stages.

- 1 = 10 Nm ( 7 ft.lbs)
- 2 = 30 Nm (22 ft.lbs)
- 3 = 60 Nm (44 ft.lbs)

F8

**Install other cylinder head**

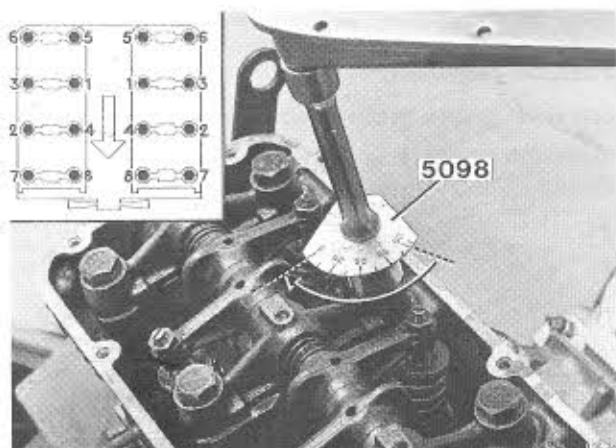
(F1-7)

F9

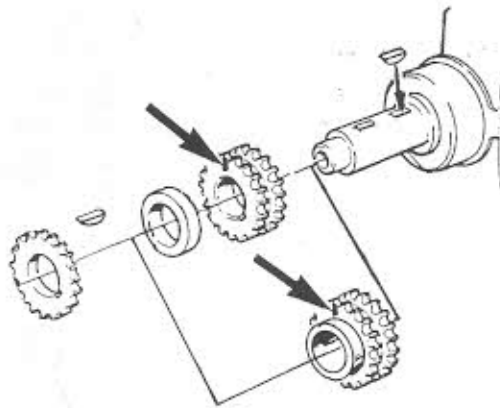
**Angle-tighten cylinder head bolts**

At the earliest, 10-15 minutes after F7.

- 1 = Slacken all bolts in order shown adjacent.
- 2 = Tighten to a torque of 15-20 Nm (11-15 ft.lbs) in order shown.
- 3 = Angle-tighten 113-117° in order shown adjacent. Use protractor 5098. The rocker arm bridge can be used as a line of sight.



**IMPORTANT!** Bolts must be retightened after engine has cooled.



**TIMING GEARS**

F10

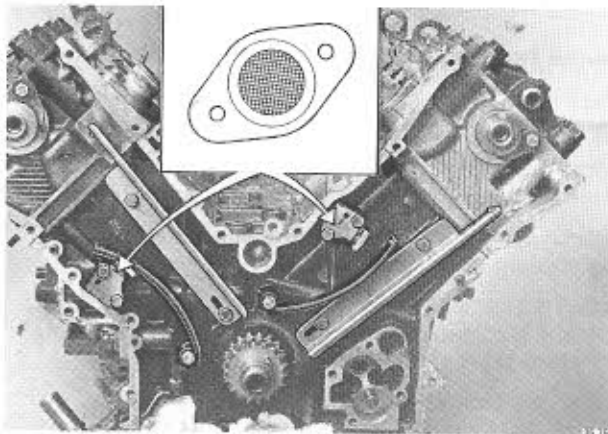
**Install crankshaft gears and keys**

Block holes in crankcase with paper to prevent keys from falling in.

Lubricate parts.

The mark on the inner gear must face out.

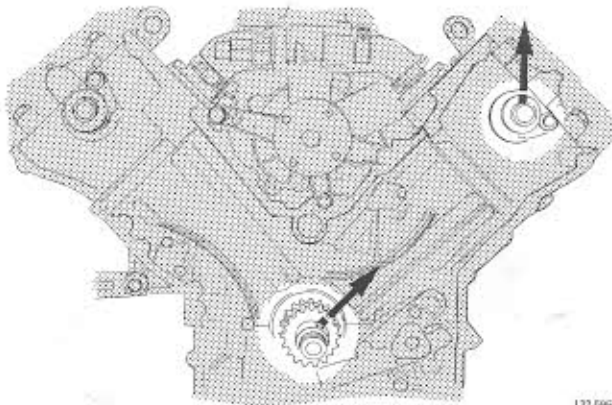
Note! On early types, gear and spacer are manufactured in one unit.



F11

**Install:**

- new strainers in cylinder block
- chain tensioners
- straight chain dampers
- bent chain dampers. Apply locking fluid (P/N 116 1053-2) to bolts.

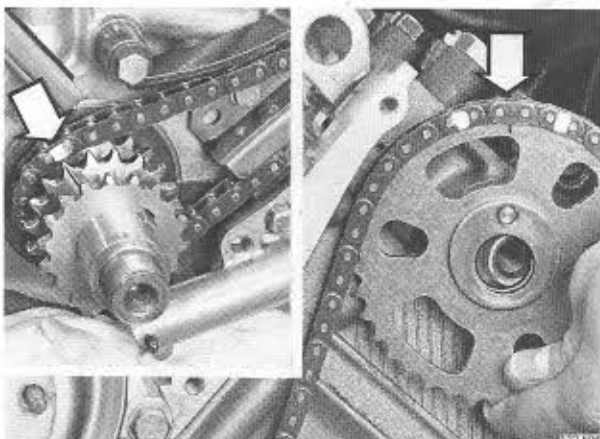


F12

**Set crankshaft and left-hand camshaft**

The key in the crankshaft should point towards the left-hand camshaft.

The groove in the camshaft should point upwards.



F13

**Install left-hand camshaft chain and sprocket**

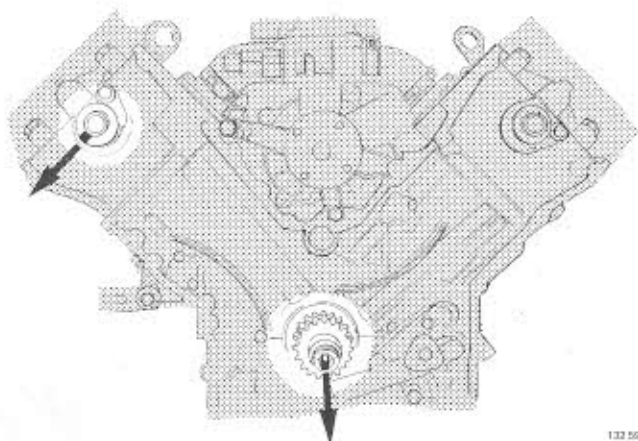
Place the chain on the camshaft sprocket, with the mark on the sprocket between the two marks on the chain.

Place the chain on the inner crankshaft sprocket, with the mark on the chain opposite the mark on the sprocket.

Stretch the chain on the pulling side (the side against the straight chain damper).

Position the camshaft sprocket. Make sure that the sprocket fits in the groove in the camshaft.

Install the centre bolt.



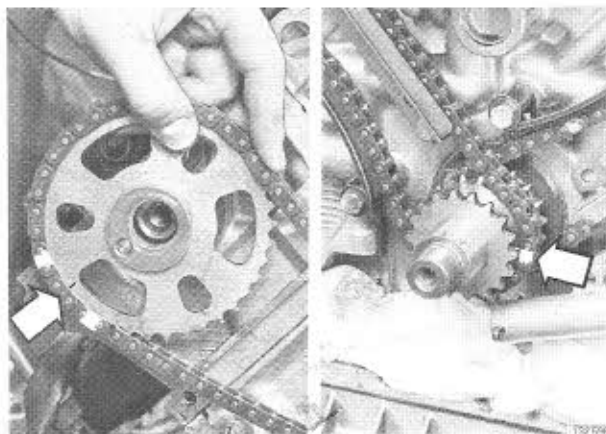
132 597

F14

**Set crankshaft and right-hand camshaft**

Install the crankshaft nut. Turn the crankshaft **clockwise** so that the key points directly downwards.

The groove in the camshaft should point outwards, see fig.



132 598

F15

**Install right-hand camshaft chain and sprocket**

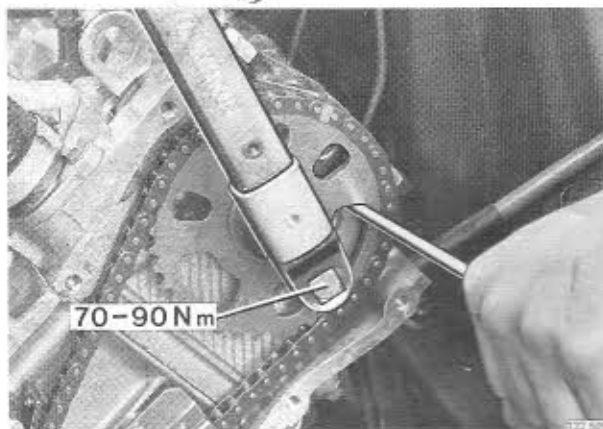
Place the chain on the camshaft sprocket, with the mark on the sprocket between the two marks on the chain.

Place the chain on the crankshaft sprocket, with the mark on the chain opposite the mark on the sprocket.

Stretch the chain on the pulling side (the side against the straight chain damper)

Install the camshaft sprocket. Make sure that the sprocket fits in the groove in the camshaft. If necessary rotate the **crankshaft** slightly.

Install the centre bolt.

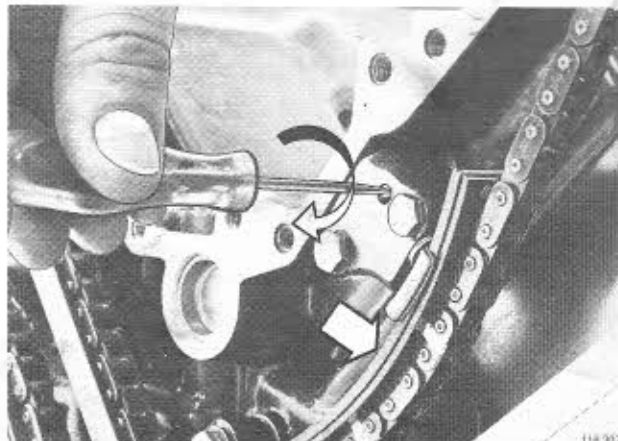


132 599

F16

**Tighten both camshaft centre bolts**

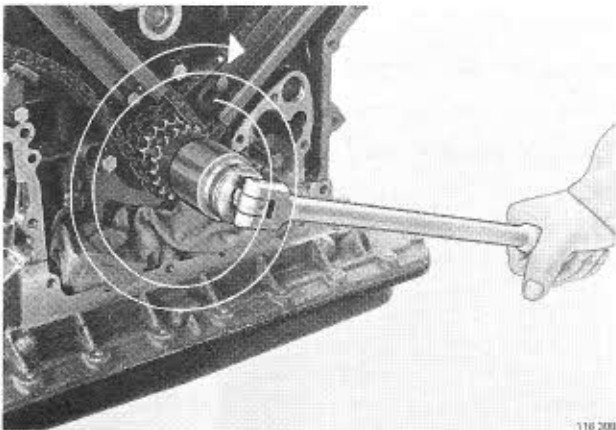
Tighten to a torque of **70-90 Nm** (52-66 ft.lbs). Insert screwdriver through sprocket to prevent it from moving.



118 907

F17

**Turn locks 1/4 turn clockwise**



F18

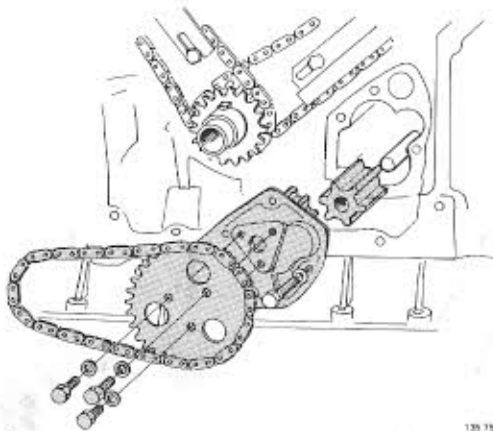
**Set chain tension**

Rotate the crankshaft twice.

Remove the crankshaft nut.

**Note:** The key in the crankshaft should point upwards to prevent it from falling out of its groove.

When the crankshaft has been rotated the marks for the chains and sprockets do not coincide. It is necessary to rotate the crankshaft a large number of turns to obtain the correct position.

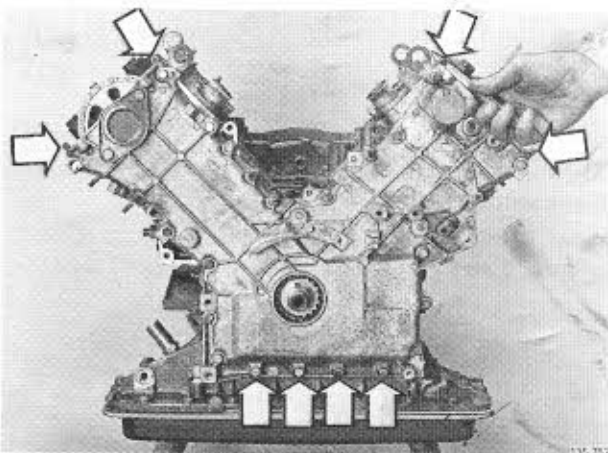


F19

**Install:**

- oil pump with sprocket
- chain and gear.

Apply locking fluid (P/N 116 1053-2) to the bolts.



F20

**Install timing gear case + gaskets**

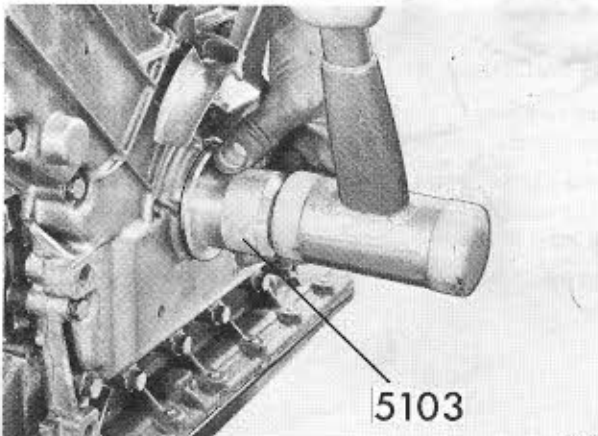
First remove paper from crankcase (see F10).

Smear the four lower bolts with locking fluid P/N 116 1056-5.

Tightening torque 10-15 Nm (7-11 ft.lbs).

Cut sides of gaskets so that they are flush with cylinder heads.

**CRANKSHAFT FRONT OIL SEAL, PULLEY**



F21

**Install new seal in timing gear case**

Grease the seal.

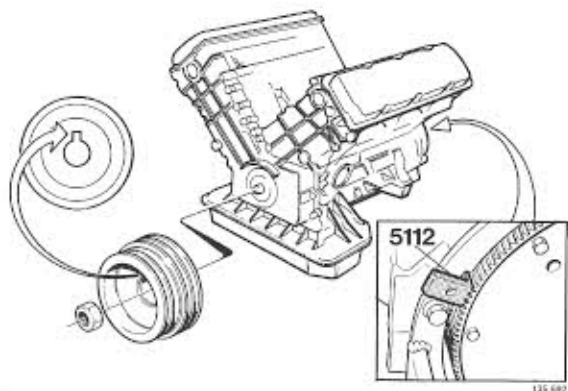
Use drift **5103**, to install seal.

F22

### Install crankshaft pulley

Make sure that key in crankshaft does not fall out.  
Torque nut to **240–280 Nm (174–203 ft.lbs)**.  
36 mm socket.

Use tool **5112** to prevent flywheel moving.

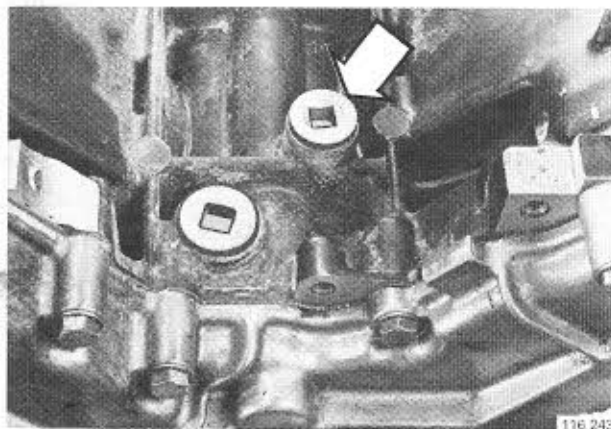


### TIMING SCALE

Check/adjust timing scale only if necessary, e.g. if scale is removed or replaced.

F23

### Remove rear plug in cylinder block



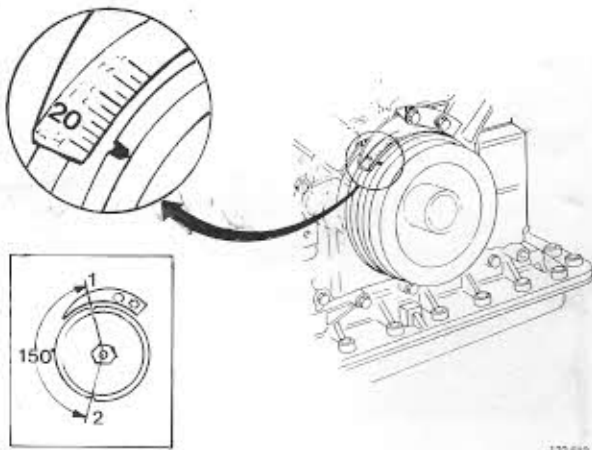
F24

### Set crankshaft statically

36 mm socket.

Turn the crankshaft so that the mark for T.D.C. cylinder 1 aligns with the 20° mark on the timing scale.

**Note:** There are two marks on the pulley, 1 = T.D.C. cylinder 1 and 2 = T.D.C. cylinder 6.



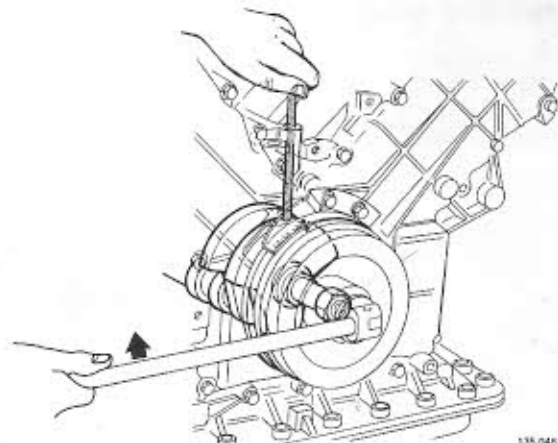
F25

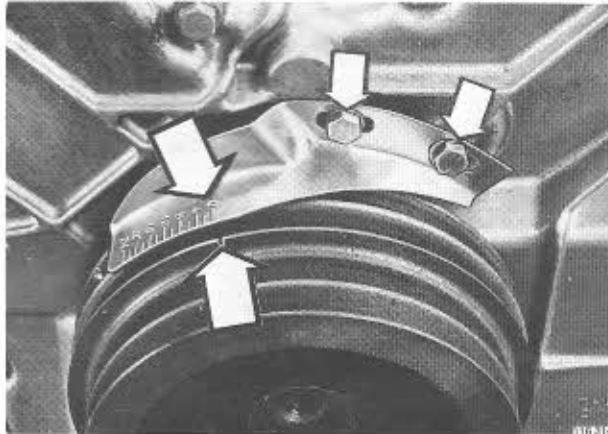
### Set crankshaft at T.D.C. cylinder 1

Insert a 8 mm (0.315 in) drill in the blanking plug hole so that it rests on the crankshaft counterweight.

Press lightly on the drill and turn the crankshaft slowly in the normal direction of rotation until the drill fits into the hole in the counterweight.

The engine is now set at exactly T.D.C. for cylinder 1.

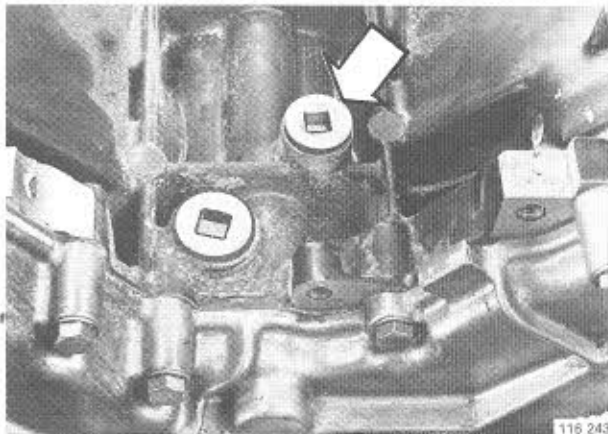




F26

**Check/adjust timing scale**

The zero-mark on the scale must align exactly with the mark on the pulley.



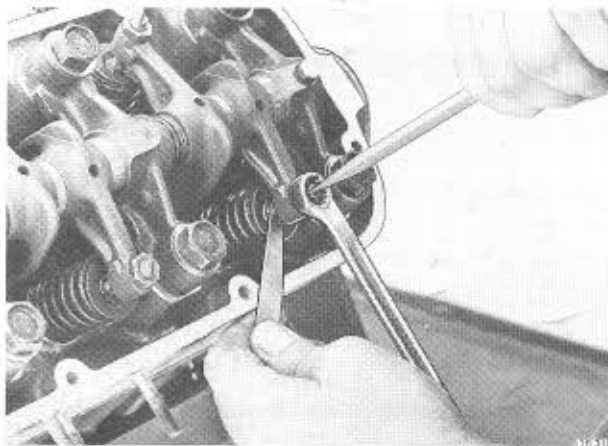
F27

**Install blocking plug**

Use a new seal.

Tightening torque 35–40 Nm (26–30 ft.lbs).

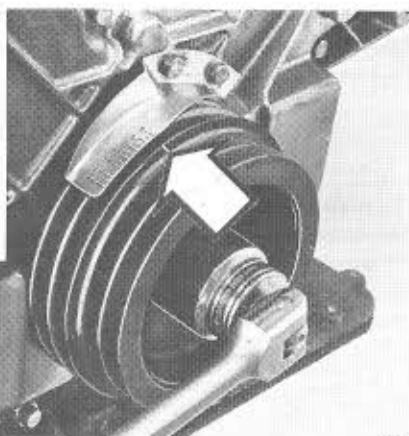
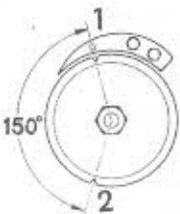
**Before proceeding with valve clearance check:**  
Camshaft setting must be checked. See specifications on page 6.



**VALVE ADJUSTMENT, VALVE COVERS**

Valve clearance, cold engine:

- intake ..... 0.10–0.15 mm (0.004–0.006 in)
- exhaust ..... 0.25–0.30 mm (0.010–0.012 in)

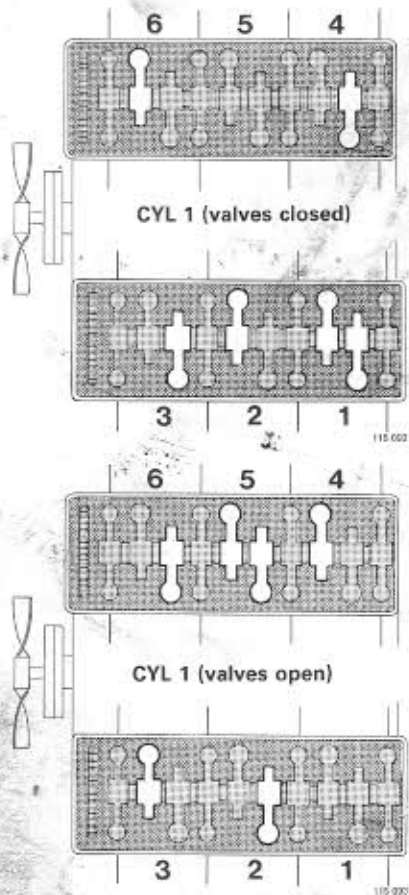


F28

**Turn crankshaft to firing position for No. 1 cylinder**

The mark "1" on the pulley should align with the zero-mark on the timing scale. **Both rocker arms for No. 1 cylinder should have clearance.**

I.004-.006  
E.010-.012



F29

**Check/adjust valve clearances**

Check the following valves in the set position.

**Intake:** cylinders 1, 2 and 4

**Exhaust:** cylinders 1, 3 and 6

F30

**Turn crankshaft one turn in normal direction to overlap position for No. 1 cylinder**

The mark "1" on the pulley should align with the zero-mark on the scale. There should be no clearance between the rocker arms and valve stem tops for No. 1 cylinder.

F31

**Check/adjust valve clearances**

Check the following valves in the set position.

**Intake:** cylinders 3, 5 and 6

**Exhaust:** cylinders 2, 4 and 5

F32

**Turn crankshaft one turn to firing position for No. 1 cylinder**

The mark "1" on the pulley should align with the zero-mark on the timing scale. The rocker arms for No. 1 cylinder should have clearance.

This is now the correct setting for installing the distributor.

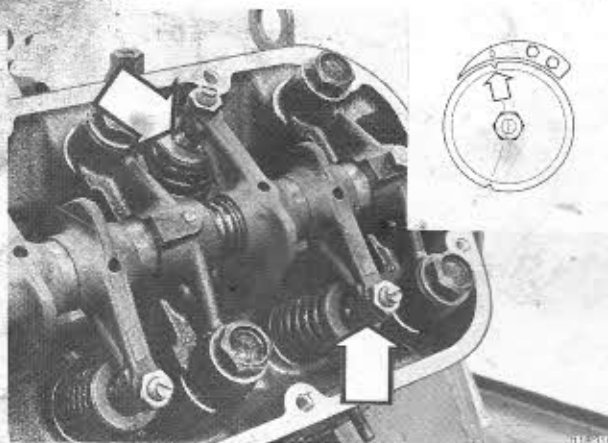
F33

**Install gaskets and valve covers**

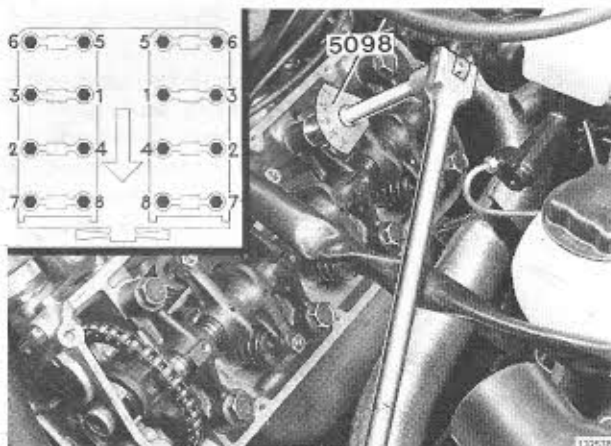
Use new gaskets. Apply a few spots of sealing compound. (P/N 116 1026-8).

Place only four bolts in each valve cover. Do not tighten since the covers are to be removed later on.

To ensure that the junction between the valve cover, cylinder block and timing gear case is fully leak-proof, a thin coat of silicone (P/N 116 1048-2) can be applied to the joint. **Note!** Do not use too much silicone otherwise it may enter the lubrication system and block the oil channels.



F34



### Retorquing of cylinder head bolts

Warm-up engine and leave to cool down for 30 mins.

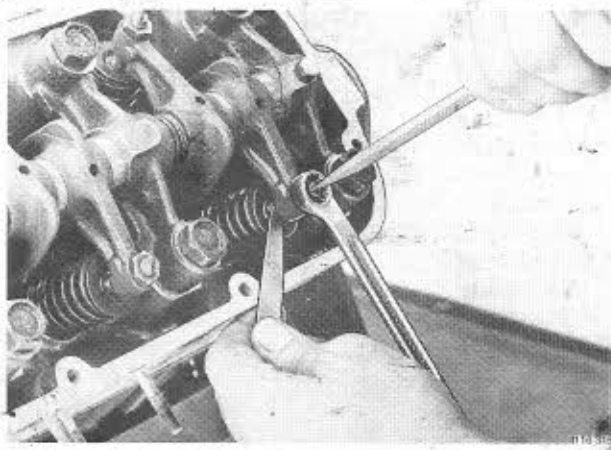
Remove valve covers.

Noting correct tightening sequence, perform following operations on each bolt in turn.

- A. Slacken bolt
- B. Torque to **15–20 Nm** (11–14.5 ft.lbs)
- C. Angle-tighten **113–117°**. Use protractor 5098.

Refit valve covers

F35



### After 6,000 miles (10,000 km)

Valve clearance should be checked if work has been performed on valve train.

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