

**WORK ON THE ENGINE  
INDIVIDUAL PARTS**

**5**

# WORK ON THE ENGINE INDIVIDUAL PARTS

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**5.1 PREFACE**

This section contains the information and data required by the professional mechanic to work on the engine individual parts.

Carefully read 4.2 (IMPORTANT INFORMATION).

**⚠ CAUTION**

Any components removed must be set aside in groups arranged according to their assembly position.

This will ensure that when you reassemble the engine, all parts will be fitted in their proper locations.

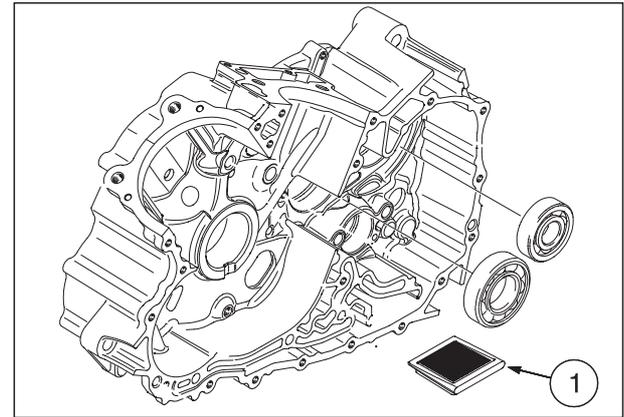
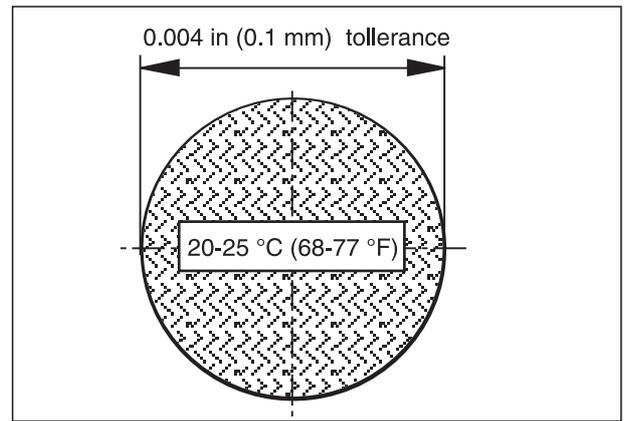
**NOTE** Before going ahead with the work on the engine individual parts, gather the appropriate special tools, see 2.7 (SPECIAL TOOLS .

**⚠ WARNING**

Take care not to burn yourself when handling hot engine parts.

**⚠ CAUTION**

If any of the components have exceeded any of their wear limits, or if, during visual inspection of a component you determine that it is in any way defective, it must be replaced. It is false economy to reuse a marginal part. If the limits or values for measurements indicated are given with the precision of smaller than 0.004 in (0.1 mm) the temperature of the component when it is measured must be between 20 °C – 25 °C (68 °F – 77 °F).

**5.2 ENGINE CASE**

Carefully read 5.1 (PREFACE).

**⚠ CAUTION**

Do not use aggressive, caustic, or acidic cleaning products or detergents while attempting to clean engine components.

Use a fire-proof solvent such as Stoddard solvent only.

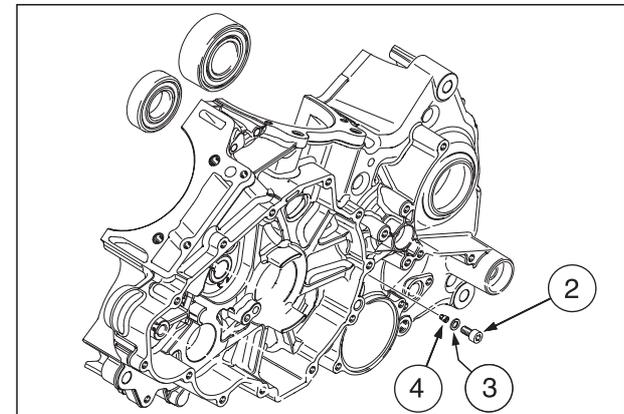
- ◆ Clean the two sections of the engine case, ball bearings and all bearing housings thoroughly with a fire-proof solvent such as Stoddard solvent.
- ◆ Clean all the gasket surfaces and check for damage.

**NOTE** Place the two halves of the engine case on a flat surface to prevent damage.

- ◆ Ensure that the two halves of the engine case have no cracks or signs of damage.
- ◆ Ensure that all the threads are in a perfect state of repair.
- ◆ Ensure that all the oil seals remaining in their recesses are not worn or damaged.
- ◆ Check the play of all ball bearings and ensure that they roll smoothly and are not distorted. They should display no radial clearance.

**NOTE** Use motor oil to lubricate the ball bearings before performing the check.

If the inner race does not turn easily and silently, or if it makes a noise, it means the bearing is defective and needs replacing.



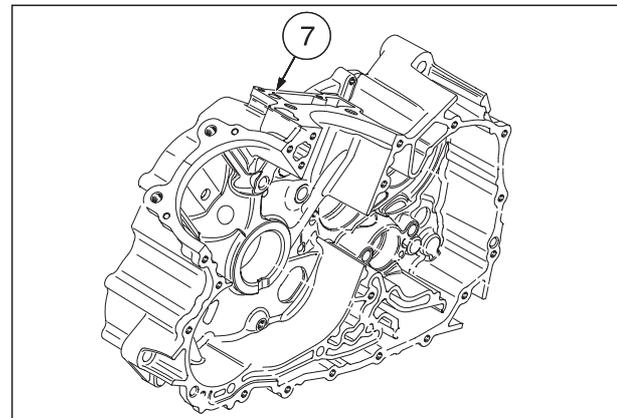
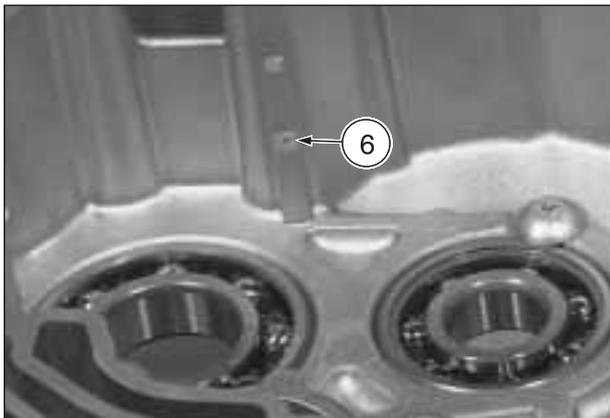
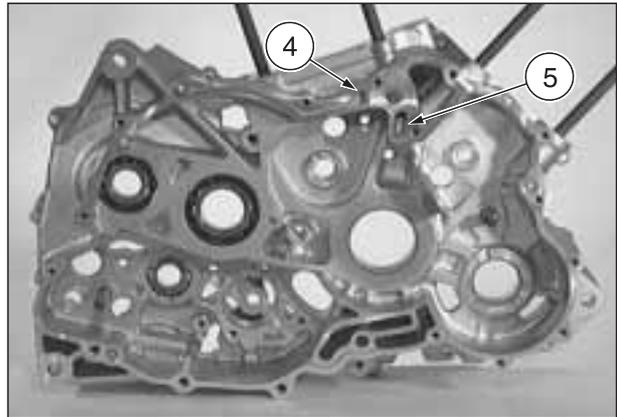
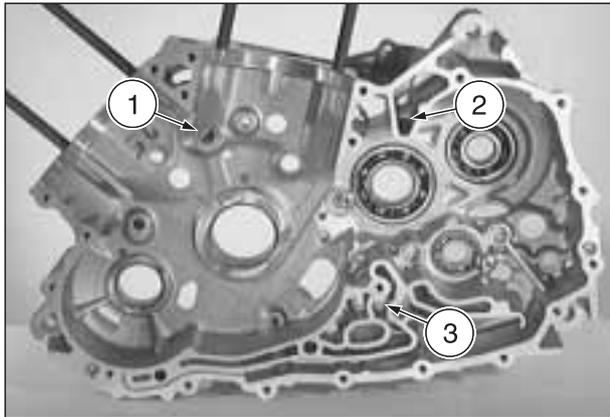
- ◆ Remove the oil filter (1).
- ◆ Clean the oil filter with a fire-proof solvent such as Stoddard solvent and check the screen for possible signs of damage.
- ◆ Unscrew and remove the M6 Allen screw (2), the seal (3) and the nozzle (4).

Follow ►

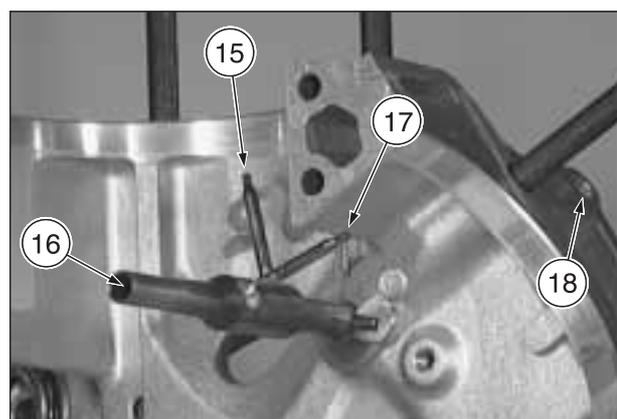
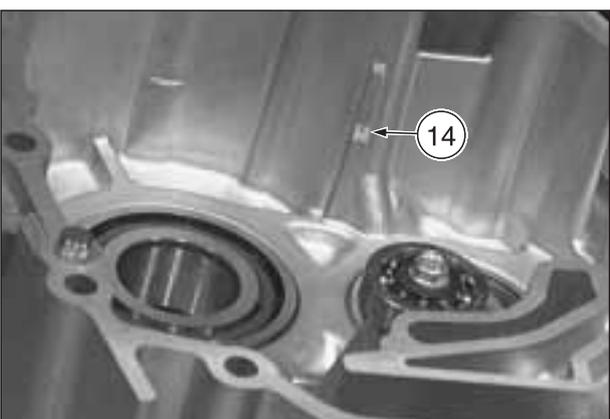
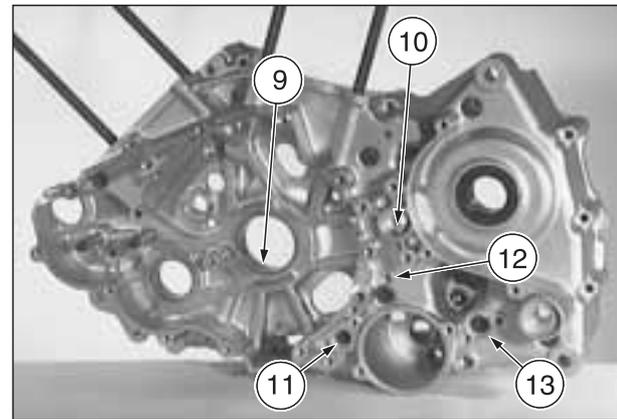
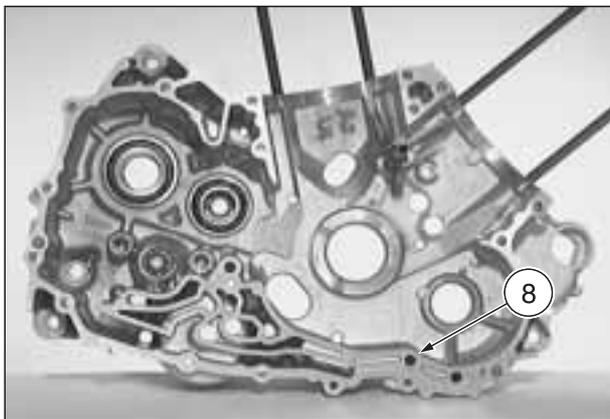
Follow ►

- ◆ Ensure that the galleries are clear in all the lubrication holes (1 - 2 - 3 - 4 - 5 - 6 - 7 - 8 - 9 - 10 - 11 - 12 - 13 - 14 - 15 - 16 - 17 - 18) in the two halves of the engine case and, where necessary, clean them by blowing a jet of compressed air inside.

**ENGINE HALF-CASE, CLUTCH SIDE.**



**ENGINE HALF-CASE, ALTERNATOR SIDE.**



### 5.3 MAIN BEARINGS AND OIL SEALS, MOUNTED ONTO ENGINE HALF-CASES

Carefully read 5.1 (PREFACE).

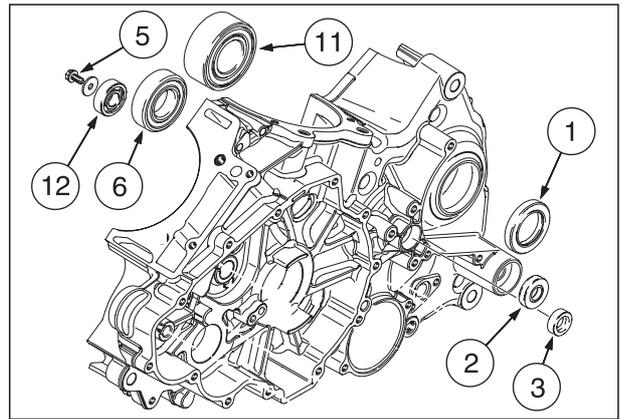
#### 5.3.1 OIL SEAL DISASSEMBLY

**NOTE** The oil seals can be disassembled and assembled without removing the engine from the vehicle.

◆ Lift and take out:

- the countershaft oil seal (1);
- the selector shaft oil seal (2);
- the clutch disengaging shaft oil seal (3).

**NOTE** As a rule, the disassembled oil seals should be replaced.



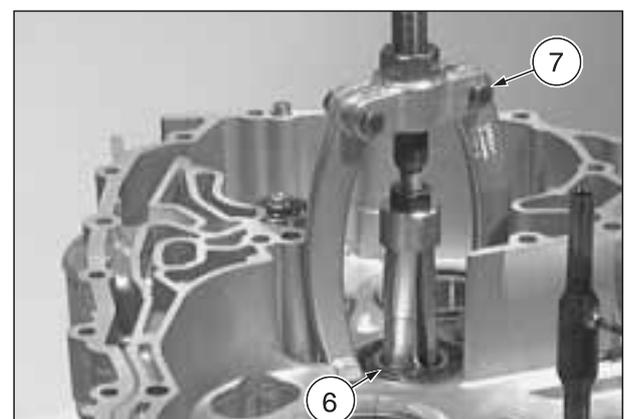
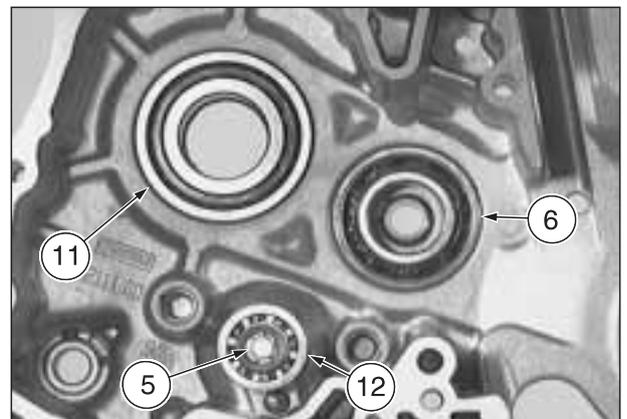
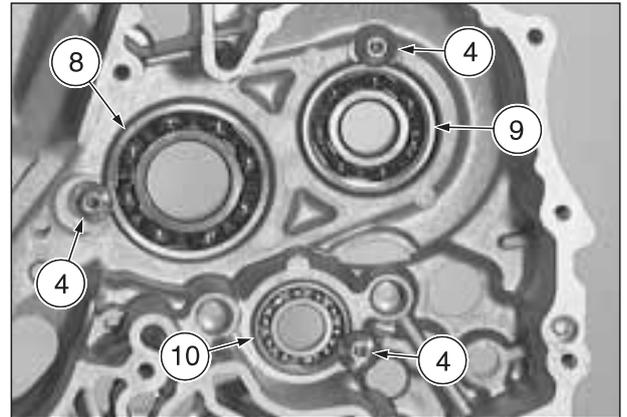
#### 5.3.2 MAIN BEARING DISASSEMBLY

- ◆ Unscrew and remove the M6 flanged-head Allen screws (4) securing the ball bearings.
- ◆ Remove the M6 x 13 flanged-head Allen screw (5).
- ◆ Check to ensure that there is no damage or any sign of grooving or scoring on the bearing lands.
- ◆ In order to remove and insert the ball bearings, heat the engine case to a temperature of approx. **80 – 100 °C (176 – 212 °F)**.

**NOTE** In order to avoid damaging the gasket surface, an old engine case gasket should be placed underneath the puller plate.

- ◆ Remove the main shaft ball bearings (6) with the aid of a universal sleeve puller (7).
- ◆ Remove the ball bearings using the drift.
- main shaft (8), clutch side;
- countershaft (9), clutch side;
- shift cam (10), clutch side;
- countershaft (11), alternator side.
- ◆ Remove the shift cam ball bearings (12).

**NOTE** As a rule, the disassembled ball bearings should be replaced.

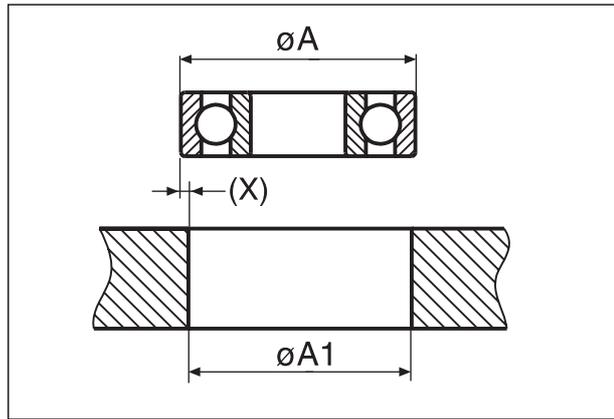


**5.3.3 MAIN BEARING ASSEMBLY**

◆ Check the interference fit between the bearing and the engine case hole.

**Interference (X) (diameter A – diameter A1): min. (tight) 0.0004 in (0.01 mm).**

- ◆ Lubricate the external diameter of the bearings slightly and, with due care, fit them all the way in on the outer race using a suitable assembly drift:
- gearbox main shaft (6), alternator side;
  - gearbox main shaft (8), clutch side;
  - gearbox countershaft (9), clutch side;
  - shift cam (10), clutch side;
  - gearbox countershaft (11), alternator side.



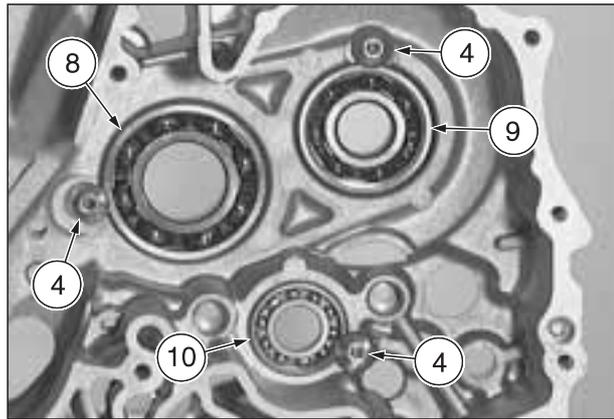
**⚠ CAUTION**

The gasket of the gearbox main shaft ball bearing (6), alternator side, must face outwards.

**NOTE** As a rule, the disassembled ball bearings should be replaced.

- ◆ Lubricate the internal diameter of the shift cam ball bearing (12), alternator side, slightly and, with due care, fit it all the way in on the inner ring using a suitable assembly drift.
- ◆ Apply LOCTITE® 243 on the screws (4) (5) securing the ball bearings and screw them into the engine case.

**Screws tightening torque: 8 ftlb (11 Nm).**



**5.3.4 OIL SEAL ASSEMBLY**

**NOTE** Have the appropriate special tool **OPT** available:

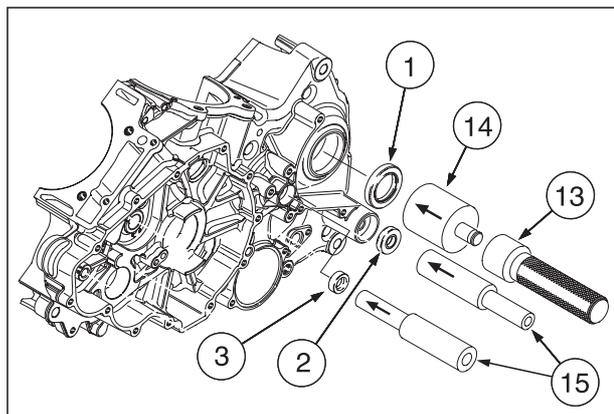
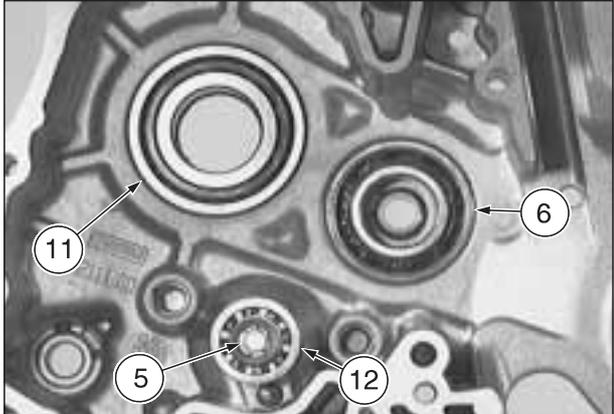
- **aprilia** part# 0877650 (handle for drift) (13);
- **aprilia** part# 0277680 (countershaft oil seal assembly drift) (14);
- **aprilia** part# 8140155 (main shaft oil seal-clutch shaft oil seal assembly drift) (15).

**NOTE** Before assembling the shaft seals, their external diameter must be lubricated slightly. The closed side of the shaft seals must face outwards. Grease the sealing lips.

**⚠ CAUTION**

The oil seal (1) of the countershaft must not touch the inner race of the bearing in any way as this would result in damage.

- ◆ Insert the oil seal (1) flush with the engine case using the assembly drift (14).
- ◆ Insert the shaft seals (2) (3) all the way using the assembly drift (15).



## 5.4 CRANKSHAFT MAIN BUSHINGS AND LOWER BALANCESHAFT MAIN BUSHINGS

Carefully read 5.1 (PREFACE).

### CAUTION

The main bushings should only be replaced by repair shops that possess the appropriate measurement. We strongly suggest that you return engine cases which require main bushing service to:

**aprilia USA inc.**  
110 Londonderry Court, Suite 130  
Woodstock, GA 30188  
USA  
Tel 770 592 2261  
Fax 770 592 4878

- ◆ Measure the internal diameter of the crankshaft main bushings (1) in both halves of the engine case.

**Crankshaft main bushings (1): wear limit diameter 1.81239 in (46.035 mm).**

- ◆ Measure the internal diameter of the lower balancer shaft main bushings (2) in both halves of the engine case.

**Lower balancer shaft main bushings (2): wear limit diameter 1.2622 in (32.060 mm).**

### CAUTION

Take a number of measurements, especially in the direction of the axis of both cylinders. None of the values must exceed the limit value.

**NOTE** Measure the radial play between the crankshaft main bushings (1) and the journals of the crankshaft, see 5.10 (CRANKSHAFT).

**NOTE** Measure the radial play between the lower balancer shaft main bushings (2) and the journals of the lower balancer shaft, see 5.13 (LOWER BALANCESHAFT AND LOWER BALANCESHAFT MECHANISM).

- ◆ Check for signs of wear or slipping on the axial thrust-bearing lands (3) (4), for the crankshaft, in both halves of the engine case.
- ◆ Check for signs of wear or slipping on the axial thrust-bearing lands (5) (6), for the lower balancer shaft, in the clutch side engine half-case.

### CAUTION

Check the axial play of the crankshaft, see 5.10 (CRANKSHAFT).

Check the axial play of the lower balancer shaft, see 5.13 (LOWER BALANCESHAFT AND LOWER BALANCESHAFT MECHANISM).

### 5.4.1 DISASSEMBLY

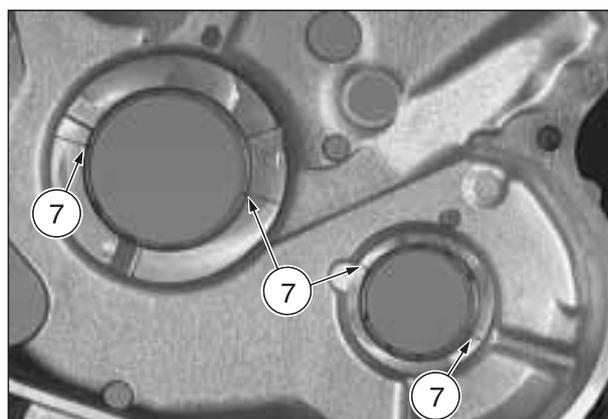
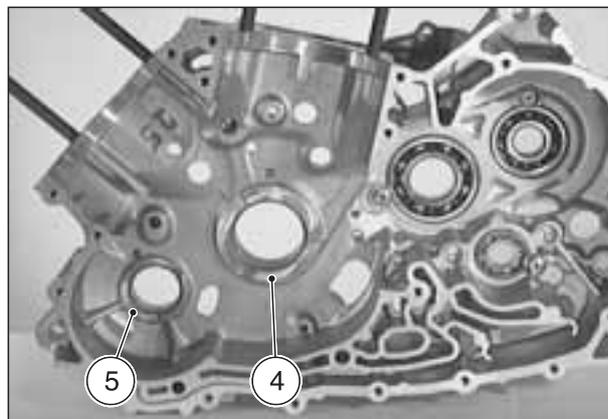
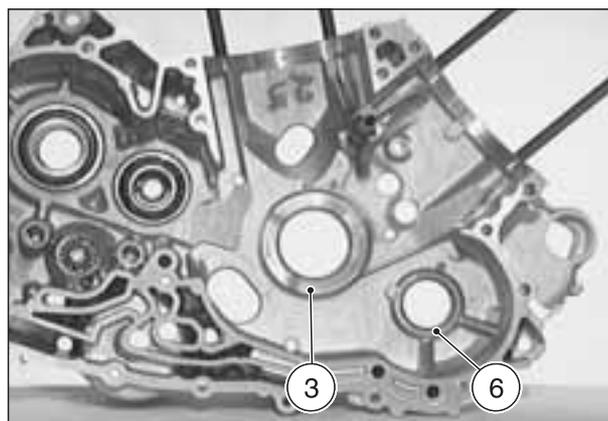
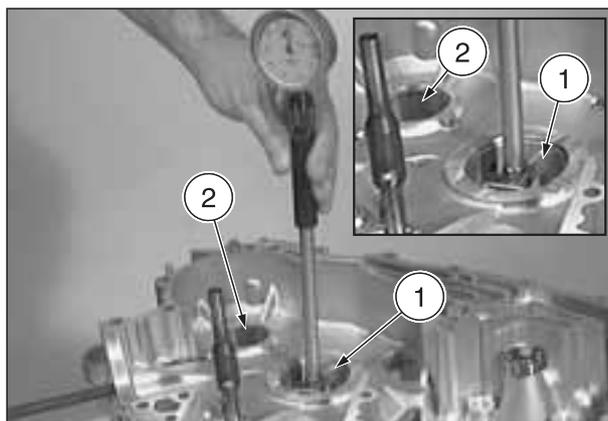
Remove the main bushing by working from inside of the corresponding engine half-case.

- ◆ Use a felt pen to mark the contact surfaces (7) of the main bushings on both halves of the engine case so as to provide an external visual reference.

### CAUTION

Do not scratch or engrave any markings.

Follow ►



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- NOTE** Have the appropriate special tool **OPT** available:
- **aprilia** part# 0277720 (crankshaft sleeve puller drift) (8);
  - **aprilia** part# 8140074 (lower balanceshaft bushing extractor drift) (9).

**NOTE** Use an hand press to disassemble the main bushings.

**NOTE** In order to remove (and insert) the main bushings, use two supports (A) to bear the half-case of the engine in question.

The two supports must be made of hard wood and offer smooth surfaces and the following dimensions:

- length (L) = 12 in (300 mm);
- width (W) = 8 in (200 mm);
- height (H) = 2 in (50 mm).

- ◆ Place the two supports (A) on the press work surface.
- ◆ Heat the engine case to 150 °C (302 °F) for approximately 15 minutes.

**⚠ WARNING**

**Risk of burns.**  
Wear heavy leather gloves and use fire-proof thermal insulated material when handling heated engine half-cases.

**NOTE** Place the engine half-case on its outer side in order to permit operations on its inside.

- ◆ Place the engine half-case (B) on the two supports (A).

**⚠ WARNING**

To support the case against the force exerted by the press, position the two supports (A) near the main bushings which are being serviced. Be careful to allow clearance for the bushing, (C). Unless the case is properly supported, the force of the press can cause micro cracks in the case, which may not be immediately evident, but will subsequently cause engine failure and seizure, with risk of serious accident and subsequent injury or even death.

**⚠ WARNING**

Disassemble one bushing at a time. Disassembling both bushings at the same time may damage the bushings, and the case halves, and could lead to the kind of damage described above.

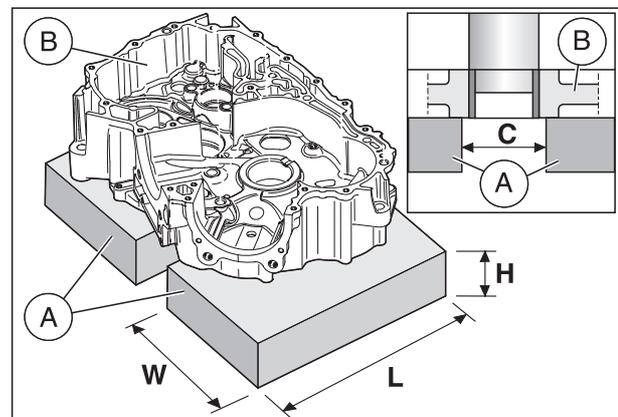
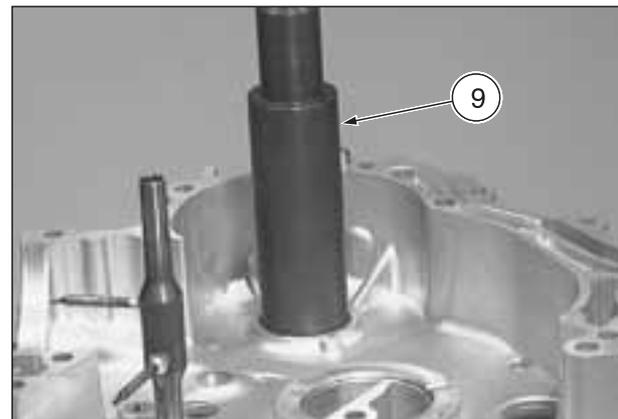
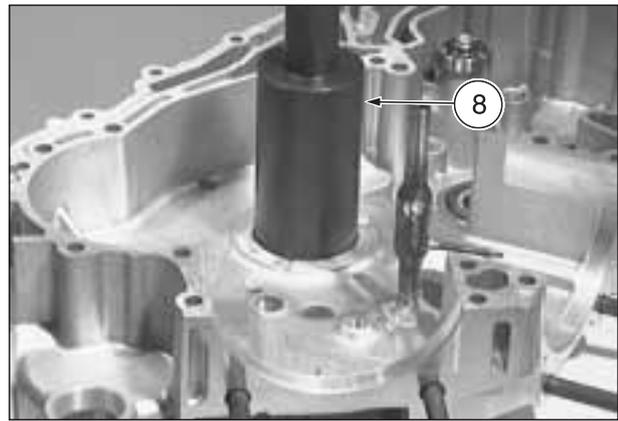
- ◆ Place the appropriate puller drift (8) or (9) on the bushing to be disassembled.

**⚠ WARNING**

Use the press with great care. Make sure that there are no spectators close to the press. The bush, the case, or parts of the press could fail, causing injury to spectators.

- ◆ Proceed with great caution, using an hand press remove the main bushings from the engine half-case.

**NOTE** As a rule, the disassembled main bushings should be replaced in pairs.



5.4.2 ASSEMBLY

**NOTE** The main bushings must be mounted inside the engine half-case.

- ◆ Clean the bore of the main bushing housing inside the engine case.
- ◆ Determine the main bushing size group based on the colored markings (10) on the engine case.

**CAUTION**

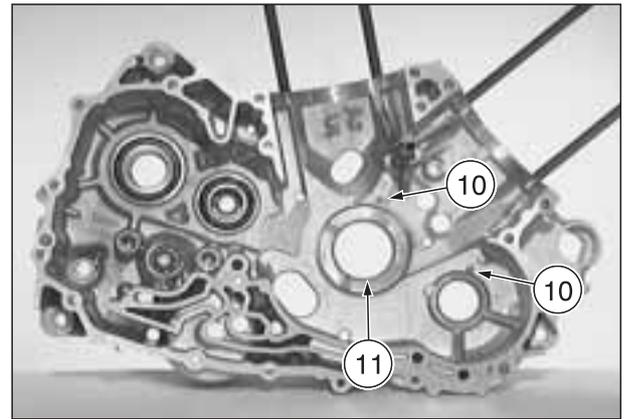
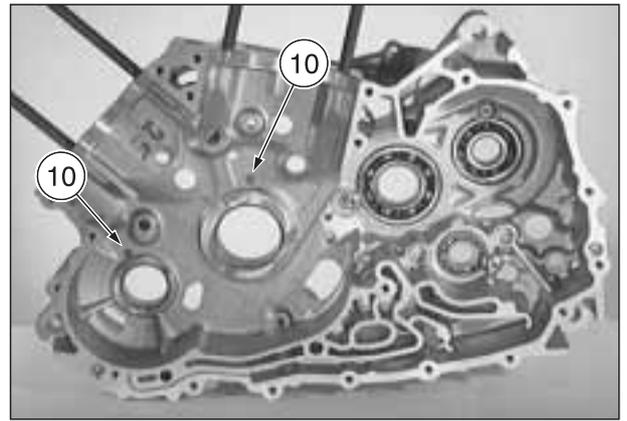
The lower main bushing (11) of the crankshaft alternator side is provided with a lubrication hole.

**NOTE** The size group of the main bushings is also marked with a colored dot.

- ◆ If the colored marking applied on the engine case is no longer clearly legible, calculate the diameter based on the average of a number of different measurements.

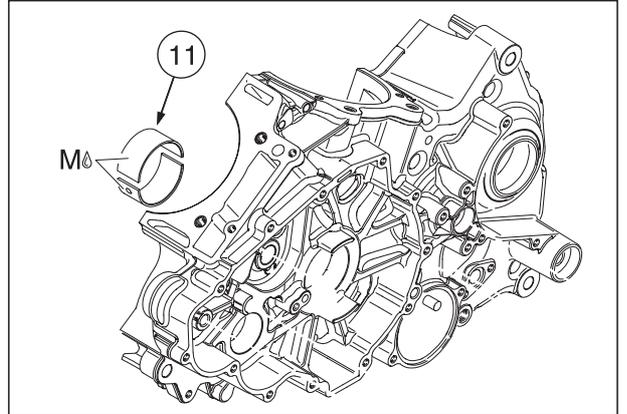
**CAUTION**

Take a number of measurements, especially in the direction of the axis of both cylinders.



CRANKSHAFT		
Bushing bore in the engine half-case	Main bushings marking	Engine half-case marking
Ø 1.9645 – 1.9648 in (49.899 – 49.908 mm)	red	red
Ø 1.9648 – 1.9652 in (49.908 – 49.918 mm)	blue	blue
Ø 1.9652 – 1.9657 in (49.918 – 49.929 mm)	yellow	yellow

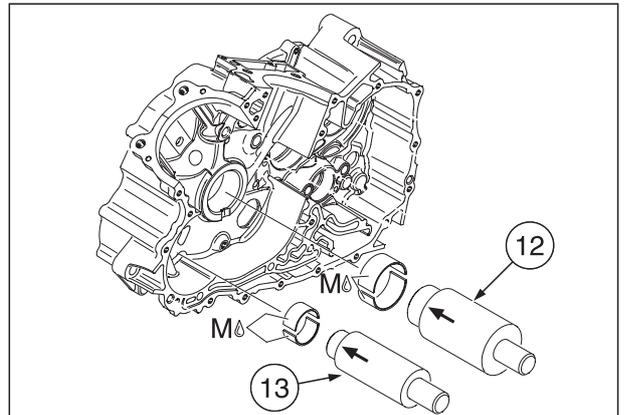
LOWER BALANCESHAFT		
Bushing bore in the engine half-case	Main bushings marking	Engine half-case marking
Ø 1.4137 – 1.4141 in (35.909 – 35.918 mm)	red	red
Ø 1.4141 – 1.4145 in (35.918 – 35.928 mm)	blue	blue
Ø 1.4145 – 1.4149 in (35.928 – 35.939 mm)	yellow	yellow



- NOTE** Have the appropriate special tool **OPT** available:
- **aprilia** part# 0277725 (crankshaft bushing inserter drift) (12);
  - **aprilia** part# 0277729 (lower balancershaft bushing inserter drift) (13).
  - ◆ Heat the engine case to **approx. 150 °C (302 °F)**.
  - ◆ Coat the main bushing and the crankcase bore with **MOLYKOTE® G-N**.

M = MOLYKOTE® G-N.

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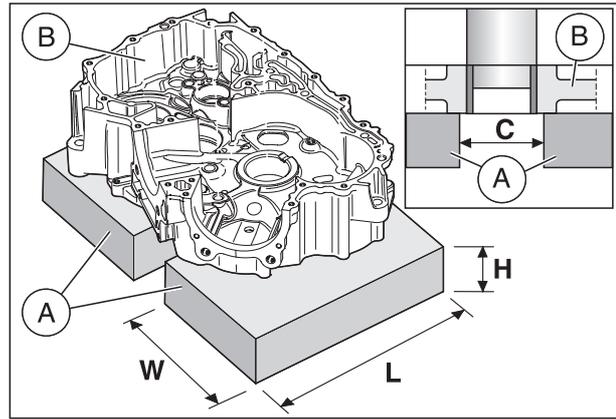
**NOTE** Use an hand press to assemble the main bushings.

**NOTE** In order to remove (and insert) the main bushings, use two supports (A) to bear the half-case of the engine in question.

The two supports must be made of hard wood and offer smooth surfaces and the following dimensions:

- length (L) = 12 in (300 mm);
- width (W) = 8 in (200 mm);
- height (H) = 2 in (50 mm).

- ◆ Place the two supports (A) on the press work surface.
- ◆ Heat the engine case to 150 °C (302 °F) for approximately 15 minutes.



**⚠ WARNING**

**Risk of burns.**

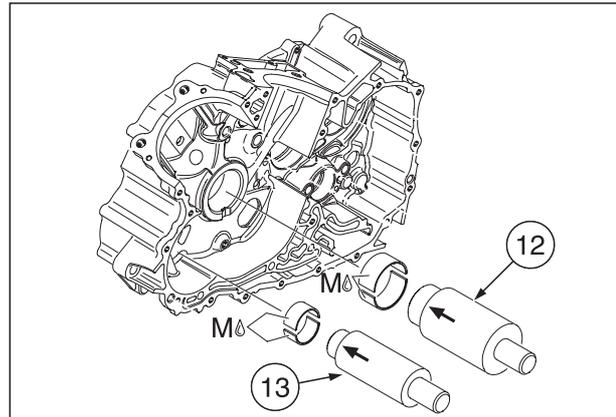
**Wear heavy leather gloves and use fire-proof thermal insulated material when handling heated engine half-cases.**

**NOTE** Place the engine half-case on its outer side in order to permit operations on its inside.

- ◆ Place the engine half-case (B) on the two supports (A).

**⚠ WARNING**

**To support the case against the force exerted by the press, position the two supports (A) near the main bushings which are being serviced. Be careful to allow clearance for the bushing, (C). Unless the case is properly supported, the force of the press can cause micro cracks in the case, which may not be immediately evident, but will subsequently cause engine failure and seizure, with risk of serious accident and subsequent injury or even death.**



**⚠ WARNING**

**Assemble one bushing at a time. Assembling both bushings at the same time may damage the bushings, and the case halves, and could lead to the kind of damage described above.**

- ◆ Place the bushings, complete with drift and O-ring, in their housings in the engine half-case and align the main bushing contact surface with the colored mark (7) applied previously.

**⚠ WARNING**

**Use the press with great care. Make sure that there are no spectators close to the press. The bush, the case, or parts of the press could fail, causing injury to spectators.**

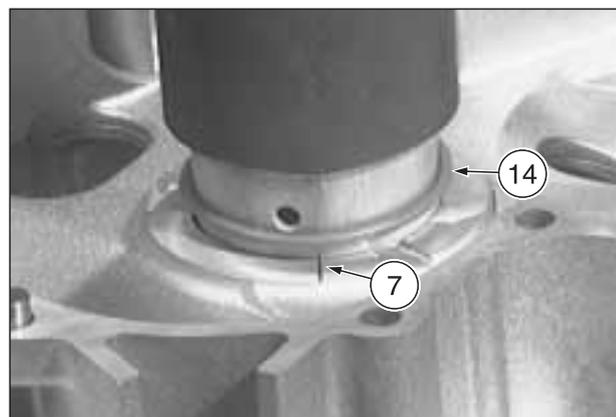
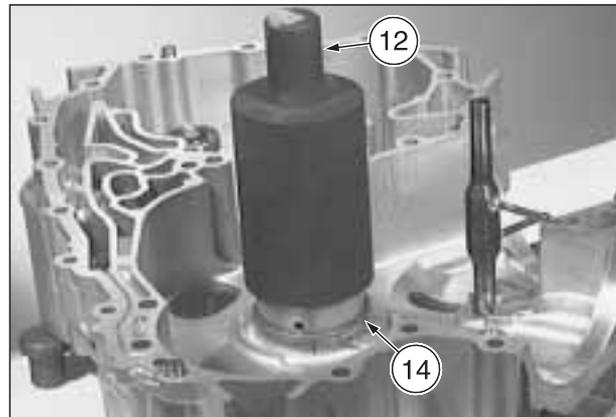
**NOTE** During this phase, do not insert the bushings completely.

- ◆ Proceed with great caution, using an hand press insert the main bushings until half of their height.

**⚠ CAUTION**

**Be careful to avoid cutting or damaging the outer surfaces of the bushing.**

- ◆ Pull the O-ring (14) away from the bushing, and then cut it to remove it.



M = MOLYKOTE® G-N.

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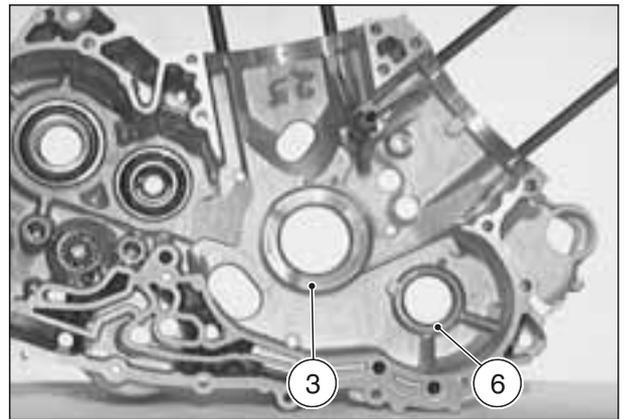
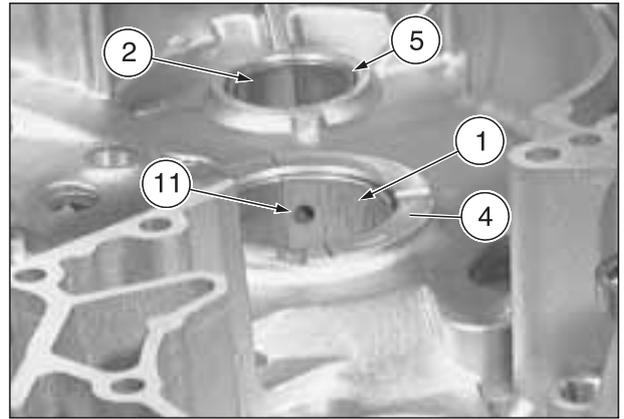
- ◆ Proceed with great caution, using an hand press insert the main bushings until the assembly drift (12) or (13) comes into light contact with the engine half-case thrust bearing land (3), or (4), or (5) or (6).
- ◆ The crankshaft main bushings (1) are fitted so that they are **0.0787 in (2.0 mm)** below the thrust-bearing lands (3) (4).
- ◆ The lower balanceshaft main bushings (2) are fitted so that they are **0.0591 in (1.5 mm)** below the thrust-bearing land (5) (6).

**NOTE** The lower main bushings of the crankshaft alternator side is provided with a lubrication hole (11).

- ◆ Once assembled, ensure that the lubrication hole (11) in the main bushing is lined up with the hole in the engine case.

**⚠ CAUTION**

**Should the main bushings be assembled incorrectly, they must be removed using the disassembly drift as described above, see DISASSEMBLY. Disassembled main bushings may not be reused.**



**5.5 REPLACING THE ENGINE HALF-CASE CYLINDRICAL PINS**

Carefully read 5.1 (PREFACE).

- ◆ Use a micrometer to check the wear of the cylindrical pins (1) (2) of the starter motor drive assembly and (3) coolant pump idler gear.

Wear limit  $\varnothing$  0.3933 in (9.990 mm).

**5.5.1 DISASSEMBLY**

**NOTE** Should a cylindrical pin be worn, it may be removed by heating the case around its base with a hot-air gun (4).

- ◆ Heat the area to about 100 °C (212 °F), then pull the cylindrical pin out with pliers, rotating it upwards.

**5.5.2 ASSEMBLY**

**NOTE** Coat the cylindrical pin (3) of the coolant pump idler gear with LOCTITE® 648.

**NOTE** Insert the cylindrical pin (5) of the needle spring with the chamfered part external.

- ◆ Using great care, install the cylindrical pins in the case until they bottom.

**5.6 NEUTRAL GEAR INDICATION**

Carefully read 5.1 (PREFACE).

- ◆ Ensure that the contact pin (6) of the contact screw (7) slides smoothly and check the strength of the spring.

**CAUTION**

The cap on the pin must not display any wear. If it does, replace the contact screw.

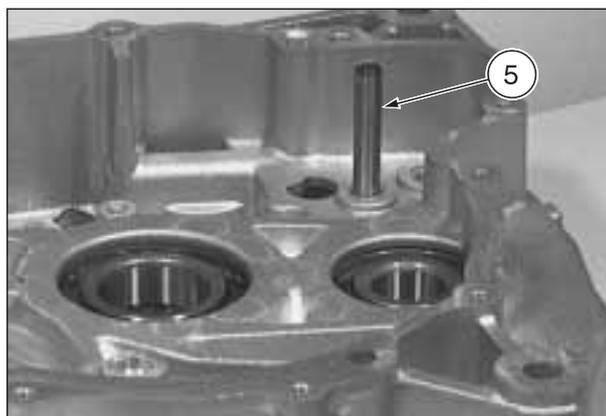
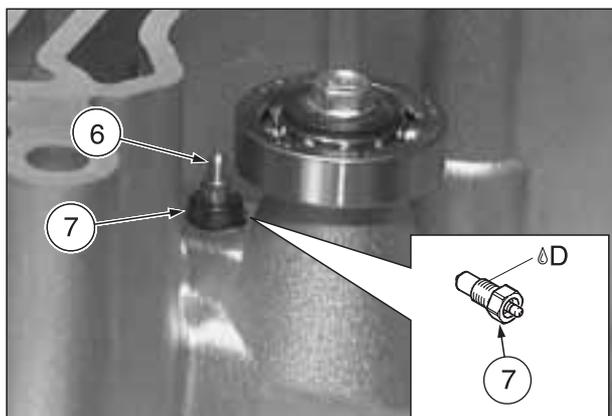
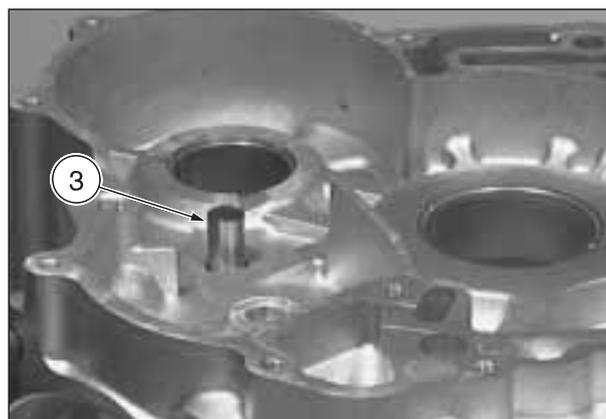
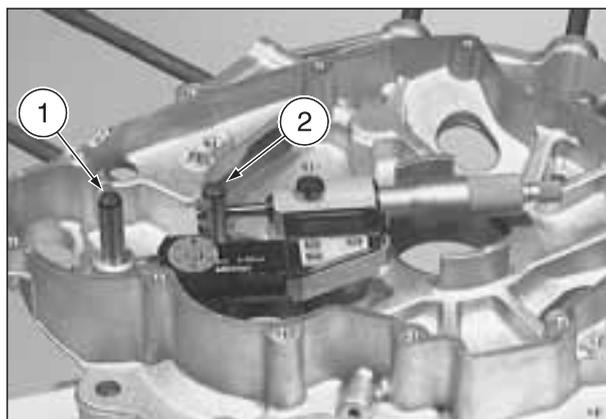
If the contact screw (7) is renewed or replaced:

**NOTE** Apply a couple of drops of LOCTITE® 574 to the threads.

- ◆ Tighten the contact screw (7).

Contact screw tightening torque: 2.9 ftlb (4 Nm).

D = LOCTITE® 574.



**5.7 ASSEMBLING THE ENGINE HALF-CASE**

Carefully read 5.1 (PREFACE).

**⚠ CAUTION**

Should a stud (1) be damaged, it must be replaced.

If the stud (1) is renewed or replaced:

**NOTE** Apply a couple of drops of LOCTITE® 243 to the threads.

◆ Tighten the stud (1).

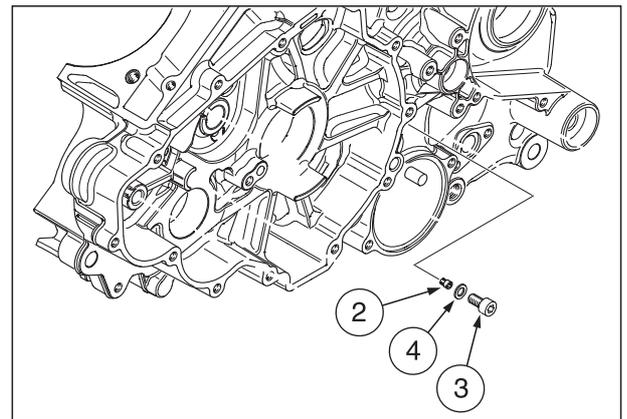
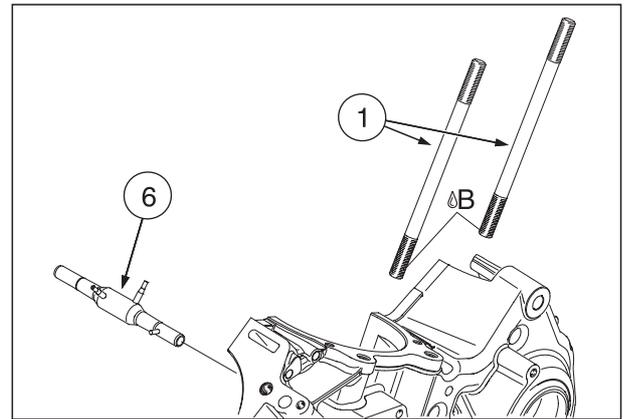
**Stud tightening torque: 7.2 ftlb (10 Nm).****NOTE** Ensure that both studs are screwed in completely and properly tightened.

◆ Install the jet (2).

◆ Install the M6 Allen screw (3) along with its seal (4).

**Allen screw tightening torque: 4.4 ftlb (6 Nm).**

◆ Insert the oil filter (5).

**5.8 COMPLETE OIL-SPRAY PIPE**

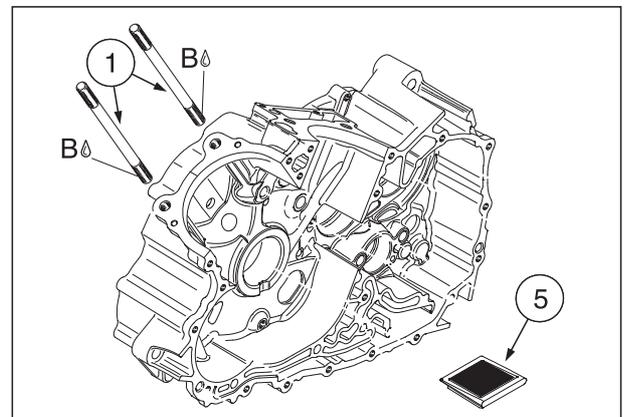
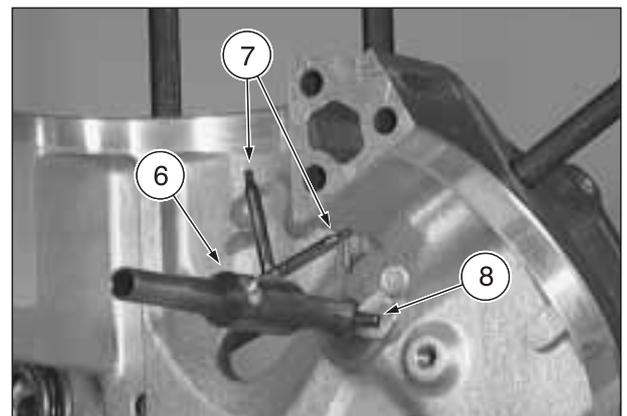
Carefully read 5.1 (PREFACE).

**5.8.1 DISASSEMBLY**

Using a hot-air gun, heat up the case in the area where the oil spray pipe is installed to approximately 100 °C (212 °F). Rotate it up and out of the case using a pair of pliers.

**5.8.2 ASSEMBLY****NOTE** There is an oil passage in the engine case. It must be correctly aligned with the oil-spray pipe (6) inlet.**⚠ WARNING****Failure to correctly align the oil spray pipe and the passage in the engine case can result in engine seizure, with subsequent serious accident and even death.****⚠ CAUTION****Take care not to damage the nozzles (7).**

◆ Maintaining the proper position for the oil spray pipe (6), insert it into the alternator side of the engine case (8).

**B** = LOCTITE® 243.

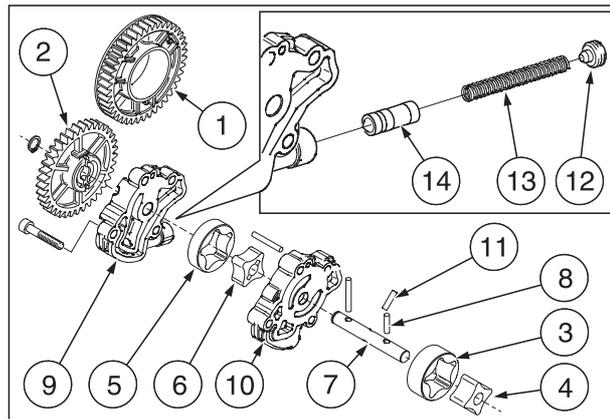
**5.9 OIL PUMP AND OIL PUMP DRIVE ASSEMBLY**

Carefully read 5.1 (PREFACE).

**CAUTION**

The oil pump gears, both driving (1) and driven (2), must always be replaced once they have been disassembled.

**NOTE** The oil pump drive gear (1) is attached to the support plate of the complete clutch housing.



**5.9.1 DISASSEMBLING THE OIL PUMP**

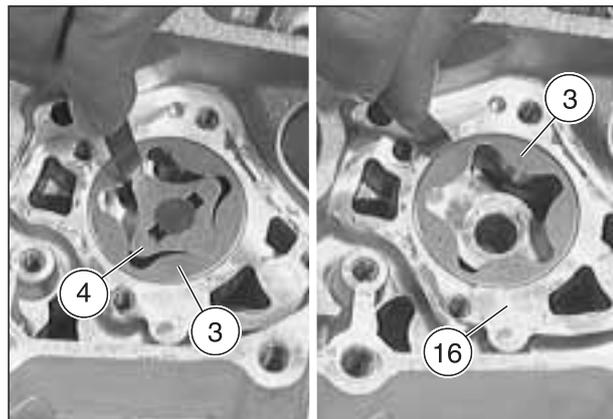
◆ Disassemble the oil pump, see 4.15 (REMOVING THE OIL PUMP).

**NOTE** Store, to keep separately, the groups:

- external rotor (3), internal rotor (4) (of the suction pump);
- external rotor (5), internal rotor (6) (of the pressure pump).

**Do not mix-up the components of these groups.**

- ◆ Remove the suction pump internal rotor (4) from the oil pump shaft (7).
- ◆ Remove the pin (8).
- ◆ Slip off the oil pump cover (9).
- ◆ Remove the pressure pump external rotor (5).
- ◆ Remove the oil pump shaft (7) from the pressure pump case (10).
- ◆ Remove the pressure pump internal rotor (6) and pin (11).
- ◆ Unscrew the plug (12) and remove the pressure release spring (13) and valve (14).



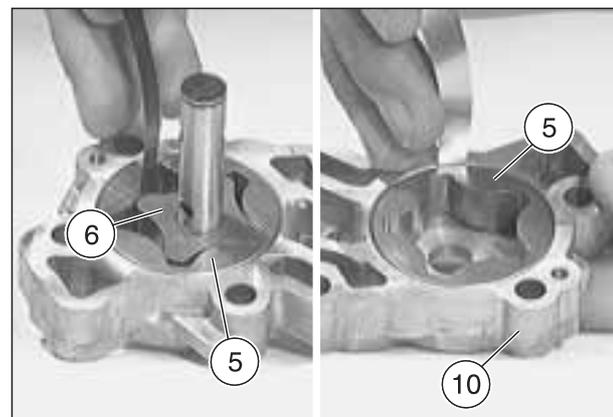
**5.9.2 CHECKING THE OIL PUMP**

- ◆ Check the oil pump rotors, the sliding surfaces of the external rotors in both pump cases and the thrust-bearing surfaces for any signs of grooving.
- ◆ Using a feeler gauge, measure the play between:
  - external rotor (3) and internal rotor (4) (of the suction pump);
  - external rotor (5) and internal rotor (6) (of the pressure pump).

**Wear limit max. 0.0098 in (0.25 mm).**

- ◆ Using a feeler gauge, measure the play between:
  - suction pump external rotor (3) and engine case (16);
  - pressure pump external rotor (5) and pressure pump case (10).

**Wear limit max. 0.0098 in (0.25 mm).**



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- ◆ Measure the end play (17) of the rotors.

**Wear limit max. 0.0059 in (0.15 mm).**

**NOTE** If either of the wear limits is exceeded, the defective component must be replaced.

- ◆ Ensure that the pressure relief valve (14) slides freely in the oil pump cover (9).
- ◆ Check the pressure relief valve (14) and oil pump cover (9) for signs of wear:
  - pressure relief valve (14),  
**wear limit (18) min.  $\varnothing$  0.3927 in (9.975 mm);**
  - oil pump cover (9),  
**wear limit (19) max.  $\varnothing$  0.3950 in (10.035 mm);**
  - pressure relief spring (13),

**minimum length of the spring (20) when not compressed: 2.2 in (56.0 mm).**

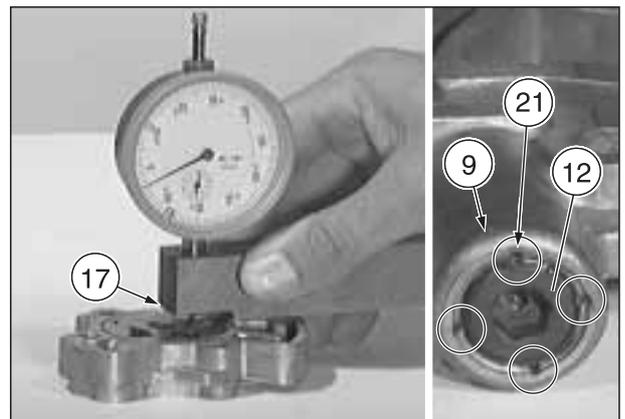
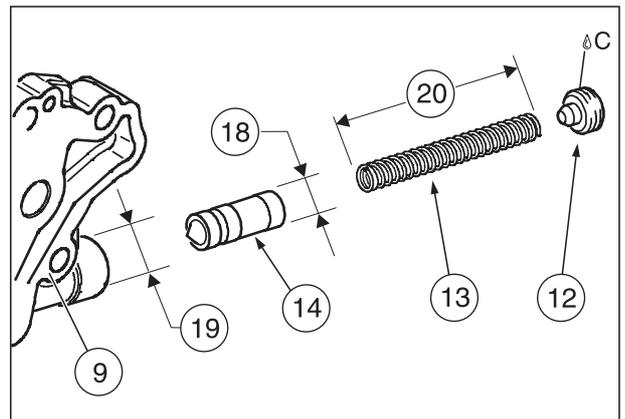
**NOTE** Apply a couple of drops of LOCTITE® 648 to the thread of the cap (12).

- ◆ Install the cap (12).

**NOTE** It should be screwed in until it is 0.078 in (2 mm) below the surface of its recess.

- ◆ Secure the cap by center punching at four diametrically opposed points (21).

**C** = LOCTITE® 648.



**5.10 CRANKSHAFT**

Carefully read 5.1 (PREFACE).

Check the wear of the crankshaft:

- main bushings (engine half-case) land alternator side (1A), main bushings (alternator cover) land clutch side (1B),  
**wear limit min. Ø 1.8092 in (45.955 mm);**
- clutch side outer support bushings land (2),  
**wear limit min. Ø 1.1799 in (29.970 mm);**
- sprag clutch gear bearing land (3),  
**wear limit min. Ø 1.3763 in (34.960mm);**
- connecting rod small end (4);  
**wear limit max. Ø 0.8673 in (22.030 mm);**
- end play between connecting rod big end and crank pin (5);  
**wear limit max. 0.023 in (0.60 mm);**

**NOTE** Measure the eccentricity of the crankshaft between centers as shown.

- crankshaft eccentricity alternator side (6);  
**limit max. 0.0008 in (0.020 mm);**
- crankshaft eccentricity clutch side (7);  
**limit max. 0.0008 in (0.020 mm).**

**NOTE** Never reuse an used engine case gasket. Use only new, original equipment **aprilia** engine case gasket. Use a dial gauge to determine the end play of the crankshaft in the two halves of the engine case once they are assembled.

**End play of the crankshaft max. 0.02 in (0.5 mm).**

- ◆ Using a dial gauge, evaluate the clearance (8) in the bottom end of each of connecting rods.

**Wear limit: max. 0.002 in (0.060 mm).**

- ◆ Determine the radial play of both sides (1A) (1B) of the crankshaft. To do this, you must temporarily assemble the crankcase halves and install the crankshaft. Use a light machine oil on the bearing lands.

**Max. permissible radial play 0.002 in (0.060 mm).**

**⚠ CAUTION**

If the max. permissible radial play is exceeded, the worn part must be replaced.

The radial play may be determined by measuring: the crank pins diameter (1A) (1B) and the internal diameter of the corresponding main bushings and then subtracting the crank pin diameter from the corresponding main bushing diameter.

- ◆ Measure the main bushing diameter, see 5.4 (CRANKSHAFT MAIN BUSHINGS AND LOWER BALANCE-SHAFT MAIN BUSHINGS).
- ◆ Measure the radial play of the support bushings (2).

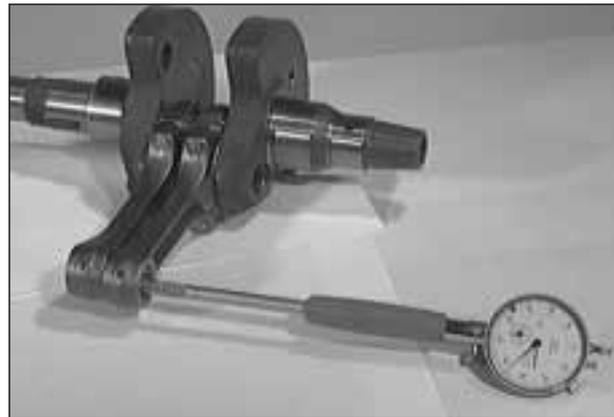
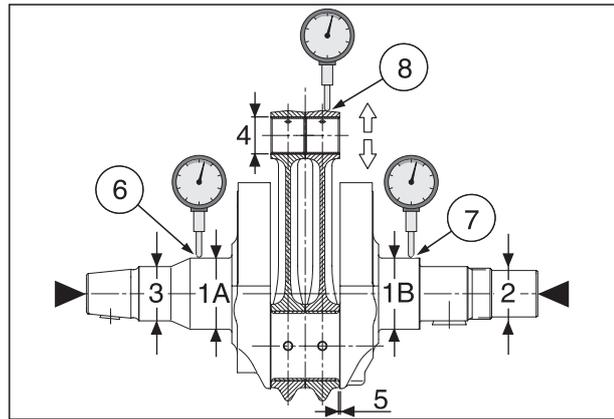
**Permissible radial play max. 0.0025 in (0.065 mm).**

The radial play may be determined by measuring: the crank pin diameter (2) and the internal diameter of the support bushing and then subtracting the crank pin diameter from the support bushing diameter.

- ◆ Measure the support bushing diameter, see 4.11 (REMOVING THE CLUTCH COVER).

**⚠ CAUTION**

If the max. permissible radial play is exceeded, the worn part must be replaced.

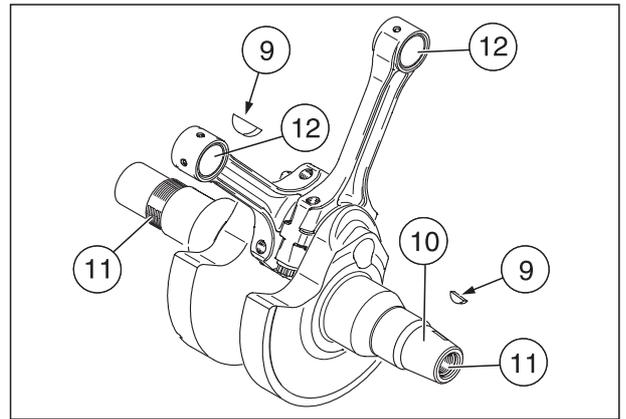


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The following components must all be checked for wear or damage:

- ◆ Key (9) and key seat in the crankshaft.
- ◆ Discoloration of any bearing housing.
- ◆ Tapered surface (10) of the crankshaft on the alternator side.
- ◆ Clean any LOCTITE® residues from the thread (11) and inspect to ensure that it is perfect condition.
- ◆ Check the small end bushing for correct installation and centering.



**5.11 DISASSEMBLING THE CONNECTING RODS**

Carefully read 5.1 (PREFACE).

**CAUTION**

Before disassembling the connecting rods (1) and rod caps (2), mark them so they are refitted in the same position (cylinder "1" and "2") and with the same direction of rotation.

- ◆ Unscrew and remove the M10x1 connecting rod bolts (3) and remove the rod cap (2) by tapping lightly with a plastic mallet.
- ◆ Remove the connecting rod bolts with the rod cap (2), and connecting rod (1).
- ◆ Clean the crankshaft lubrication holes.
- ◆ Check the bushings (4) for signs of wear, distortion and discoloration.
- ◆ Check the connecting rod big end for wear, distortion, or fretting:
  - connecting rod pins (5);  
wear limit min.  $\varnothing$  1.6527 in (41.98 mm);
  - connecting rod big end (6);  
wear limit max.  $\varnothing$  1.6555 in (42.050 mm).

**CAUTION**

To measure the diameter of the connecting rod big end, replace the rod cap (2) and rod bolts (3). Tighten the bolts (3) to the appropriate torque, see 5.12 (REPLACING AND INSTALLING THE CONNECTING RODS). Use a torque wrench or dial gauge, and a 12 mm socket.

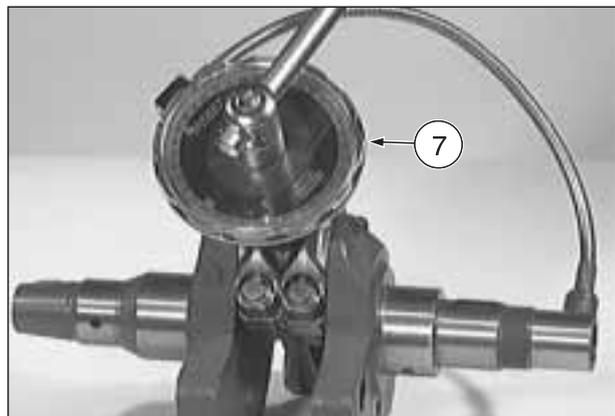
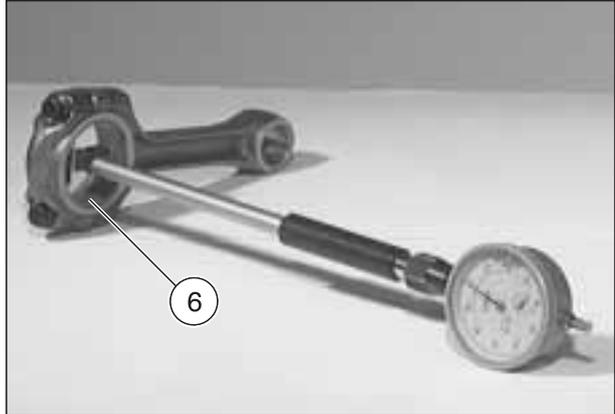
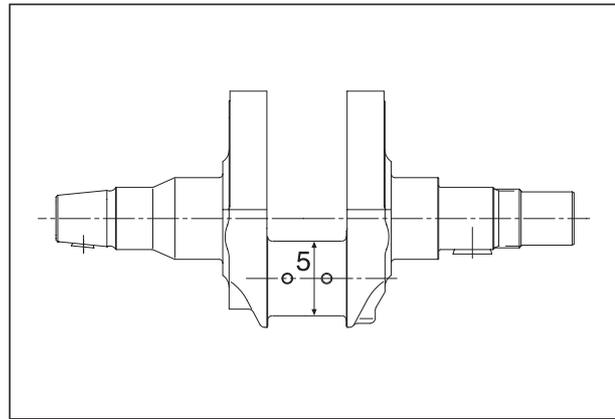
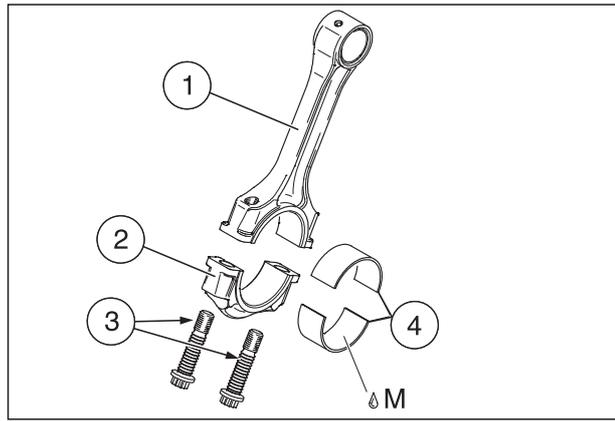
**NOTE** None of the measurements may exceed the limit value. If the connecting rod is determined to be worn or distorted, it must be replaced complete, with rod cap and bolts.

- ◆ Measure the radial play of the connecting rod big end (6).

**Wear limit max.  $\varnothing$  0.0028 in (0.070 mm).**

**NOTE** The radial play of the crankshaft is calculated by subtracting the diameter of the crank pin from the diameter of the bearings.

**NOTE** The radial clearance may also be calculated using plasti-gauge. If plasti-gauge is used, the connecting rod must not be moved.



## 5.12 REPLACING AND INSTALLING THE CONNECTING RODS

Carefully read 5.1 (PREFACE).

**NOTE** Complete connecting rods are supplied as spare parts with all three size rod bearing inserts (see table). The bearing halves are marked, according to size, in red, blue and yellow (4).

- ◆ Install the minimum thickness (red) bearing halves in the connecting rod (1) and the rod cap (2), taking care to place them correctly (3). Line the bushings up by placing the mating surface of the rod and the rod cap against a surface plate.
- ◆ Install the connecting rod and rod caps on the crank pin so that the two reference points (5) and part number (6) coincide on the two connecting rods.

### CAUTION

Correctly torquing the rod cap bolts requires the use of both a torque wrench and protractor gauge (8), see the figure, with a 12 mm socket.

- ◆ Tighten the rod caps (2) using the old bolts (7) in three stages.
  - The first** pre-tightening stage:
    - tighten the two bolts to a torque of 1.4 ftlb (2 Nm).
  - Second** tightening stage:
    - tighten the two bolts to a torque of 21.7 ftlb (30 Nm).
  - Third** (final) tightening stage:
    - further turn each bolts 70°.
- ◆ Measure the radial play of the connecting rod big end using a dial gauge (9).

**Radial play 0.0008 – 0.0018 in (0.020 – 0.045 mm).**

If the radial play is greater than 0.0018 in (0.045 mm), the bearings of the size corresponding to the colors blue or yellow must be chosen based on the following table, and must be inserted in place of the red bearings.

Bearing color	Thickness
Red	0.0579 – 0.0581 in (1.471 – 1.476 mm)
Blue	0.0581 – 0.0583 in (1.476 – 1.481 mm)
Yellow	0.0583 – 0.0585 in (1.481 – 1.486 mm)

- ◆ Unscrew the bolts (7).
- ◆ Lubricate the bearing halves and the crank pin.

**NOTE** Use new M10x1 bolts (7) only.

- ◆ Lubricate the bearing lands of the heads of the new bolts (7).

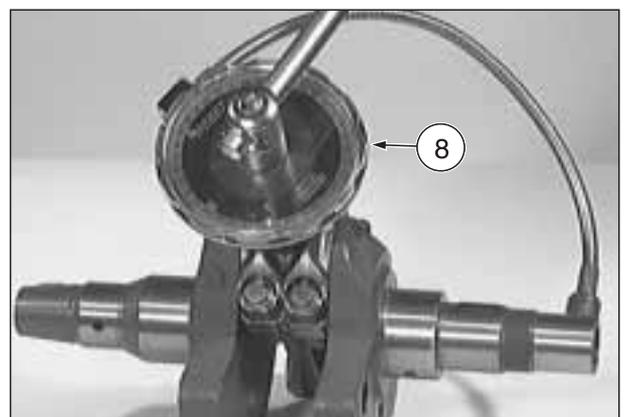
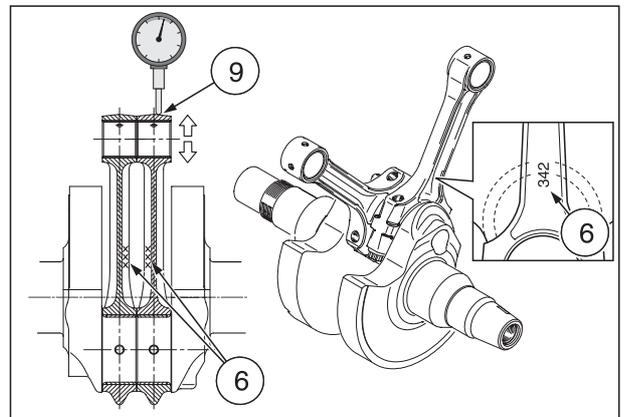
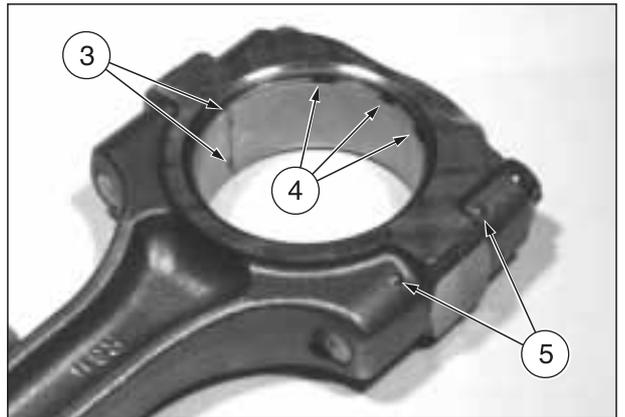
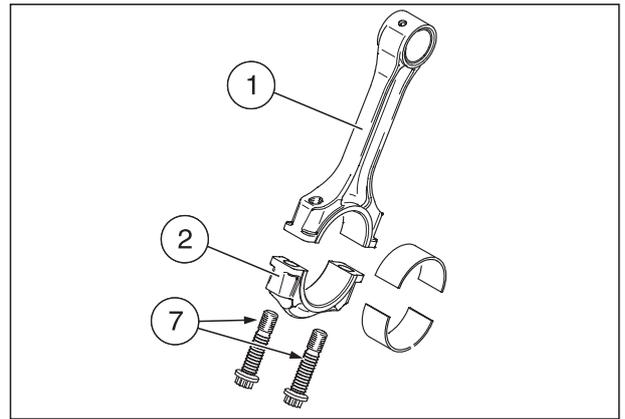
### CAUTION

Correctly torquing the rod cap bolts requires the use of both a torque wrench and protractor gauge (8), see the figure, with a 12 mm socket.

- ◆ Fasten the rod cap (2) in the three stages described above using the two new bolts (7).
- ◆ Measure the radial play of the connecting rod big end using a dial gauge (9).

**Radial play 0.0008 – 0.0018 in (0.020 – 0.045 mm).**

- ◆ Ensure that the connecting rods are free to turn completely around the crank pin.



**5.13 LOWER BALANCESHAFT AND LOWER BALANCESHAFT MECHANISM**

Carefully read 5.1 (PREFACE).

**Check the wear of the lower balancershaft:**

- lower balancershaft bearing (engine half-case) land (1);  
**wear limit min. Ø 1.2591 in (31.980 mm);**
- support bearing (clutch cover) land (2);  
**wear limit min. Ø 0.7870 in (19.990 mm);**
- lower balancershaft bearing (engine half-case) land (1);  
**permissible radial play min. Ø 0.0023 in (0.060 mm);**
- support bearing (clutch cover) land (2);  
**permissible radial play min. Ø 0.0023 in (0.060 mm).**

**Check the permissible radial play:**

The radial play may be determined by measuring: the crank pins diameter and the internal diameter of the corresponding bearings (engine half-case) and support bearings (clutch cover) and then subtracting the crank pin diameter from the corresponding bearing diameter.

Measure the main bearings diameter, see 5.4 (CRANKSHAFT MAIN BUSHINGS AND LOWER BALANCESHAFT MAIN BUSHINGS) and 4.11 (REMOVING THE CLUTCH COVER).

**NOTE** If the max. permissible radial play is exceeded, the worn part must be replaced.

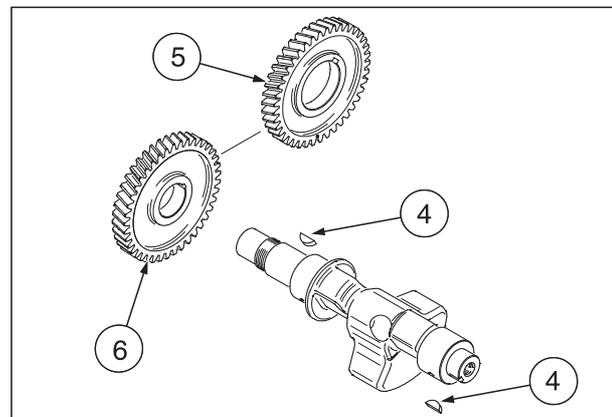
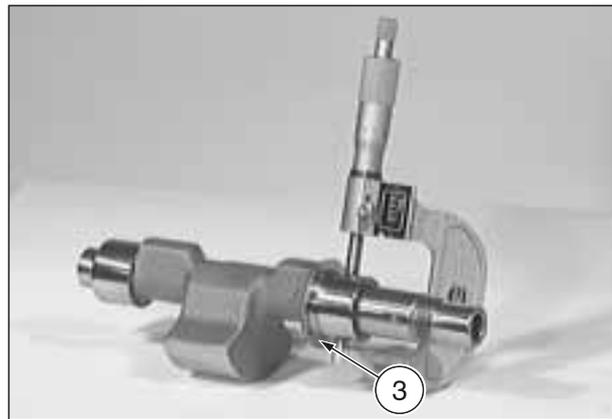
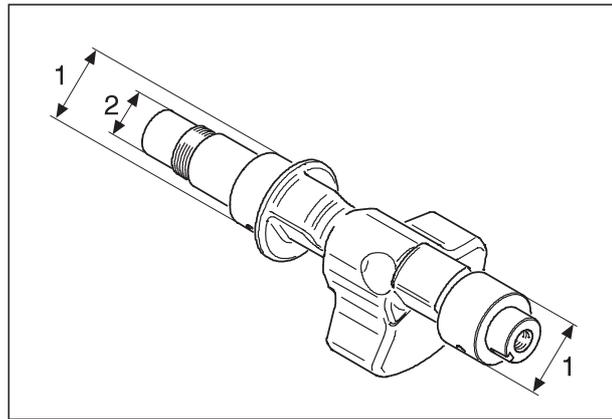
**Permissible radial play of the lower balancershaft max. 0.012 in (0.30 mm).**

**NOTE** Once the two halves of the engine case have been assembled, check the end play of the lower balancershaft with the dial gauge.

The following components must all be checked for wear and damage:

- thrust bearing land (3);
- key (4) and key seat in the lower balancershaft;
- discoloration of the lower balancershaft.
- ◆ Carefully clean the thread. Remove any traces of LOC-TITE® residue. Ensure that the thread is in perfect condition.
- ◆ Check the flanks of the driving gear (5) and driven gear (6) for any signs of distress.

**NOTE** In order to check the lower balancershaft's main bearings (engine half-case), see 5.4 (CRANKSHAFT MAIN BUSHINGS AND LOWER BALANCESHAFT MAIN BUSHINGS). In order to check the lower balancershaft's support bearings (clutch side), see 4.11 (REMOVING THE CLUTCH COVER).

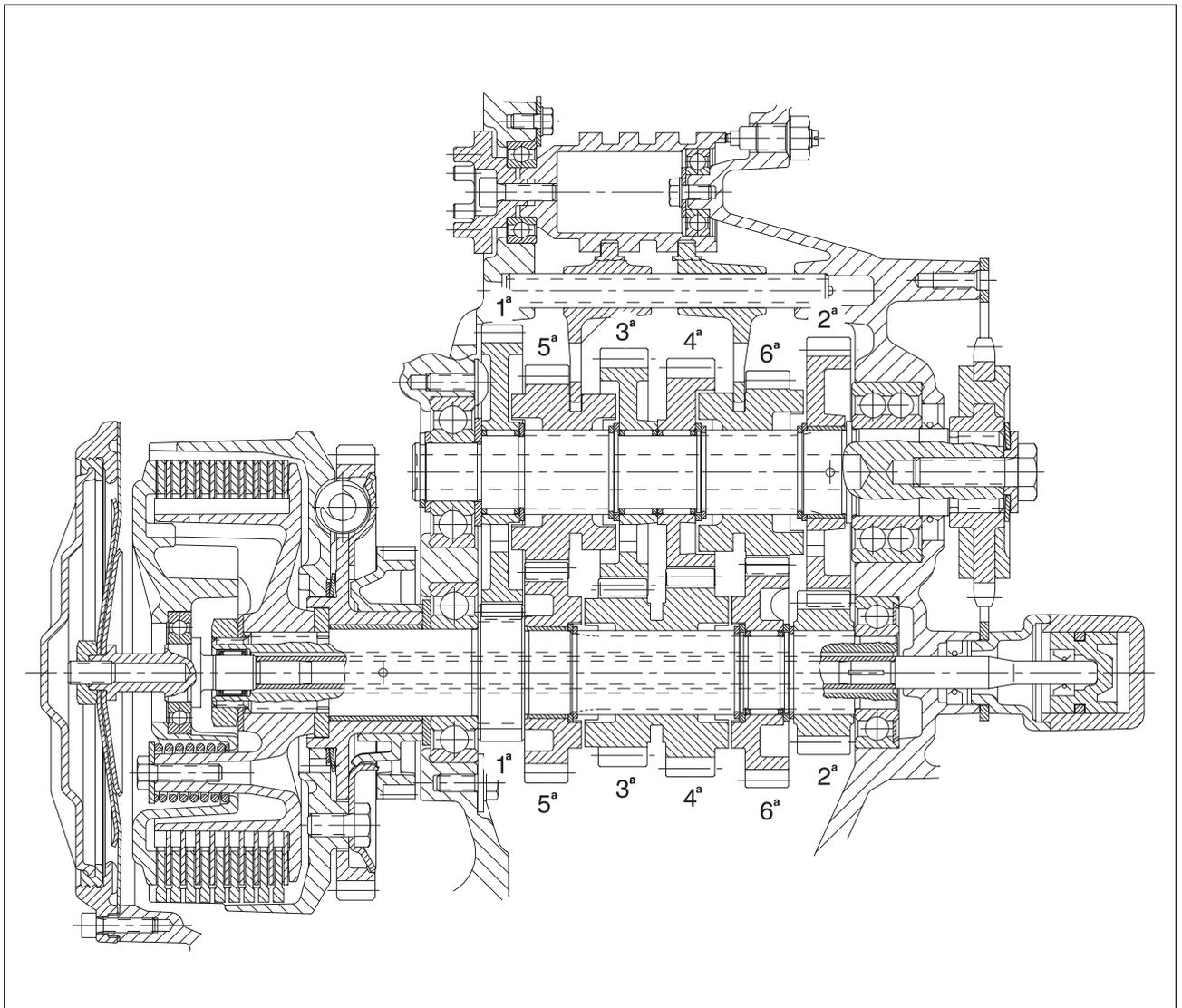


**5.14 GEARBOX**

Carefully read 5.1 (PREFACE).

**⚠ CAUTION**

When disassembling the gearbox, arrange the disassembled components in order as you take them apart to ensure that you are able to reassemble and install them correctly. Never reuse a snap ring. Snap rings must always be replaced once they are removed from a shaft.

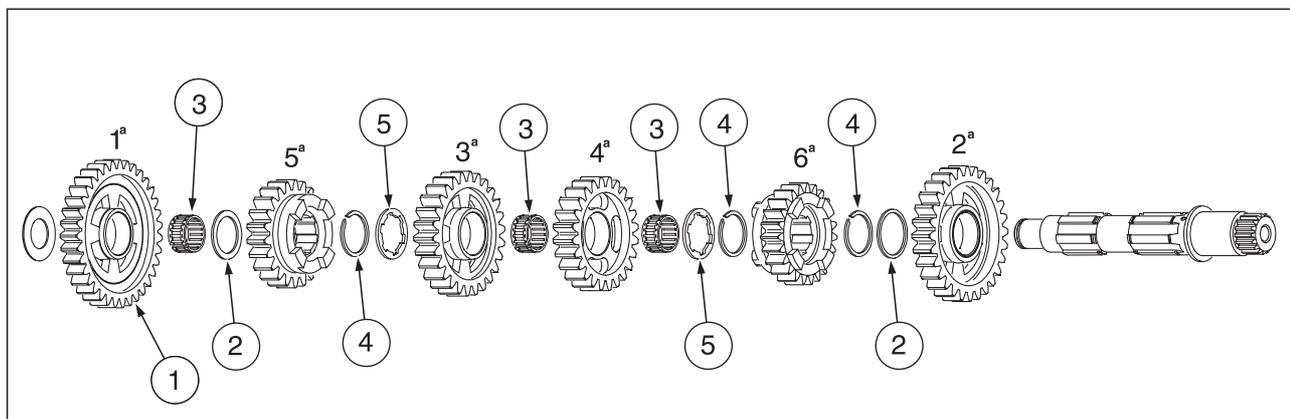


5.14.1 TAKING THE GEARBOX APART

**Countershaft**

Use snap ring pliers to remove the circlips (4).

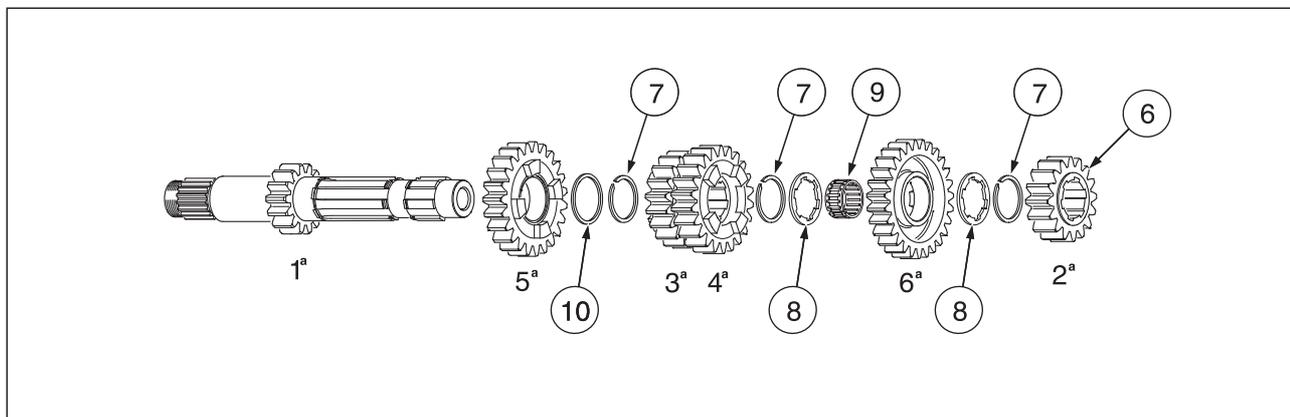
- ◆ Remove the gears from the countershaft, starting with the free gear of 1<sup>st</sup> gear (1) and then moving on to the shim washers (2), roller cages (3), circlips (4) and shim rings (5).



**Main shaft**

Use snap ring pliers to remove the circlips (7).

- ◆ Remove the gears from the main shaft, starting with the tied gear of 2<sup>nd</sup> gear (6) and then moving on to the circlips (7), shim rings (8), the roller bearing (9) and shim washer (10).



5.14.2 CHECKING

◆ Check the following components for wear:

**CAUTION**

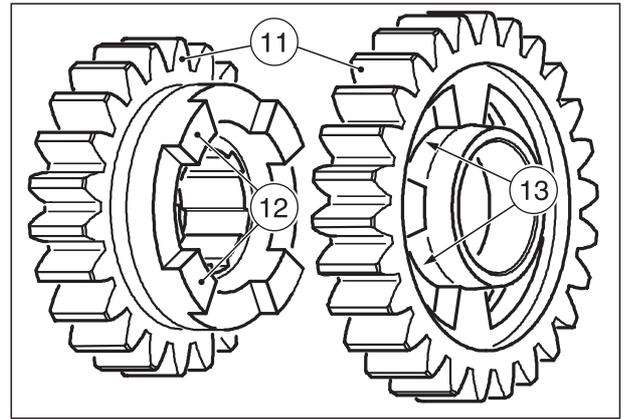
Never reuse the roller bearings (3) (9). The roller bearings (3) (9) must be replaced every time they are removed.

– check the flanks (11) of the gears for any distress.

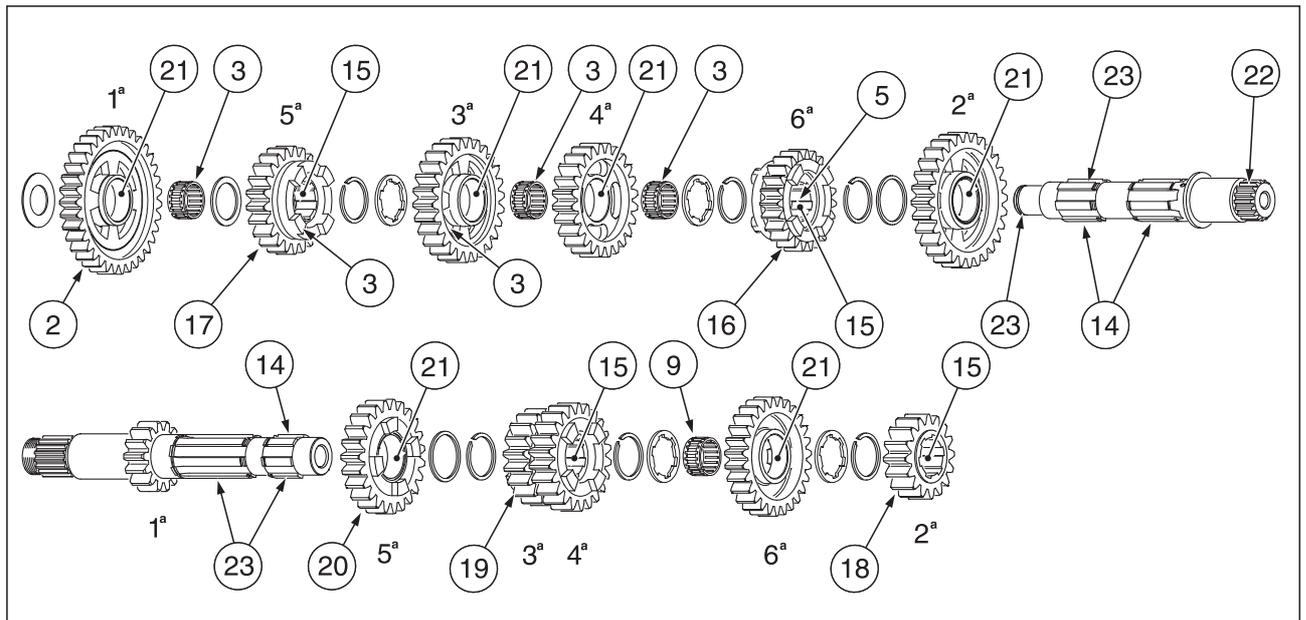
**NOTE** Small areas of discoloration and very small pits are acceptable up to a maximum of approximately 0.5% (½ of 1%) of the tooth surface area.

**NOTE** Should the flanks of the teeth be worn, the damaged gear and its mating gear must be replaced as a set. Should the dogs or mating recesses be worn, both gears must again be replaced as a set.

- dogs (12) and recesses (13) of all gears;
- condition of shaft splines (14) of main shaft and countershaft;
- condition of splines (15) of all sliding gears;
- check for smooth and effortless lateral movement of the sliding gears (16), (17) on the countershaft and sliding gears (18), (19), (20) on the main shaft.
- check for any sign of damage, grooving or scoring of the bore (21) of the freely rotating gears;
- spline (22) of the countershaft sprocket;
- grooves for circlips (23) on the main shaft and countershaft. The edges of the grooves must be sharp, and not worn round.

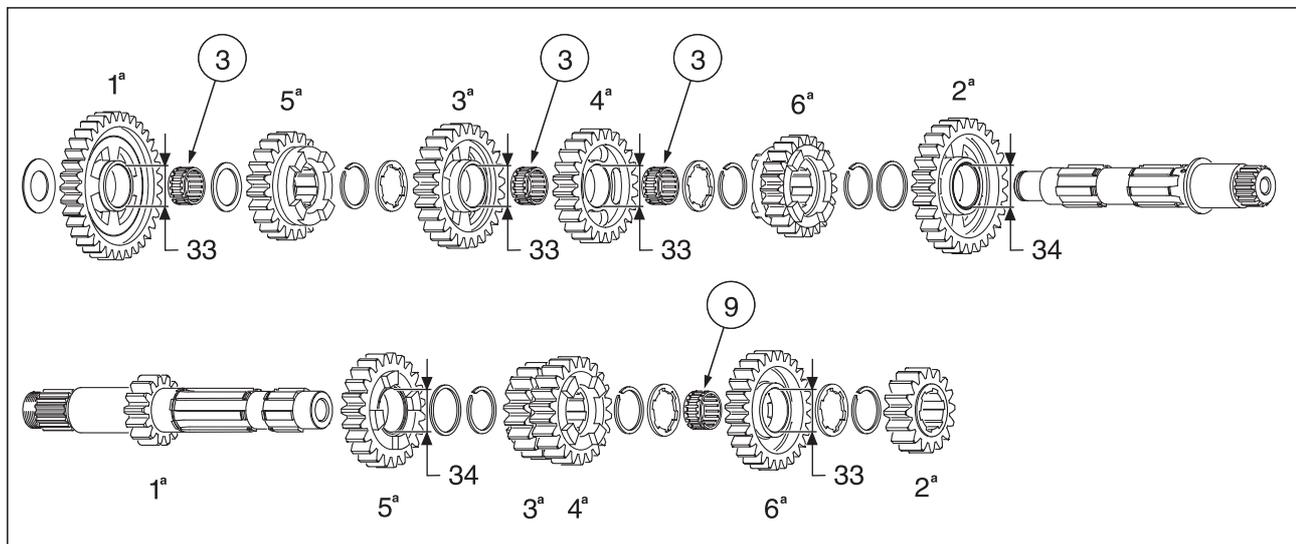
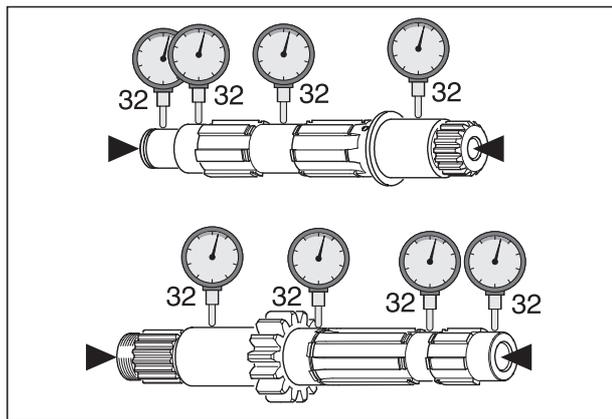
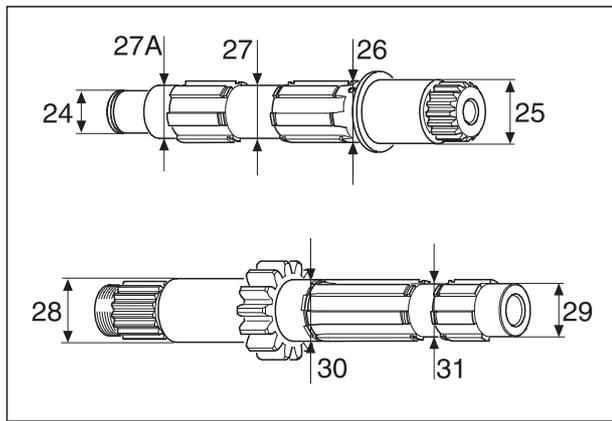


Follow ►



Follow ►

- ◆ Check the bearing lands of countershaft for wear:
    - land (24) wear limit min. diam. 0.7863 in (19.972 mm);
    - land (25) wear limit min. diam. 1.7776 in (29.915 mm);
    - land (26) wear limit min. diam. 1.1429 in (29.030 mm);
    - land (27) wear limit min. diam. 0.9833 in (24.978 mm);
    - land (27A) wear limit 0.9833 in (24.978 mm).
  - ◆ Check the bearing lands of main shaft for wear:
    - land (28) wear limit diam. 1.1797 in (29.965 mm);
    - land (29) wear limit diam. 0.9831 in (24.972 mm);
    - land (30) wear limit diam. 1.1429 in (29.030 mm);
    - land (31) wear limit diam. 0.9833 in (24.972 mm).
  - ◆ Check the eccentricity (32) of all lands of main shaft and countershaft.
    - for all lands permissible eccentricity max diam. 0.0008 in (0.02 mm);
  - ◆ Check for any sign of damage, grooving, or scoring on all of the bearing lands.
  - ◆ Check the internal diameter (33) of the freely rotating of 1<sup>st</sup>, 3<sup>rd</sup>, 4<sup>th</sup> and 6<sup>th</sup> gear.
- Wear limit max. diam. 1.1426 in (29.022 mm).**
- ◆ Check the internal diameter (34) of the freely rotating of 2<sup>nd</sup> and 5<sup>th</sup> gear.
- Wear limit max. diam. 1.1467 in (29.125 mm).**
- ◆ Ensure that the lubrication hole (35) of the countershaft is clear.



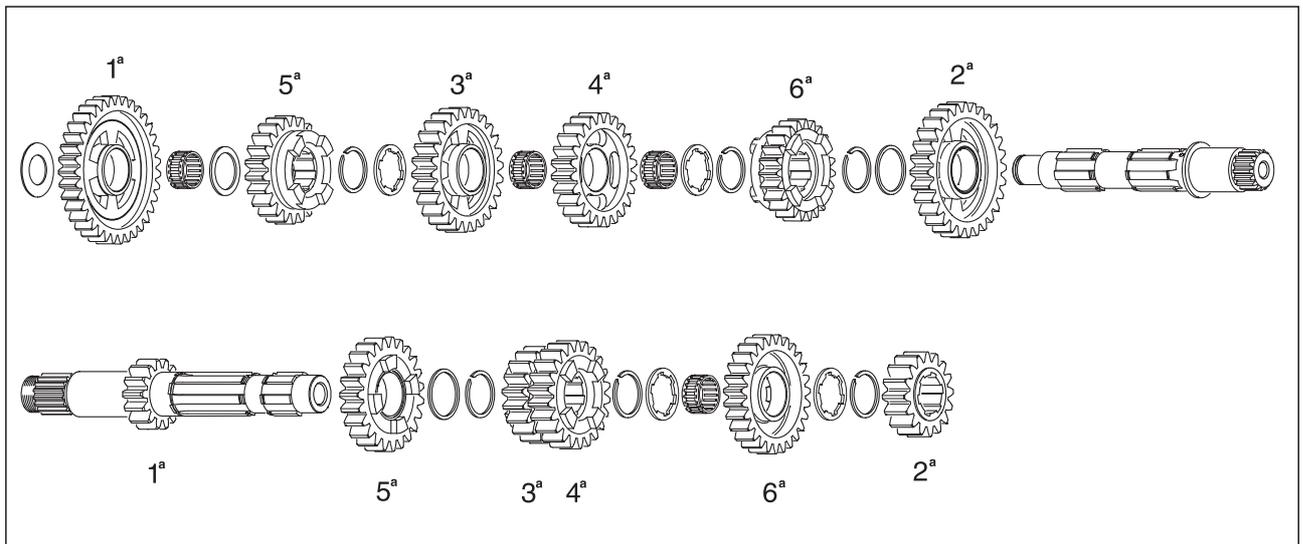
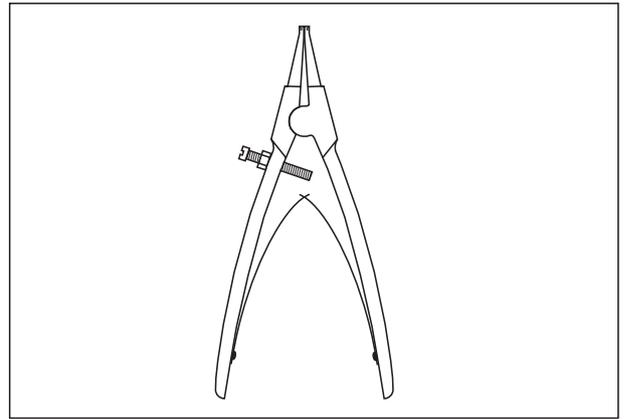
**5.14.3 ASSEMBLY**

- ◆ Oil the countershaft, main shaft, gearbox gears and roller bearings lightly.
- ◆ Reassemble the gears on both shafts, in the reverse order of disassembly, see 5.14.1 (TAKING THE GEARBOX APART).
- ◆ Fit the circlip, using special circlip pliers.

**⚠ WARNING**

Never reuse circlips. Circlips must be replaced every time they are removed. Stretch the circlip ends far apart just enough to slide the circlip onto the shaft. If the circlip is stretched too much, it will not properly retain the gears on the shaft, which could lead to seizure, and subsequent accident with serious injury or even death. Ensure that all circlips are properly and snugly installed in their appropriate grooves.

- ◆ Once the two gearbox shafts have been assembled, ensure that the gears turn smoothly.



**5.15 GEAR SELECTION**

Carefully read 5.1 (PREFACE).

- ◆ Check the end play (1) of the gearshift forks inside the corresponding grooves in the sliding gears.

**Wear limit max. 0.006 in (0.15 mm).**

**NOTE** If the wear limit is exceeded, you must determine which component needs replacing by checking the gearshift forks and sliding gears.

- ◆ Width of the groove (2) of the sliding gears.

**Wear limit max. 0.171 in (4.35 mm).**

- ◆ Check the wear on the chromium-plated fingers (3) of the gearshift forks.

**Wear limit max. 0.156 in (3.950 mm).**

**NOTE** If the finish is worn through, replace the fork.

- ◆ Check the diameters (4) of the gearshift fork guide pins.

**Wear limit min. Ø 0.230 in (5.850 mm).**

- ◆ Check the eccentricity of the two fork shafts (5).

**Max. permissible eccentricity 0.0008 in (0.02 mm).**

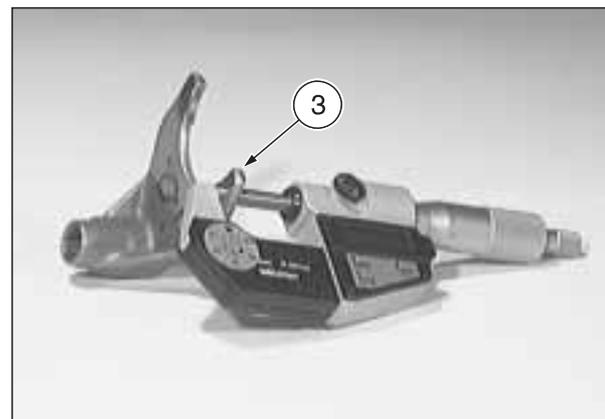
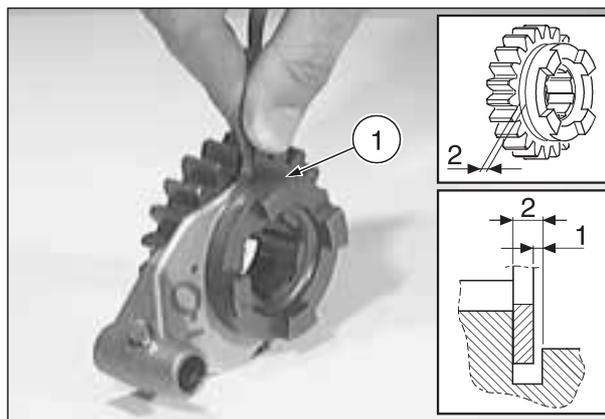
- ◆ Check the wear of the ratchet gear in the area in which it comes into contact with the index plate pins.

**Wear limit (6): visual inspection.**

- ◆ Check the eccentricity of the selector shaft (7) and also check for any signs of rolling on the sliding surface of the shaft sealing ring.

**Max. permissible eccentricity 0.001 in (0.25 mm).**

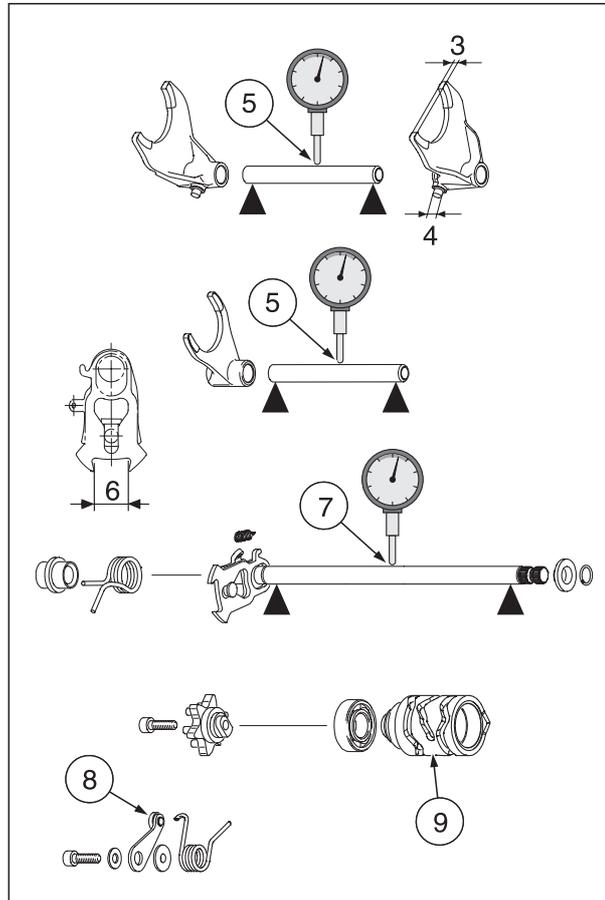
- ◆ The roller (8) of the detent lever must turn freely.
- ◆ Check the wear of the guide tracks (9) of the shift cam.



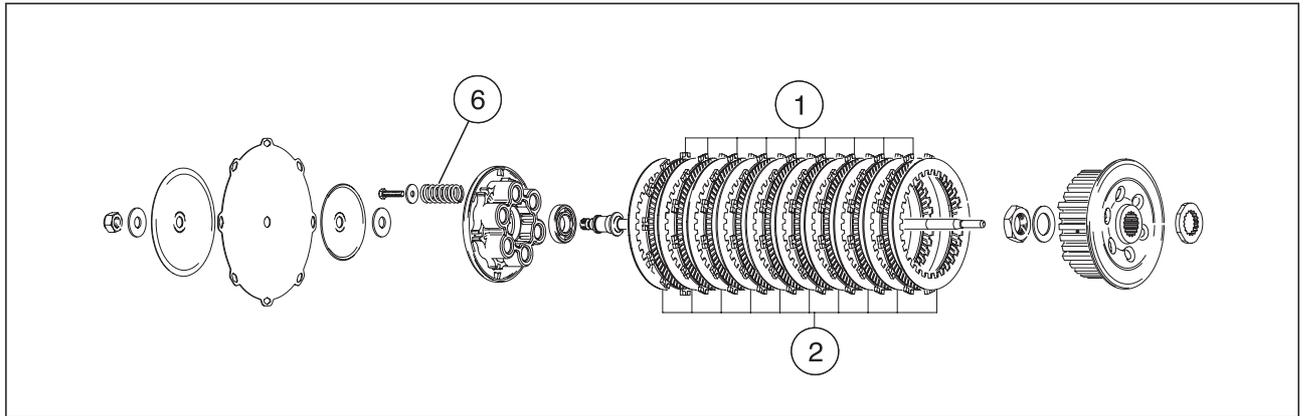
**5.16 CLUTCH (VERSIONS)**

**NOTE** There are different clutch versions. For information regarding the components of the clutch, refer to the specific spare parts catalogue, according to the vehicle model on which the engine is installed, see 0.4.2 (SPARE PARTS CATALOGUE).

For the clutch check, see 5.17 (CHECKING THE CLUTCH).



## 5.17 CHECKING THE CLUTCH



**NOTE** The following information may refer and should be observed with regard to all clutch versions.

For information refer to the clutch versions, see 5.16 [CLUTCH (VERSIONS)].

**Carefully read 5.1 (PREFACE).**

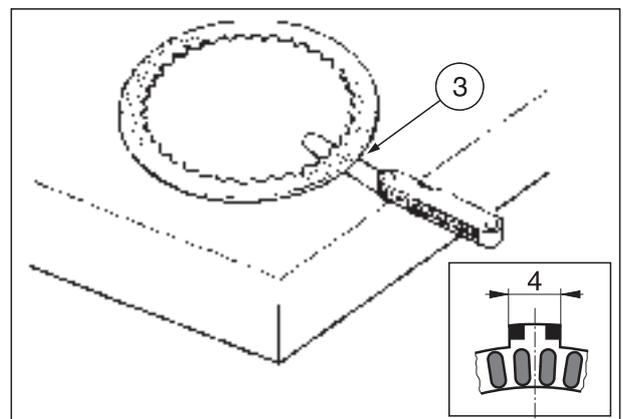
- ◆ Check the lined discs (1) and steel discs (2) for cracks or any distortion (3) by placing them on a flat surface.

**Max. permissible distortion (3): 0.006 in (0.15 mm).**

**NOTE** Reject any disc that is discolored or shows deep scratches or grooves.

- ◆ Measure the width (4) of the tab.

**Wear limit (4) min. 0.54 in (13.7 mm).**



**NOTE** Check the wear of the clutch discs, measuring the entire set of clutch discs (5).

Do not measure the steel disc set and the lined disc set separately, since separate measurements are not acceptable when checking the wear.

- ◆ Measure (5) the entire set of clutch discs (comprising ten steel discs and nine lined discs).

**Wear limit (5) min. 1.77 in (44.9 mm).**

**NOTE** The wear of one or more clutch discs (steel or lined discs) requires the renewal of the entire set of clutch discs (comprising ten steel discs and nine lined discs).

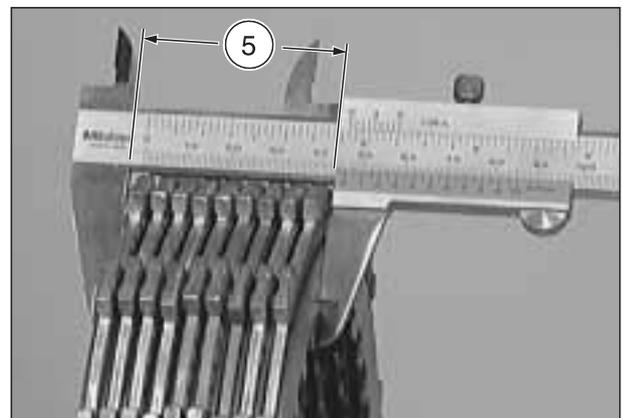
No partial renewal (of the worn discs only) is allowed.

**NOTE** The renewal of the entire set of clutch discs requires the renewal of all the clutch springs. It is not possible to install a new set of clutch discs with an old set of clutch springs.

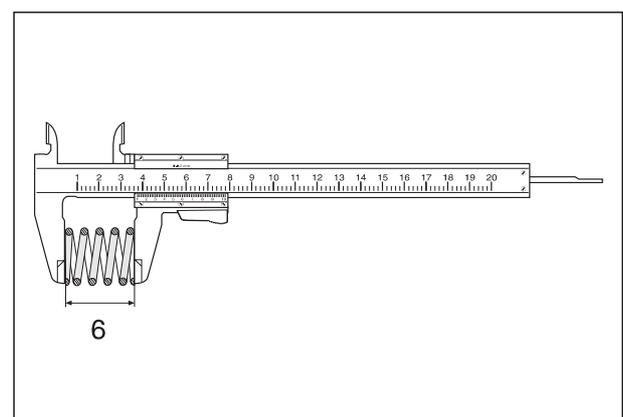
- ◆ Measure the length of each clutch spring (6) in the free position.

**Wear limit (6) min. 1.69 in (43.0 mm).**

**NOTE** The wear of one or more clutch springs requires the renewal of all the clutch springs. No partial renewal (of the worn springs only) is allowed.



Follow ►



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- ◆ Check the ball bearings (7) on the support-spring cups (8) for smoothness and play. They should have no radial play and rotation should be completely smooth. If not, replace the bearings.

**NOTE** When removing the ball bearings, heat the spring plate to 80 – 100 °C (176 – 212 °F) and use the appropriate assembly drift.

- ◆ Check the compression surface (9) of the spring plate (8) for signs of distortion, discoloration or wear. Ensure that this surface is completely flat.

**Max. permissible distortion (9): 0.0039 in (0.1 mm).**

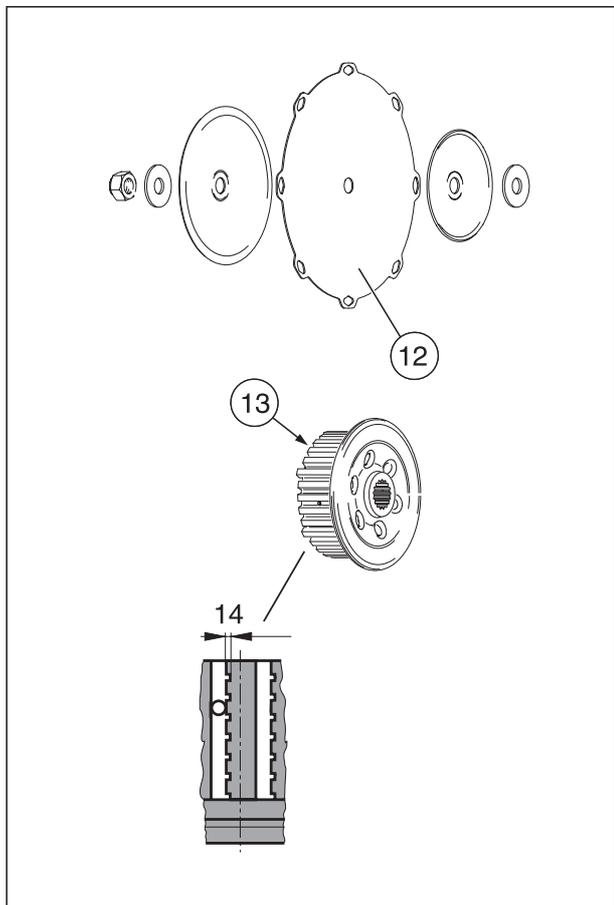
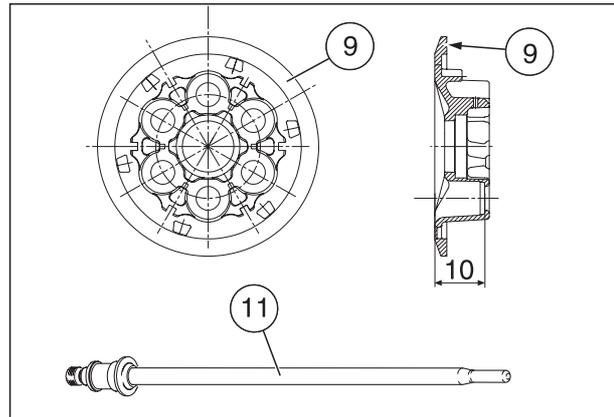
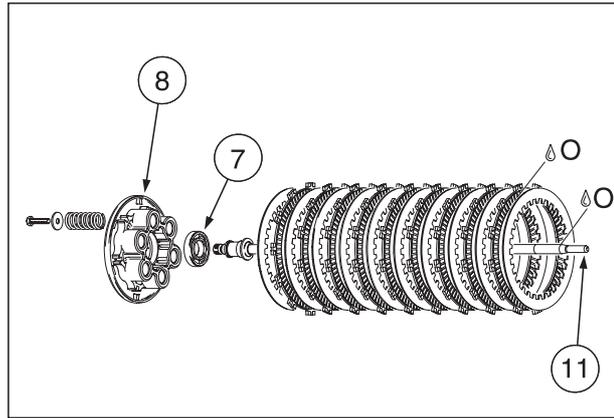
- ◆ Check the dimension (10) of the spring plate.

**Wear limit (10) max. 1.32 in (33.5 mm).**

- ◆ Check the clutch shaft (11) for eccentricity and signs of scoring or wear on the oil seal sliding surface.
- ◆ Check the diaphragm (12) for cracks and. If it is cracked, replace it.
- ◆ Check the splines on the clutch hub (13) for distortion, unevenness or wear (14).

**Max. distortion, unevenness or wear (14) depth: 0.01 in (0.3 mm).**

○ = Engine oil.



**5.18 PRIMARY DRIVE (VERSIONS)**

**NOTE** There are different primary transmission versions.

Consult the paragraph corresponding to the vehicle model on which the engine is installed.

Vehicle	Model	Primary transmission	Paragraph
	'98 – '99	aprilia part# 0295790	5.19.1 (PRIMARY DRIVE aprilia part# 0295790)
	SP '99		
	2000		
	2001 		
	2000		
	2001 		
	2000 - 2001		
	2001 (engines up to aprilia part# 854075)		
 	2001             	aprilia part# 0295792	5.19.2 (PRIMARY DRIVE aprilia part# 0295792 and 0295793)
			
	2001		
    	2001 (engines aprilia part# 954103 and later)	aprilia part# 0295793	5.19.2 (PRIMARY DRIVE aprilia part# 0295792 and 0295793)

**NOTE** Engines up to aprilia part# 954102 the primary drive is coded as follows: aprilia part# 0295792.

Engines aprilia part# 954103 and later the primary drive is coded as follows: aprilia part# 0295793.

**Difference between the two codes:** the primary drive aprilia part# 0295793 is provided with an additional shim (aprilia part# 0627910).

Code aprilia part# 0295793 cancels and replaces code aprilia part# 0295792.

It is possible to install the additional shim (aprilia part# 0627910) on the primary transmission aprilia part# 0295792 (thus transforming it into code aprilia part# 0295793).

In case this replacement is performed, only the primary transmission code aprilia part# 0295793 will be available as spare part.



**5.19 DISASSEMBLING THE PRIMARY DRIVE**

**NOTE** For information refer to the primary drive versions, see 5.18 [PRIMARY DRIVE (VERSIONS)].

**5.19.1 PRIMARY DRIVE aprilia part# 0295790**

**Carefully read 5.1 (PREFACE).**

**DISASSEMBLY**

- ◆ Remove the clutch, see 4.12 (DISASSEMBLING THE CLUTCH).
- ◆ Remove the primary drive assembly from the main shaft.
- ◆ Remove the washer (A) from the main shaft.
- ◆ Slip off the oil pump drive gear (1).
- ◆ Unscrew and remove the three M8 screws (2) and remove the spring-support plate (3).
- ◆ Remove the six compression rings (5) together with the twelve spring pins (6) from the clutch gear (4).
- ◆ Remove the clutch gear (4) with the spring washer (7) and the washer (8) from the clutch housing (9).

**INSPECTION**

- ◆ Check the wear of primary drive components, see 5.19.3 (PRIMARY DRIVE WEAR LIMITS).

**PREASSEMBLY**

- ◆ Insert the washer (8) and the spring washer (7) into clutch housing (9).

**⚠ CAUTION**

**Install the spring washer with the concave face next to the clutch gear (4).**

- ◆ Place the clutch gear (4) on the clutch housing and insert the six compression springs (5) along with the two spring pins (6) for each spring into their appropriate recesses in the clutch gear.

**⚠ CAUTION**

**Use LOCTITE® 648 on the three M8x16 Allen screws (2) of the spring-support plate (3).**

**NOTE** Apply a couple of drops of LOCTITE® 648 to the threads of the M8 screws (2).

- ◆ Install a spring-support plate (3) to the clutch gear (4) and fasten it with the three M8x16 screws (2).

**Spring-support plate screws (2) tightening torque: 21.7 ftlb (30 Nm).**

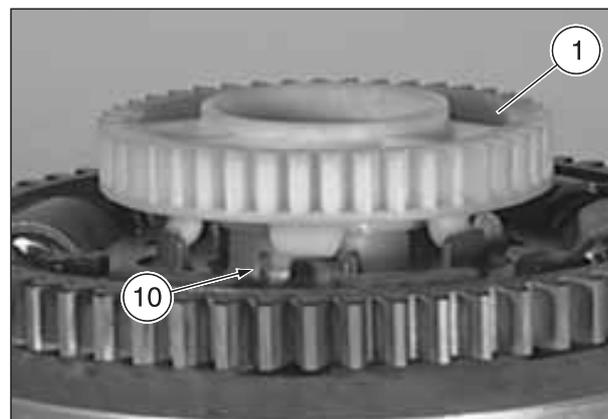
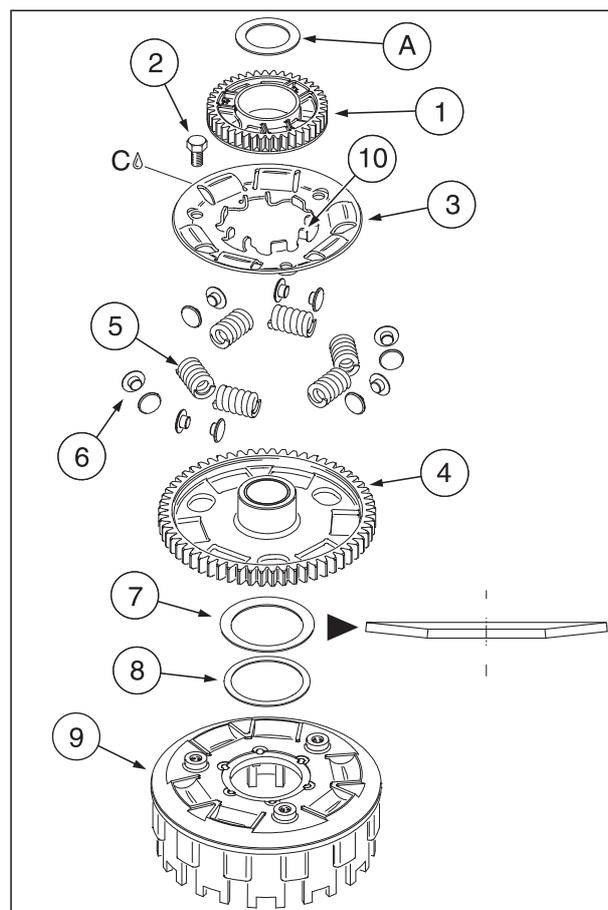
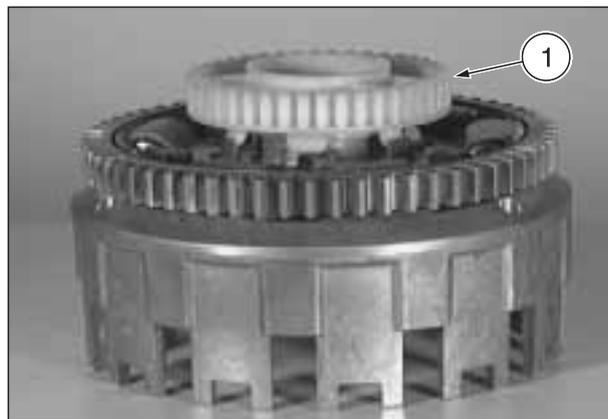
**⚠ CAUTION**

**Once disassembled, always replace the oil pump drive gear (1).**

- ◆ Place a new oil pump drive gear (1) so that its pins are engaged in the tabs (10) of the spring-support plate (3).
- ◆ Install the washer (A) on the main shaft.

**NOTE** To install the primary drive assembly on the main shaft, see 6.12 (ASSEMBLING THE PRIMARY DRIVE AND CLUTCH).

C = LOCTITE® 648.



**5.19.2 PRIMARY DRIVE aprilia part# 0295792 and 0295793**

Carefully read 5.1 (PREFACE).

DISASSEMBLY

- ◆ Remove the clutch, see 4.12 (DISASSEMBLING THE CLUTCH).
- ◆ Remove the primary drive assembly from the main shaft.
- ◆ Remove the washer (A) from the main shaft.
- ◆ Slip off the oil pump drive gear (1).

**Nut (2) tightening torque: 21.7 ftlb (30 Nm).**

- ◆ Unscrew and remove the three M8 nuts (2).
- ◆ Retrieve the three M8 screws (3).
- ◆ Remove the external spring-support plate (4).
- ◆ Retrieve the three spacer bushing (5).

**NOTE** Observe the assembly position of the different compression springs (7) (8) (9).

- ◆ Remove the clutch gear (6) complete with compression springs (7) (8) (9) and spring pins (10) (11).
- ◆ Extract the compression springs (7) (8) (9) and the spring pins (10) (11) from the clutch gear (6).
- ◆ Remove the spring washer (12).
- ◆ **For primary drive aprilia part# 0295793 (and, if installed, primary drive aprilia part# 0295792) only.** Remove the additional thrust washer (aprilia part# 0627910) (13).
- ◆ Remove the internal spring-support plate (14).

INSPECTION

- ◆ Check the wear of primary drive components, see 5.19.3 (PRIMARY DRIVE WEAR LIMITS).

PREASSEMBLY

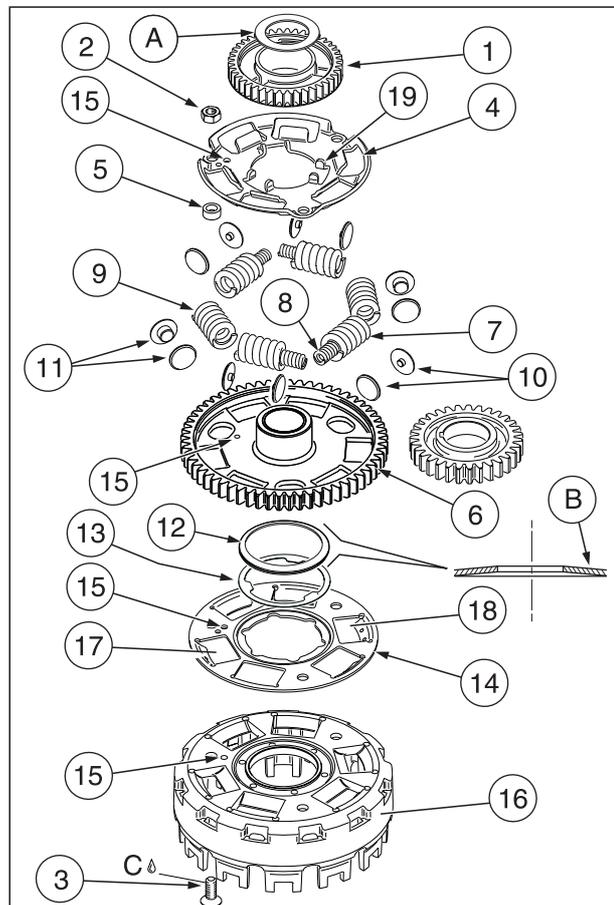
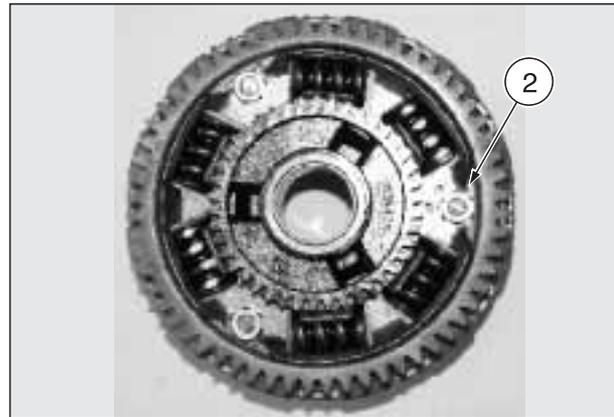
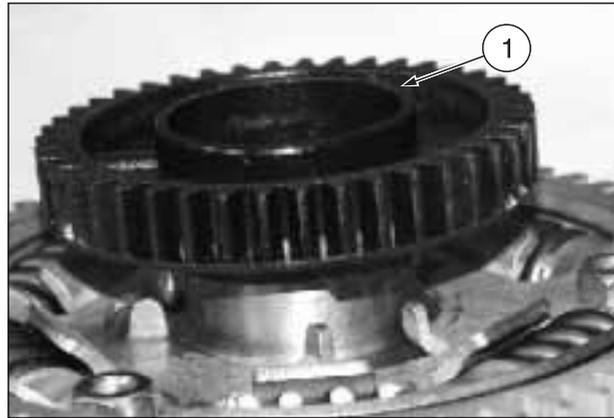
**NOTE** A reference hole (15) present on clutch gear (6) on external spring-support plate (4) on internal spring-support plate (14) and on clutch housing (16) indicates the correct assembly position of these components. Install these components so that the reference holes (15) coincide.

- ◆ Install the internal spring-support plate (14) on the clutch housing (16) so that the two respective reference holes (15) coincide.

**NOTE** It is possible to install the additional thrust washer (aprilia part# 0627910) (13) on the primary drive aprilia part# 0295792 (thus transforming it into code aprilia part# 0295793).

- ◆ **For primary drive aprilia part# 0295793 (and, if installed, primary drive aprilia part# 0295792) only.** Install the additional thrust washer (aprilia part# 0627910) (13).

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- ◆ Install the spring washer (12) with external diameter (B) towards the internal spring-support plate (14).
- ◆ Install the clutch gear (6) so that its reference hole (15) coincide with the reference holes (15) of the internal spring-support plate (14).
- ◆ Insert the two compression springs (9), marked with color white, along with the corresponding two spring pins (11) for each spring, into their appropriate recesses:
  - (17) (marked with one hole);
  - (18) (marked with two holes);
- in the internal spring-support plate (14).
- ◆ Insert the four internal compression springs (8) in the four external compression springs (7) and insert in each compression spring group the two spring pins (10).
- ◆ Install the four compression spring groups (7) (8) (10) in the appropriate recesses.
- ◆ Install the three spacer bushing (5).
- ◆ Install the external spring-support plate (4).

**CAUTION**

Use **LOCTITE® 648** on the three M8x25 Allen screws (17) of the external spring-support plate (4).

**NOTE** Apply a couple of drops of **LOCTITE® 648** to the threads of the M8x25 screws (3).

- ◆ Working from the clutch housing (16) side, install the three of the M8x25 screws (3).
- ◆ Screw in and tighten the three M8 nuts (2).

**External spring-support plate nut (2) tightening torque: 21.7 ftlb (30 Nm).**

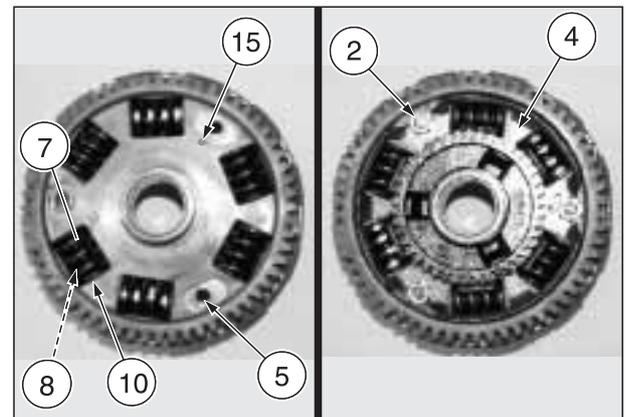
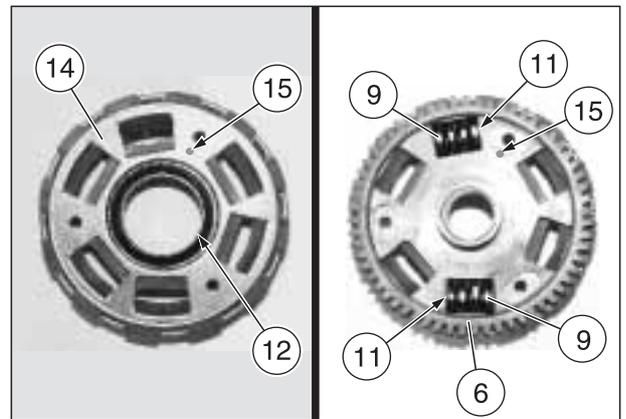
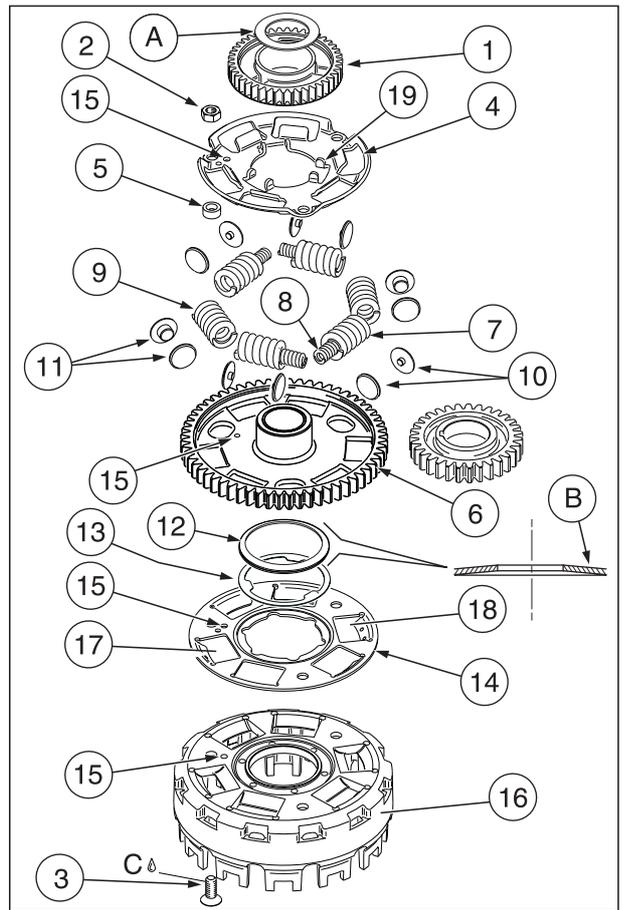
**CAUTION**

Once disassembled, always replace the oil pump drive gear (1).

- ◆ Place a new oil pump drive gear (1) so that its pins are engaged in the tabs (19) of the external spring-support plate (4).
- ◆ Install the washer (A) on the main shaft.

**NOTE** To install the primary drive assembly on the main shaft, see 6.12 (ASSEMBLING THE PRIMARY DRIVE AND CLUTCH).

**C** = **LOCTITE® 648**



5.19.3 PRIMARY DRIVE WEAR LIMITS

**NOTE** If not otherwise indicated, the following information is valid for all types of primary drive.

**PRIMARY DRIVE aprilia part# 0295790:**

- ◆ Measure the length (A) of the spring housing in the clutch housing.

**Wear limit (A) max. 1.285 in (32.65 mm).**

**NOTE** If any compression springs (B) are damaged, they all must be replaced, together with the spring pins (C).

**PRIMARY DRIVE aprilia part# 0295792 and 0295793:**

- ◆ Measure the length in released position of the:
  - external compression springs (1), **wear limit min. 1.05 in (26.75 mm);**
  - internal compression springs (2), **wear limit min. 1.05 in (26.75 mm);**
  - compression springs (3), marked with color white, **wear limit min. 1.05 in (26.75 mm),**

**NOTE** If any external compression springs (1), internal compression springs (2), compression springs (3) are damaged, they all must be replaced, together with the spring pins (4) (5).

- ◆ Check the spring pins (C) (4) (5) to ensure that there are no damage or any sign of galling or scoring.
- ◆ Check the slot in the clutch housing for distortion, unevenness or wear (6).

**Max. distortion, unevenness or wear (6) depth: 0.01 in (0.3 mm).**

- ◆ Check the clutch gear bearing land (7) for scoring and damage.
- ◆ Measure the internal diameter (9).

**Wear limit (9) max. Ø 1.183 in (30.060 mm).**

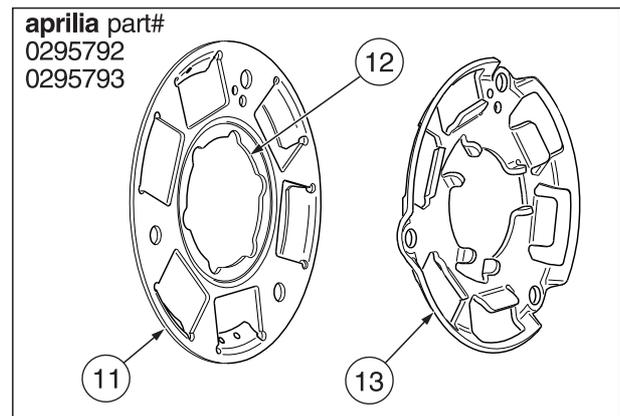
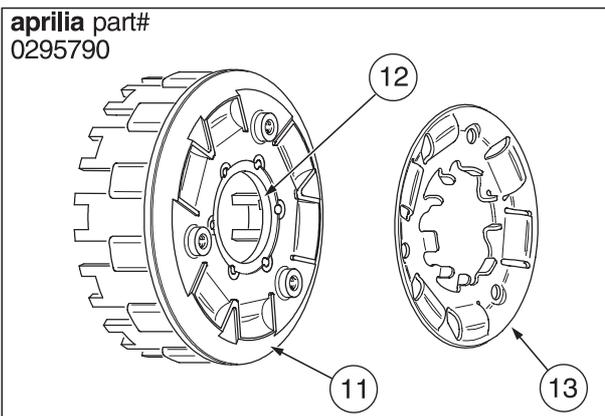
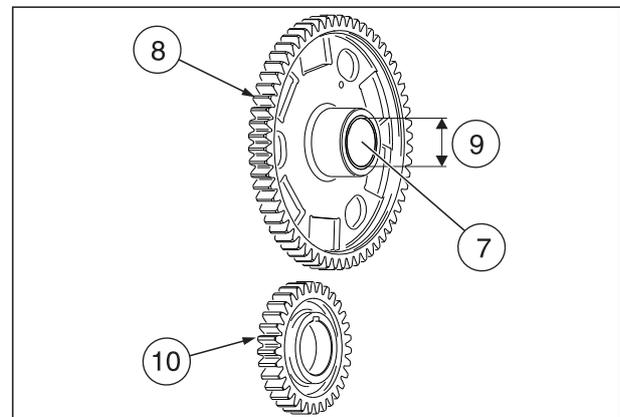
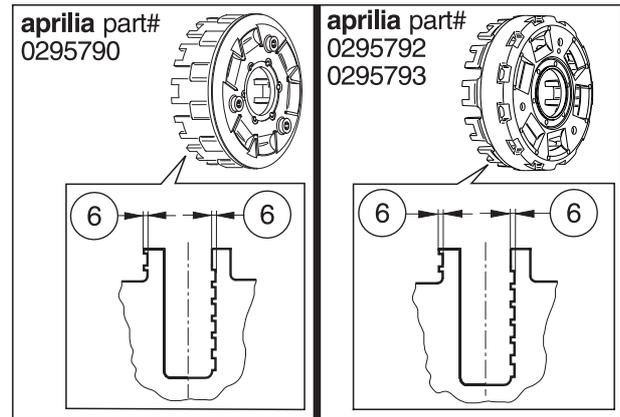
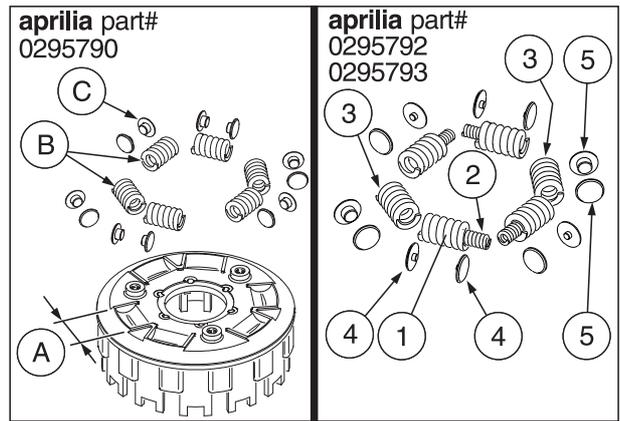
- ◆ Check the flanks of the clutch gear teeth (8) and drive gear teeth (9) for signs of pitting, wear, or distortion.

**NOTE** Should the clutch gear (8) or drive gear (10) be worn, replace them as a pair.

- ◆ Check the internal spring-support plate (11) for distortion or wear with especially on the contact surface (12).

**NOTE** Distortion or wear on the internal spring-support plate (11) can cause noisy operation of the engine at idling speed.

- ◆ Check the internal spring-support plate (11) and the external spring-support plate (11) for cracks.

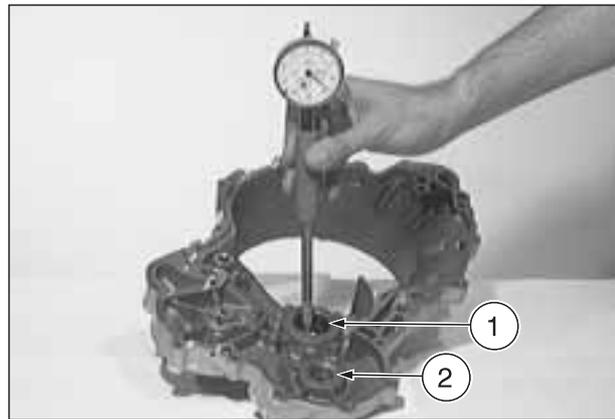




**5.20 CLUTCH COVER**

Carefully read 5.1 (PREFACE).

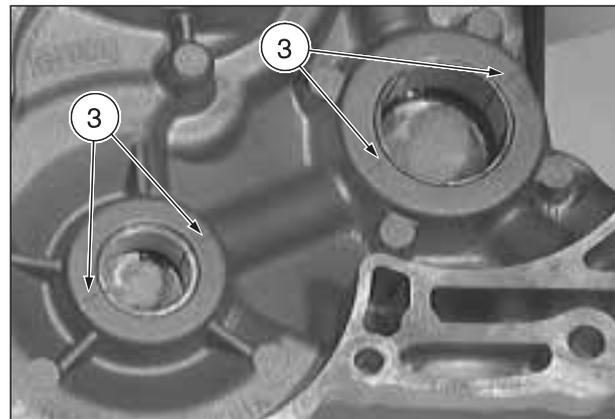
- ◆ Check the gasket surface for signs of damage and check the complete thread to ensure it is in a perfect state of repair.
- ◆ Check the crankshaft support bearings (1) and bal-  
anceshaft support bearings (2) for signs of galling or  
scoring.
- ◆ Measure the diameter of the two support bearings.
  - Crankshaft support bearings:  
**wear limit Ø 1.1827 in (30.040 mm).**
  - Balanceshaft support bearings:  
**wear limit Ø 0.7898 in (20.060 mm).**



**⚠ CAUTION**

Take a number of measurements, especially in the di-  
rection of the axis of both cylinders.  
None of the values must exceed the limit value.

- ◆ Measure the radial play of the crankshaft and lower bal-  
anceshaft, see 5.4 (CRANKSHAFT MAIN BUSHINGS  
AND LOWER BALANCESHAFT MAIN BUSHINGS).



**5.21 SUPPORT BEARINGS**

Carefully read 5.1 (PREFACE).

**5.21.1 DISASSEMBLY**

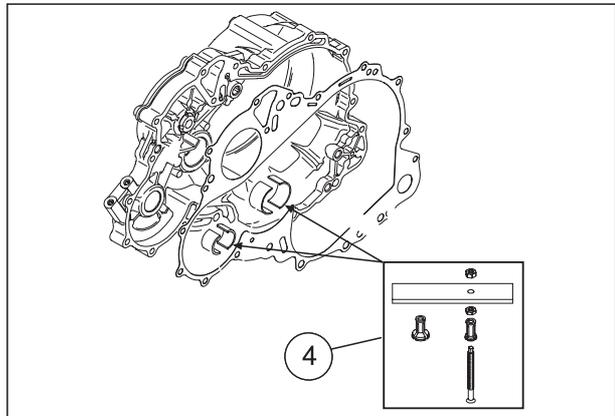
- ◆ Mark the contact surface (3) of the two bearings on the  
clutch cover.

**NOTE** Have the appropriate special tool **OPT** available:  
– **aprilia** part# 8140156 + 8140157 + 0276377 (clutch  
cover sleeve puller) (4).

- ◆ Remove the main bearings with the special tool (4).

**⚠ CAUTION**

As a rule, the main bearings should all be replaced  
together.



## 5.21.2 ASSEMBLY

- ◆ Clean the diameter of the main bearing housing and the lubrication hole between the bearing housings inside the clutch cover.
- ◆ Determine the crankshaft bearings size group based on the colored markings (5) on the clutch cover.

**NOTE** The size group of the main bearings is also marked with a colored dot.

- ◆ If the colored marking on the clutch cover is no longer clearly visible, calculate the diameter based on the average of a number of separate measurements.

 **CAUTION**

Take a number of measurements, especially in the direction of the axis of both cylinders.

Hole in the clutch cover	Bearing cover marking	Clutch cover marking
Ø 1.2961 – 1.2965 in (32.921 – 32.930 mm)	red	red
Ø 1.2965 – 1.2968 in (32.930 – 32.940 mm)	blue	blue
Ø 1.2986 – 1.2973 in (32.940 – 32.951 mm)	yellow	yellow

- ◆ Heat the engine case to approximately 130 °C (266 °F).
- ◆ Coat the main bearings and the bearing housings in the clutch cover with MOLYKOTE® G-N.

**NOTE** Have the appropriate special tool  available:

- **aprilia** part# 0277727 (crankshaft-clutch cover bushing inserter drift) (6);
- **aprilia** part# 0277729 (lower balancshaft bushing inserter drift) (7).
- ◆ Place the crankshaft and balancshaft main bearings on the assembly drift (6) (7), using the suitable O-ring (8) to hold them in place.
- ◆ Line up your marks on the main bearings and the case (3).
- ◆ Using great care, insert the main bearings into the case. Using the appropriate assembly drift and a press, press the bearings in until the assembly drift just touches the case.

 **CAUTION**

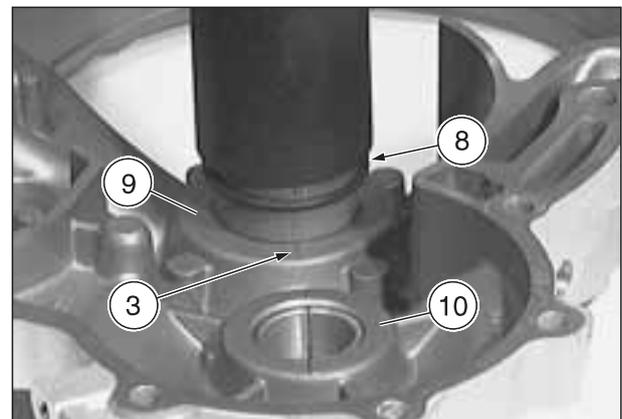
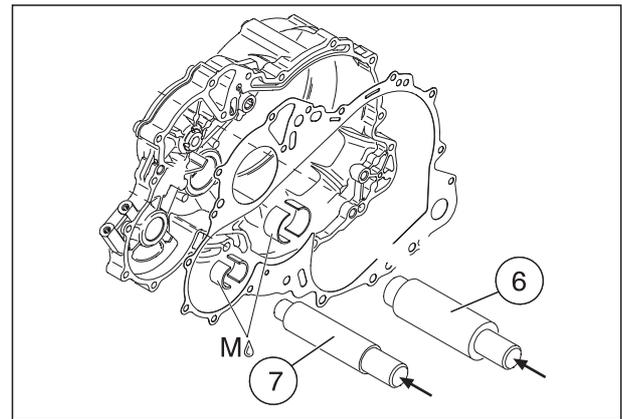
While inserting or removing the main bushings, the engine case must be supported through 360°, in the area of the bushing bore. The best way to accomplish this is to use a cylindrical support surface, which supports the case in the vicinity of the bushing bore, and hold the case absolutely perpendicular to the press used to remove or install the bushings.

- ◆ Remove the O-ring (8) before the installer drift makes contact.
  - The crankshaft main bearings must be flush with the thrust surface (9).
  - The balancshaft bearings must be pressed **0.039 in (1.0 mm)** below the thrust surface (10).

 **CAUTION**

Once disassembled, the bearings must not be re-used.

M = MOLYKOTE® G-N.



**5.22 COOLANT PUMP**

Carefully read 5.1 (PREFACE).

**⚠ CAUTION**

Disassemble the coolant pump only in the event of oil or coolant leakage.

- ◆ Check the drainage hole (1) for any signs of oil or coolant leakage.

**5.22.1 DISASSEMBLY**

- ◆ Prevent the coolant pump gear from rotating by holding it with a rag while unscrewing the impeller (3).
- ◆ Slide the coolant pump gear (2) up and off, and remove the pin (4) together with the washer (5).

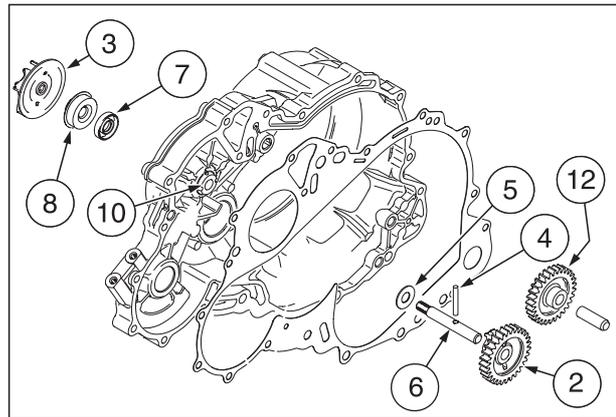
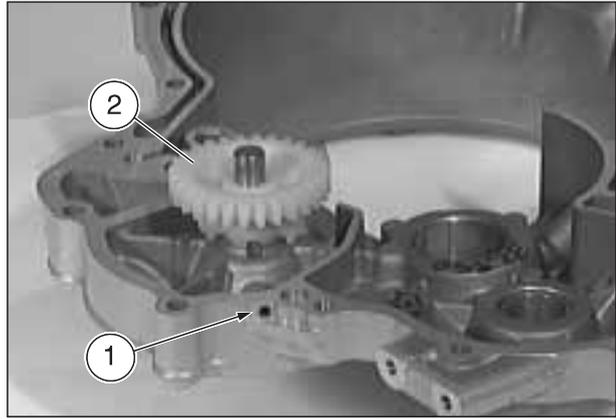
**⚠ CAUTION**

Take care not to damage the thread of the coolant pump shaft.

- ◆ Remove the coolant pump shaft (6) in the direction of the coolant pump gear (2).

**NOTE** There are two holes (A) (B) inside the clutch cover. Use a pin punch inserted through these holes to disassemble the oil seals and the sliding sealing ring.

- ◆ Tap lightly on the pin punch only once with the punch inserted in hole (A), then move it to hole (B), and tap lightly again. Repeat this operation until the two components (7) and (8) are safely removed without damage.

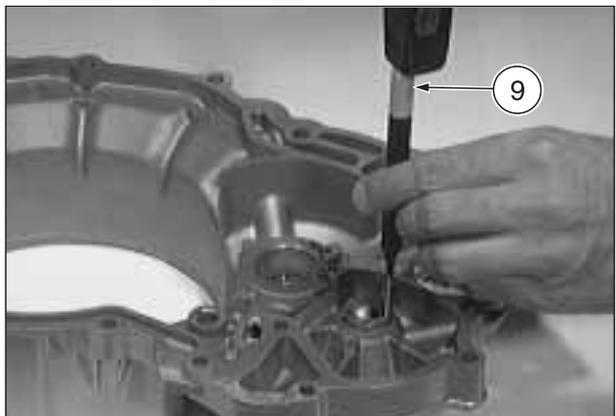
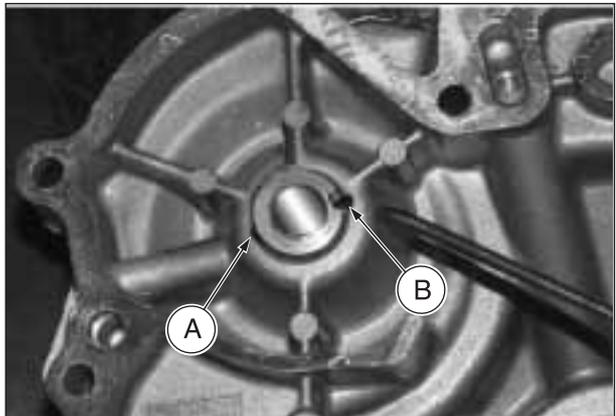


**5.22.2 INSPECTION**

- ◆ Check the impeller (3) for signs of damage or distortion and, where necessary, replace it.
- ◆ Check the coolant pump shaft (6) for signs of scoring or galling where the oil seal rides on the shaft. If any damage is evident, replace the shaft.
- ◆ Measure the coolant pump shaft housing bore (10) on the clutch cover.

**Bore wear limit (10) max. Ø 0.397 in (10.10 mm).**

Follow ►



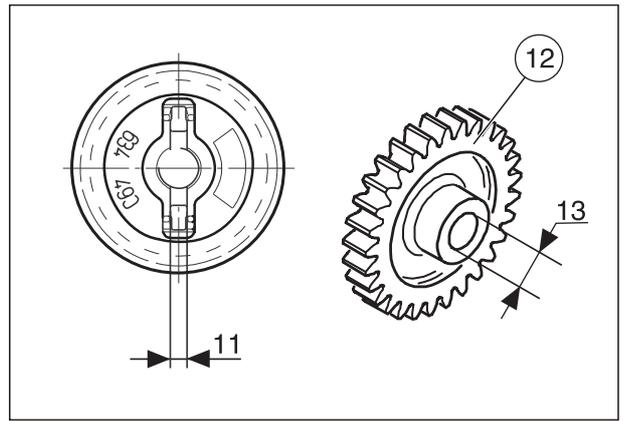
Follow ►

- ◆ Check the teeth of the coolant pump gear (2) for signs of damage or scoring. Check the width of the drive pin groove (11).

**Groove wear limit (11) max. Ø 0.146 in (3.70 mm).**

- ◆ Check the teeth of the coolant pump idler gear (12) for damage or pitting.
- ◆ Measure the gear bore (13).

**Gear bore wear limit (13) max. Ø 0.402 in (10.22 mm).**



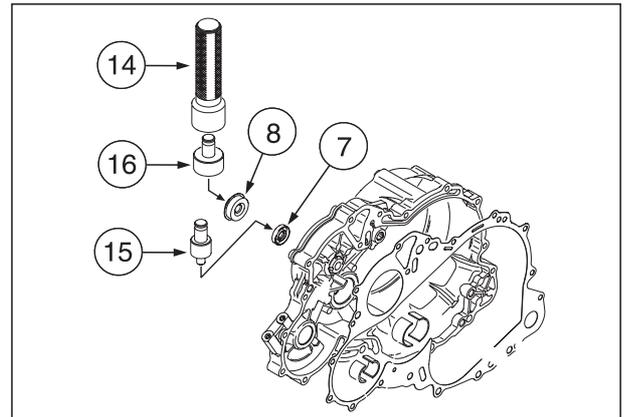
**5.22.3 ASSEMBLY**

**NOTE** Have the appropriate special tool **OPT** available:

- **aprilia** part# 0877650 (handle for drift) (14);
- **aprilia** part# 0277670 (coolant pump shaft housing oil seal assembly drift) (15);
- **aprilia** part# 0877257 (coolant pump shaft housing sliding ring assembly drift) (16).

**NOTE** The closed side of the oil seal must be fitted so that it faces the impeller (3).

- ◆ Install the oil seal (7) completely into its recess using the drift.
- ◆ Install the sliding sealing ring (8) into the recess as far as it will go using the assembly drift.



**CAUTION**

**Take care not to damage the impeller (3).**

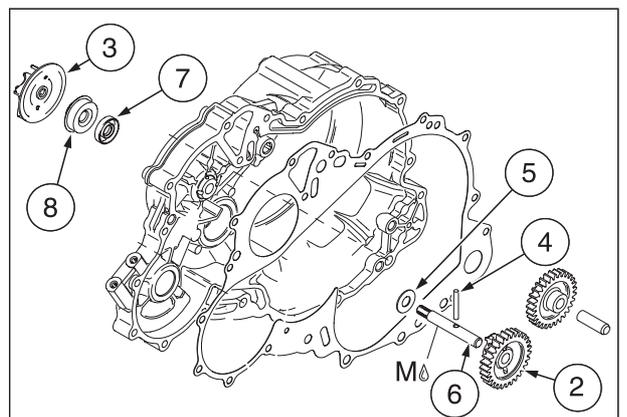
- ◆ Screw in the impeller (3), by hand, until it bottoms onto the coolant pump shaft (6).
- ◆ Coat the coolant pump shaft (6) with **MOLYKOTE® G-N** and insert it from the outside all the way onto the oil seal assembly.
- ◆ Install the washer (5) on the coolant pump shaft.
- ◆ Install the pin (4) in its hole in the coolant pump shaft and then install the coolant pump gear (2) on the shaft.

**NOTE** Ensure that the pin is perfectly aligned with its mating groove in the cooling pump gear.

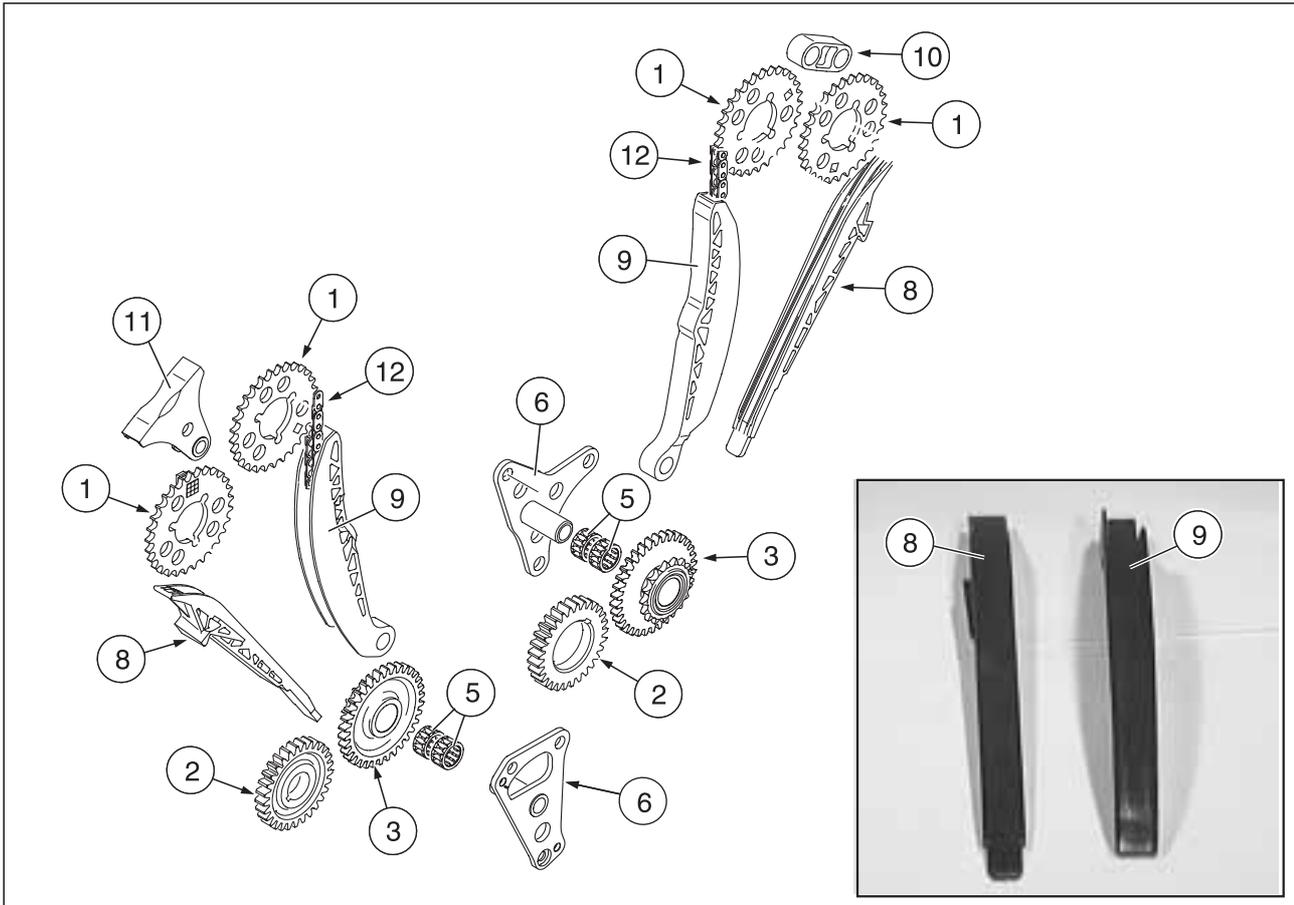
- ◆ Tighten the impeller (3) by hand, while you hold the coolant pump gear (2) with a rag.



**M** = **MOLYKOTE® G-N**.



**5.23 CAM DRIVE ASSEMBLY**



Carefully read 5.1 (PREFACE).

**CAUTION**

Do not mix up parts from cylinder "1" and cylinder "2" cam drive assemblies. Upon reassembly, ensure that you put all parts in their original positions.

- ◆ Check the flanks of the teeth on the timing gear (1), drive gears (2) and intermediate drive gears (3) for pitting and wear.
- ◆ Check the bore (4) of the idler gears (3) for wear.

**Bore (4) wear limit: max. diameter 0.788 in (20.015 mm).**

- ◆ Check the roller bearings (5) for wear.
- ◆ Check the two bearing flanges (6) for wear around the bearing support surface (7) of the roller bearings (5).

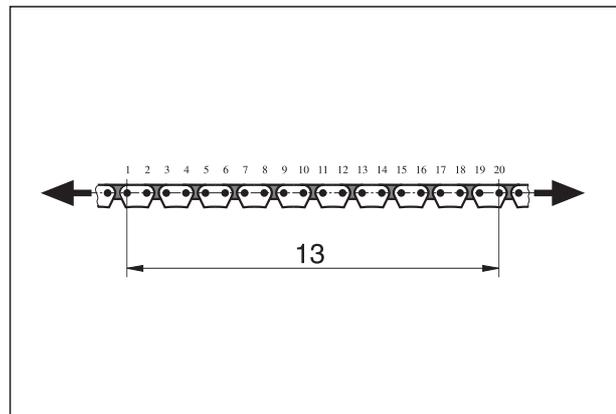
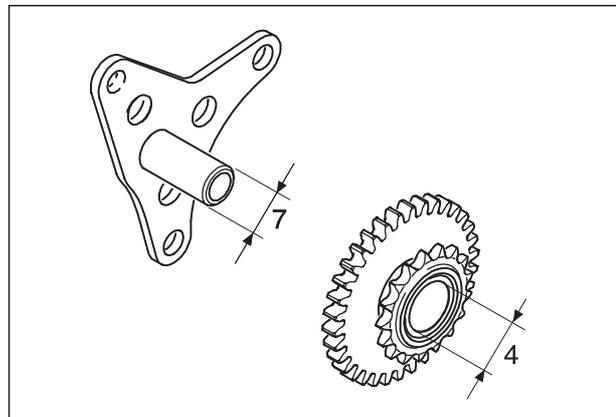
**Bearing support surface (7) wear limit: min. diameter 0.629 in (15.98 mm).**

- ◆ Check the chain guide shoe (8), chain tensioner shoe (9), chain guide (10) and chain guide bracket (11) for any traces of galling or scoring.

**Max. depth of the galling or scoring traces: 0.047 in (1.2 mm).**

- ◆ Check the teeth of the two timing chains (12) for any signs of distortion.
- ◆ Stretch the cam chain tight, count 20 pins (19 links), and measure the distance (13) between the centers of the first and the twentieth pin. Repeat for the second cam chain.

**Distance (13) wear limit: max. 6.54 in (166.2 mm).**



**5.24 HEAD AND CAMSHAFT**

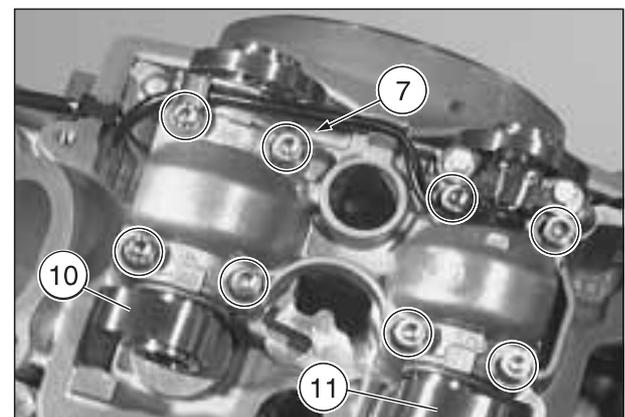
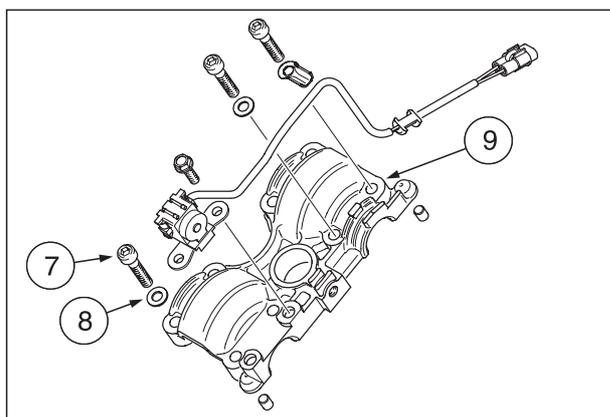
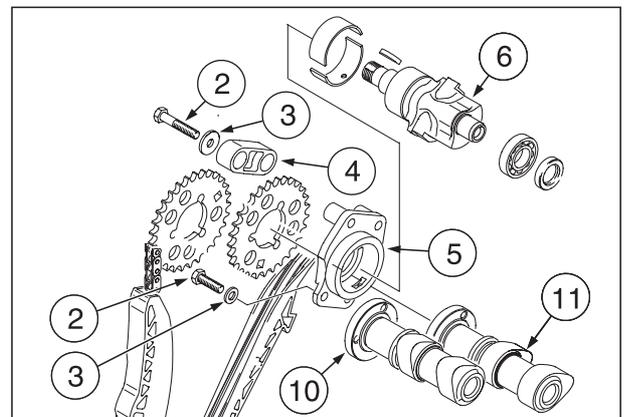
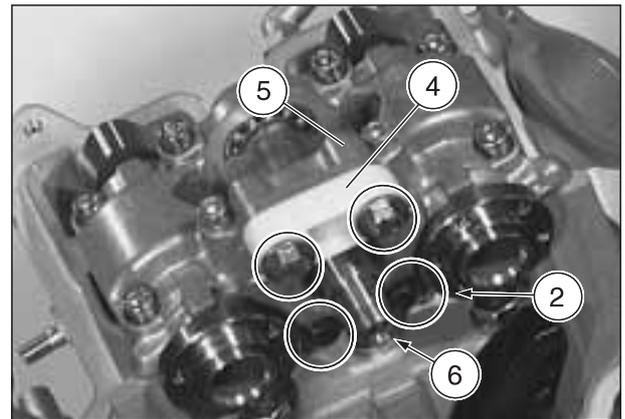
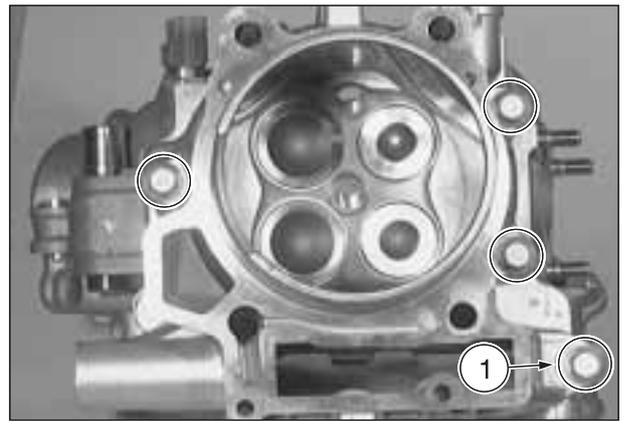
Carefully read 5.1 (PREFACE).

**5.24.1 ASSEMBLY**

- ◆ Unscrew and remove the four shouldered M8 screws (1) respectively and remove head "1" and "2" from the cylinder.
- ◆ Unscrew and remove the four M6 Allen screws (2) together with the respective washers (3) from head "2" and remove the chain guide (4) and the bushing plate (5).
- ◆ Remove the upper balanceshaft (6) from head "2".
- ◆ Unscrew and remove the eight M6 Allen screws (7), together with the respective washers (8), and remove the camshaft cap (9) from head "1" and "2".
- ◆ Remove the intake camshaft (10) and exhaust camshaft (11) from head "1" and "2".

** CAUTION**

Do not mix up components from cylinder "1" and cylinder "2". When you reassemble the cylinders, ensure that all parts fit in their original positions.



**5.25 DISASSEMBLING THE INTAKE AND EXHAUST VALVES**

Carefully read 5.1 (PREFACE).

**NOTE** The following information refers to one valve only, but is valid for all of them.

◆ Place the head on a clean and clear work bench.

**CAUTION**

Once the valve keepers are removed, the valve can fall freely out of the head, and could be damaged.

Before disassembling the valves, check valve leakage using a special cylinder head leakage tester (Bosch or Sun).

**NOTE** If the leakage is less than 5%, the valves and valve seat are in satisfactory condition.

**NOTE** Remove the valve units one by one and keep them separated, in such a way as to avoid mixing up components from different valve units.

**NOTE** Mark the component associated with each valve, and its corresponding seat in the head, in order to be able to reinstall the components in their original position.

**NOTE** Before disassembly, mark the upper end of each valve spring. The valve springs are progressively wound, so must be installed properly. The end of the valve with the more tightly wound coils must face the combustion chamber.

**CAUTION**

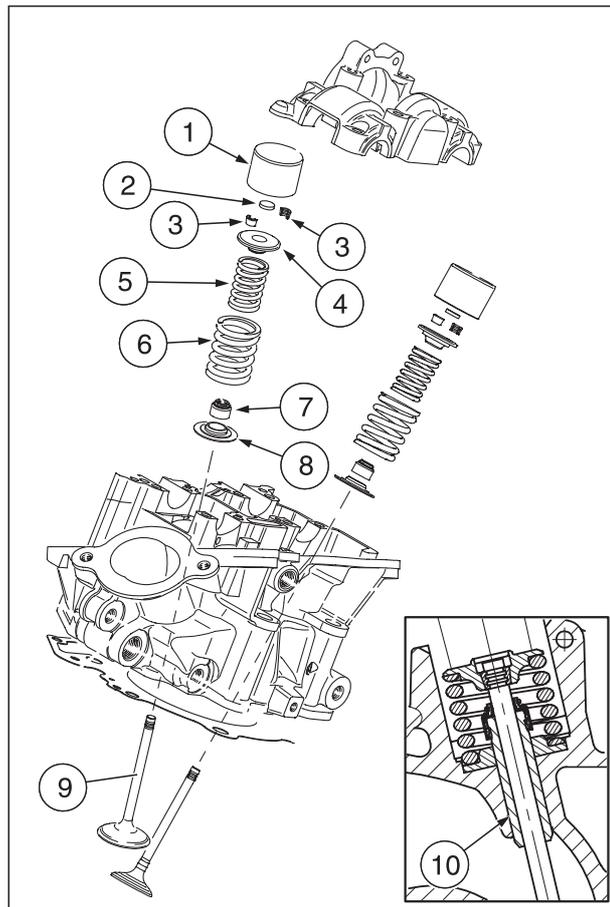
Do not assemble the valve springs upside down. This can cause irreparable engine damage.

**Valve unit components (intake or exhaust valve):**

- bucket (1);
- adjusting shim (2);
- valve keepers (3);
- valve spring upper cup (4);
- valve inner spring (5);
- valve outer spring (6);
- valve guide oil seal (7);
- valve spring lower cup (8);
- valve (9);
- valve guide (10).

**NOTE** The valve guide (10) must not be removed during the disassembly of the valve.

Follow ►

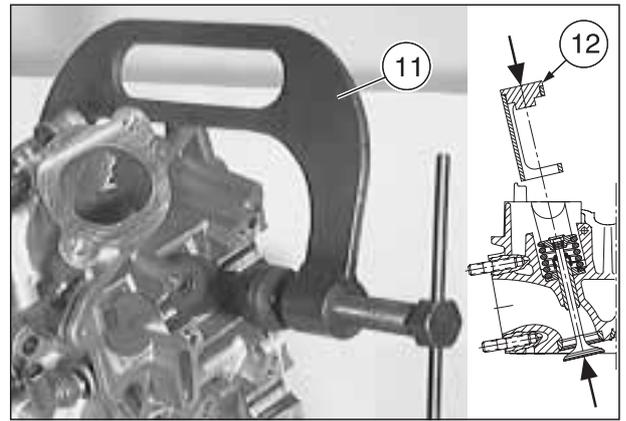


Follow ►

**NOTE** Have the appropriate special tool **OPT** available:

- **aprilia** part# 8140179 (valves disassembly and reassembly clamp) (11);
- **aprilia** part# 0276479 (valves spring-pusher tool) (12).

- ◆ Remove the valve lifter bucket (1) and the adjusting shim (2).
- ◆ Compress the valve springs (5) (6) using the clamp (11) and the valve spring compression tool (12), and remove the valve keepers (3).
- ◆ \* Release the valve springs (5) (6).
- ◆ \* Remove the spring compressor (12) and the clamp (11).
- ◆ \* Remove the valve spring upper cup (4).
- ◆ \* Withdraw the two valve springs (5) (6).
- ◆ \* Raise and rotate the head by 180° (upside down).
- ◆ \* Withdraw the valve (9).



**NOTE** Repeat the operations marked with “\*” for the second valve.

- ◆ Clean the combustion chamber, removing the residual combustion products and the deposits from the cooling chamber.
- ◆ Check the thread of the spark plugs and the fastening thread, making sure they are in a perfect state of repair.
- ◆ Check that the oil galleries are unobstructed and blow them clean using compressed air.
- ◆ Check the gasket surfaces for any signs of damage and ensure that they are flat.

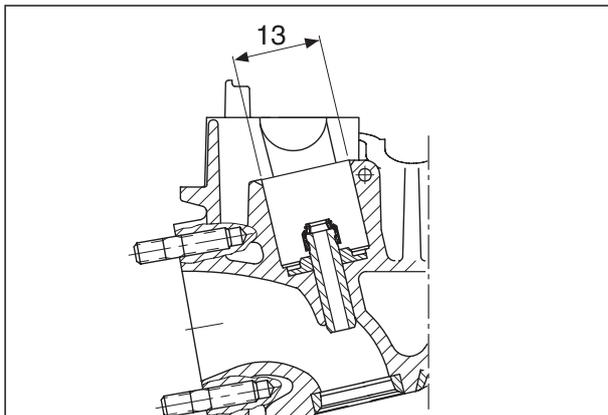
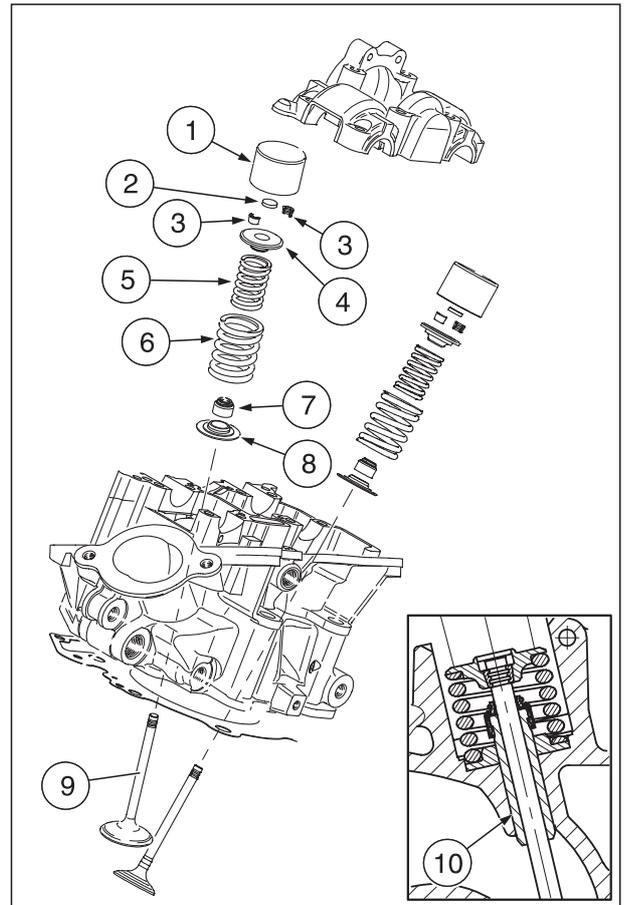
**Max. permissible distortion: 0.001 in (0.03 mm).**

**CAUTION**

If the limit value is exceeded, we strongly suggest that you contact:

**aprilia USA inc.**  
 110 Londonderry Court, Suite 130  
 Woodstock, GA 30188  
 USA  
 Tel 770 592 2261  
 Fax 770 592 4878

- ◆ Inspect the valve buckets (1) and their mating bore in the head; they must be in perfect condition.
- Buckets mating bore in the head (13):  
**wear limit: max. Ø 1.322 in (33.58 mm);**
- Buckets (1) external diameter:  
**wear limit: min. Ø 1.316 in (33.44 mm);**
- Buckets radial play (1):  
**wear limit: max. Ø 0.003 in (0.08 mm).**



**5.26 CAMSHAFT AND CAMSHAFT BEARINGS**

Carefully read 5.1 (PREFACE).

- ◆ Inspect the cams (1) for galling, distortion or discoloration. If any damage is present, replace the camshaft, see 5.26.1 (CAMSHAFTS FEATURES CLASSIFICATION).

**⚠ CAUTION**

When a camshaft is replaced, the valve buckets which it operates must also be replaced, regardless of their apparent condition.

Measure the clearance of the camshafts bearings:

- ◆ Install the camshafts in the head.
- ◆ Apply a plasti-gauge (2) on the bearing lands of the camshafts.
- ◆ Install the cam bearing caps in their proper position and fasten them with the M6 Allen screws.

Cam bearing caps screws tightening torque: 7.2 ftlb (10 Nm).

- ◆ Unscrew the cam bearing caps screws and remove the cam bearing caps.
- ◆ Measure the maximum width of the plasti-gauge with the scale provided (3) on the plasti-gauge package (2A).

Wear limit: max. 0.0024 in ( 0.060 mm).

If the wear limit is exceeded:

- ◆ Remove the plasti-gauge (2A).
- ◆ Remove the camshafts from the head.
- ◆ Measure the cam bearing bores on the head and the bearing lands of the camshaft. Replace the worn part.

– Bearing lands of the camshafts (4):  
wear limit : min. diameter 0.9429 in (23.950 mm).

– Cam bearing bores on the head:  
wear limit: max. diameter 0.9465 in (24.040 mm);

- ◆ Install the camshafts in the head.
- ◆ Install the cam bearing caps in their proper position and fasten them with the M6 Allen screws.

Cam bearing caps screws tightening torque: 7.2 ftlb (10 Nm).

- ◆ Measure the end play of the camshaft with a dial gauge (5).

– End play of the camshafts,  
wear limit: max. 0.016 in (0.40 mm).

If the wear limit is exceeded:

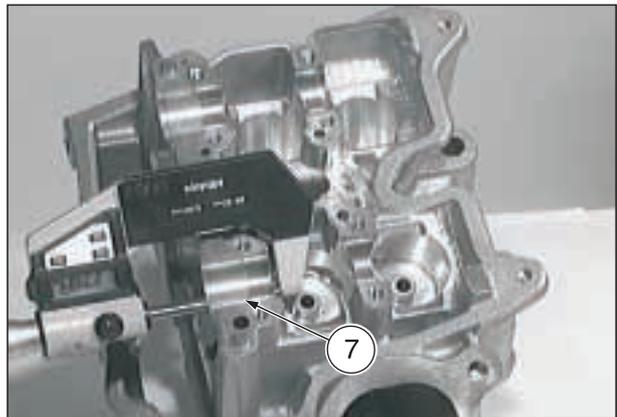
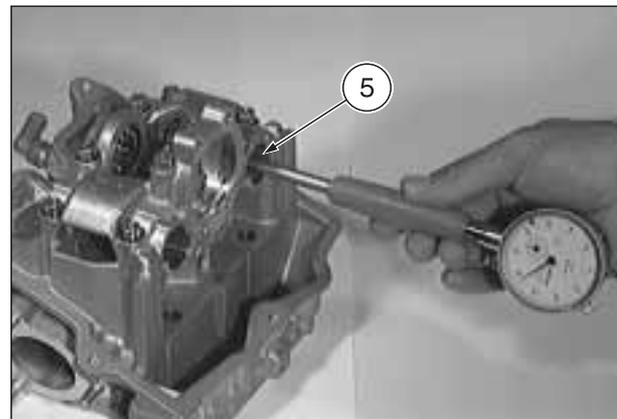
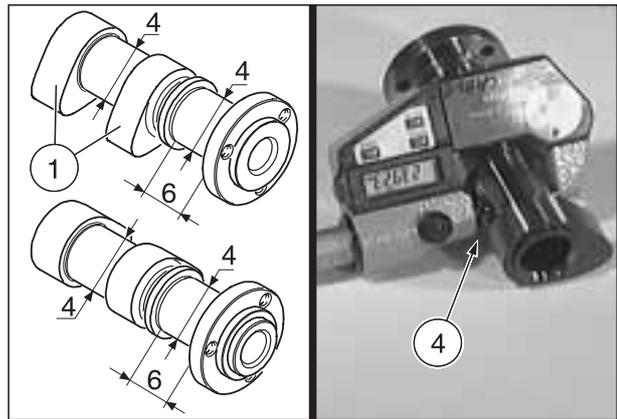
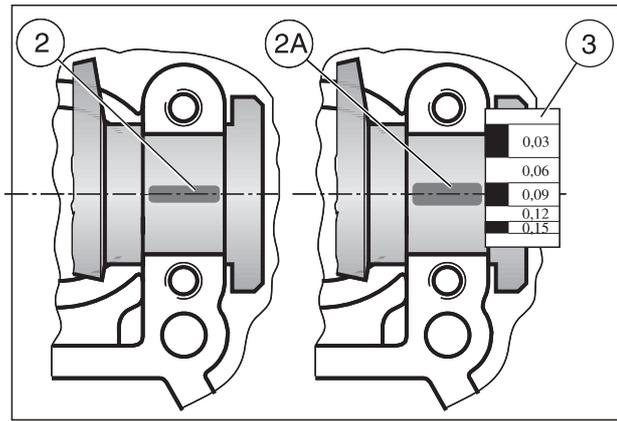
- ◆ Unscrew the cam bearing caps screws and remove the cam bearing caps.
- ◆ Remove the camshafts from the head.
- ◆ Measure the length (6) of the bearing land on the camshaft that contains the thrust faces and the width (7) of the cam bearing in the head. Replace the worn part.

– Distance between thrust contact surfaces:  
wear limit: max. 1.093 in (27.77 mm).

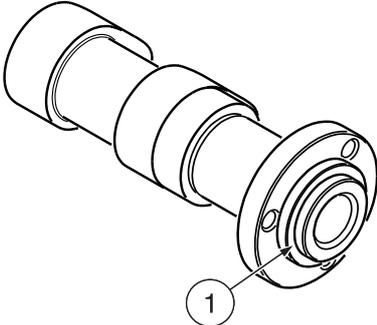
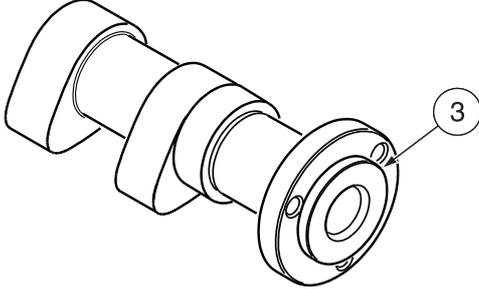
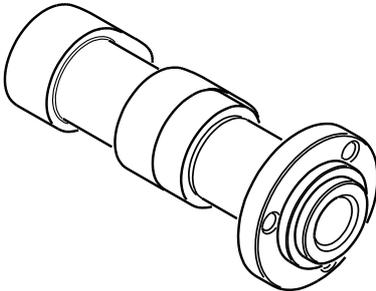
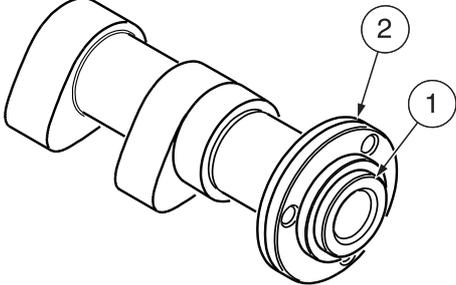
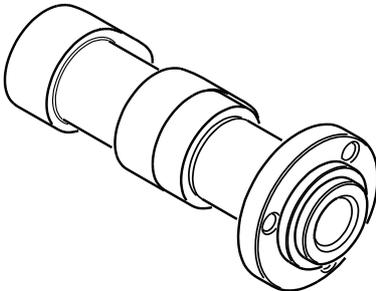
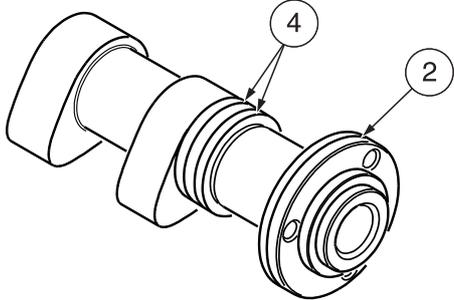
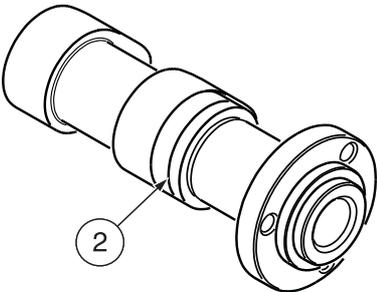
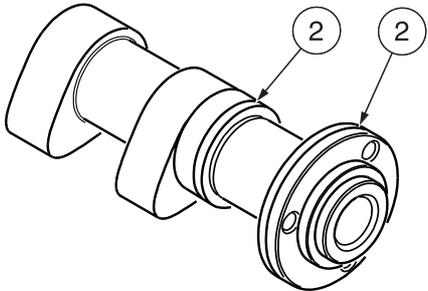
– Width of cam bearing and head:  
wear limit: min. 1.067 in (27.10 mm).

**⚠ CAUTION**

If the camshaft is replaced, the corresponding buckets must also be replaced.



5.26.1 (CAMSHAFTS FEATURES CLASSIFICATION)

Vehicle model	Exhaust camshaft	Intake camshaft
<p><b>RSV RSV R</b> (engines up to # 524388).</p>	<p><b>aprilia part# 0220385</b></p> 	<p><b>aprilia part# 0220380</b></p> 
<p><b>RSV RSV R</b> (engines # 524389 and later);</p> <p><b>RSV RSV R</b> (vehicles up to year 2000);</p> <p><b>SL</b> ;</p> <p><b>RST</b> .</p>	<p><b>aprilia part# 0220385</b></p> 	<p><b>aprilia part# 0220380</b></p> 
<p><b>RSV RSV R</b> (vehicles year 2001 and later).</p>	<p><b>aprilia part# 0220385</b></p> 	<p><b>aprilia part# 0220384</b></p> 
<p><b>ETV</b> .</p>	<p><b>aprilia part# 0220387</b></p> 	<p><b>aprilia part# 0220382</b></p> 

**Key**

- 1) Double shoulder
- 2) Recognition groove

- 3) Shoulder
- 4) Double recognition groove

**5.27 UPPER BALANCSHAFT**

Carefully read 5.1 (PREFACE).

- ◆ Check the balancshaft for wear.

**NOTE** The bearing land (1) is slightly tapered. The measurement must be taken half-way along its length.

- Bearing land (1):  
**wear limit: min. diameter 1.377 in (34.98 mm).**
- Ball bearing land (2):  
**wear limit: min. diameter 0.589 in (14.97 mm).**

**NOTE** The bearing land (3) is slightly tapered.

- ◆ Check the internal diameter (3) for cracking, wear, distortion or scoring.
- ◆ Install the balancshaft in the plate (3) and measure the radial play using a dial gauge.

**Max. permissible radial play 0.028 in (0.70 mm).**

**⚠ CAUTION**  
If the maximum permissible radial play is exceeded, the worn part must be replaced.

**⚠ CAUTION**  
Should the bearing surface in the plate (3) be worn, the complete plate (6) must be replaced.

- ◆ Install the balancshaft in the head "2" (rear) and measure the end play with a dial gauge.

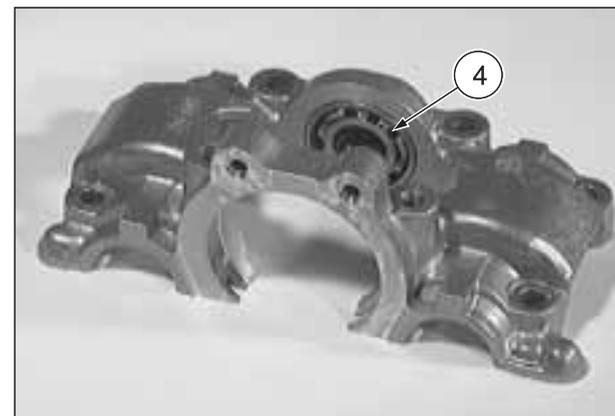
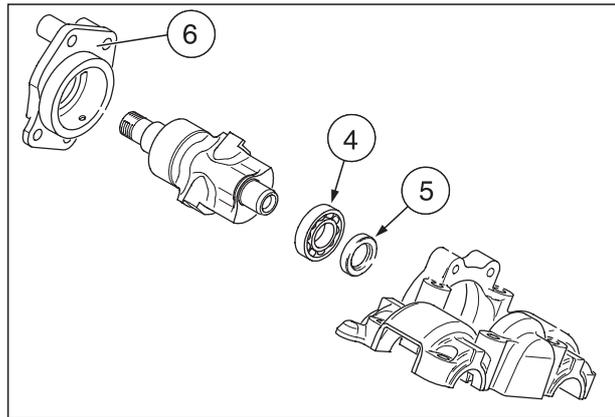
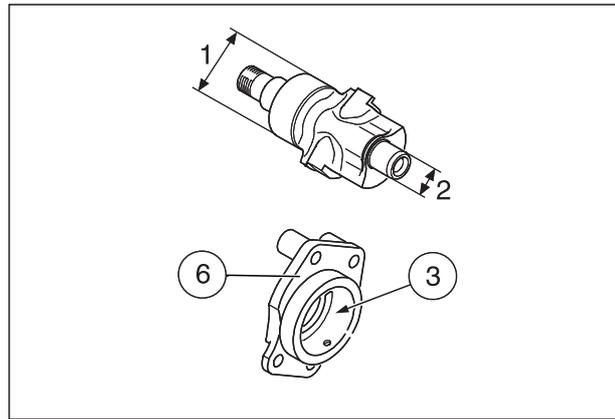
**Wear limit: max. 0.0016 in ( 0.040 mm).**

**⚠ CAUTION**  
If the end play wear limit is exceeded, replace the plate (6).

- ◆ Install the balancshaft in head "2" (rear), see 6.15 [ASSEMBLING HEAD "2" (REAR) CAMSHAFT] .
- ◆ Inspect the ball bearing (4) for pitting or roughness.
- ◆ Install the bearing in the cam bearing cap assembly; ensure that it slides smoothly in its bore.

**NOTE** Oil the ball bearings with motor oil before performing this check.  
If the ball bearing inner race does not turn easily and silently, or if you detect any roughness or pitting, the bearing must be replaced.

- ◆ Check the oil seal (5) for any signs of wear or damage. Replace if in any way defective.



**5.28 DISASSEMBLING AND REASSEMBLING THE UPPER BALANCESHAFT BALL BEARINGS AND OIL SEAL**

Carefully read 5.1 (PREFACE).

- NOTE** Have the appropriate special tool **OPT** available:
- **aprilia** part# 0277265 (balanceshaft bearings - main shaft bearings - countershaft bearings, puller) (6);
  - **aprilia** part# 0877650 (handle for drift) (7);
  - **aprilia** part# 0277660 (upper balanceshaft oil seal assembly drift) (8).

◆ Heat the camshaft bearing cap assembly to approximately 80 – 100 °C (176 – 212 °F) .

**NOTE** This assembly is fragile. Handle with care. Be sure that it is not damaged.

◆ Remove the ball bearings (4) with the puller (6) and with the expansion sleeve suitable for this bearing.

**NOTE** As a rule, the ball bearings and the oil seals should be replaced.

◆ Lift the oil seal (5).

**NOTE** Before assembling, oil the external diameter of the oil seal slightly. The closed side of the oil seal must face outwards. Grease the sealing lips.

**CAUTION**

In order to avoid damaging the ball bearing, under no circumstances should the oil seal touch the bearing inner race.

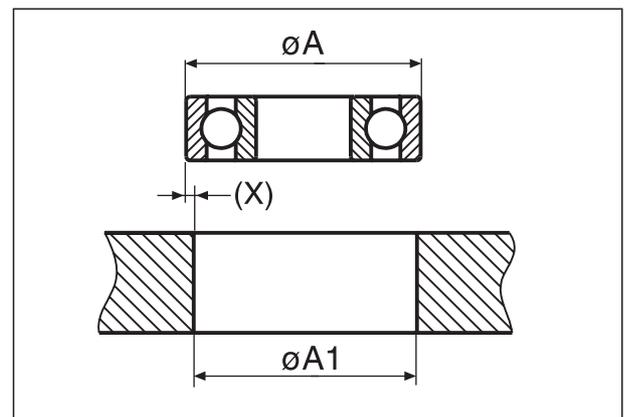
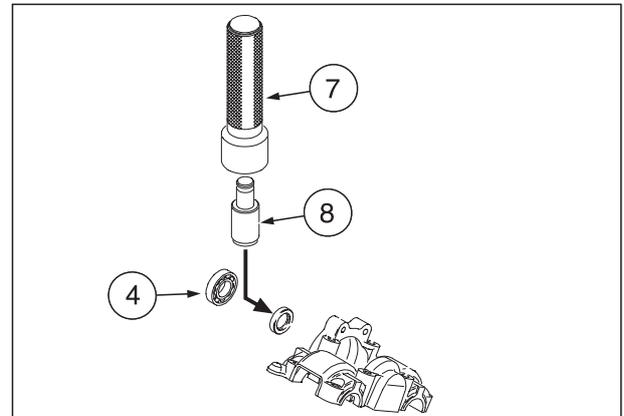
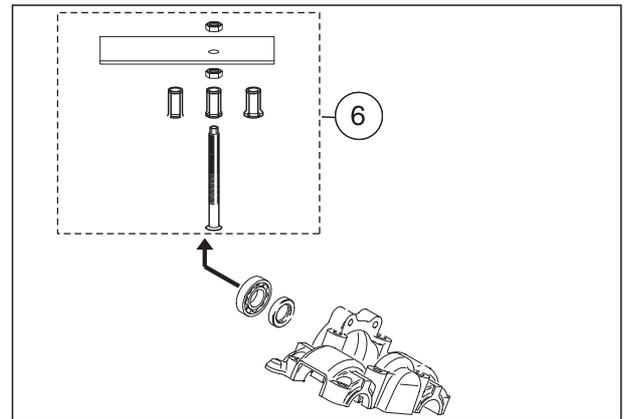
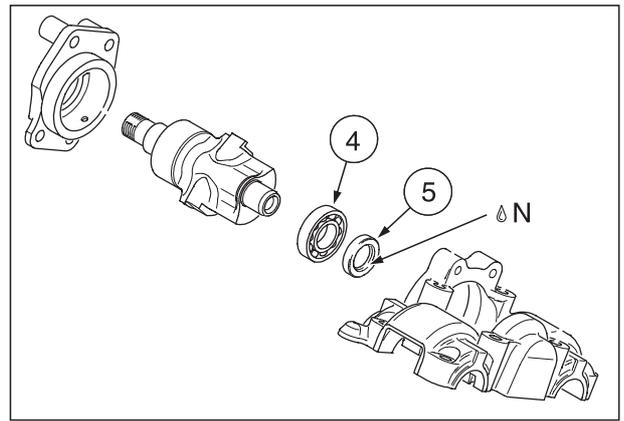
- ◆ Insert the oil seal (5) all the way in using the assembly drift (8).
- ◆ Oil the external diameter of the ball bearing (4) slightly and insert it all the way onto the outer race with a suitable assembly drift.
- ◆ Check the ball bearing housing (4) on the cam bearing cap assembly for wear, distortion, or scoring.

**Interference (X) (diameter A – diameter A1):**  
min. (tight) 0.0012 in (0.030 mm).

**CAUTION**

Replace if any defect is present.

**N** = Multi-purpose grease bp lz.



**5.29 VALVE GUIDES**

Carefully read 5.1 (PREFACE).

- ◆ Use a dial gauge to measure the wear of the valve guide (1).

**Wear limit (2): max. Ø 0.238 in (6.05 mm).**

**NOTE** If the valve guide is worn, it can be replaced.

**5.29.1 DISASSEMBLY AND REASSEMBLY**

- ◆ Remove the valve spring seat (3) and remove the valve spring shim (4).

**NOTE** Replace the valve spring seat (3).

- ◆ Using the special reamer (5) as far as the top of the notch (6).

**NOTE** The sharp edge near the top of the valve guide must be machined away. Otherwise, it will foul the valve guide hole in the head, and destroy the head, as the valve guide is removed.

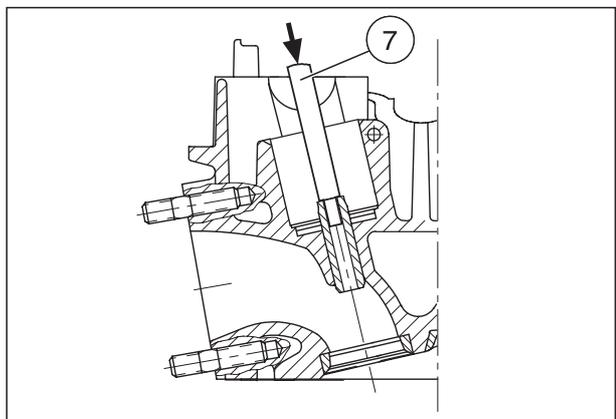
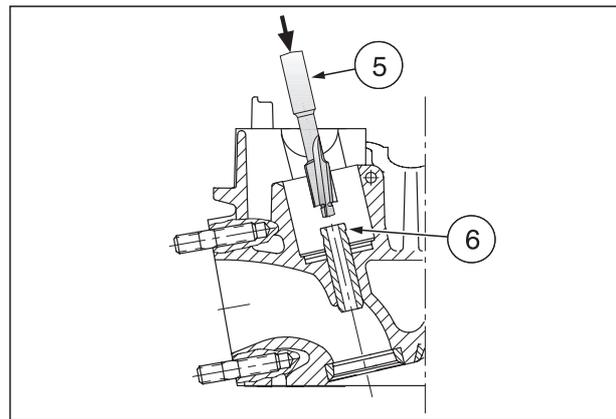
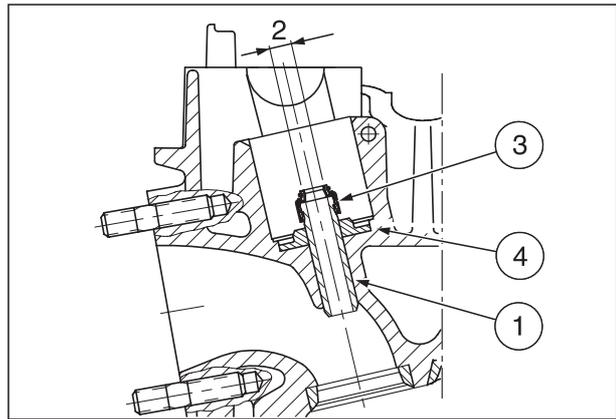
**NOTE** Have the appropriate special tool **OPT** available:  
 – **aprilia** part# 0277510 (valve guide disassembly drift) (7).

**NOTE** Do not heat the head.

- ◆ Use the drift (7) to remove the rest of the valve guide in the direction of the exhaust manifold.
- ◆ Check the valve guide hole for scoring or damage.

**NOTE** Should you see any signs of galling, you must replace the head.

Follow ►



Follow ►

**⚠ CAUTION**

Always apply the MOLYKOTE® G-N on the head hole and on the valve guide assembly edge.

Failure to observe this caution cause damage to the head and valve guide.

- ◆ Always apply MOLYKOTE® G-N to the bore in the head and the outside of the valve guide, before assembly.

**NOTE** Have appropriate the special tool **DPT** available:

- **aprilia** part# 0277695 (valve guide oil seal assembly drift) (8).

- ◆ Using the assembly drift (8), insert the new valve guide in the head, working from the top of the head towards the combustion chamber, until the assembly drift (8) bottoms against the head.

**NOTE** The exhaust valve and intake valve guides are different.

The intake valve guide is longer, with a longer finished surface.

- ◆ Check how much the head of the valve guide protrudes (10) on the camshaft side.

**Protrusion (10) = 0.52 ± 0.008 in (13.3 ± 0.2 mm).**

- ◆ Carefully ream the valve guide to size using an adequate reamer.

**Valve guide inside diameter: 0.2365 – 0.2369 in (6.006 – 6.018 mm).**

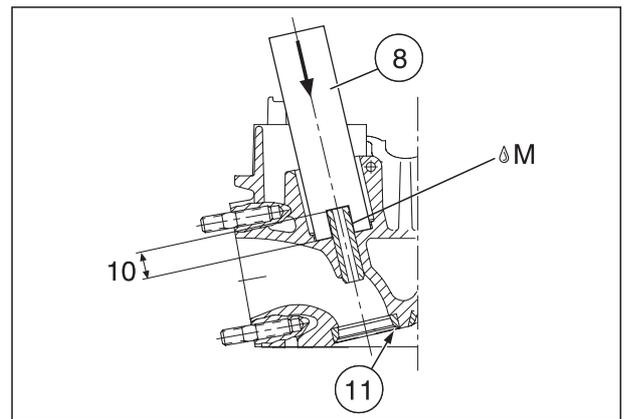
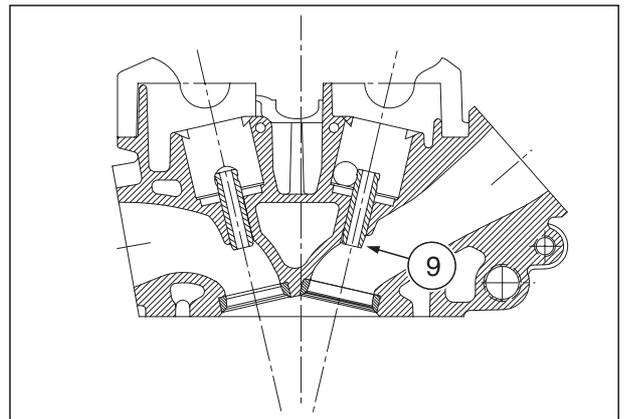
**NOTE** Use only cutting fluid to lubricate the reamer.

The reamer should be turned in only the cutting direction, never backwards. Clean chips from the reamer frequently, remembering always to rotate the reamer only in the cutting direction.

- ◆ Once the valve guides have been properly reamed, clean the head thoroughly. Grind the valve seat (11), smoothing the valve seat with valve seat grinder, see 5.30 (VALVES).

- ◆ Using Prussian blue, check the valve to valve seat contact.

**M** = MOLYKOTE® G-N.



**5.30 VALVES**

Carefully read 5.1 (PREFACE).

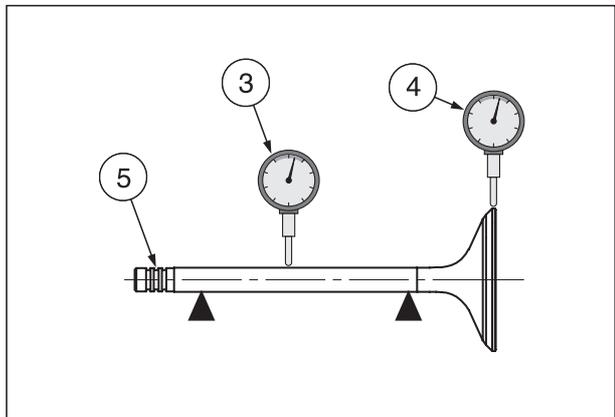
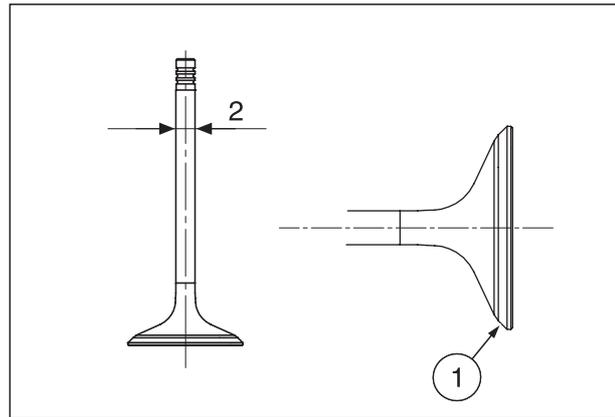
**⚠ CAUTION**

Replace the valves one by one. Do not mix up the components. Ensure that each valve is replaced in its appropriate seat, as marked, during disassembly.

**⚠ CAUTION**

These valves have induction hardened heads (1), therefore, the valve must not be reground. If the seating surface of the valve is pitted or warped, the valve must be replaced. Also, the tip of the valve stem is hardened, and therefore must not be ground. However, it is permitted to use a small amount of valve grinding compound to hand finish the valve and valve seat contact surfaces.

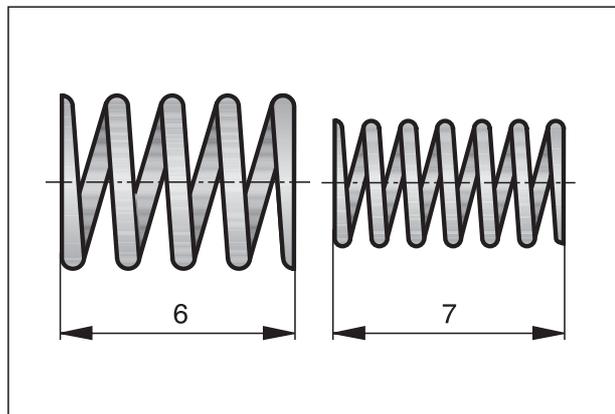
- ◆ Carefully clean the valves, removing all carbon and other combustion products.
- ◆ Check the seat of the valve head (1) with a straight edge. The surface of the seat must not be concave. If it is, the valve must be replaced.
- ◆ Measure the diameter of the stem using a micrometer:
  - intake valve:  
**wear limit (2) min. Ø 0.2343 in (5.950 mm);**
  - exhaust valve:  
**wear limit (2) min. Ø 0.2337 in (5.935 mm).**
- ◆ Check the eccentricity of the valve:
  - valve stem:  
**permissible eccentricity (3) max. 0.002 in (0.05 mm);**
  - valve head:  
**permissible eccentricity (4) max. 0.002 in (0.05 mm).**
- ◆ Check the keeper grooves (5). They must be in perfect condition. In they are not, replace the valve.



**5.30.1 VALVE SPRINGS**

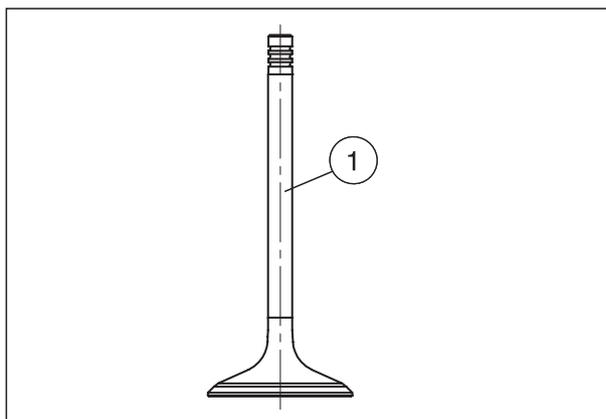
- ◆ Measure and visually inspect the valve springs to check for breakage, distortion or loss of tension.
- ◆ Measure the spring's free length:
  - valve spring's free length (6):  
**wear limit (6) min. 1.71 in (43.4 mm);**
  - valve spring's free length (7):  
**wear limit (7) min. 1.61 in (40.9 mm).**

**NOTE** Weak valve springs may result in valve float and engine damage at high RPM, as well as increased valve rattle and reduced power.



**5.30.2 VALVE SEATS**

- ◆ Apply a thin film of Prussian blue to the valve seating surface.
- ◆ Insert the valve (1) into the valve guide, holding the valve firmly against the seat, turn the valve through one complete revolution.
- ◆ Check the width of the valve seat (2) (3) and the contact mark, checking for any signs of wear:
  - (vehicles up to year 2000) intake valve wear limit (2) max. 0.063 in (1.6 mm);
  - (vehicles year 2001 and later) intake valve wear limit (2) max. 0.059 in (1.5 mm);
  - exhaust valve: wear limit (3) max. 0.071 in (1.8 mm).



**NOTE** The circular contact mark on the valve seat and valve surfaces must be continuous and unbroken. If the width of the valve seat exceeds the wear limit or if the valve seat surface is not continuous, the valve seat must be reground.

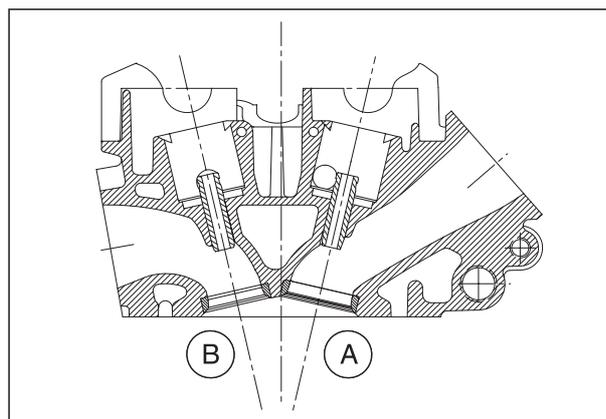
**5.30.3 GRINDING THE VALVE SEATS**

**A = intake**

**B = exhaust**

**NOTE** The valve seats may be reground with a valve seat grinder which centers on the valve guide.

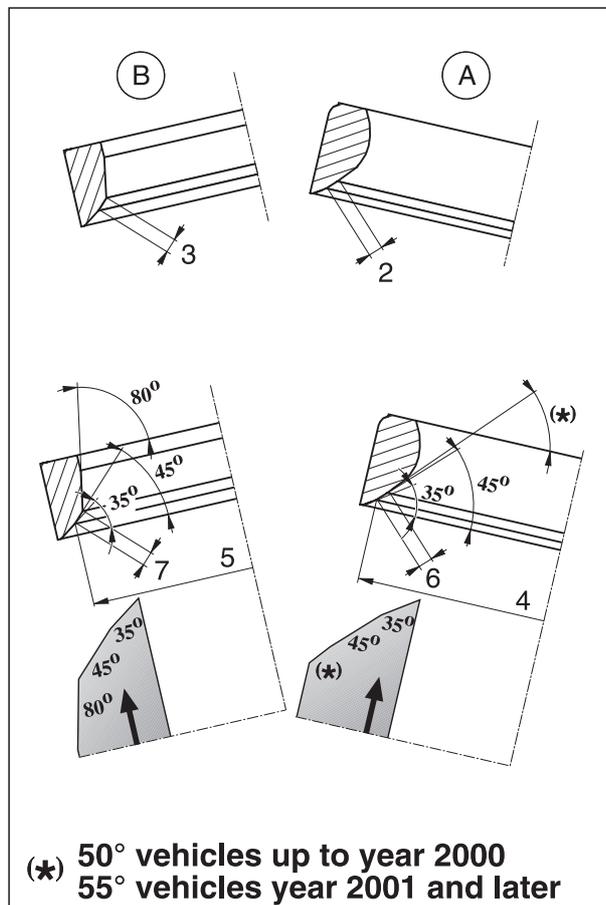
- ◆ Grind the valve seat at 45°. Remove no more material than absolutely necessary to clean the seat up.
- ◆ Using a 35° stone, narrow the valve seat until the appropriate outer diameter (4) (5) is obtained:
  - (vehicles up to year 2000) intake valve diameter (4) Ø 1.39 in (35.3 mm);
  - (vehicles year 2001 and later) intake valve diameter (4) Ø 1.48 in (37.7 mm);
  - exhaust valve (5) Ø 1.19 in (30.3 mm).

**Working on the intake valve:**

- ◆ Using:
  - (vehicles up to year 2000) a 50° stone;
  - (vehicles year 2001 and later) a 55° stone;
 reduce the width of the seating surface until the appropriate value (6) is obtained:
  - (vehicles up to year 2000) intake valve value (6) 0.041 – 0.053 in (1.05 – 1.35 mm);
  - (vehicles year 2001 and later) intake valve value (6) 0.039 – 0.055 in (1.00 – 1.40 mm).

**Working on the exhaust valve:**

- ◆ Using an 80° stone, reduce the width of the seating surface until the appropriate value (7) is obtained:
  - exhaust valve value (7) 0.049 – 0.061 in (1.25 – 1.55 mm).
- ◆ Finally, coat the valve head sealing seating surface with a fine paste of valve grinding compound using a manual valve grinding mandrel. Lightly grind the valves until a smooth, even, uniform sealing surface of the appropriate inside and outside diameter is obtained on both the valve and the seat. For this final valve seat finishing operation, do not use an electric drill or other motorized device. Use only a hand held valve grinding mandrel with a suction cup, rotating the valve back and forth through about 45°, and then advancing the valve 45° before repeating this operation.



5.30.4 ASSEMBLING THE VALVES IN THE HEAD

**NOTE** The following information refers to a single valve, but is valid for all of them.

**CAUTION**

Replace the valve units one by one.  
Do not mix up components belonging to different valve units.  
Replace each valve unit in the corresponding seat marked upon disassembly.

**NOTE** Have the appropriate special tool **OPT** available:

- **aprilia** part# 0277210 (valve guide assembly drift) (3);
- **aprilia** part# 0276479 (valves spring-pusher tool) (8);
- **aprilia** part# 8140179 (valves disassembly and reassembly clamp) (9).

- ◆ Place the valve spring seat (1) over the valve guide.
- ◆ Fit a new valve stem oil seal (2) with the appropriate assembly drift (3).
- ◆ Turn the head over.

**NOTE** When inserting the valve (4), take care not to damage the new valve stem oil seal (2).

- ◆ Apply motor oil to the valve stem and insert the valve (4) into the appropriate guide.

**NOTE** Ensure that the valve stem oil seal (2) is positioned correctly.

- ◆ If you have a Bosch or Sun tester available, check the valve leakage.

**NOTE** If it is less than 5%, the valves are properly seated.

- ◆ Turn the head over.
- ◆ Install the valve springs (5) (6) and the valve spring collar (7).

**NOTE** Be sure to install the valve springs properly. Remember that the more tightly wound coils are next to the head.

**CAUTION**

Do not compress the valve springs any more than is absolutely necessary, as this could damage the spring. Compress the springs only as much as necessary to fit the valve keepers in their seat on the valve.

- ◆ Compress the valve springs (5) and (6), complete with cup (7), by means of the valve spring compressor (8) and the appropriate clamp (9).

**NOTE** Apply some grease to the valve keepers (10), in order to facilitate their assembly.

- ◆ Insert the valve keepers (10) in the groove (11) on the valve (4).

**NOTE** When releasing the clamp (9), ensure that the valve keepers (10) are perfectly inserted in the valve groove (11); if necessary, use a plastic hammer and proceed with care.

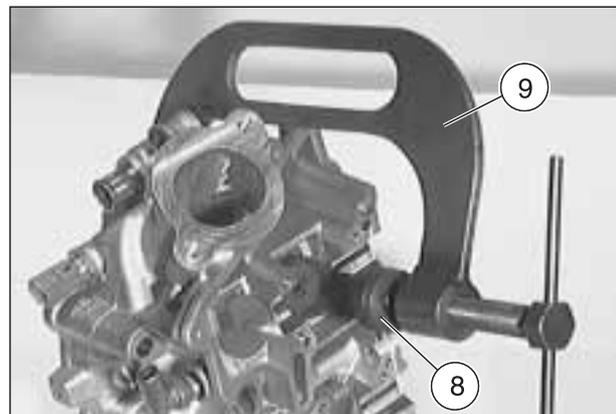
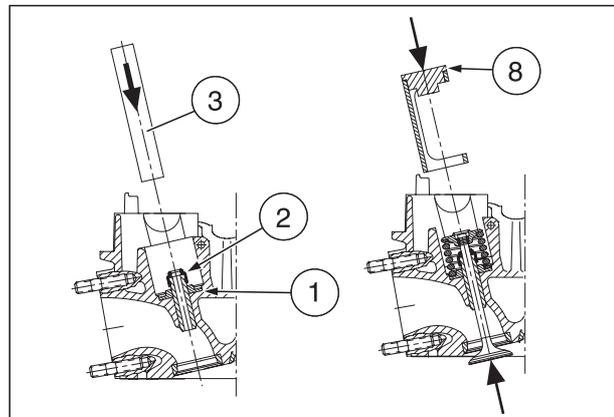
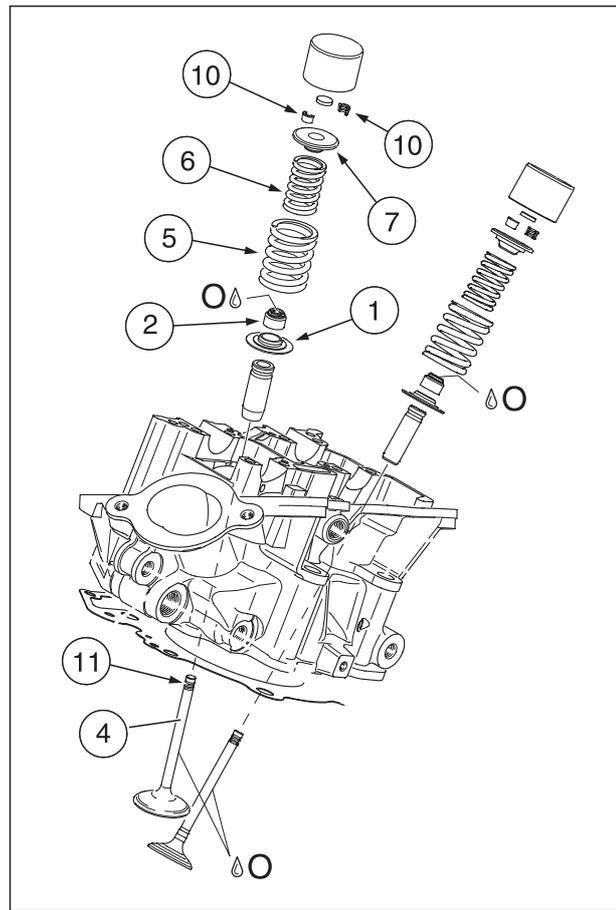
- ◆ Remove the compressor (8) and the clamp (9).

**CAUTION**

Ensure that the valve springs are placed correctly. If the springs are oblique, they will inevitably cause the breakage of the valve stem.

- ◆ Repeat the operations for the second valve.
- ◆ After reassembling the valves, check valve leakage using a special cylinder head leakage tester (Bosch or Sun).

**NOTE** If the leakage is less than 5%, the valves and valve seats are in satisfactory condition.



O = Engine oil.

**5.31 CYLINDER**

Carefully read 5.1 (PREFACE).

- ◆ Before reassembly, all gasket surfaces must be completely clean, and flat. Flatness of the gasket surfaces:

**Max. permissible distortion: 0.0016 in (0.04 mm).**

- ◆ Ensure that all the threads are in a perfect state of repair.
- ◆ Inspect the cylinder bore. Slight up and down scoring is permissible, but if there are deep gouges, scoring or galling in the lining of the cylinder, the complete cylinder, along with the piston, must be replaced.
- ◆ Inspect the cooling passages. Remove any mineral deposits.
- ◆ Measure the bore of the cylinder in three places at a distance of **1.77 in (45 mm)** from the upper edge (1). The largest diameter measured must be less than the wear limit:

**NOTE** The size group "A" or "B" is stamped onto the lower side of the cylinder (2).

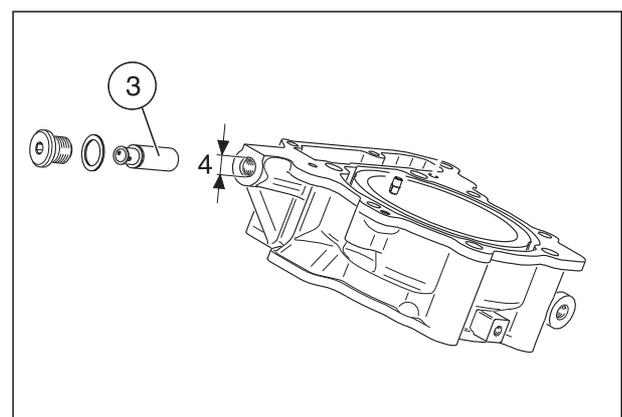
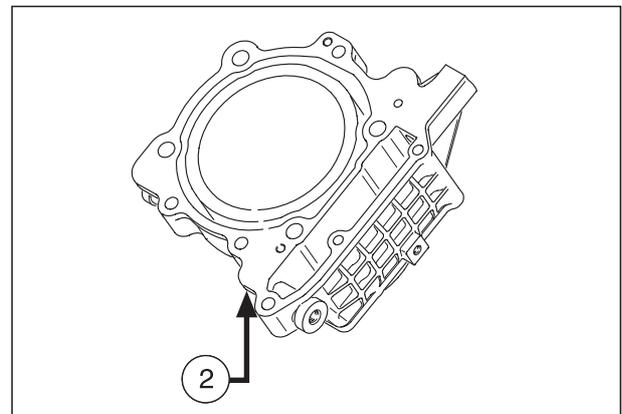
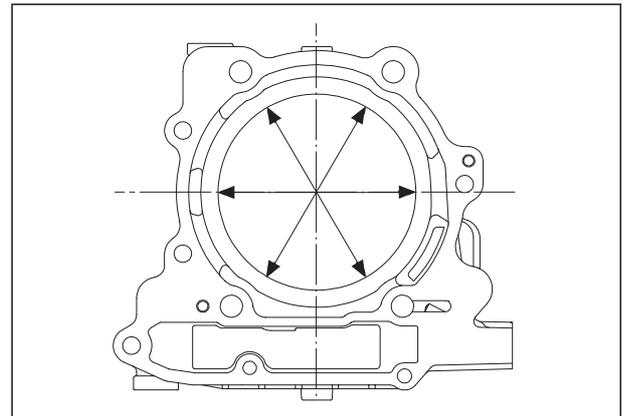
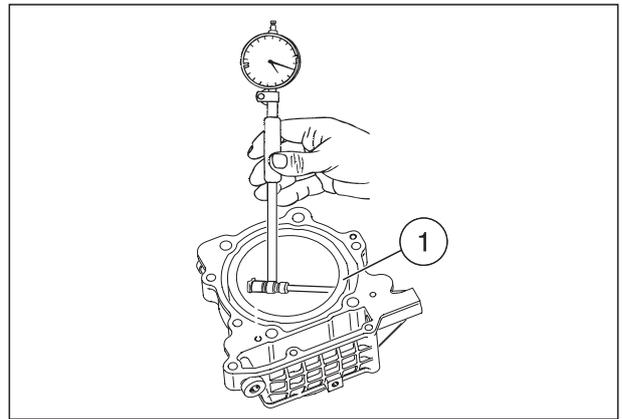
- size group "A", dimension when new:  
**bore  $\varnothing$  3.8976 – 3.8193 in (97.000 – 97.012 mm);**  
**wear limit: max.  $\varnothing$  3.8199 in (97.027 mm).**
- size group "B", dimension when new:  
**bore  $\varnothing$  3.8193 – 3.8198 in (97.012 – 97.025 mm);**  
**wear limit: max.  $\varnothing$  3.8205 in (97.040 mm).**

**NOTE** In order to assess the wear limit, the assembly play must be determined, see 5.32 (PISTON AND GUIDGEON PIN).

- ◆ Ensure that the chain tightener (3) and guide in the cylinder are in perfect condition.

Chain tightener (3) / hole (4) on the cylinder clearance:  
**wear limit (hole diameter - chain tightener diameter):**  
**max. 0.003 in (0.08 mm);**

Hole for chain tightener in the cylinder:  
**wear limit (4): max.  $\varnothing$  0.554 in (14.07 mm).**



**5.32 PISTON AND GUDGEON PIN**

Carefully read 5.1 (PREFACE).

- ◆ Clean the piston crown (1) and the area above the upper piston ring (2) carefully to remove any residual combustion products.
- ◆ Inspect the piston carefully for cracking, discoloration, galling or seizing. Particularly inspect the skirts of the piston for any signs of galling on the cylinder. If there is any sign of metal transfer from cylinder to piston or piston to cylinder, both the cylinder and the piston must be replaced, see 5.32.1 (PISTONS FEATURES CLASSIFICATION).

**NOTE** Small up and down scratches on the piston skirt that do not show any sign of metal transfer or galling are acceptable.

- ◆ Measure the piston diameter **0.39 in (10 mm)** (3) above the bottom of the piston, and at right angles to the gudgeon pin.

- "red" piston:  
**wear limit, min. diameter Ø 3.8145 in (96.890 mm);**
- "green" piston:  
**wear limit, min. diameter Ø 3.8149 in (96.900 mm);**
- piston play - measurement:  
**piston play = cylinder diameter minus piston diameter**  
**wear limit max. 0.0047 in (0.120 mm).**

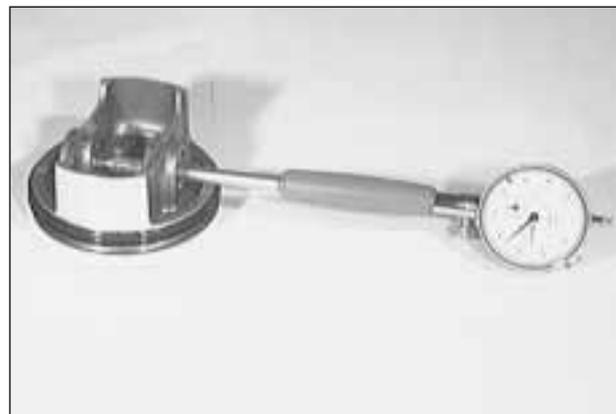
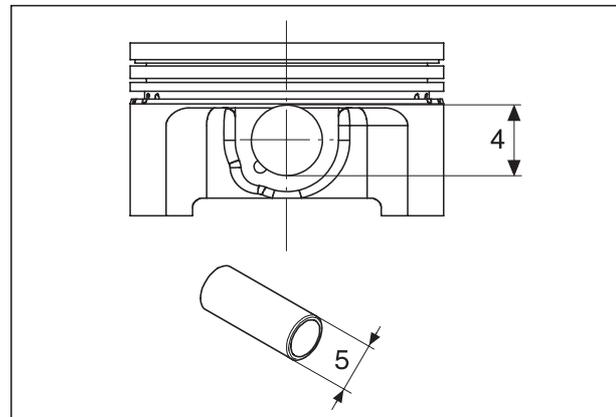
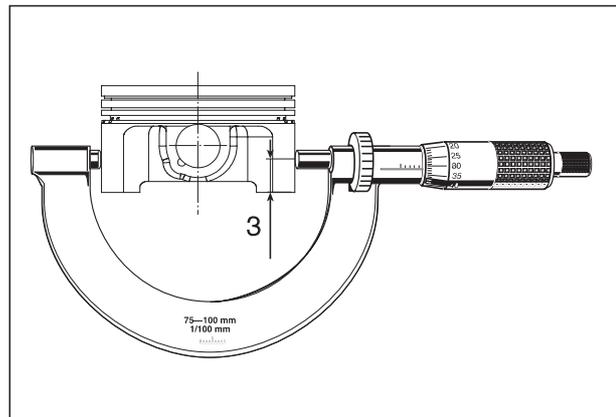
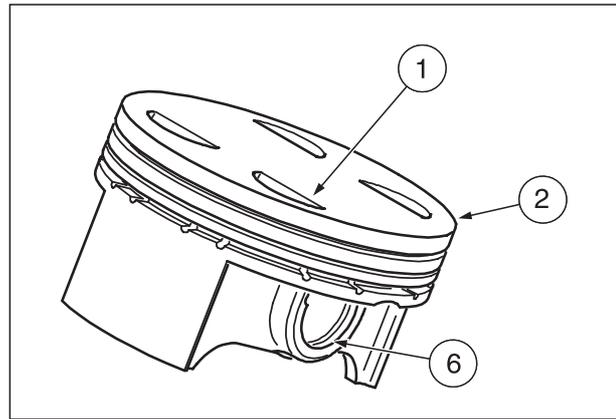
**NOTE** If the wear limit is exceeded, a new piston must be used or the cylinder replaced, complete with piston. If the piston is replaced, the two circlips securing the gudgeon pin must always be replaced, along with the actual gudgeon pin.

**Take special care when matching the cylinder - piston:**

- "red" piston - Cylinder "A";
- "green" piston - Cylinder "B".
- ◆ Using an inside micrometer, measure the diameter of the gudgeon pin hole in the piston in the up and down direction. Make several measurements at different locations along the gudgeon pin hole:
  - gudgeon pin hole in the direction of lift:  
**wear limit (4) max. Ø 0.8668 in (22.018 mm);**
  - gudgeon pin:  
**wear limit (5) min Ø 0.8661 in (21.998 mm).**
- ◆ Carefully inspect the circlips and relevant grooves (6) on the piston which hold the gudgeon pin in the piston.

**NOTE** We recommend you never replace a gudgeon pin circlip. They should always be renewed whenever they are disassembled.

Follow ►



Follow ►

- ◆ Use a feeler gauge to measure the end play (7) (8) (9) of the piston rings inside the grooves.
- “L-section” ring  
**wear limit (7) max. 0.0047 in (0.12 mm);**
- tapered protruding ring:  
**wear limit (8) max. 0.0047 in (0.12 mm);**
- oil ring  
**wear limit (9) max. 0.0039 in (0.10 mm).**

**⚠ CAUTION****The piston rings are fragile.**

- ◆ Carefully remove the piston rings from the piston.

**NOTE** The piston ring groove can be cleaned using a scraper or an old piston ring.

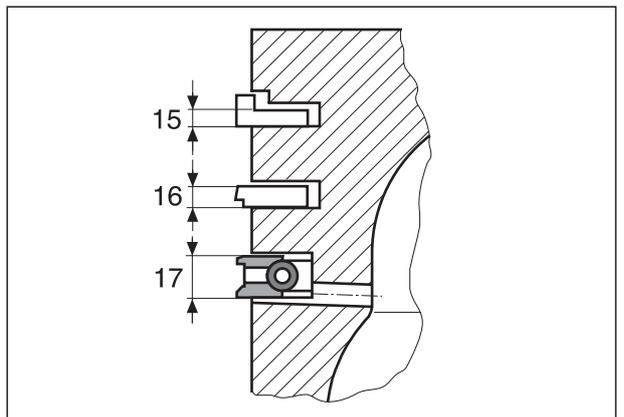
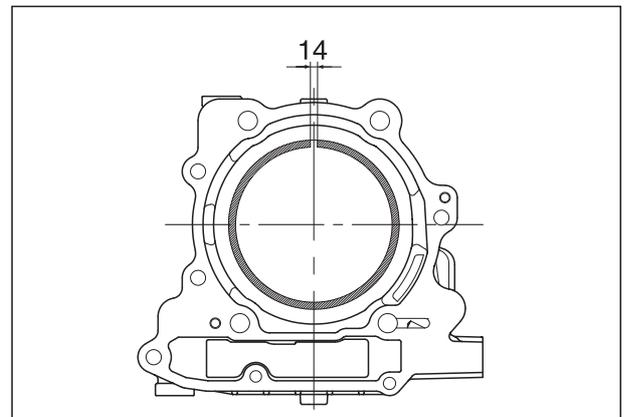
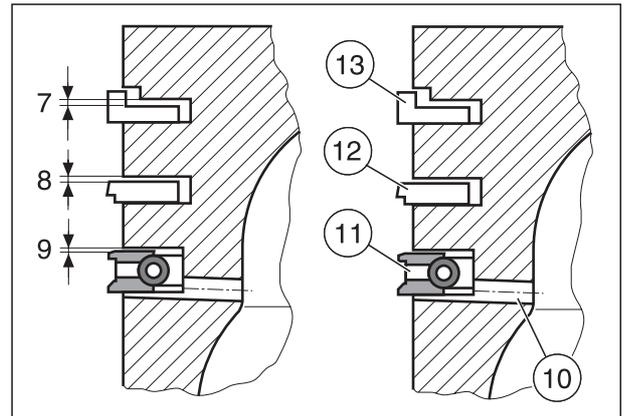
- ◆ Clean the piston rings and the oil return holes (10) and the oil ring groove, carefully blow out the oil return holes.
- ◆ Check the oil ring (11), the tapered protruding ring (12) and the L-section ring (13) to ensure that they rotate freely in the piston, and that there are no scores, scrapes, discolorations or carbon deposits on the bearing surface of the piston rings.
- ◆ Measure the piston ring gap (14) with a feeler gauge.

**wear limit max. 0.039 in (1.00 mm).**

**NOTE** In order to measure the gap required, insert the piston ring in the cylinder and push it inside so that it is lined up with the piston.

- ◆ Measure the thickness of the rings with a micrometer:
  - “L-section” ring:  
**wear limit (15) min. 0.033 in (0.85 mm);**
  - tapered protruding ring:  
**wear limit (16) min. 0.047 in (1.20 mm);**
  - oil ring:  
**wear limit (17) min. 0.096 in (2.45 mm).**
- ◆ Fit the oil ring (11), the tapered protruding ring (12) and the “L-section” ring (13) from the bottom up; the word “TOP” on the rings must face up.

**NOTE** Rotate the piston rings so that the three gaps are staggered by approx. 120°.

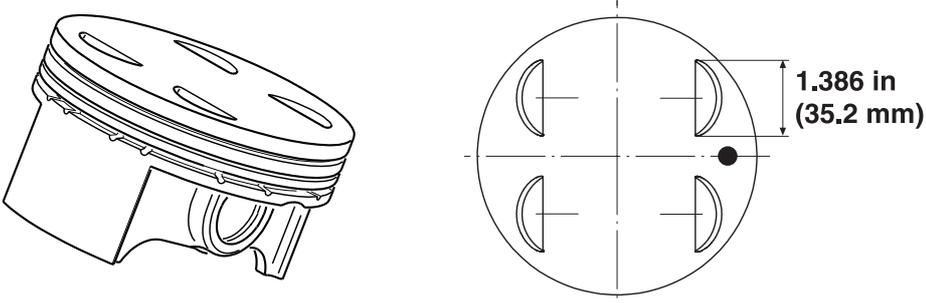
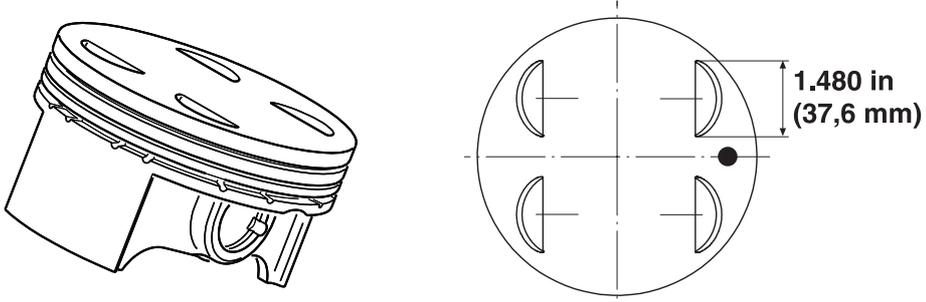
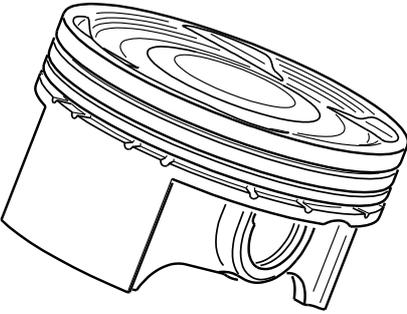


5.32.1 (PISTONS FEATURES CLASSIFICATION)

**CAUTION**

On **RSV RSV R** (vehicles up to year 2000) and on **SL** (vehicles up to year 2000) engines, the **aprilia** part# 0295855 must not be installed since the inlet valves touch this piston.

**NOTE** On **RSV RSV R** (vehicles year 2001 and later), on **SL** (vehicles year 2001 and later) and on **RST** engines, the **aprilia** part# 0295852 can be installed.

Vehicle model	Pistons
<p><b>RSV RSV R</b> (vehicles up to year 2000);</p> <p><b>SL</b> (vehicles up to year 2000).</p>	<p><b>aprilia</b> part# 0295855 (piston and piston rings set).</p> 
<p><b>RSV RSV R</b> (vehicles year 2001 and later);</p> <p><b>SL</b> (vehicles year 2001 and later);</p> <p><b>RST</b>.</p>	<p><b>aprilia</b> part# 0295852 (piston and piston rings set).</p> 
<p><b>ETV</b>.</p>	<p><b>aprilia</b> part# 0296590 (piston and piston rings set).</p> 



**5.33 STARTER MOTOR DRIVE ASSEMBLY**

Carefully read 5.1 (PREFACE).

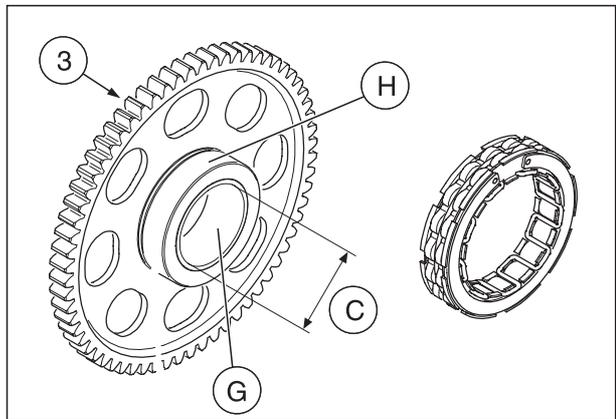
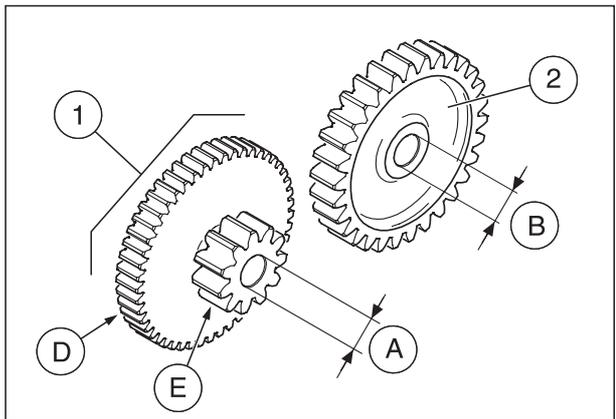
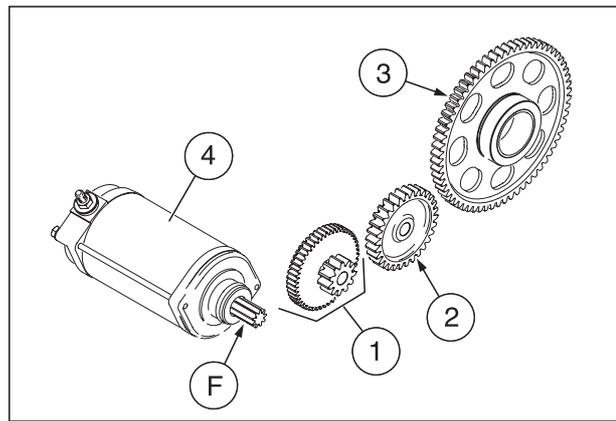
- ◆ Remove the starter double gear (1), starter idler gear (2) and the sprag clutch gear (3), see 4.8 (REMOVING THE ALTERNATOR COVER AND ALTERNATOR SYSTEM).
- ◆ Measure:
  - the gear bearing diameter (A) of the starter double gear (1):  
**wear limit: max.Ø 0.398 in (10.10 mm);**
  - the gear bearing diameter (B) of the starter idler gear (2):  
**wear limit: max.Ø 0.397 in (10.08 mm);**
  - the gear bearing diameter (C) of the sprag clutch gear (3):  
**wear limit: max.Ø 1.381 in (35.07 mm).**
- ◆ Inspect:
  - the teeth (D) and (E) of the starter double gear (1);
  - the teeth of the starter idler gear (2);
  - the teeth of the sprag clutch gear (3);
 for wear, pitting, distortion or discoloration.

**NOTE** If the teeth (D) of the starter double gear (1) are distorted, pitted or damaged in any way, the starter motor pinion (F) must also be inspected.

- ◆ Inspect the surface of the starter double gear (1), starter idler gear (2) and the sprag clutch gear (3) for wear, pitting, distortion or discoloration.
- ◆ Inspect the bore of the bushing (G) in the sprag clutch gear (3) for signs of scoring or galling.

**NOTE** The bushing (G) in the sprag clutch gear (3) is an interference fit, and must not move in the gear.

- ◆ Inspect the contact surface (H) of the sprag clutch for wear, pitting, distortion, or discoloration.



**CAUTION**  
If the contact surface (H) is damaged in any way, the sprag clutch gear (3) must be replaced.

- ◆ Check the sprag clutch, see 5.34.6 (CHECKING THE SPRAG CLUTCH ) or 5.35.6 (CHECKING THE SPRAG CLUTCH )

**5.34 ALTERNATOR** **RSV RSV R SL**

Carefully read 5.1 (PREFACE).

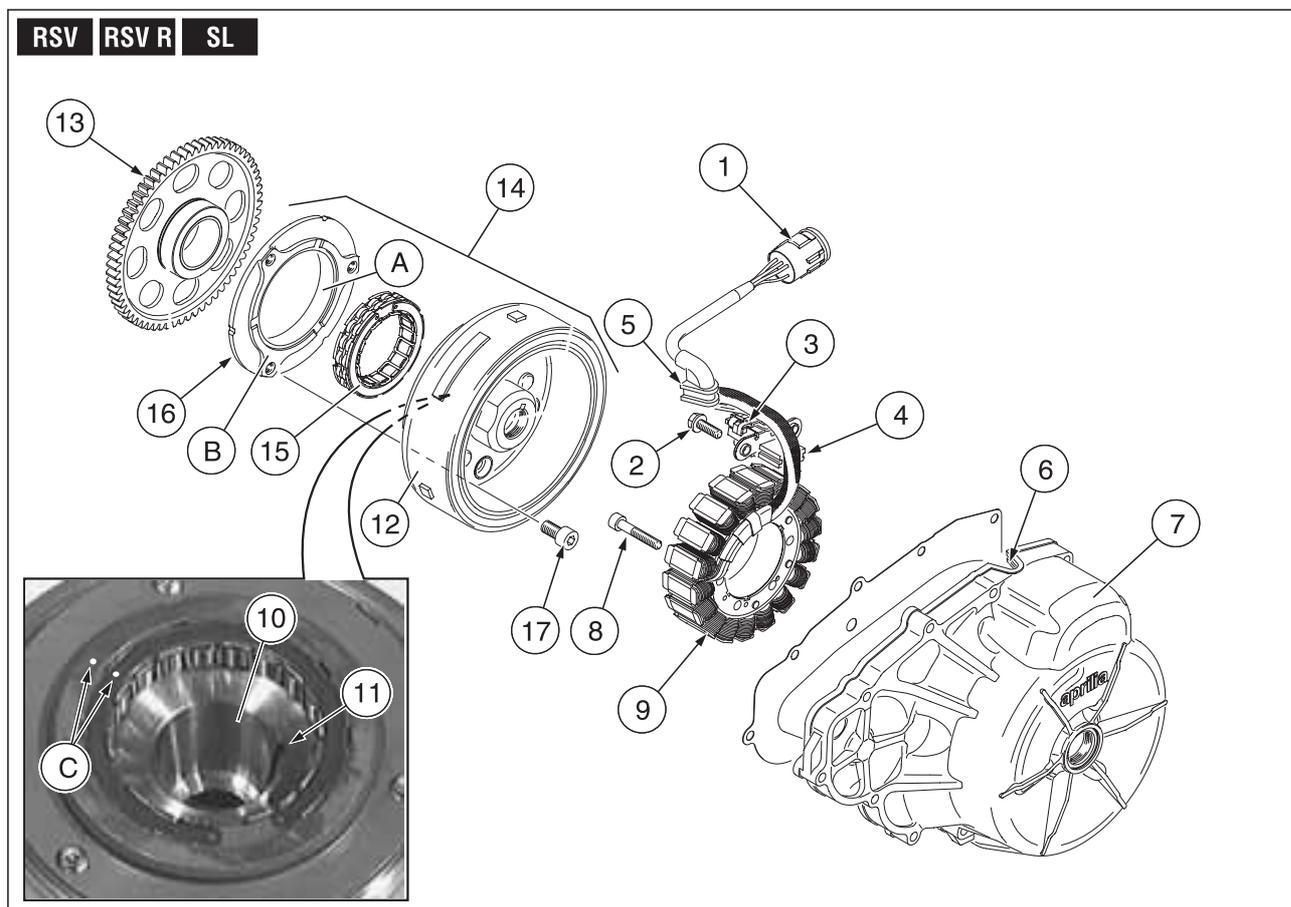
**NOTE** The alternator produces alternating current which is then transformed into direct current by the regulator/rectifier, which then charges the battery.

**▲ WARNING**

When performing work on the alternator:

- switch off the engine;

- disconnect the battery: always disconnect the negative pole (–) first;
- drain the engine oil tank completely, see section 2 (SERVICE AND SETTING UP) of specific vehicle workshop manual see 0.4.1 (VEHICLE WORKSHOP MANUAL).
- lock the crankshaft at the TDC of piston “1” or “2”.

**Key**

- |  |   |
|--|---|
| 1) Alternator connector.                       | 12) Alternator rotor.   |
| 2) # two screws of crankshaft position sensor. | 13) Sprag clutch gear.  |
| 3) Crankshaft position sensor.                 | 14) Alternator rotor group.   |
| 4) Cable hanger.                               | 15) Sprag clutch.   |
| 5) Rubber cable guide.                         | 16) Sprag clutch flange.  |
| 6) Seat of rubber cable guide.                 | 17) # three Allen screws of sprag clutch flange.                      |
| 7) Alternator cover.                           | A) Inside contact land of sprag clutch flange.                        |
| 8) # three Allen screws of stator.             | B) Contact flat surface of sprag clutch flange with alternator rotor. |
| 9) Stator.                                     | C) Reference dot (for correct reassembly).                            |
| 10) Alternator rotor taper.                    |   |
| 11) Key seat.                                  |   |

**5.34.1 TO GAIN ACCESS TO THE ALTERNATOR** **RSV RSV R SL**

◆ Remove the alternator cover (7) with:

- stator (9);
- crankshaft position sensor (3);

see 4.8 (REMOVING THE ALTERNATOR COVER AND ALTERNATOR SYSTEM).

5.34.2 CHECKING THE STATOR **RSV RSV R SL**

**CAUTION**

Do not force the electric cables.

- ◆ Measure the resistance between the three yellow cables of the alternator connector (1) using an ohmmeter.
- **Standard resistance value in the range 0.2 – 0.5 Ω at 20 °C (68 °F).**

**NOTE** If the resistance value does not fall within this range, the stator must be replaced.

5.34.3 DISASSEMBLING THE STATOR **RSV RSV R SL**

**Crankshaft position sensor screws M6 (2) tightening torque: 8 ftlb (11 Nm).**

- ◆ Unscrew and remove the two M6 screws (2).
- ◆ Remove the crankshaft position sensor (3) and the cable hanger (4).
- ◆ Release the rubber cable guide (5) from its seat (6) of the alternator cover (7).

**Stator M6 Allen screws (8) tightening torque: 8 ftlb (11 Nm).**

- ◆ Unscrew and remove the three M6 Allen screws (8) of the stator.
- ◆ Extract the stator (9) from the alternator cover seat.
- ◆ Check the sealing surface of the current alternator cover (7) for damage or warpage.

5.34.4 ASSEMBLING THE STATOR **RSV RSV R SL**

- ◆ Insert the stator (9) in the alternator cover seat.

**NOTE** Apply a couple of drops of LOCTITE® 243 to the threads of the three screws (8).

- ◆ Install and tighten the three M6 Allen screws (8).

**Stator M6 Allen screws (8) tightening torque: 8 ftlb (11 Nm).**

**NOTE** Apply a layer of SILASTIC 732 RTV to the rubber cable guide (5).

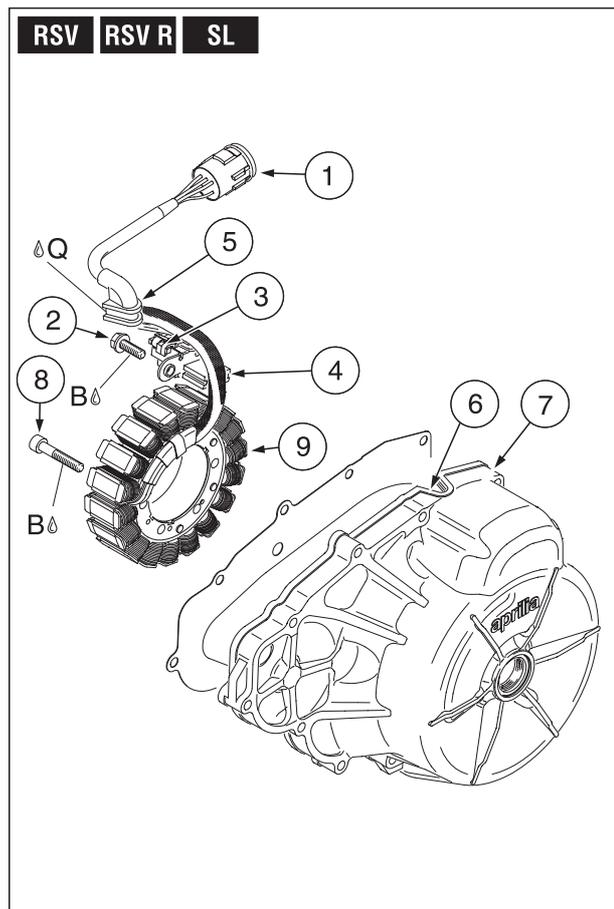
- ◆ Insert the rubber cable guide (5) in the seat (6) of the alternator cover (7).
- ◆ Correctly place the cable hanger (4) and the crankshaft position sensor (3).

**NOTE** Apply a couple of drops of LOCTITE® 243 to the threads of the two screws (2).

- ◆ Install and tighten the two M6 screws (2).

**Crankshaft position sensor M6 screws (2) tightening torque: 8 ftlb (11 Nm).**

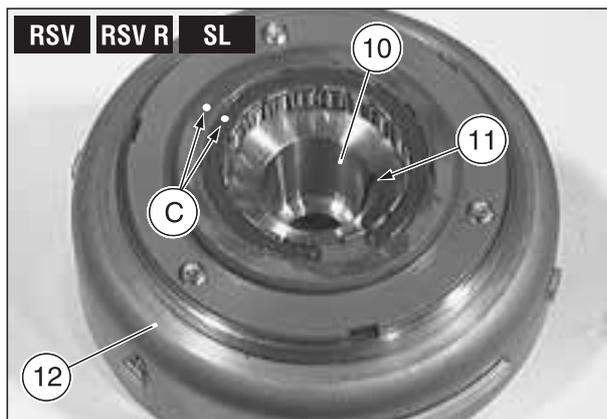
Q = SILASTIC 732 RTV.  
B = LOCTITE® 243.



**5.34.5 ALTERNATOR ROTOR** **RSV RSV R SL**

- ◆ Clean the alternator rotor taper (10) thoroughly. Remove any LOCTITE® residue.
- ◆ Ensure that the taper (10) and the key seat (11) are in perfect condition.

**NOTE** If the taper (10) or the key seat (11) are damaged, the alternator rotor (12) must be replaced.

**5.34.6 CHECKING THE SPRAG CLUTCH** **RSV RSV R SL**

- ◆ Check the sprag clutch gear (13), see 5.33 (STARTER MOTOR DRIVE ASSEMBLY).
- ◆ Clean the alternator rotor taper (10) thoroughly. Remove any LOCTITE® residue.
- ◆ Correctly install the sprag clutch gear (13) on the alternator group (14).

**CAUTION**

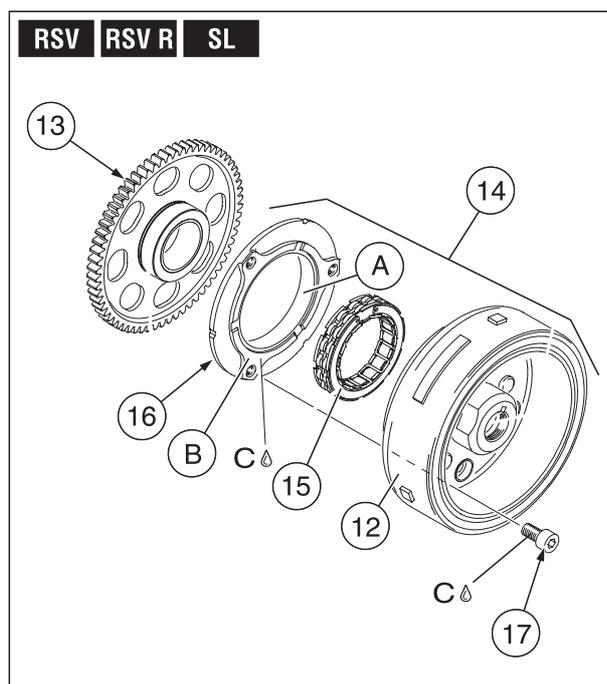
The sprag clutch gear (13) must rotate smoothly without jerkiness or roughness and in one-way only.

- ◆ Manually turn the sprag clutch gear (13), it rotate move smoothly without jerkiness or roughness and in one-way only.

If the sprag clutch gear display any of these signs:

- ◆ Withdraw the sprag clutch gear (13) from the alternator group (14).
- ◆ Extract the sprag clutch (15), see 5.34.7 (DISASSEMBLING THE SPRAG CLUTCH **RSV RSV R SL**).
- ◆ Inspect the sprag clutch (15):
  - the rollers of the sprag clutch for wear, galling, pitting, or discoloration;
  - the external helical spring preload must be sufficient to hold the rollers snugly in place.
- ◆ Inspect the inside contact land (A) of sprag clutch flange (16):
  - for wear, galling, pitting, or discoloration.

**NOTE** If the inside contact land (A) is damaged, the complete sprag clutch flange (16) must be replaced.

**5.34.7 DISASSEMBLING THE SPRAG CLUTCH** **RSV RSV R SL**

**Sprag clutch flange M8x16 Allen screw tightening torque: 21.7 ftlb (30 Nm).**

- ◆ Unscrew and remove the three M8x16 Allen screws (17).

**CAUTION**

Before removing the sprag clutch flange (16) mark it and the sprag clutch (15) with a dot (C), to remind you which direction them should be reassembled and so that you are sure to refit the sprag clutch (15) with the same direction of rotation.

- ◆ Using a felt pen, mark the sprag clutch flange (16) and the sprag clutch (15) with a dot (C).
- ◆ Detach the sprag clutch flange (16) from the alternator rotor (12).
- ◆ Remove the sprag clutch (15) from its seat, on the sprag clutch flange (16).

**5.34.8 ASSEMBLING THE SPRAG CLUTCH** **RSV RSV R SL****CAUTION**

When replacing the sprag clutch (15) observe the reference dot (C) as marked upon disassembly.

- ◆ Correctly insert the sprag clutch (15) in its seat, on the sprag clutch flange (16). Refer to the reference dot (C) applied during disassembly.

**CAUTION**

Use LOCTITE® 648 on the contact flat surface (B) of the sprag clutch flange (16) with alternator rotor.

- ◆ Apply a couple of drops of LOCTITE® 648 to the contact flat surface (B) of the sprag clutch flange (16) and correctly place it in the center of the alternator rotor (12).

**CAUTION**

Use LOCTITE® 648 on the three M8x16 Allen screws (17) of the sprag clutch flange (16).

- ◆ Apply a couple of drops of LOCTITE® 648 to the threads of the M8x16 Allen screws (17).
- ◆ Screw in and tighten the three M8x16 Allen screws (17).

**Sprag clutch flange M8x16 Allen screw tightening torque: 21.7 ftlb (30 Nm).**

C = LOCTITE® 648.

**5.35 ALTERNATOR**  

Carefully read 5.1 (PREFACE).

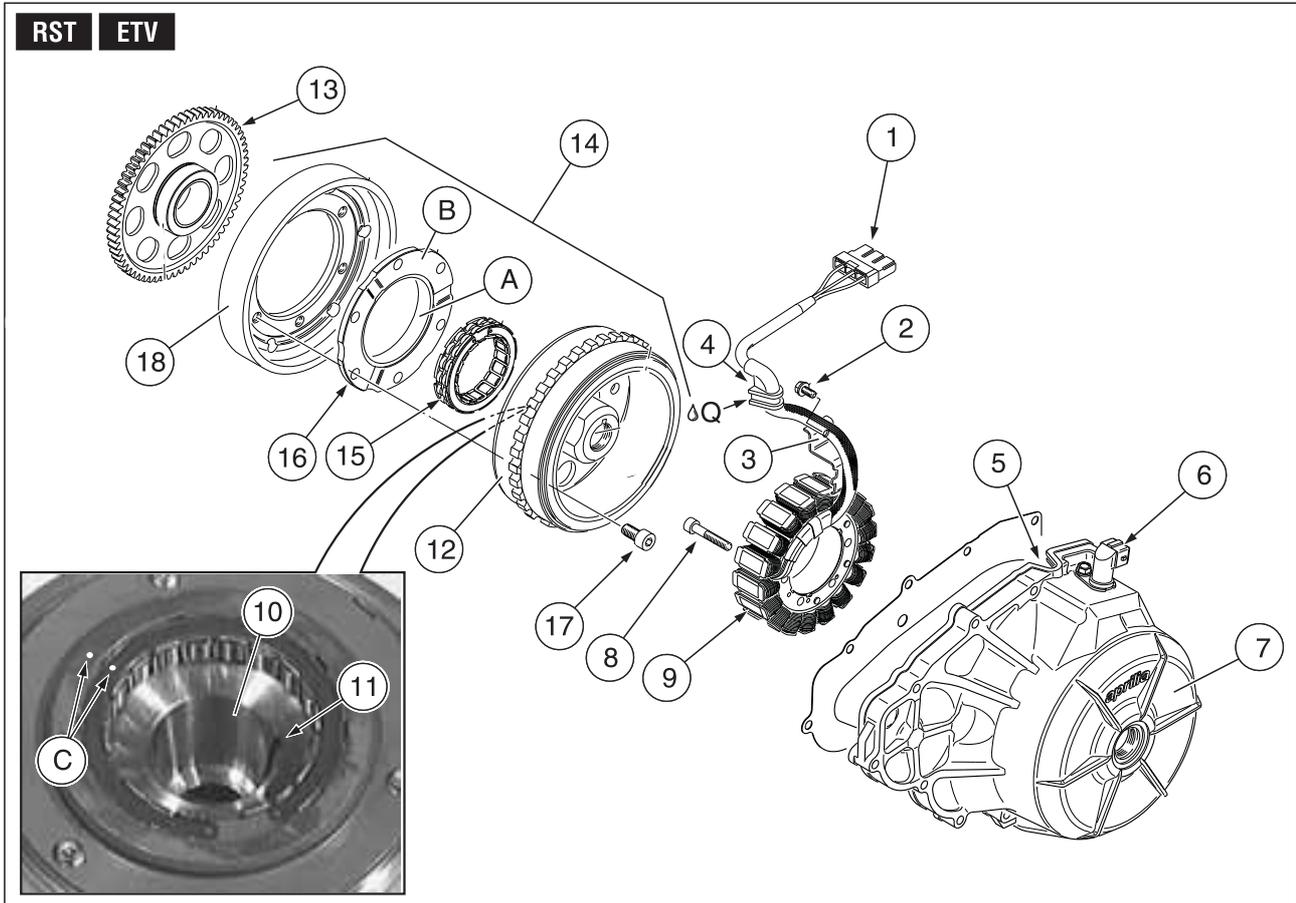
**NOTE** The alternator produces alternating current which is then transformed into direct current by the regulator/rectifier, which then charges the battery.

**⚠ WARNING**

When performing work on the alternator:

- switch off the engine;

- disconnect the battery: always disconnect the negative pole (-) first;
- drain the engine oil tank completely, see section 2 (SERVICE AND SETTING UP) of specific vehicle workshop manual see 0.4.1 (VEHICLE WORKSHOP MANUAL).



**Key**

- |   |  |
|---|--|
| <ul style="list-style-type: none"> <li>1) Alternator connector.</li> <li>2) # one screw of stator cable hanger.</li> <li>3) Stator cable hanger.</li> <li>4) Rubber cable guide.</li> <li>5) Seat of rubber cable guide.</li> <li>6) Crankshaft position sensor.</li> <li>7) Alternator cover.</li> <li>8) # three Allen screws of stator.</li> <li>9) Stator.</li> <li>10) Alternator rotor taper.</li> <li>11) Key seat.</li> </ul> | <ul style="list-style-type: none"> <li>12) Alternator rotor.</li> <li>13) Sprag clutch gear.</li> <li>14) Alternator rotor group.</li> <li>15) Sprag clutch.</li> <li>16) Sprag clutch flange.</li> <li>17) # three Allen screws of alternator rotor housing.</li> <li>18) Alternator rotor housing.</li> <li>A) Inside contact land of sprag clutch flange.</li> <li>B) Contact flat surface of sprag clutch flange with alternator rotor.</li> <li>C) Reference dot (for correct reassembly).</li> </ul> |
|---|--|

**5.35.1 TO GAIN ACCESS TO THE ALTERNATOR**  

- ◆ Remove the alternator cover (7) with:
  - stator (9);
  - crankshaft position sensor (6);
 see 4.8 (REMOVING THE ALTERNATOR COVER AND ALTERNATOR SYSTEM).

**5.35.2 CHECKING THE STATOR**  **⚠ CAUTION**

Do not force the electric cables.

- ◆ Measure the resistance between the three yellow cables of the alternator connector (1) using an ohmmeter.
- **Standard resistance value in the range 0.1 – 1.0 Ω at 20 °C (68 °F).**

**NOTE** If the resistance value does not fall within this range, the stator must be replaced.

**5.35.3 DISASSEMBLING THE STATOR**  

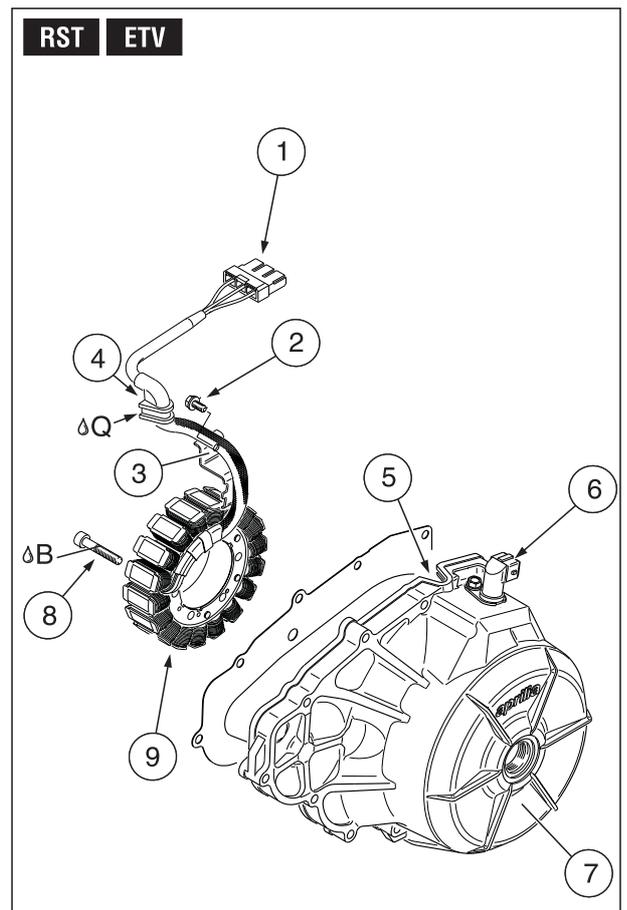
**Stator cable hanger M6 screw (2) tightening torque: 8 ftlb (11 Nm).**

- ◆ Unscrew and remove the M6 screw (2).
- ◆ Remove the stator cable hanger (3).
- ◆ Release the rubber cable guide (4) from its seat (5) of the alternator cover (7).

**NOTE** Do not remove the crankshaft position sensor (6) from the alternator cover (7).

**Stator M6 Allen screws (8) tightening torque: 8 ftlb (11 Nm).**

- ◆ Unscrew and remove the three M6 Allen screws (8) of the stator.
- ◆ Extract the stator (9) from the alternator cover seat.
- ◆ Check the sealing surface of the current alternator cover (7) for damage or warpage.

**5.35.4 ASSEMBLING THE STATOR**  

- ◆ Insert the stator (9) in the alternator cover seat.

**NOTE** Apply a couple of drops of LOCTITE® 243 to the threads of the stator M6 Allen screws (8).

- ◆ Install and tighten the three M6 Allen screws (8).

**Stator M6 Allen screws (8) tightening torque: 8 ftlb (11 Nm).**

**NOTE** Apply a layer of SILASTIC 732 RTV to the rubber cable guide (4).

- ◆ Insert the rubber cable guide (4) in its seat (5) of the alternator cover (7).
- ◆ Correctly place the stator cable hanger (3).

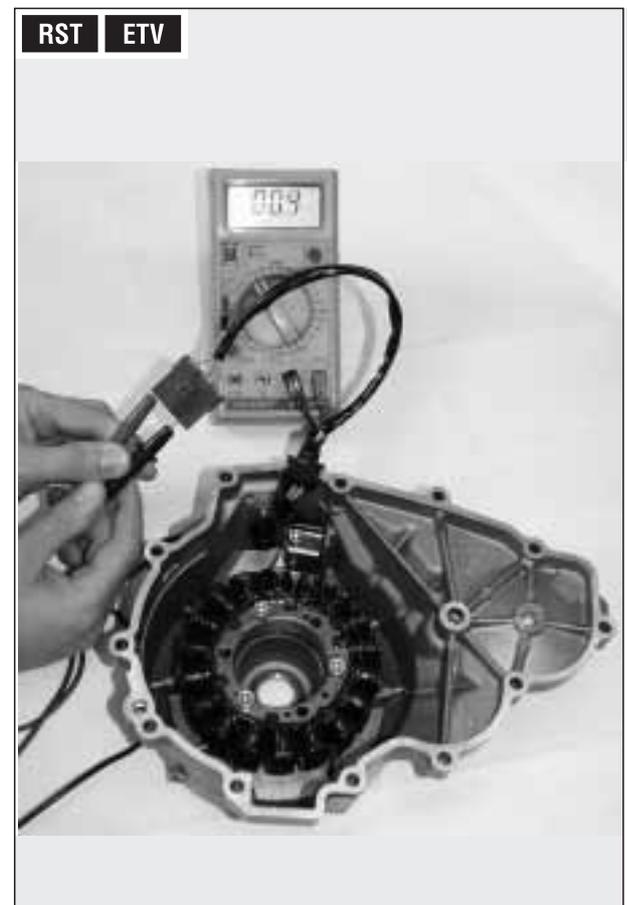
**NOTE** Apply a couple of drops of LOCTITE® 243 to the threads of the stator cable hanger M6 screw (2).

- ◆ Install and tighten the M6 screw (2).

**Stator cable hanger M6 screw (2) tightening torque: 8 ftlb (11 Nm).**

**B** = LOCTITE® 243.

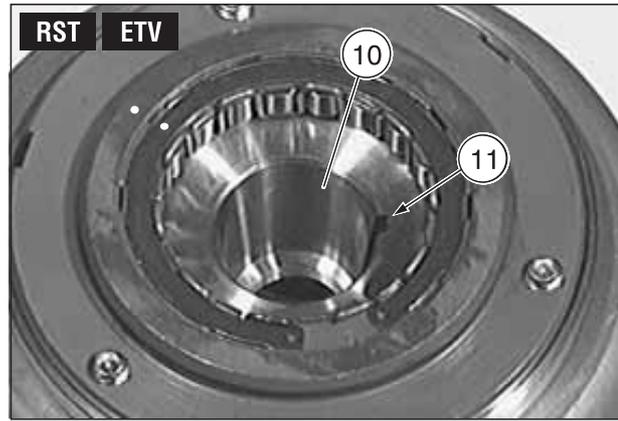
**Q** = SILASTIC 732 RTV.



**5.35.5 ALTERNATOR ROTOR**  

- ◆ Clean the alternator rotor taper (10) thoroughly. Remove any LOCTITE® residue.
- ◆ Ensure that the taper (10) and the key seat (11) are in perfect condition.

**NOTE** If the taper or the key seat are damaged, the alternator rotor must be replaced.



**5.35.6 CHECKING THE SPRAG CLUTCH**  

- ◆ Check the sprag clutch gear (13), see 5.33 (STARTER MOTOR DRIVE ASSEMBLY).
- ◆ Clean the alternator rotor taper (10) thoroughly. Remove any LOCTITE® residue.
- ◆ Correctly install the sprag clutch gear (13) on the alternator group (14).

**⚠ CAUTION**

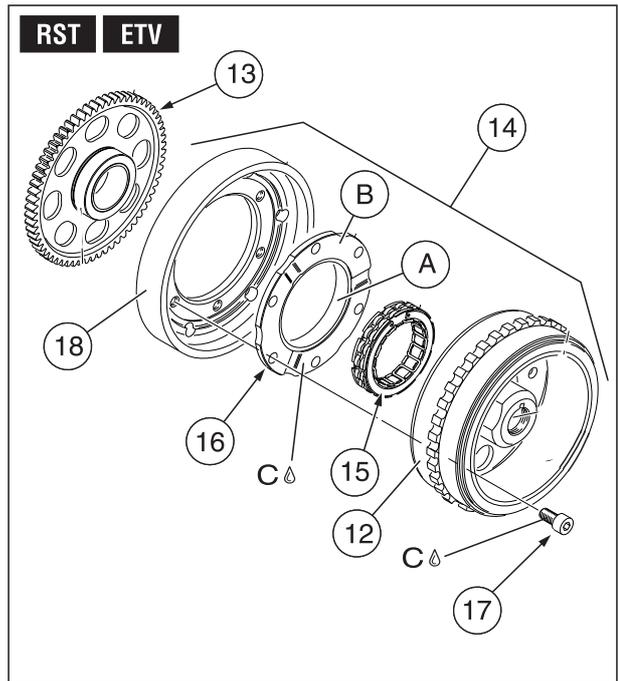
The sprag clutch gear (13) must rotate smoothly without jerkiness or roughness and in one-way only.

Manually turn the sprag clutch gear (13), it rotate move smoothly without jerkiness or roughness and in one-way only.

If the sprag clutch gear display any of these signs:

- ◆ Withdraw the sprag clutch gear (13) from the alternator group (14).
- ◆ Extract the sprag clutch (15), see 5.35.7 (DISASSEMBLING THE SPRAG CLUTCH  ).
- ◆ Inspect the sprag clutch (15):
  - the rollers of the sprag clutch for wear, galling, pitting, or discoloration;
  - the external helical spring preload must be sufficient to hold the rollers snugly in place.
- ◆ Inspect the inside contact land (A) of sprag clutch flange (16):
  - for wear, galling, pitting, or discoloration.

**NOTE** If the inside contact land (A) is damaged, the complete sprag clutch flange (16) must be replaced.



**5.35.7 DISASSEMBLING THE SPRAG CLUTCH**  

Alternator rotor housing M8x18 Allen screw tightening torque: 21.7 ftlb (30 Nm).

- ◆ Unscrew and remove the six M8x18 Allen screws (17).
- ◆ Remove the alternator rotor housing (18).

**⚠ CAUTION**

Before removing the sprag clutch flange (16) mark it and the sprag clutch (15) with a dot (C), to remind you which direction they should be reassembled and so that you are sure to refit the sprag clutch (15) with the same direction of rotation.

- ◆ Using a felt pen, mark the sprag clutch flange (16) and the sprag clutch (15) with a dot (C).
- ◆ Detach the sprag clutch flange (16) from the alternator rotor (12).
- ◆ Remove the sprag clutch (15) from its seat, on the sprag clutch flange (16).

**5.35.8 ASSEMBLING THE SPRAG CLUTCH**  

**⚠ CAUTION**

When replacing the sprag clutch (15) observe the reference dot (C) as marked upon disassembly.

- ◆ Correctly insert the sprag clutch (15) in its seat, on the sprag clutch flange (16). Refer to the reference dot (C) applied during disassembly.

**⚠ CAUTION**

Use LOCTITE® 648 on the contact flat surface (B), of the sprag clutch flange (16), with the alternator rotor.

- ◆ Apply a couple of drops of LOCTITE® 648 to the contact flat surface (B) of the sprag clutch flange (16) and correctly place it in the center of the alternator rotor (12).
- ◆ Correctly place the alternator rotor housing (18) on the alternator rotor (12).

**⚠ CAUTION**

Use LOCTITE® 648 on the six M8x18 Allen screws (17) of the alternator rotor housing (17).

- ◆ Apply couple of drops of LOCTITE® 648 to the threads of the M8x18 Allen screws (17).
- ◆ Screw in and tighten the six M8x18 Allen screws (17).

Alternator rotor housing M8x18 Allen screw tightening torque: 21.7 ftlb (30 Nm).

C = LOCTITE® 648.

**5.36 SPARK PLUGS**

Consult the section 2 (SERVICE AND SETTING UP) of specific vehicle workshop manual see 0.4.1 (VEHICLE WORKSHOP MANUAL).

**5.37 COUNTERSHAFT SPROCKET**

Carefully read 5.1 (PREFACE).

- ◆ Check the sprocket's internal spline (1) for wear.

**NOTE** If the teeth is worn, change the countershaft sprocket and check the teeth of the countershaft.

- ◆ Check the sprocket's external teeth (2) for wear and distortion.

**NOTE** If the teeth of the countershaft sprocket are worn or distorted, the countershaft sprocket, rear sprocket and chain must be replaced as a set.

**5.38 STARTER MOTOR**

Carefully read 5.1 (PREFACE).

- ◆ Remove the starter motor, see 4.5 (REMOVING THE STARTER MOTOR).

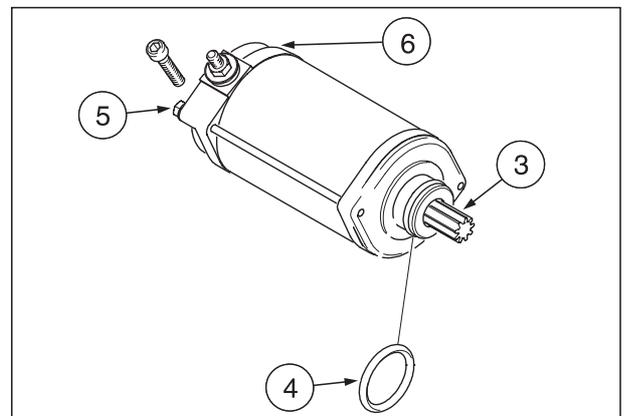
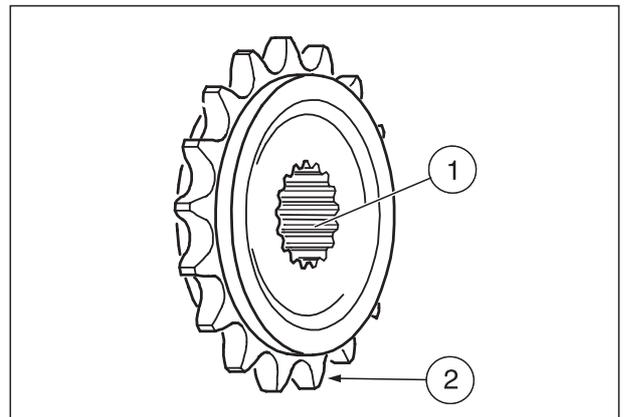
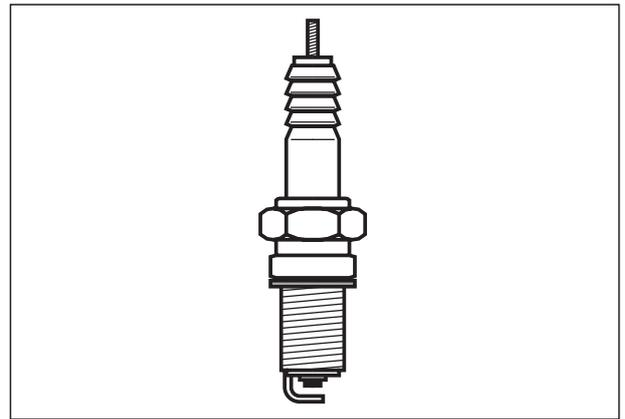
**NOTE** The starter motor does not normally wear out, and has a very long life. If the carbon brushes are worn, they may be replaced using the available repair kit. This is the only repair authorized for this component. Any other damage or defect requires that the complete starter motor be replaced.

- ◆ Check the starter motor pinion (3) for pitting, distortion or discoloration. If it is damaged, replace the complete starter motor.
- ◆ Check the starter motor mount O-ring (4) for any signs of damage. It is advisable to replace this O-ring any time a starter motor is removed.
- ◆ Unscrew and remove the two M6 screws (5) and remove the complete rear cover (6).
- ◆ Check the four carbon brushes for freedom of movement in their holders. If they are stuck and cannot be freed, the starter motor must be repaired or replaced.
- ◆ Check the preloading of the brush springs.
- ◆ Check the length of the carbon brushes.

**Wear limit min. 0.31 in (8.0 mm).**

**NOTE** A kit is available which contains a rear cover complete with carbon brushes and seals.

- ◆ Replace the complete rear cover (6), install and tighten the two M6 screws (6).





**REASSEMBLING THE ENGINE**

**6**

# REASSEMBLING THE ENGINE

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**6.14 ADJUSTING VALVE CLEARANCE** ..... 6-17-00

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**6.16 ASSEMBLING HEAD "2" (REAR) TIMING DRIVE ASSEMBLY** ..... 6-19-00

**6.17 ASSEMBLING HEAD "1" (FRONT) TIMING DRIVE ASSEMBLY** ..... 6-21-00

**6.18 ASSEMBLING THE STARTER MOTOR DRIVE ASSEMBLY AND ALTERNATOR** ..... 6-23-00

**6.19 ASSEMBLING THE PISTON AND CYLINDER "1" (FRONT)** ..... 6-24-00

**6.20 ASSEMBLING HEAD "1" (FRONT) CAMSHAFT** ..... 6-27-00

**6.21 ASSEMBLING HEAD "1" (FRONT) TIMING DRIVE ASSEMBLY** ..... 6-28-00

**6.22 ASSEMBLING THE VALVE COVER** ..... 6-29-00

**6.23 ASSEMBLING THE ALTERNATOR COVER** ..... 6-30-00

**6.24 ASSEMBLING THE CLUTCH HOUSING** ..... 6-31-00

**6.25 ASSEMBLING THE STARTER MOTOR** ..... 6-32-00

**6.26 ASSEMBLING THE ENGINE OIL FILTER** ..... 6-32-00

6

**6.1 PREFACE**

This section contains the information and data required by the professional mechanic to reassembly the engine.

Carefully read 4.2 (IMPORTANT INFORMATION).

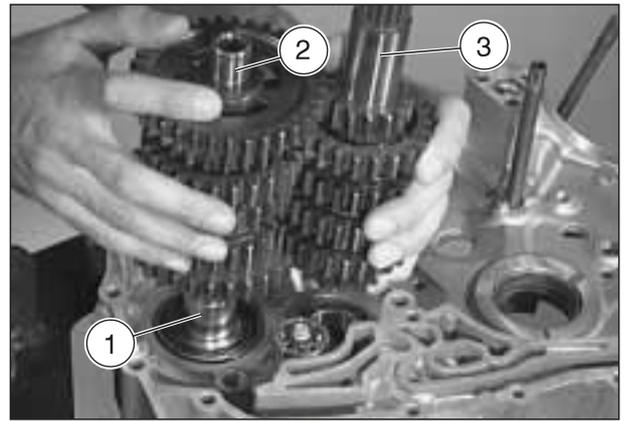
**⚠ WARNING**

Touching the engine while hot may cause burns.

**⚠ CAUTION**

When reassembling the engine, always replace all gaskets, circlips, O-rings and seals.

Unless otherwise instructed, lubricate all moving and sliding parts with engine oil as the engine is reassembled.



**6.2 ENGINE REASSEMBLY SEQUENCE**

**⚠ CAUTION**

Any components removed must be set aside in groups arranged according to their assembly position. This will ensure that when you reassemble the engine, all parts will be fitted in their proper locations.

**NOTE** Before going ahead with the reassembly of the engine, gather the appropriate special tools, see 2.7 (SPECIAL TOOLS ).

**NOTE** For the engine reassembly sequence, see 4.4 (ENGINE DISASSEMBLY SEQUENCE), following the diagram sequence in reverse order.



**6.3 ENGINE CHECKS SUBSEQUENT TO REASSEMBLY**

Consult the corresponding chapter in the section 3 (ENGINE) of specific vehicle workshop manual, see 0.4.1 (VEHICLE WORKSHOP MANUAL).

**6.4 ASSEMBLING THE GEARBOX**

Carefully read 6.1 (PREFACE).

**NOTE** Assemble the gears on the driving shafts, see 5.14 (GEARBOX).

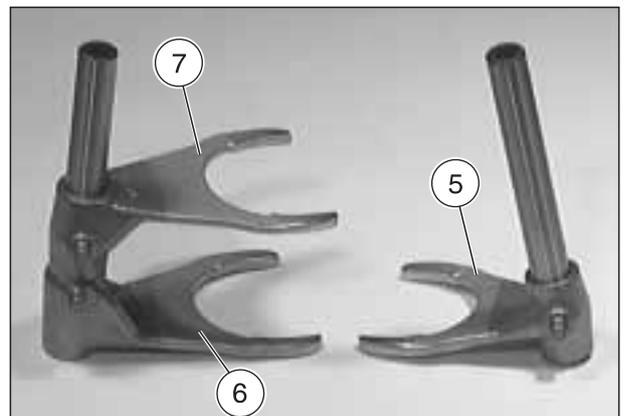
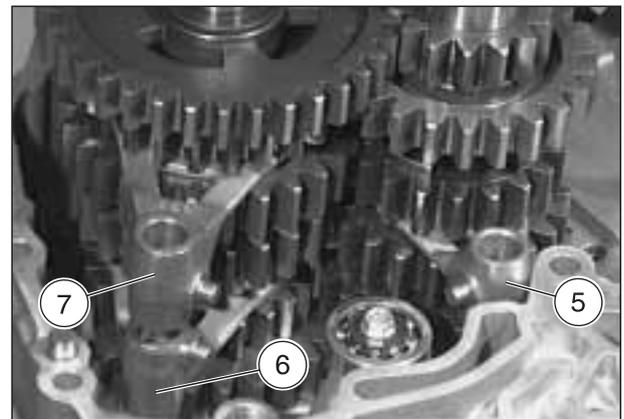
**NOTE** Have the appropriate special tool  available:  
– **aprilia** part# 0277308 (countershaft guide bushing) (1).

- ◆ Insert the guide bushing (1) into the gear of the countershaft (2).
- ◆ Fill the space between the two lips of the secondary shaft wheel with grease.
- ◆ Apply a thin coat of LOCTITE® Anti Seize to the areas of the countershaft (2) and main shaft (3), where they are inserted into the bearings.
- ◆ Insert the main shaft (3) into its bore on the alternator side half of the engine case.
- ◆ Insert the countershaft (2) into its bore on the alternator side half of the engine case.
- ◆ Insert the complete gear assembly into the case, tapping the two shafts lightly until they are driven completely home.

**NOTE** Proceed with caution. Do not force the gears into place. If properly assembled, they will easily tap into place.

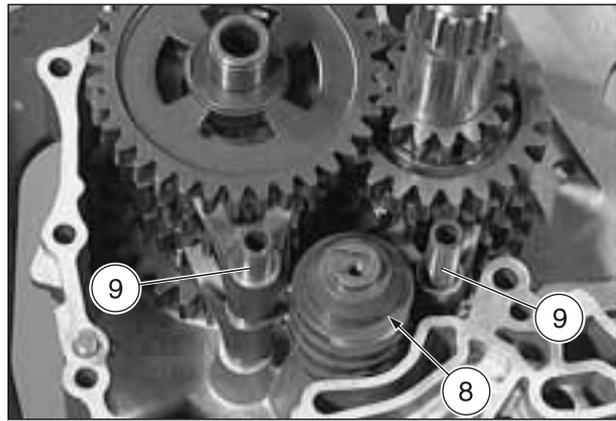
- ◆ Install the washer (4) on the countershaft (2).
- ◆ Coat the forks of the fifth and sixth gear (5) with engine oil and insert them into the appropriate selector gear slots on the main shaft (3).
- ◆ Coat the fork of the second and fourth gear (6) and the first and third gear fork (7) with engine oil, and install them into their respective selector gear grooves on the countershaft (2).

Follow 



Follow ►

- ◆ Apply a little oil to the shift cam (8) and insert it into its appropriate bearing in the case.
- ◆ Ensure that the three gearshift fork pegs are properly aligned and installed in the appropriate slots in the gearshift cam (8).
- ◆ Insert the two gearshift shafts (9), pushing them all the way home into their respective holes in the alternator side half engine case.



**6.5 ASSEMBLING THE CRANKSHAFT AND LOWER BALANCESHAFT**

Carefully read 6.1 (PREFACE).

- ◆ Apply a coat of MOLYKOTE® G-N on the bearing lands of the crankshaft and the lower balanceshaft.

**⚠ CAUTION**

Do not permit the crankshaft to be tilted during installation. This will damage the main engine bushings.

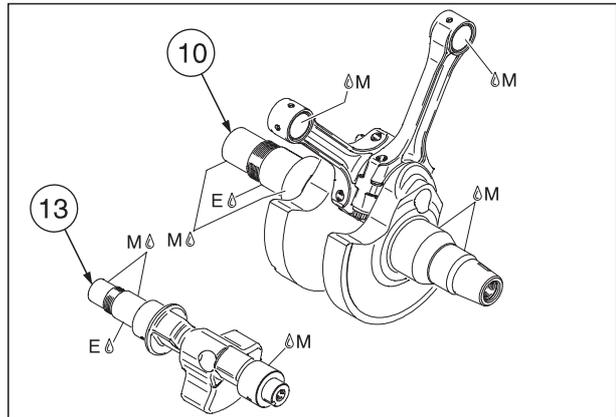
- ◆ Insert the crankshaft (10) into its bushing in the alternator side engine case.

**NOTE** Place the lower connecting rod (11) towards cylinder "2" (rear) and the upper connecting rod (12) towards cylinder "1" (front).

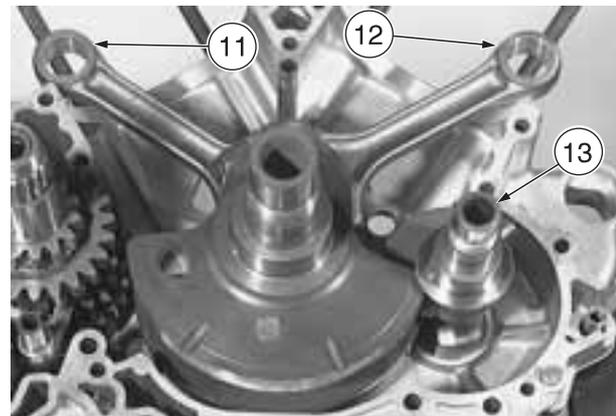
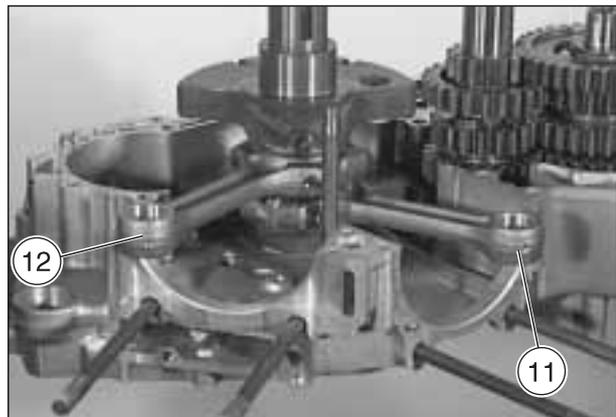
**⚠ CAUTION**

Do not permit the lower balanceshaft to be tilted during installation. This will damage the lower balanceshaft bushings.

- ◆ Insert the lower balanceshaft (13) into its appropriate bushing.



M = MOLYKOTE® G-N.  
E = LOCTITE® Anti Seize 15378.



**6.6 ASSEMBLING THE ENGINE CASES**

Carefully read 6.1 (PREFACE).

**⚠ CAUTION**

Never reuse an used engine case gasket. Use only new, original equipment **aprilia** engine case gasket.

- ◆ Place the engine case gasket (1) on the alternator side half of the engine case.

**NOTE** The gasket must line up with all engine case holes. You may apply grease to the gasket to hold it in place. Be very careful to ensure that the gasket does not move out of position as you assemble the cases.

- ◆ Ensure that the washer (2) is properly placed on the countershaft (3).
- ◆ Apply **LOCTITE**® Anti Seize to the countershaft (3) and to main shaft (4).
- ◆ Apply **MOLYKOTE**® G-N to the crankshaft (5) and lower balancershaft (6).
- ◆ Ensure that the oil spray pipe (7) is fitted.
- ◆ Ensure that the oil screen is inserted in the clutch side half of the engine case.
- ◆ Assemble the cases by installing the clutch side half of the engine case over all of the shafts on the alternator side.

**NOTE** If necessary, use a plastic mallet to lightly tap on the case ribs only near the shafts. Be extremely careful not to damage the gasket surface of the clutch cover (9).

- ◆ Rotate the engine case to 90° as shown in the illustration (A).

**NOTE** Work from the alternator side.

**⚠ CAUTION**

Apply torque to the screws in a criss-cross pattern, tightening each screw only slightly and evenly, until all the screws are properly torqued.

- ◆ Install the twenty M6 Allen screws into the engine case:
  - thirteen M6x65 screws (10);
  - five M6x45 screws (11);
  - one M6x80 screw (12);
  - one M6x25 screw (13).

**⚠ CAUTION**

Ensure that you have installed each screw in its appropriate location. Failure to do this can do irreparable damage to the engine.

**Screws tightening torque: 8 ftlb (11 Nm).**

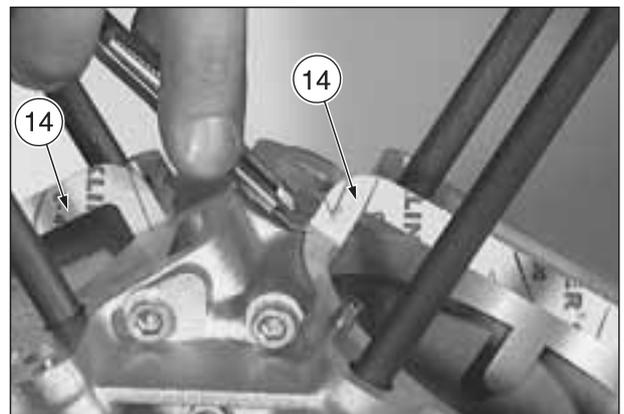
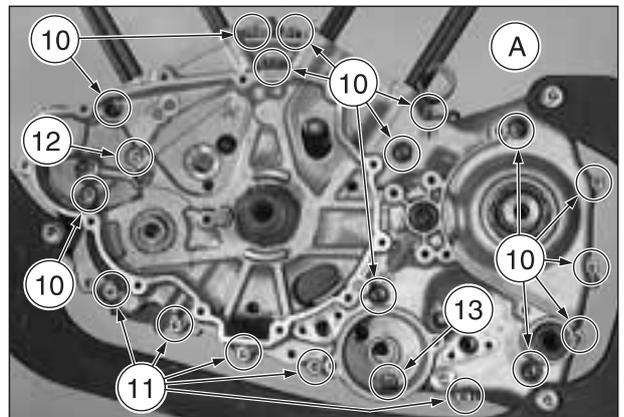
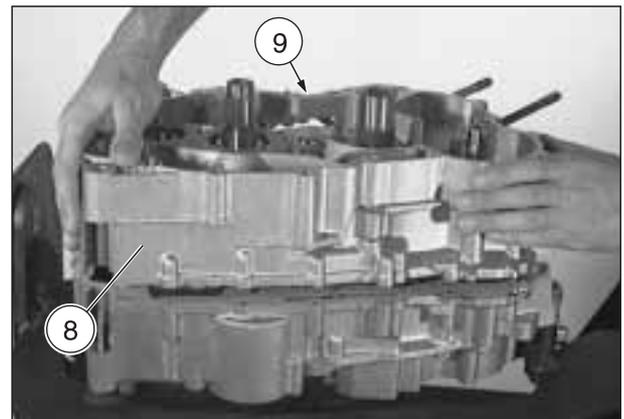
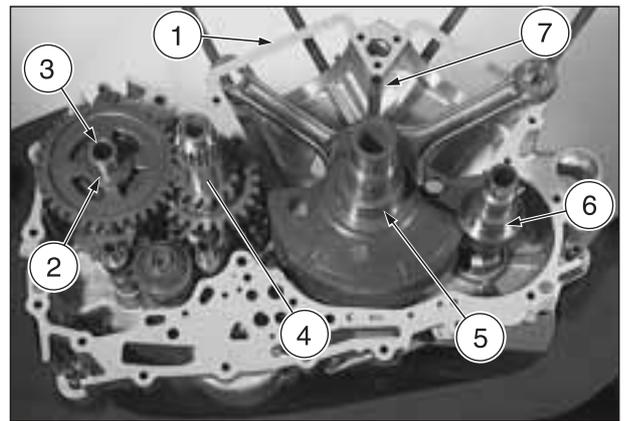
**NOTE** After you have tightened all of the screws, and ensure that they are evenly and properly torqued, turn the crankshaft, lower balancershaft, and main shaft and countershaft with your fingers. They should be able to move, at least a little distance, without noticeable resistance.

- ◆ Check the end play of the crankshaft using a dial gauge.

**Wear limit: max. 0.02 in (0.5 mm).**

**NOTE** Cover the engine compartment with a clean cloth.

- ◆ Using a razor blade or sharp hobby knife, cut away the parts of the gaskets protruding from the engine case around the cylinder flange.



**6.7 ASSEMBLING THE GEAR SELECTION MECHANISM**

Carefully read 6.1 (PREFACE).

**NOTE** Apply a couple of drops of LOCTITE® 243 to the threads of the M6 Allen screw (5).

- ◆ Fit the index spring (1), spacer (2), index lever (3) and washer (4) and secure them with the M6 Allen screw (5).

**M6 screw tightening torque: 8 ftlb (11 Nm).**

**NOTE** Apply a couple of drops of LOCTITE® 243 to the threads of the M6 Allen screw (8).

- ◆ Press the index lever (3) down with your finger and insert the index plate (6) in the slot in the end of the shift cam (7), fastening it in place with the M6 Allen screw (8).

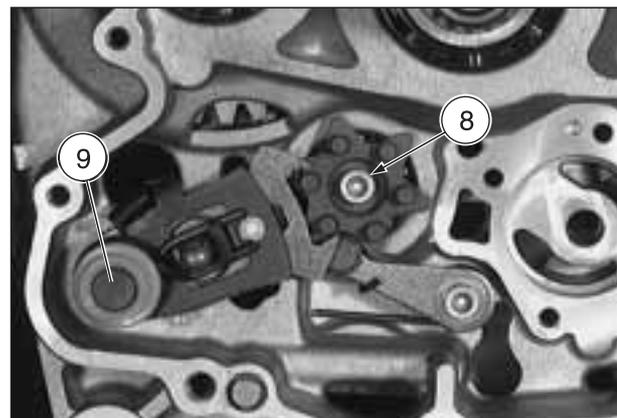
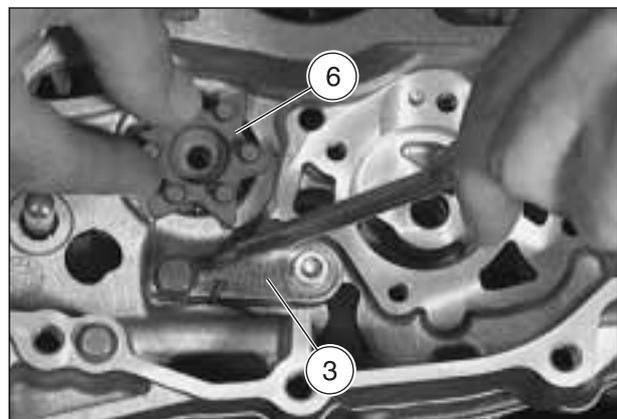
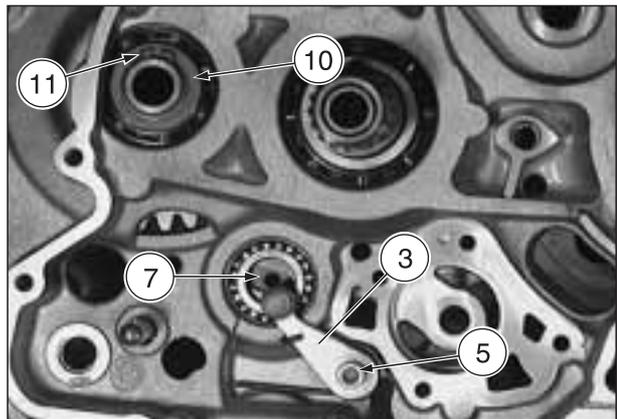
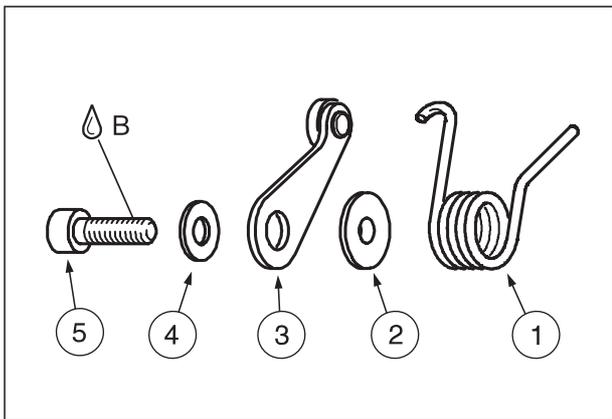
**M6 screw tightening torque: 8 ftlb (11 Nm).**

- ◆ Apply a little motor oil to the gear shift shaft (9) and insert it into its bore.
- ◆ Install the thrust washer (10) and circlip (11) in the groove on the countershaft.

**NOTE** Always use a new circlip. Ensure that the ends are not stretched any farther than necessary for installation. Use the appropriate special pliers to install the circlip.

- ◆ Check the efficiency of the gear selection mechanism, see 6.8 (CHECKING THE GEAR SELECTION MECHANISM).

B = LOCTITE® 243.



## 6.8 CHECKING THE GEAR SELECTION MECHANISM

Carefully read 6.1 (PREFACE).

- ◆ Ensure that the hair pin spring (1) in the rotating lever (2) and the cylindrical pin (3) fit tightly together. There should be no clearance between the lever or the pin and the arms of the spring.

**NOTE** If necessary, the arms of the hair pin spring (1) may be slightly bent to achieve this.

- ◆ Engage, one by one, all of the gears. Ensure that the pins (4) on the index plate (5) are centered between the pawls of the ratchet.

**NOTE** Again, if it is necessary to bend the end of the hair pin spring slightly to center the pawls, this is permissible.

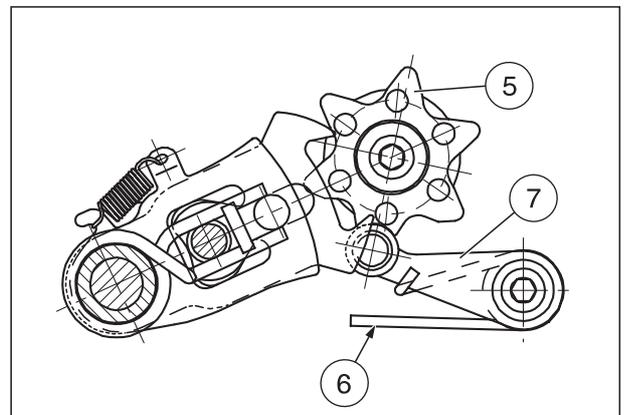
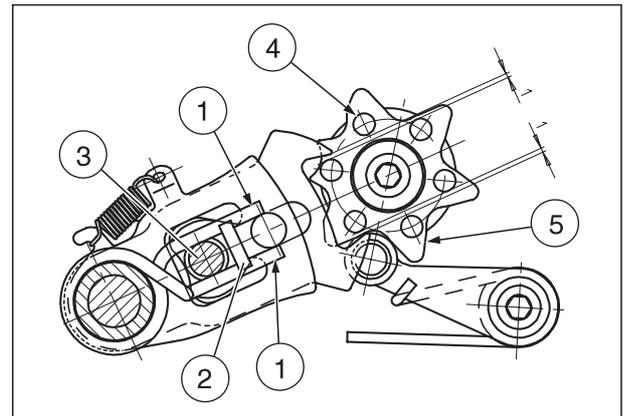
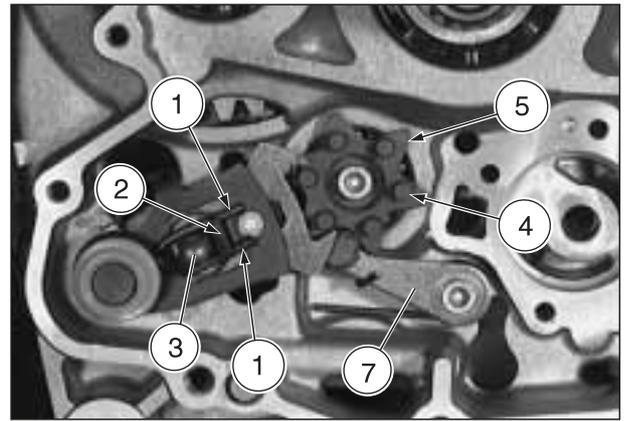
- ◆ Check the strength of the index spring (6). It must be held very firmly against the shift cam index plate.

**NOTE** Rotation of the shift cam must cause the index spring (6) to push the index lever (7) into the appropriate slot on the index plate (5) firmly.

- ◆ Put the gear shift into neutral. With your fingers, turn both shafts and all gears. Ensure that all gears and shafts turn freely.

### WARNING

Keep your fingers well away from the gears! You will be seriously injured if your fingers are caught between the gears.



**6.9 ASSEMBLING THE OIL PUMP**

Carefully read 6.1 (PREFACE).

**CAUTION**

Be extremely careful to ensure that no **LOCTITE®** is allowed to enter any of the oil passages of the oil pump.

- ◆ Apply a thin film of **LOCTITE®** 574 on the gasket surface (1) of the oil pump case.

**NOTE** Store to keep separately the groups:  
 – external rotor (2), internal rotor (5) (of the suction pump);  
 – external rotor (10), internal rotor (9) (of the pressure pump).

Do not mix-up the components of these groups.

- ◆ Apply a little engine oil to the external oil rotor. Insert it into its recess in the oil pump case.

**NOTE** The reference point must face down (towards the engine case).

- ◆ Insert the pin (3) in the hole in the oil pump shaft (4), as shown in the illustration.
- ◆ Install the suction pump internal rotor (5) onto the oil pump shaft (4), with the pin notch facing upward.
- ◆ Insert the oil pump shaft (4) into the case, complete with pressure pump internal rotor (5).
- ◆ Apply a thin film of **LOCTITE®** 574 to the external gasket surface of the oil pump case (6) and install the case on the oil pump shaft (4).
- ◆ Fasten the oil pump case (6), complete with pin (7), to engine case.
- ◆ Insert pin (8) into the central hole of the oil pump shaft.
- ◆ Lightly oil the pressure pump internal rotor (9) and install it on the oil pump shaft with the drive pin groove facing down, (see the illustration).
- ◆ Lightly oil the pressure pump external rotor (10), and insert it into the oil pump case.
- ◆ Fasten the oil pump cover (11) with the four Allen screws (12).

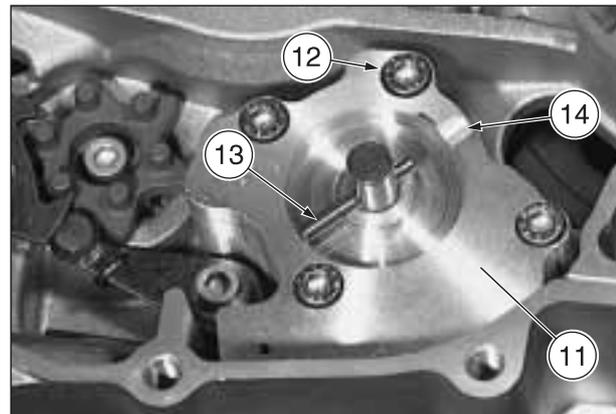
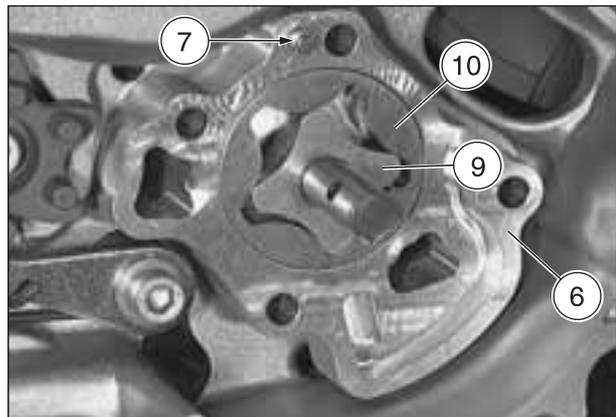
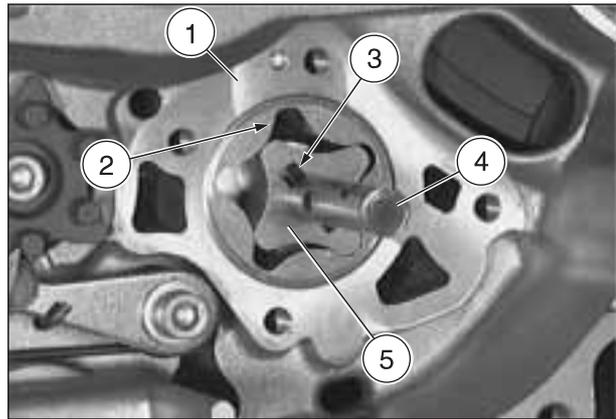
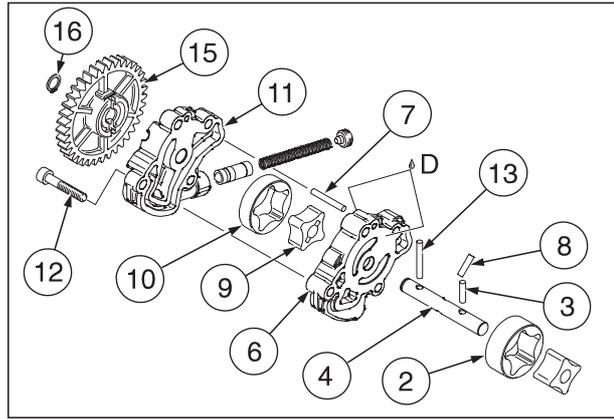
**Screws tightening torque: 8 ftlb (11 Nm).**

- ◆ Insert the pin (13) in the hole of the oil pump shaft (4).

**NOTE** There is a groove in the oil pump cover (14) which facilitates pin (13) installation. Center the pin (13) in the oil pump shaft (4).

D = **LOCTITE®** 574.

Follow ►



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**CAUTION**

Once disassembled, the oil pump gear must always be replaced.

- ◆ Fit a new oil pump gear (15).

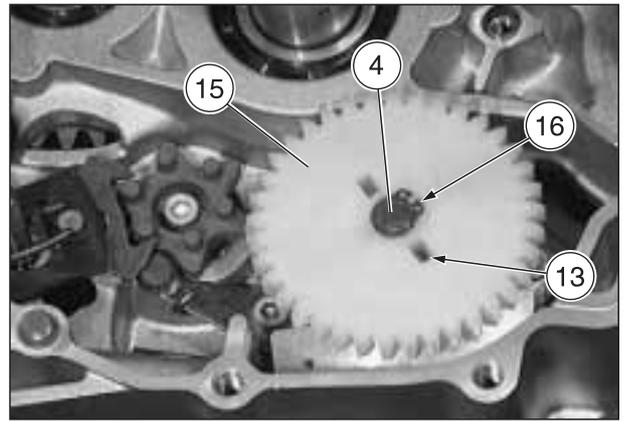
**NOTE** You must feel the pin (13) engaging perfectly inside the groove on the oil pump gear.

- ◆ Fit the circlip (16) in its groove on the oil pump shaft.

**NOTE** Ensure that the circlip is inserted all the way into the groove.

Ensure that the ends are not pulled any farther apart than necessary.

- ◆ Check the rotation and end play of the oil pump shaft (4).



### 6.10 ASSEMBLING THE CAM OPERATING MECHANISM FOR THE REAR CYLINDER (CYLINDER "2")

Carefully read 6.1 (PREFACE).

- ◆ Turn the crankshaft so that the connecting rod of cylinder "2" (rear) is at Top Dead Center (TDC).

**NOTE** Have the appropriate special tool **OPT** available:  
– **aprilia** part# 0240880 (threaded bolt for retaining the crankshaft at TDC) (17);

- ◆ Lock the crankshaft in place with the threaded bolt (17).

**NOTE** When cylinder "2" is at TDC, the locking slot (18) of cylinder "1" is visible through the gap under the lower balancershaft.

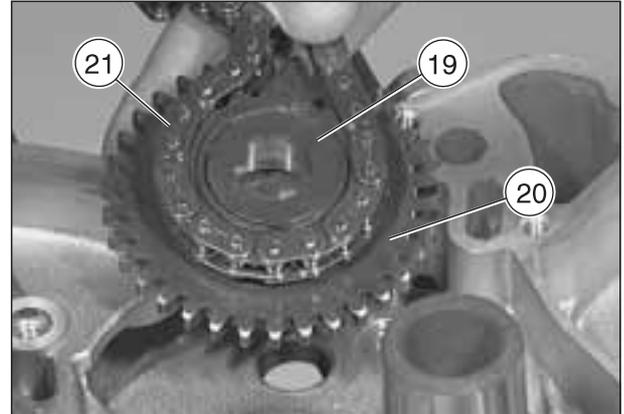
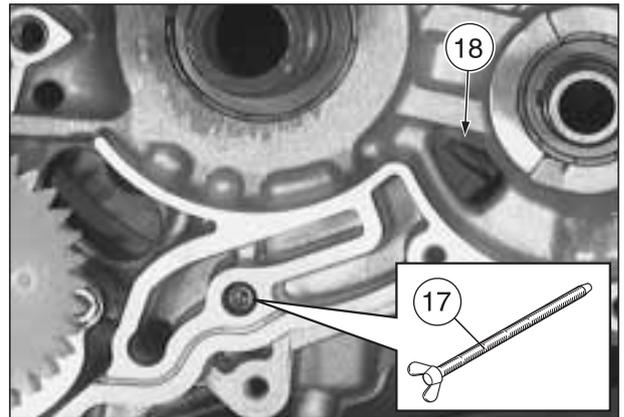
The threaded bolt (17) must never be overtightened:

**Threaded bolt tightening torque: max. 3.6 ftlb (5 Nm).**

- ◆ Apply a coat of grease to the thrust washer (19). Place it on the intermediate drive gear (20).

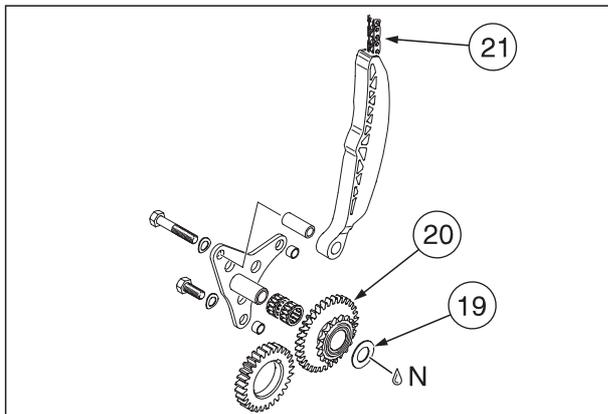
**NOTE** Install the timing chain (21) in its appropriate position. Refer to the reference marks applied during disassembly.

- ◆ Place the timing chain (21) around the intermediate drive gear (20), guiding both through the chain compartment and inserting them in the case.



**N** = Multi-purpose grease bp lz.

Follow ►



Follow ►

- ◆ Guide the chain tensioner shoe (22) through the chain compartment and fasten it to the case with a spacer bushing (23).
- ◆ Oil the two roller bearings (24) and push them into the bearing pins of the bearing flange (25).

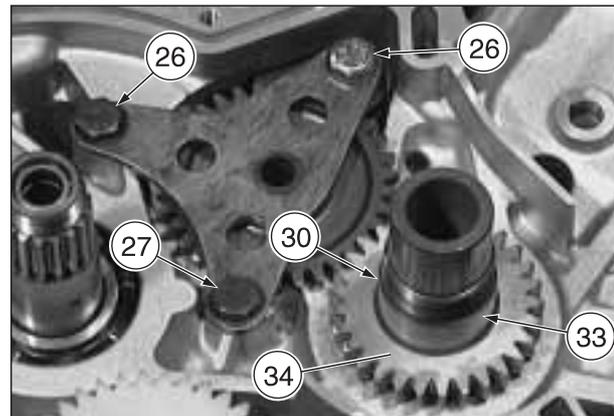
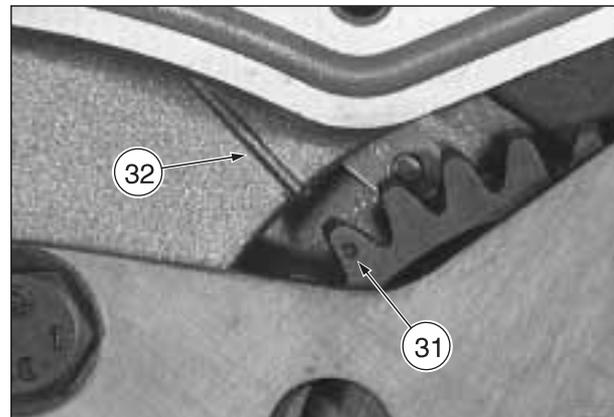
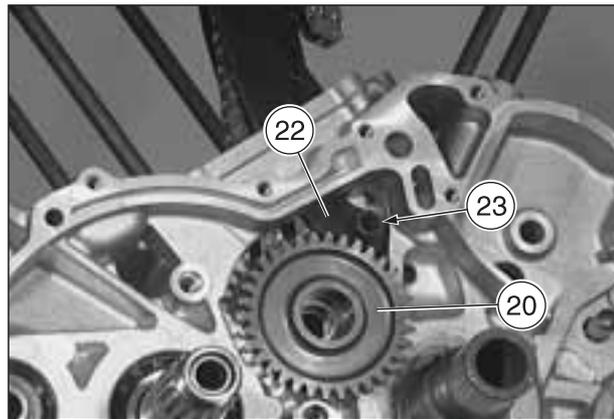
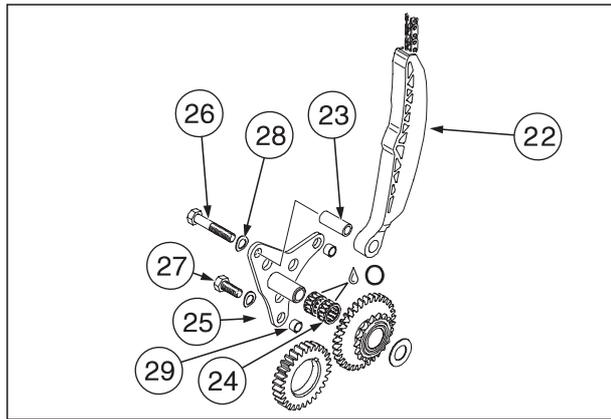
**NOTE** Install the bearing flange fully home, tapping it gently with a plastic hammer. Before this is possible, the two spacer bushings (29) must be fastened to the engine case.

- ◆ Install the bearing flange (25), fasten it using the three M8 Allen screws (26) (27) and spring washers (28):
  - two M8x45 screws (26);
  - one M8x20 screw (27).

**Screws tightening torque: 18 ftlb (25 Nm).**

- ◆ Check the rotation of the intermediate drive gear.
- ◆ Install the key (30) in the crankshaft taper.
- ◆ The reference mark (31) on the intermediate drive gear must coincide with the reference mark (32) on the case.
- ◆ Apply a coat of LOCTITE® Anti Seize on the end of the crankshaft (33).
- ◆ Push the drive gear (34) onto the crankshaft.

○ = Engine oil.



**6.11 ASSEMBLING THE COOLANT PUMP DRIVE**

Carefully read 6.1 (PREFACE).

- ◆ Coat the end of the lower balancershaft (1) with LOCTITE® Anti Seize.
- ◆ Apply engine oil to the bearing land at the end of the lower balancershaft.
- ◆ Install the key (2) in its seat on the lower balancershaft.
- ◆ Install the washer (3) on the lower balancershaft with its flared side facing down.
- ◆ Install the coolant pump gear (4) on the lower balancershaft.
- ◆ Install the coolant pump idler gear (5) on its pin.
- ◆ Install the washer (6) on the lower balancershaft.
- ◆ Install the main drive gear (7) on the crankshaft.

**NOTE** The reference point must be visible.

- ◆ Install the gear (8) on the lower balancershaft.

**NOTE** The reference point must be visible and must coincide with the reference mark on the main drive gear.

- ◆ Lift the lower balancershaft all the way in the axial direction and install the balancweight (9) on the lower balancershaft.

**NOTE** The key seat (10) in the balancweight (9) must engage the end of the weight (2).

- ◆ Install the spring washer (11) and tighten the M22x1.5 nut (12).

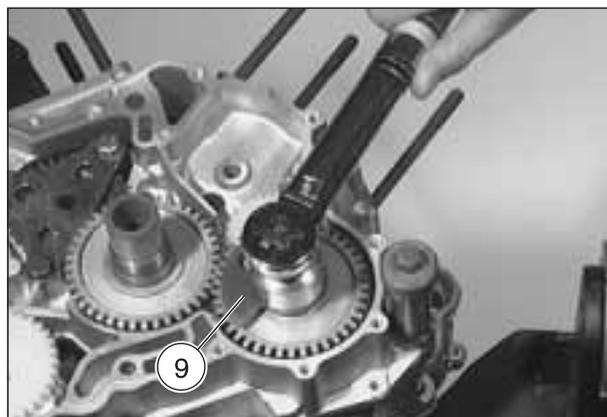
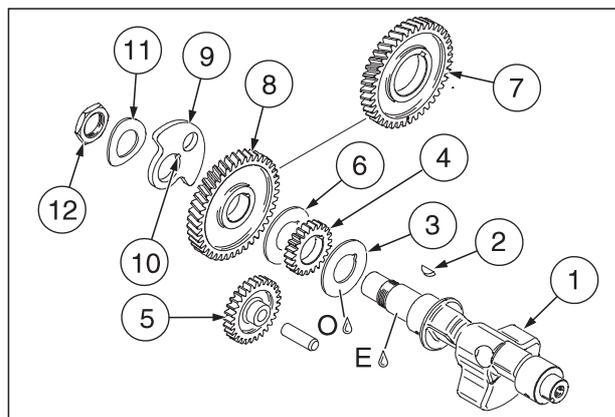
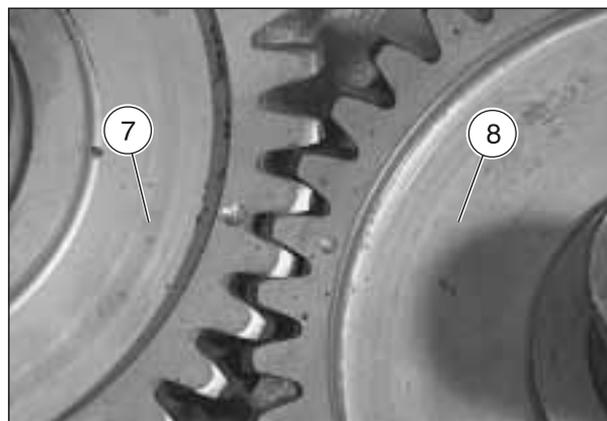
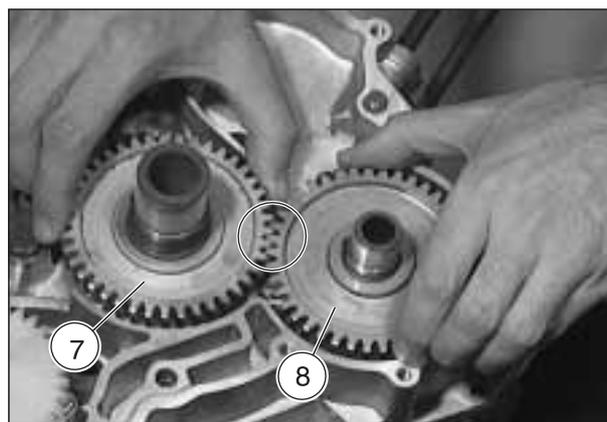
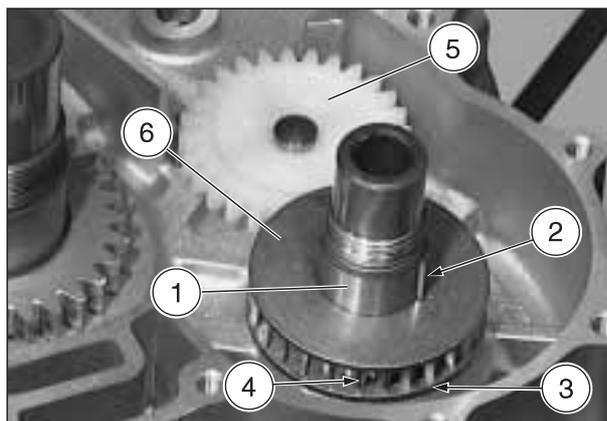
**M22x1.5 nut tightening torque: 108 ftlb (150 Nm).**

**NOTE** Ensure that the position of the hole for the counterweight (9) is at approximately 10:00.

- ◆ Check the end play of the lower balancershaft with a dial gauge:

**Wear limit: max. 0.012 in ( 0.3 mm).**

**O** = Engine oil.  
**E** = LOCTITE® Anti Seize 15378.



**6.12 ASSEMBLING THE PRIMARY DRIVE AND CLUTCH**

Carefully read 6.1 (PREFACE).

- ◆ Coat the end of the crankshaft with LOCTITE® 767 Anti Seize.

**NOTE** The collar of the main drive gear must face down.

- ◆ Install the main drive gear (1) on the crankshaft.

**NOTE** Apply a couple of drops of LOCTITE® 243 to the threads of the M33x1.5 nut (2).

- ◆ Fit the spring washer, then fasten and tighten the M33x1.5 nut (2).

**M33x1.5 nut tightening torque: 166 ftlb (230 Nm).**

- ◆ Preassembly the primary drive, see 5.19.1 (PRIMARY DRIVE aprilia part# 0295790 – PREASSEMBLY) or 5.19.2 (PRIMARY DRIVE aprilia part# 0295792 and 0295793 – PREASSEMBLY).

**NOTE** Apply a couple of drops of LOCTITE® 767 Anti-Seize to the bearing land (3) and to the spline (4) of main shaft.

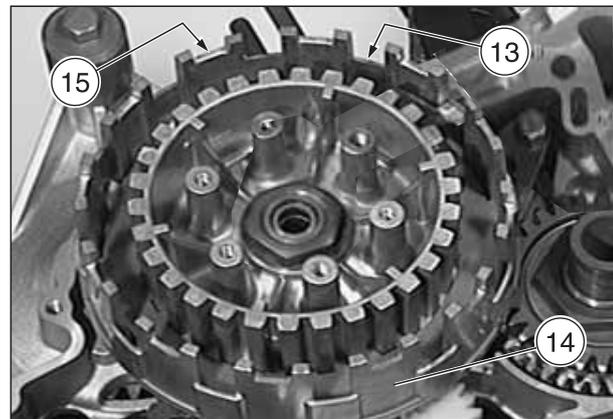
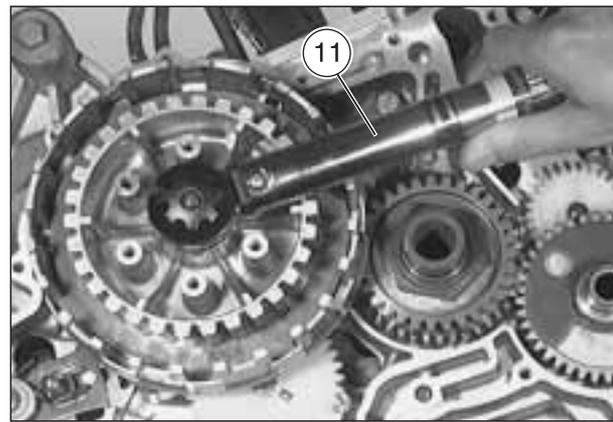
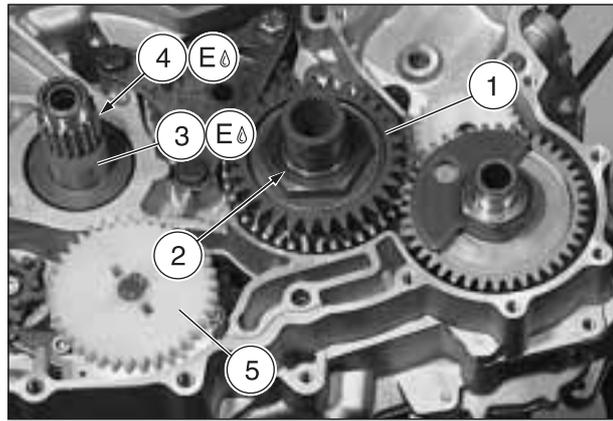
- ◆ Install the primary drive on the main shaft.

**NOTE** Rotate the oil pump driven gear (5), so that its teeth engages with the teeth of the oil pump drive gear (6) of the primary drive.

- ◆ Fit the serrated thrust ring (8), the clutch hub (9) and the spring washer (10) on the main shaft.

**NOTE** Have the appropriate special tool  available:  
– aprilia part# 0277881 (clutch locking tool) (11).

- ◆ Insert the clutch locking tool (11).



**CAUTION**

Insert the clutch locking tool (11) all the way in to the clutch basket so as not to damage the basket when the nut (12) is tightened.

**NOTE** Apply a couple of drops of LOCTITE® 648 to the threads of the nut (12).

- ◆ Install and tighten the nut (12).

**Nut (12) tightening torque: 123 ftlb (170 Nm).**

- ◆ Remove the clutch locking tool (11).

**NOTE** The top lined disc (Z) is unique. It is marked with a blue dot. It must be installed last, in its original position.

- ◆ Locate the top lined disc (Z) and keep it apart, in order to install it last of all.

**NOTE** There are different clutch versions. For information regarding the components of the clutch, refer to the specific spare parts catalogue, according to the vehicle model on which the engine is installed, see 0.4.2 (SPARE PARTS CATALOGUE).

**According to the clutch version.**

The lower steel disc can be identified:

- no mark, the disc is exactly like the others;
- space between teeth (X);
- notch (Y).

- ◆ Identify the lower steel disc, in order to be able to place it first when installing the steel discs.

Follow ►

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**NOTE** The lined discs must be inserted in the grooves (13) in the clutch housing (14) except for the top lined disc which must be inserted in the offset grooves (15). The first disc installed is the steel disc (16), followed by a lined disc (17), then another steel disc (16), etc., alternately, until all the discs are installed.

- ◆ Install a steel disc (16) and a lined disc (17), alternately.
- ◆ Insert the top lined disc (Z) in the offset grooves (15).

**NOTE** Ensure that the top lined disc (Z) fits snugly, though it must move freely in its slots.

- ◆ Apply some oil to the shaft (18) and insert it into the hole through the center of the main shaft.
- ◆ Install the spring-support cups (19).

**NOTE** There are different clutch versions.

For information regarding the components of the clutch, refer to the specific spare parts catalogue, according to the vehicle model on which the engine is installed, see 0.4.2 (SPARE PARTS CATALOGUE).

**According to the clutch version.**

The six clutch spring washers can be identified:

- normal (flat) washers (22);
- special (with collar) washers (22A).

**CAUTION**

**In case of special washers (22A), pay attention to the correct assembly position (W) the collar must face in the direction of the clutch spring.**

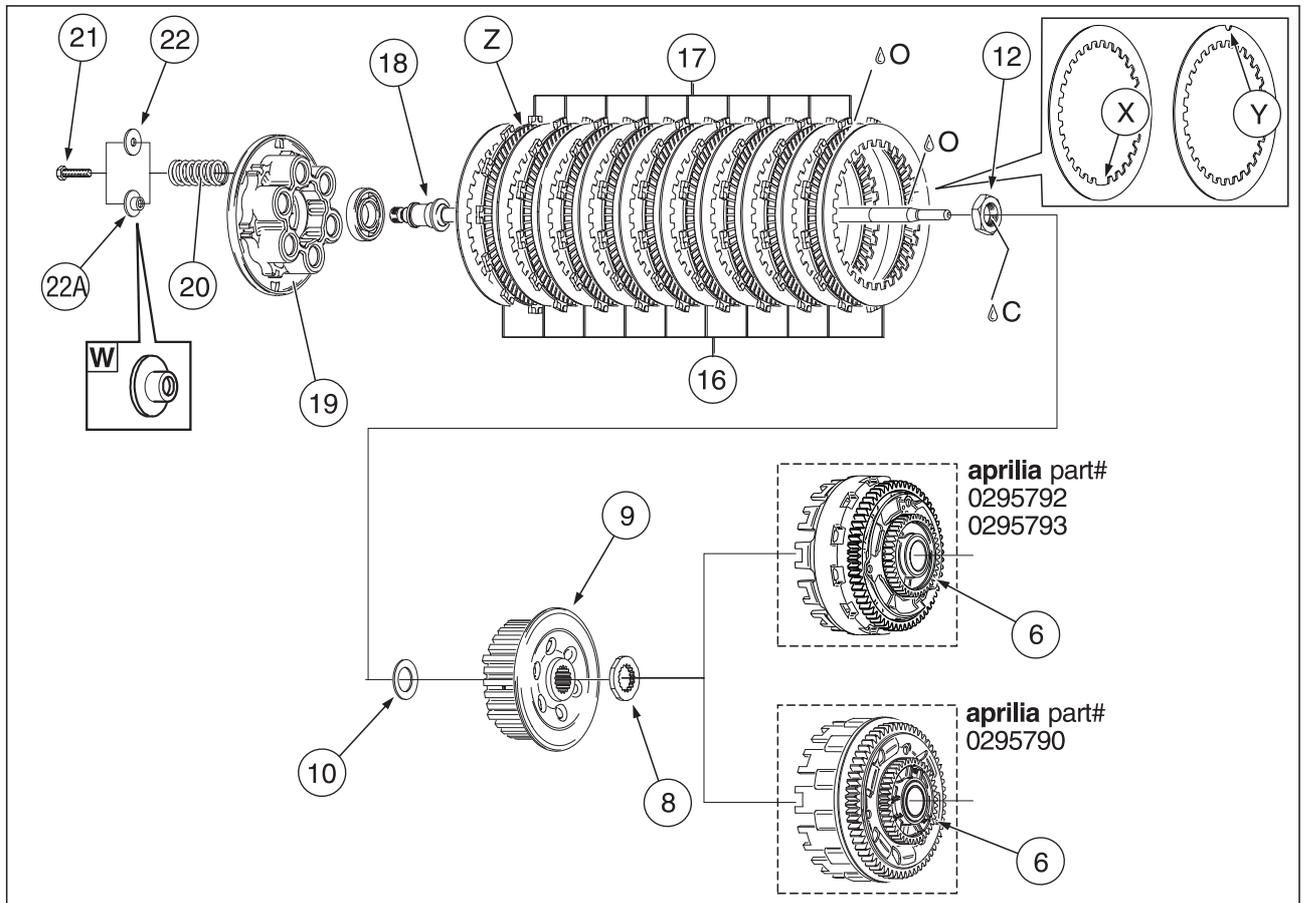
- ◆ Install the six clutch springs (20) in the appropriate recesses of the spring-support cups (19).



- ◆ Insert the six washers (22) on six M6x25 Allen screws (21)
- ◆ Screw in and tighten the six M6x25 Allen screws (21).

**M6x25 Allen screws (21) tightening torque: 8 ftlb (11 Nm).**

- C = LOCTITE® 648.
- E = LOCTITE® 767 Anti-Seize.
- O = Engine oil.



**6.13 ASSEMBLING THE PISTON AND CYLINDER "2" (REAR)**

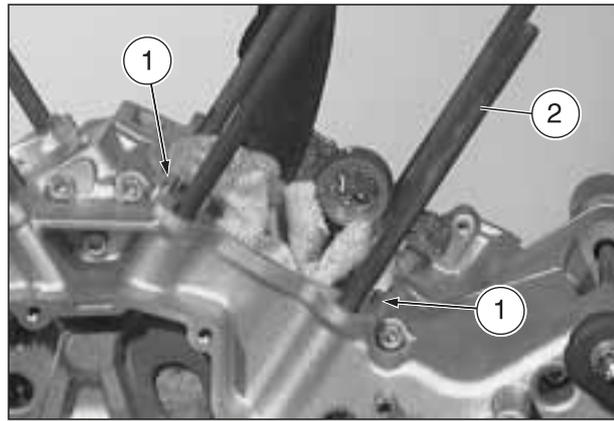
Carefully read 6.1 (PREFACE).

- ◆ Place a rag as shown in the illustration, to prevent accidentally dropping parts into the crankcase.
- ◆ Insert the two locating dowels (1).

**NOTE** Apply a couple of drops of LOCTITE® 243 to the threads of the four M10 studs (2).

- ◆ Install the four M10 studs (2) into the engine case and tighten them.

**M10 studs tightening torque: 7.2 ftlb (10 Nm).**

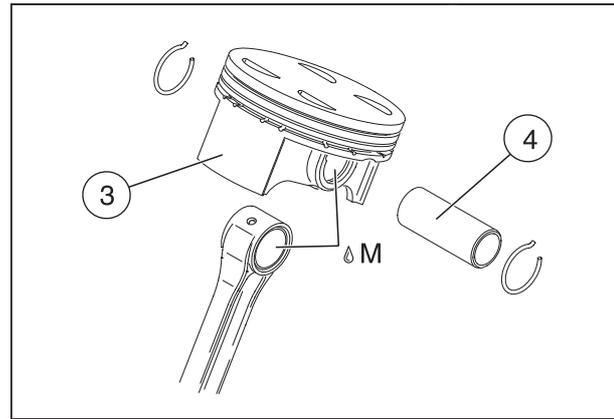


**CAUTION**

Depending of the vehicle model on which the engine is installed, various versions of pistons are used, see 5.32.1 (PISTONS FEATURES CLASSIFICATION).

- ◆ Apply a thin coat of MOLYKOTE® G-N to the connecting rod small end and the gudgeon pin bore in the piston.
- ◆ Install the piston (3) to the connecting rod, and push the gudgeon pin (4) through the connecting rod small end bushing.

**NOTE** The gudgeon pin should be a light palm push in the piston and in the connecting rod. If you have to force the gudgeon pin at this point, something is wrong. Disassemble the piston from the connecting rod and determine where the problem lies.



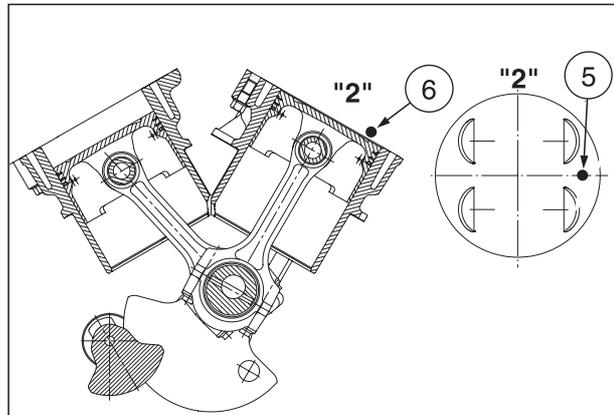
**CAUTION**

Observe the orientation of parts, as marked upon disassembly.

If a new piston is used, the "red" or "green" reference mark (5) on the piston crown must face in the direction of the exhaust (6).

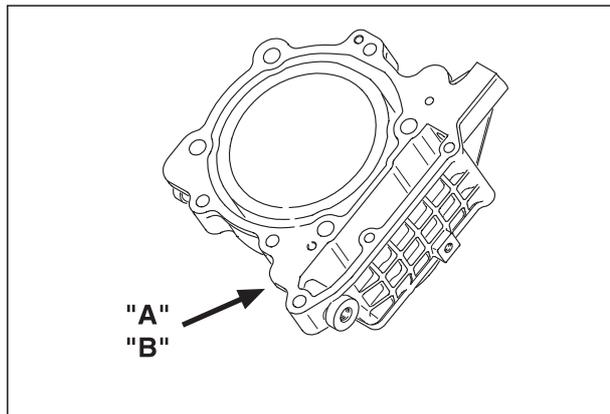
- ◆ Take special care when matching the cylinder - piston:
  - "Red" piston - cylinder "A";
  - "Green" piston - cylinder "B".

**NOTE** The cylinders size group "A" or "B" is stamped onto the lower side of the cylinder in the timing chain compartment area.



M = MOLYKOTE® G-N.

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**CAUTION****Use new bent-end gudgeon pin circlips (7) only.**

- ◆ Install the gudgeon pin circlips (7).

**NOTE** Support the piston (3).

Ensure that the two gudgeon pin circlips (7) are inserted perfectly in the groove of the piston and that the hook (8) is inserted in the slot of the piston.

- ◆ Insert the two locating dowels (9) in the cylinder.

**CAUTION****Use a new head gasket.**

- ◆ Fit the head gasket (10) in place.
- ◆ Install the pre-assembled head on the cylinder and tighten the four shouldered screws (11).

**Non-painted cylinder version:**

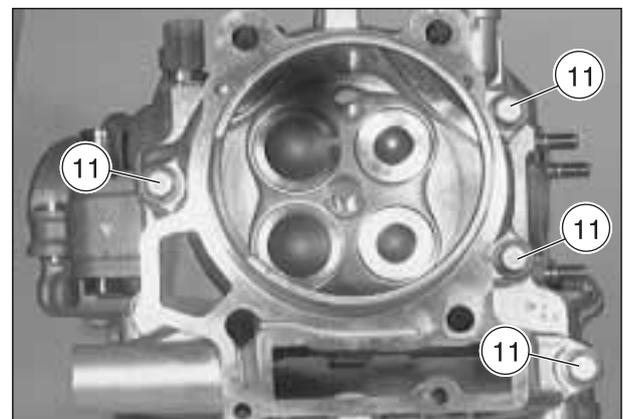
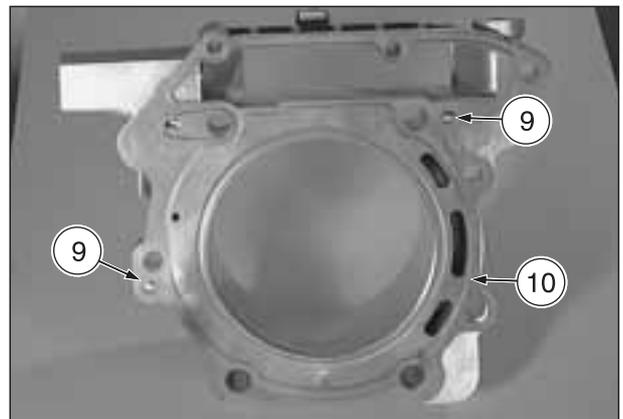
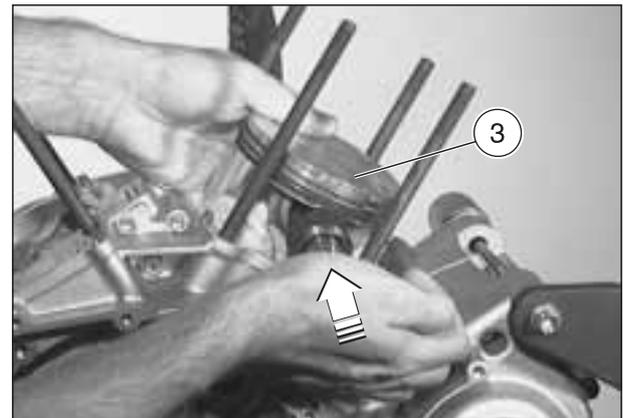
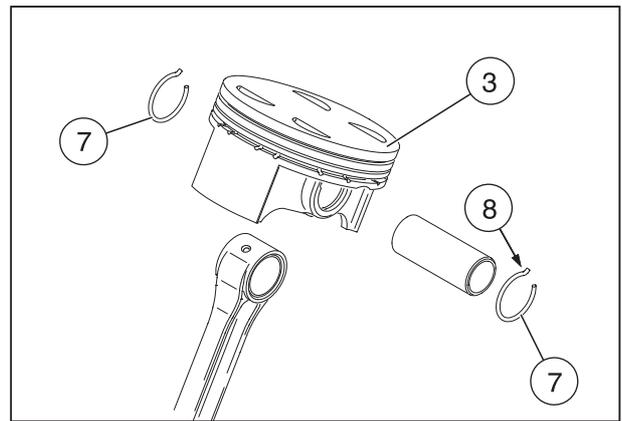
- four shouldered screws (11) tightening torque 20.2 – 21.7 ftlb (28 – 30 Nm).

**Painted cylinder version:**

- four shouldered screws (11) tightening torque 18 – 20.2 ftlb (25 – 28 Nm).

- ◆ Apply a coat of LOCTITE® 574 on the engine case in the area of the parting line of the two halves of the case and on the mating surface between the cylinder and the crankcase.
- ◆ Install the cylinder base gasket on the case.
- ◆ Oil the piston and the piston rings thoroughly using engine oil.
- ◆ Turn the piston rings so that the gaps are staggered by approximately 120°.

Follow ►



Follow ►

**NOTE** Have the appropriate special tool **OPT** available:  
 – **aprilia** part# 8140186 (piston ring compression tool) (12).

- ◆ Compress the rings using the ring compressor (12) or special piston ring pliers.
- ◆ Place the chain tensioner shoe (13) in the chain compartment on the cylinder (14) and push the cylinder down over the piston so that the ring compressor is pushed free of the piston.
- ◆ Remove the ring compressor (12).
- ◆ Insert the timing chain (15) through the chain compartment in the cylinder.

**NOTE** The timing chain can be guided inside using an O-ring or similar device to aid assembly.

- ◆ Install the cylinder (14) on the engine case, pushing it in down firmly.
- ◆ Place a drop of engine oil on the threads of the studs (2) and the area of the head where the stud nuts contact it.

**NOTE** Install the M10 nuts (16) and M6 Allen screws (17) evenly and gradually, working in a crisscross pattern.

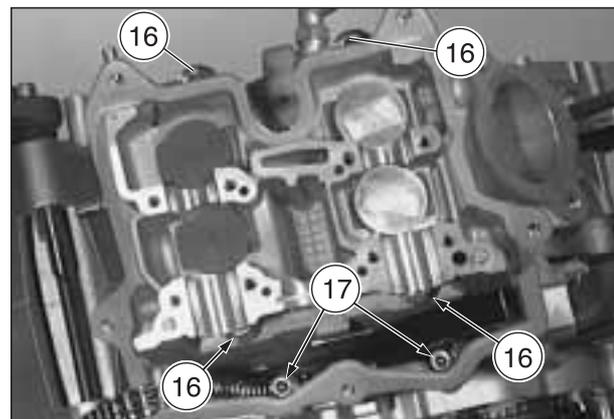
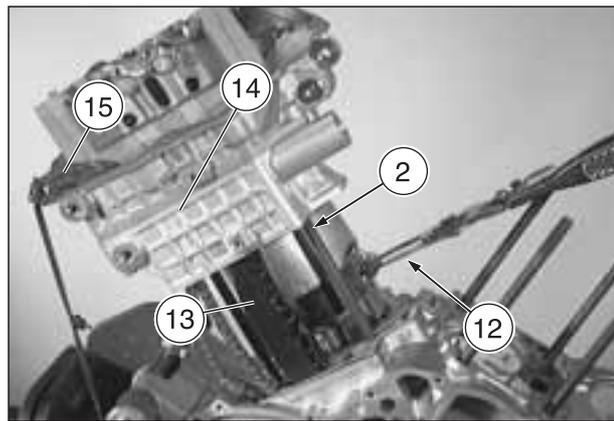
- ◆ Secure the cylinder and head with the four M10 nuts (16) and two M6 Allen screws (17).

**Non-painted head version:**

- four M10 nuts (16), tightening torque 42 ftlb (58 Nm);
- two M6 Allen screws (17), tightening torque 8.7 ftlb (12 Nm).

**Painted head version:**

- two M10 nuts (16), external, tightening torque 36.2-39.8 ftlb (50-55 Nm);
- two M10 nuts (16), chain compartment side, tightening torque 42 ftlb (58 Nm);
- two M6 Allen screws (17), tightening torque 8.7 ftlb (12 Nm).



**6.14 ADJUSTING VALVE CLEARANCE**

Carefully read 6.1 (PREFACE).

**⚠ CAUTION**

Check and, where necessary, adjust the valve clearance:

- at periodic intervals, consult the section 2 (SERVICE AND SETTING UP) of specific vehicle workshop manual see 0.4.1 (VEHICLE WORKSHOP MANUAL);
- every time the timing drive assembly is repaired or taken apart.;
- every time the head or camshaft is taken apart.

The valve clearance adjustment must be performed with the engine at room temperature.

**NOTE** The size is stamped on the adjustment shim. Insert the adjustment shims with the size numbers facing toward the bottom of the engine. Before fitting them, always measure the adjustment shims with a micrometer.

- ◆ Insert the adjustment shims (1) in the valve spring housings (2).
- ◆ Oil the external diameter of the four valve lifter buckets (3) and insert them in the head.
- ◆ Oil the four camshaft bushings (4) inside the head.
- ◆ Fit the exhaust camshaft (5) and intake camshaft (6) with the cam lobe facing up.

**⚠ CAUTION**

Depending of the vehicle model on which the engine is installed, various versions of camshaft are used, see 5.26.1 (CAMSHAFTS FEATURES CLASSIFICATION).

- ◆ Install the camshaft by hand hold it in place, and measure the valve clearance with a feeler gauge.
- ◆ Note the valve clearance measured.
- ◆ Compute the difference between the specification value and the actual value.

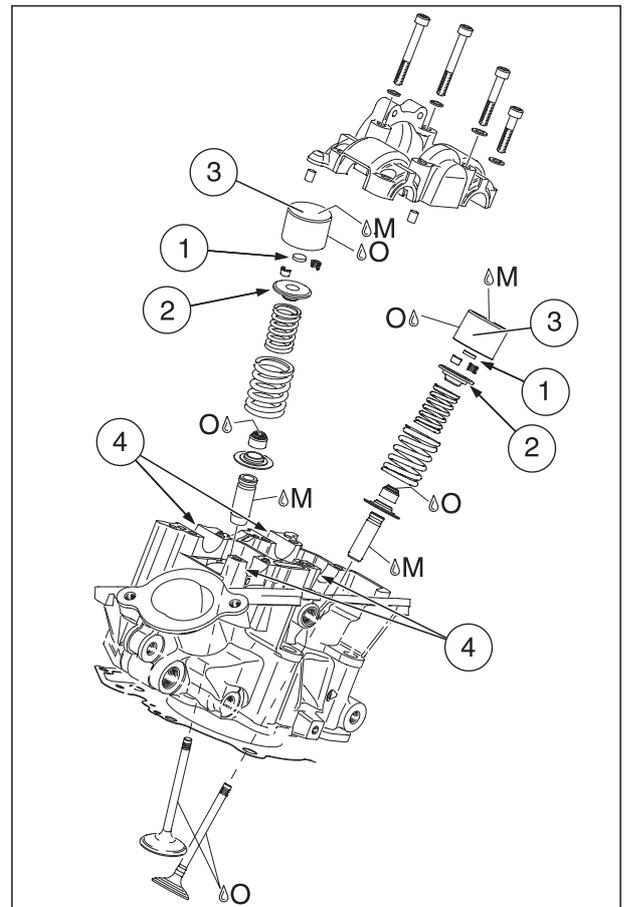
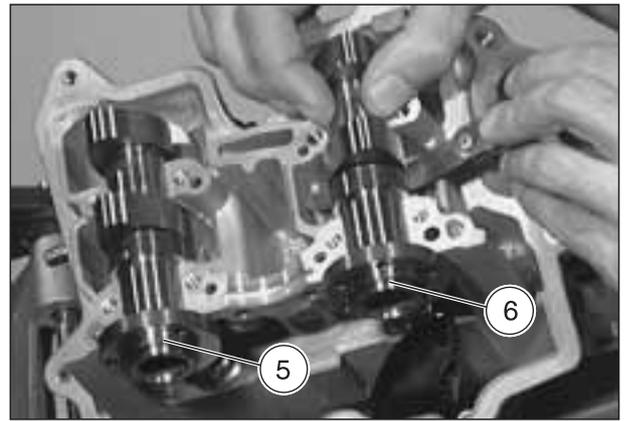
**Valve clearance:**

- intake valve 0.0047 – 0.0067 in (0.12 – 0.17 mm);
- exhaust valve 0.0090 – 0.011 in (0.23 – 0.28 mm).
- ◆ Where necessary, replace the adjustment shim (1).

**⚠ CAUTION**

- Intake valve: the 0.0059 in (0.15 mm) gauge should 'go' the 0.0079 in (0.20 mm) feeler gauge must 'not go'.
- Exhaust valve: the 0.0098 in (0.25 mm) gauge must 'go', the 0.012 in (0.3 mm) gauge must 'not go'.

M = MOLYKOTE® G-N.  
O = Engine oil.



**6.15 ASSEMBLING HEAD “2” (REAR) CAMSHAFT**

Carefully read 6.1 (PREFACE).

- ◆ Adjust the valve clearance, see 6.14 (ADJUSTING VALVE CLEARANCE).
- ◆ Oil the housings of the exhaust camshaft (1) and intake camshaft (2).
- ◆ Coat the cams (3) with MOLYKOTE® G-N and insert the camshafts in the head.

**CAUTION**

Depending of the vehicle model on which the engine is installed, various versions of camshaft are used, see 5.26.1 (CAMSHAFTS FEATURES CLASSIFICATION).

**NOTE** Tighten the camshaft bearing cap gradually, starting from the inside and working in a crisscross pattern.

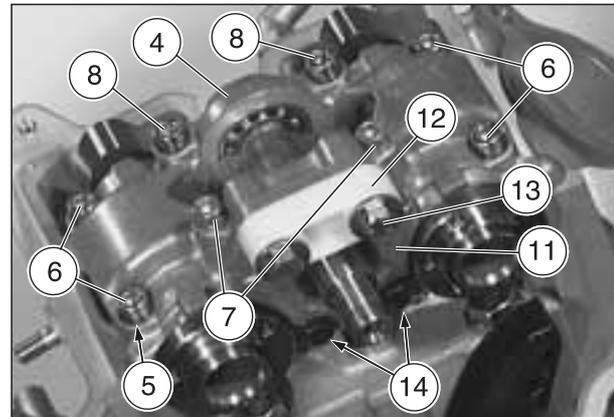
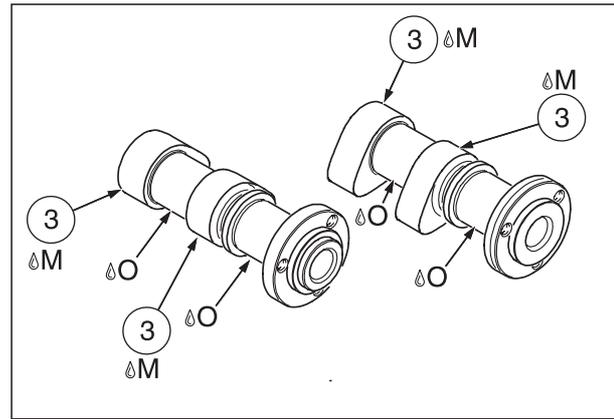
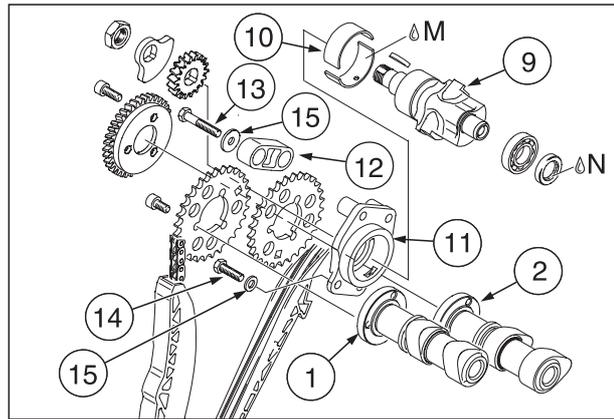
- ◆ Fasten the camshaft cap (4) with the eight washers (5) and the eight M6 Allen screws (6) (7) (8):
  - four M6x30 Allen screws (6);
  - two M6x45 Allen screws (7);
  - two M6x55 Allen screws (8).

**Screws tightening torque: 8 ftlb (11 Nm).**

- ◆ Insert the upper balancershaft (9).
- ◆ Coat both upper balancershaft bushings (10) with MOLYKOTE® G-N .
- ◆ Insert the bushing flange (11).
- ◆ Fit the chain guide (12) on the bushing flange.
- ◆ Fasten the bushing flange (11) with the four M6 screws (13) (14) and the four washers (15):
  - two M6x35 screws (13);
  - two M6x20 screws (14).

**Screws tightening torque: 8 ftlb (11 Nm).**

- M = MOLYKOTE® G-N.
- O = Engine oil.
- N = Multi-purpose grease bp lz.



**6.16 ASSEMBLING HEAD "2" (REAR) TIMING DRIVE ASSEMBLY**

Carefully read 6.1 (PREFACE).

**NOTE** The crankshaft must be locked at Top Dead Center (TDC) on cylinder "2" (rear), see 4.14 [DISASSEMBLING CYLINDER "2" (REAR) TIMING DRIVE ASSEMBLY].

- ◆ Turn the camshaft so the cam lobes (1) face away from each other.
- ◆ Install the camshaft sprocket (2) on the exhaust camshaft and line up the bolt holes.

**NOTE** In order to make assembly easier, the camshaft sprocket can be secured in place temporarily with an M6 Allen screw.

- ◆ Turn the camshaft sprocket (2) and the exhaust camshaft (3) until the "EX" reference mark (4) faces the center of the intake camshaft.
- ◆ Place the timing chain (5) over the camshaft sprocket (2) and under the chain guide (6).

**NOTE** The timing chain must be taut on the tension side (7).

- ◆ Put the intake camshaft sprocket (8) in place, engaging its teeth in the timing gear so that the "IN" reference mark (9) faces the "EX" reference mark (4) on the exhaust camshaft sprocket.
- ◆ Maintaining this position, push the intake camshaft sprocket (8) onto the intake camshaft and line up the holes in the sprocket with those on the camshaft.

**⚠ WARNING**

Use only the three originally supplied Allen M6 x 14 (11) screws with the exhaust camshaft sprocket (10). Use of any other fasteners can lead to engine failure, seizure, and subsequent injury or even death.

**NOTE** Apply a couple of drops of LOCTITE® 243 to the threads of the three M6x14 Allen screws (11).

- ◆ Push the exhaust camshaft sprocket (10) onto the exhaust camshaft and fasten it with the three M6x14 Allen screws (11).

**M6x14 screws tightening torque: 8 ftlb (11 Nm).**

**NOTE** Apply a couple of drops of LOCTITE® 243 to the threads of the three M6x10 Allen screw (12).

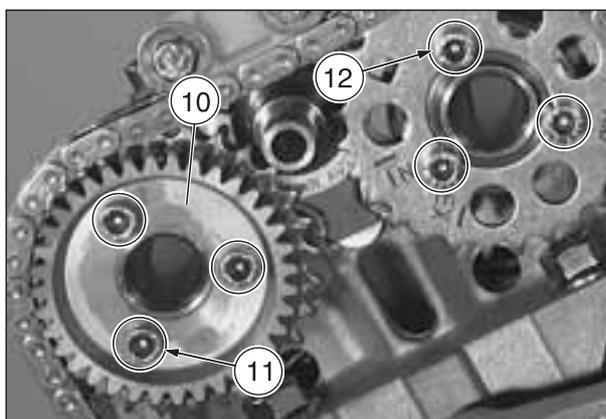
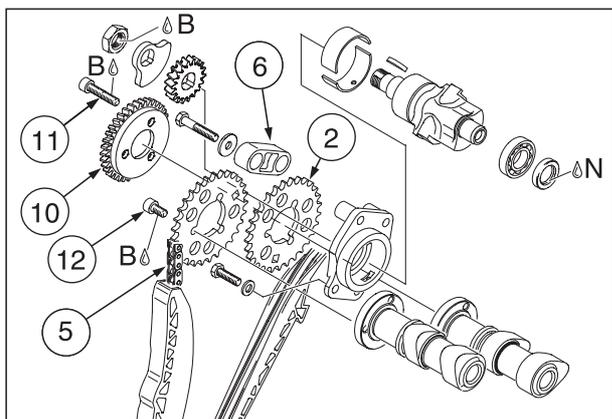
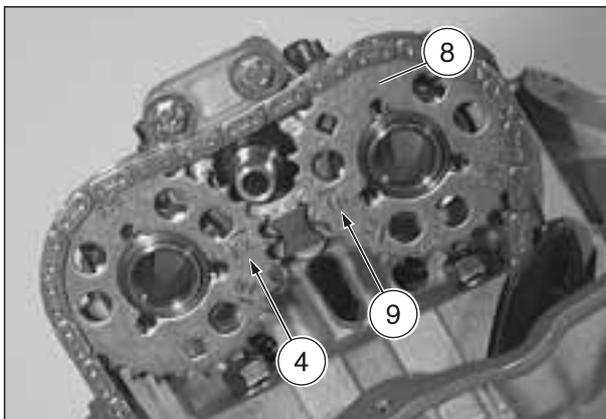
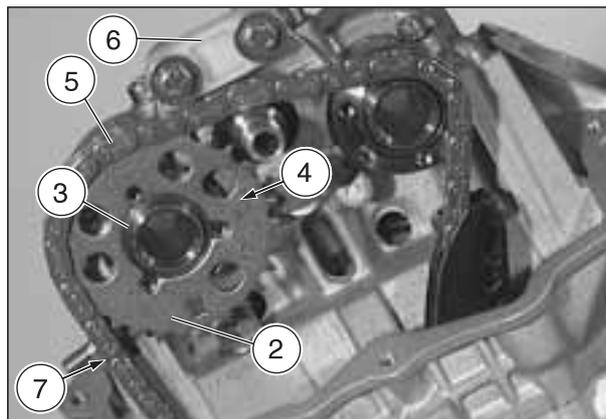
- ◆ Secure the intake camshaft sprocket with three M6x10 Allen screws (12)

**M6x10 screws tightening torque: 8 ftlb (11 Nm).**

**B** = LOCTITE® 243.

**N** = Multi-purpose grease bp lz.

Follow ►



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- ◆ Insert the chain guide (13) into the cylinder as far as it will go.
- ◆ Oil the chain tightener (14) and fit it in the cylinder with the closed end facing the chain tensioner shoe (15).
- ◆ Install and tighten the M18x1 screw (16) and seal.

**M18x1 screw tightening torque: 14.5 ftlb (20 Nm).**

- ◆ Place a rag as shown in the illustration, to prevent accidentally dropping parts into the chain compartment.

**NOTE** Be careful to keep the key (17) from dropping into the chain compartment.

- ◆ Insert the key (17) into its seat on the upper balance-shaft.
- ◆ Install the gear (18) onto the upper balanceshaft so that the two reference marks (19) are lined up.

**NOTE** Ensure that the sharp-edged side of the balanceweight faces inward.

- ◆ Install the balanceweight (20) on the upper balance-shaft.

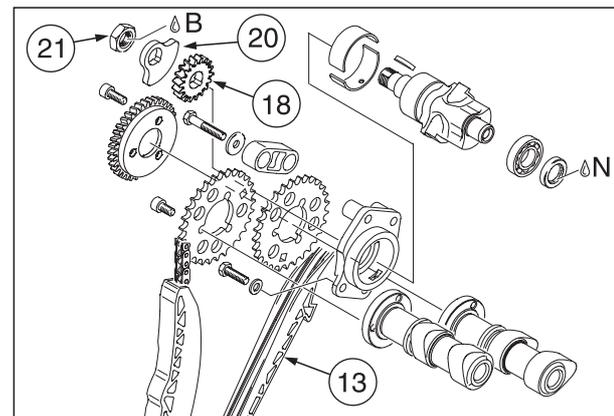
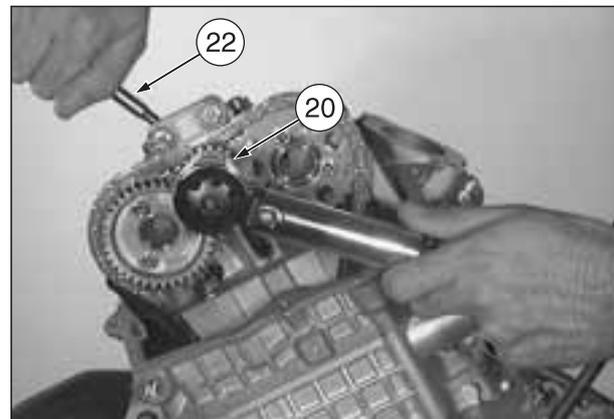
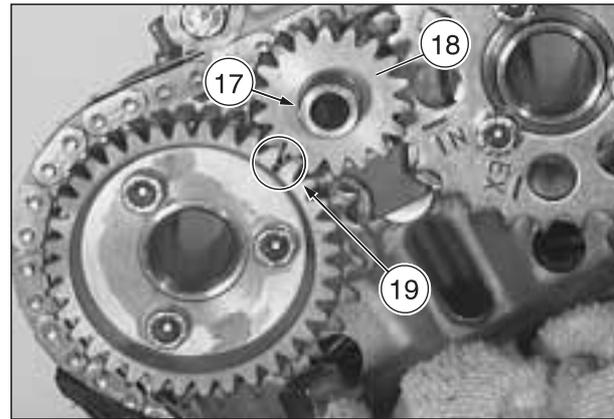
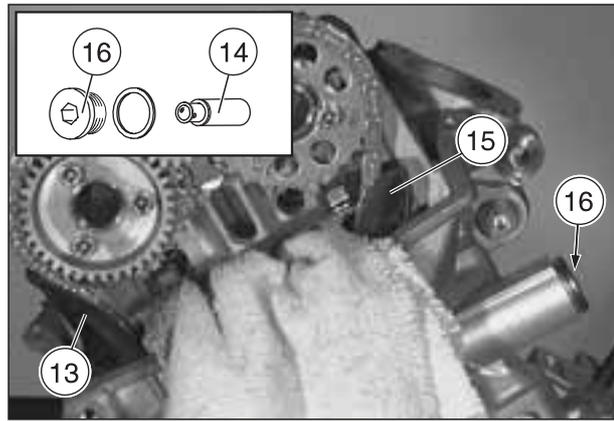
**NOTE** Apply a couple of drops of LOCTITE® 243 to the threads of the M14x1 nut.

- ◆ Install the M14x1 nut (21) and tighten it.

**M14x1 nut tightening torque: 36 ftlb (50 Nm).**

**NOTE** Hold the upper balanceshaft using a drift (22) or similar tool.

- ◆ Coat the valve lifter bucket and the cams with MOLYKOTE® G-N.



B = LOCTITE® 243.  
N = Multi-purpose grease bp lz.

### 6.17 ASSEMBLING HEAD "1" (FRONT) TIMING DRIVE ASSEMBLY

Carefully read 6.1 (PREFACE).

- ◆ Remove the setscrew (1) and turn the crankshaft (2) 300° counterclockwise so that the connecting rod (3) of cylinder "1" is at TDC.

**NOTE** Hold the connecting rod (3) in the center of the crankcase, so that it does not foul the crankcase as you turn the crankshaft.

- ◆ Screw the setscrew (1) back in.

**NOTE** Ensure that the setscrew properly engages the crankshaft slot.

**The setscrew (1) must not be overtightened:**

**Setscrew tightening torque: max. 3.6 ftlb (5 Nm).**

**NOTE** Engines # 527 354 and later, the locating dowels (4) are not employed. Centering is achieved by a modification to the bearing support flange (11).

- ◆ If not previously done, install the two locating dowels (4) in the case.

**NOTE** Work very carefully while installing these dowels, they are a tight press fit.

- ◆ Install the thrust washer (5) on the intermediate timing gear (6), using a little grease.
- ◆ Wrap the timing chain (7) around the intermediate timing gear (6). Fasten the timing chain through the chain compartment. Install the intermediate timing gear.

**NOTE** Line up the reference marks made during disassembly on the timing chain and intermediate gear.

- ◆ Guide the chain tensioner shoe (8) through the chain compartment and install it in the housing using the spacer sleeve (9).
- ◆ Oil the two roller bearings (10) and push them onto the pin of the bearing support flange (11).
- ◆ Install the bearing support flange (11) pushing it on as far as it will go, tapping lightly with a mallet.

**NOTE** Apply a couple of drops of LOCTITE® 243 to the threads of the four M6x20 Allen screw (15).

- ◆ Fasten the bearing flange (11) with the M8x20 screw (12), M8x45 screw (13), spring washers (14) and M6x20 Allen screw (15).
  - one M8x20 screw (12).
  - one M8x45 screw (13).
  - one M6x20 Allen screw (15).

**Tightening torque:**

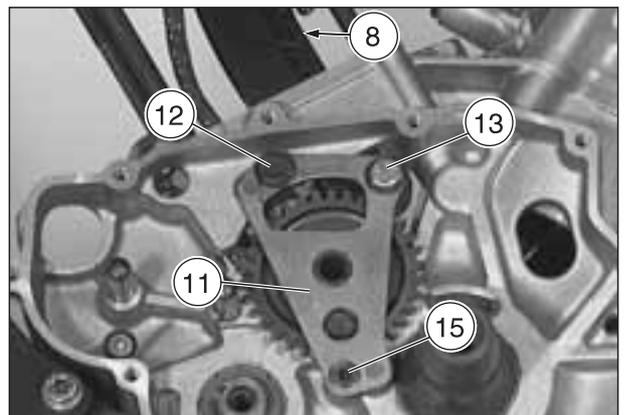
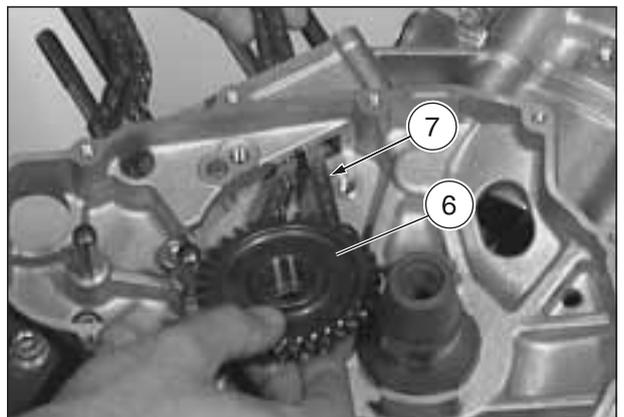
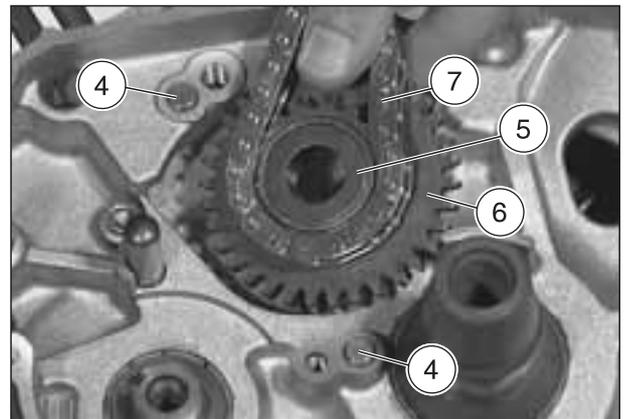
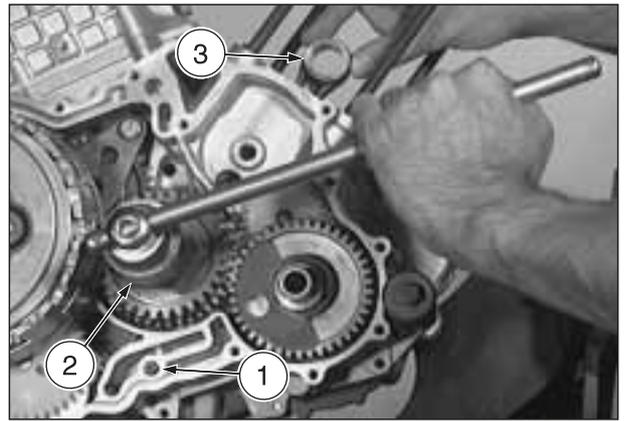
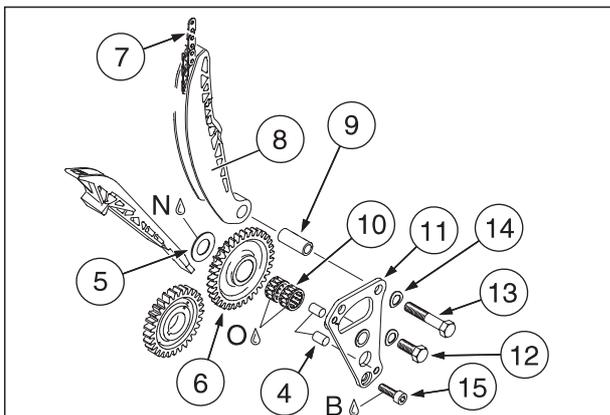
- M8x20 screw: 18 ftlb (25 Nm);
- M8x45 screw: 18 ftlb (25 Nm);
- M6 Allen screw: 8 ftlb (11 Nm).

**B** = LOCTITE® 243.

**O** = Engine oil.

**N** = Multi-purpose grease bp lz.

Follow ►



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- ◆ Rotate the intermediate timing gear (6) so that the two reference marks (16) are lined up with each other.
- ◆ Install the balanceweight (17) on the upper balance-shaft.
- ◆ Insert the key (18) into its seat in the balanceshaft.
- ◆ Install the gear (19) and balanceweight (20).

**NOTE** The woodruff key (18) must engage the inner balanceweight keyway. Ensure that the reference mark on the intermediate drive gear is matched to the reference mark (16) on the bearing flange.

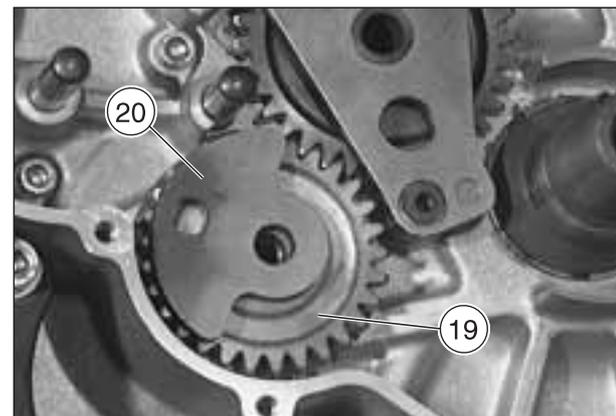
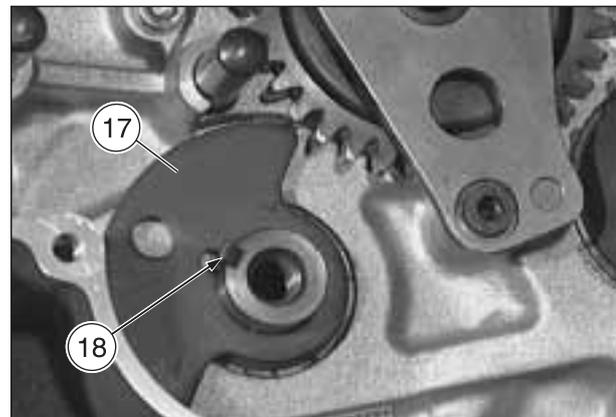
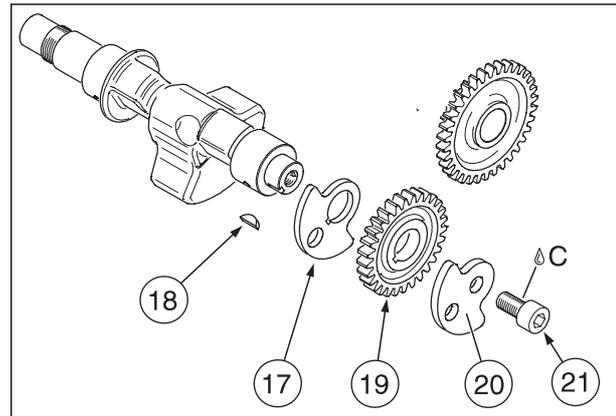
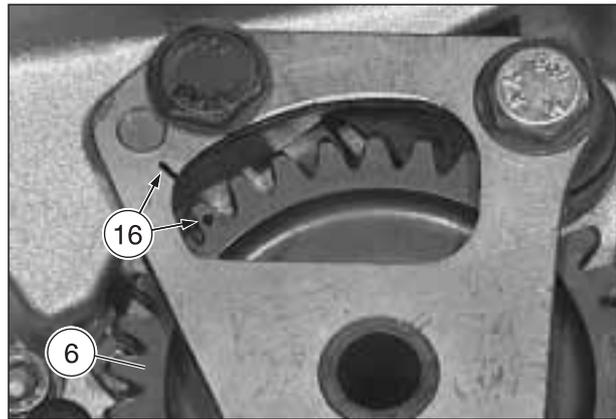
**NOTE** Apply a couple of drops of LOCTITE® 648 to the threads of the M10 Allen screw (21).

- ◆ Install, in the upper balanceshaft, the M10 Allen screw (21) and tighten it.

**Screw tightening torque: 36 ftlb (50 Nm).**

**NOTE** The balanceshaft is timed when the cams of cylinder "2" are timed.

C = LOCTITE® 648.

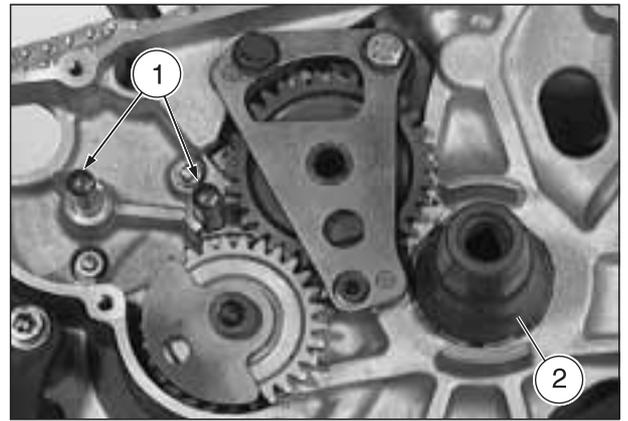


**6.18 ASSEMBLING THE STARTER MOTOR DRIVE ASSEMBLY AND ALTERNATOR**

Carefully read 6.1 (PREFACE).

**NOTE** Lock the crankshaft at the TDC of piston "1" or "2".

- ◆ Oil the two pins (1) and coat the housing (2) of the sprag clutch gear on the crankshaft with MOLYKOTE® G-N.
- ◆ Insert the double starter gear (3), idler gear (4) and sprag clutch gear (5).
- ◆ Oil the surface (6) on the sprag clutch gear (5).
- ◆ **RSV RSV R SL** Assemble the alternator rotor (7), see 5.34 (ALTERNATOR **RSV RSV R SL**).
- ◆ **RST ETV** Assemble the alternator rotor (7), see 5.35 (ALTERNATOR **RST ETV**).
- ◆ Oil the sprag clutch (8) inside the housing (9).
- ◆ Degrease the taper (10) of the crankshaft and the taper (11) of the alternator rotor hub.

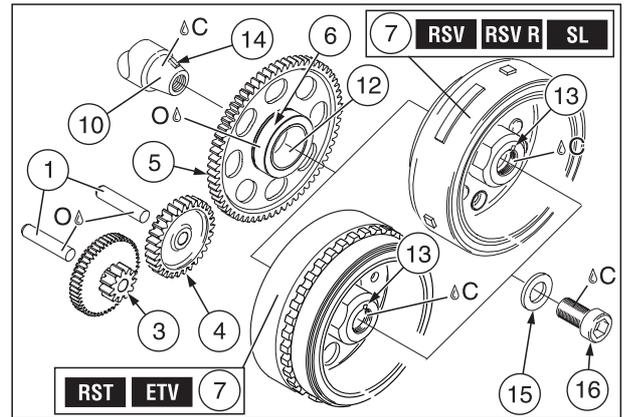


**NOTE** Upon assembly, take care to prevent LOCTITE® from penetrating inside the seat (12) of the sprag clutch gear (5).

- ◆ Apply a couple of drops of LOCTITE® 648 to the taper (11) of the alternator rotor hub.

**NOTE** To facilitate the insertion, turn the alternator rotor (7) until aligning the keyway (13) on the alternator rotor hub with the crankshaft key (14).

- ◆ Install the complete alternator rotor (7) onto the taper (10) of the crankshaft, so that the crankshaft key (14) engages the keyway (13) in the alternator rotor hub.
- ◆ Fit the washer (15) on the alternator rotor M16 Allen screw (16).

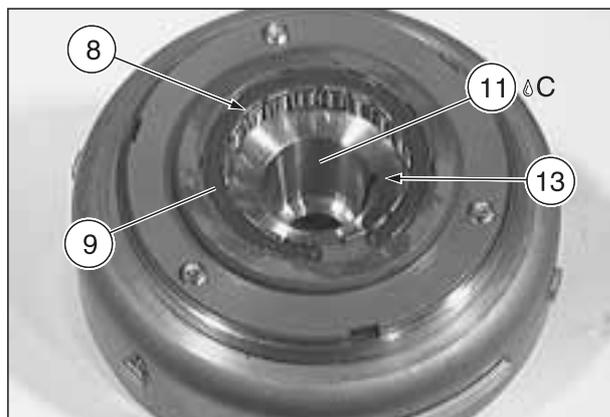
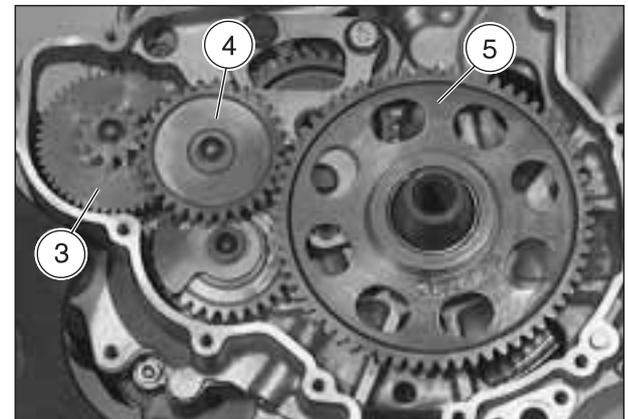


**NOTE** Apply a couple of drops of LOCTITE® 648 to the threads of the M16 Allen screw (16).

- ◆ Install and tighten the alternator rotor screw (16) on the crankshaft.

**Alternator rotor M16 Allen screw (16) tightening torque: 94 ftlb (130 Nm).**

**C** = LOCTITE® 648.  
**O** = Engine oil.



**6.19 ASSEMBLING THE PISTON AND CYLINDER "1" (FRONT)**

Carefully read 6.1 (PREFACE).

- ◆ Place a rag, as shown in the illustration, to prevent accidentally dropping parts into the crankcase.
- ◆ Insert the two locating dowels (1).

**NOTE** Apply a couple of drops of LOCTITE® 243 to the threads of the four M10 studs (2).

- ◆ Install, into the engine case, the four M10 studs (2) and tighten it.

**M10 studs tightening torque: 10.8 ftlb (15 Nm).**

**⚠ CAUTION**

Depending of the vehicle model on which the engine is installed, various versions of pistons are used, see 5.32.1 (PISTONS FEATURES CLASSIFICATION).

- ◆ Apply a thin coat of MOLYKOTE® G-N to the connecting rod small end and the piston pin bore in the piston.
- ◆ Install the piston (3) to the connecting rod, and push the gudgeon pin (4) through the connecting rod small end bushing.

**NOTE** The gudgeon pin should be a light palm push in the piston and in the connecting rod. If you have to force the gudgeon pin at this point, something is wrong. Disassemble the piston from the connecting rod and determine where the problem lies.

**⚠ CAUTION**

Observe the orientation of parts, as marked upon disassembly.

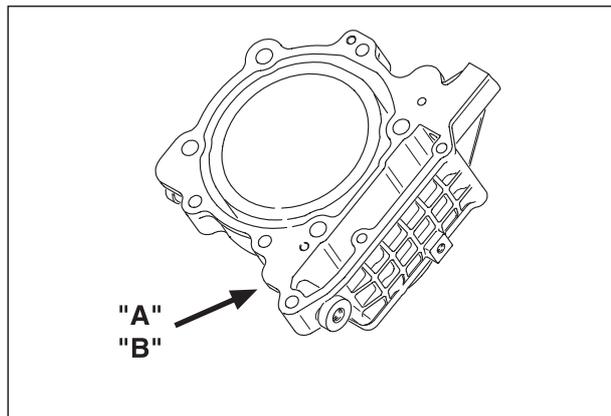
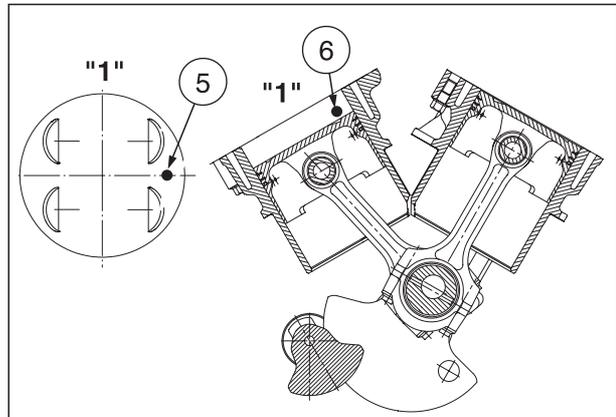
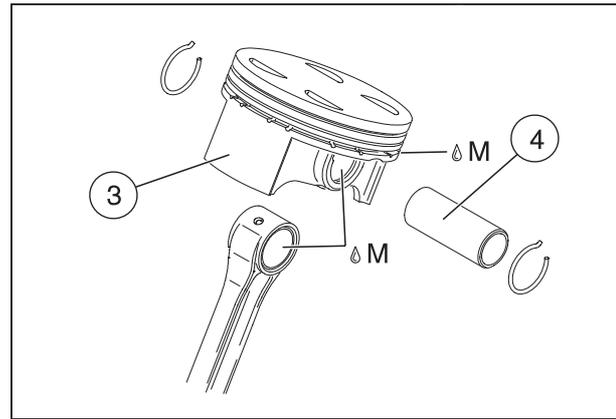
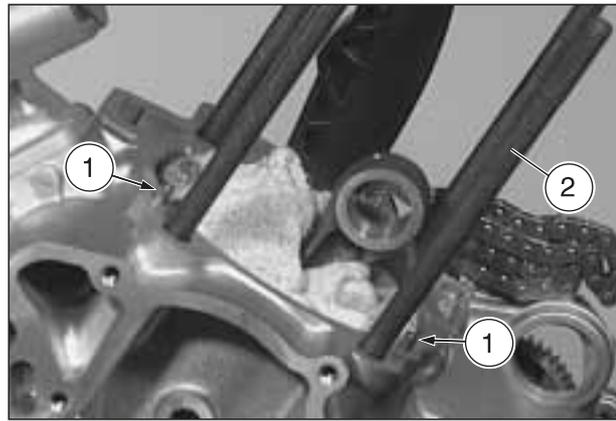
If a new piston is used, the "red" or "green" reference mark (5) on the piston crown must face in the direction of the intake (6).

- ◆ Take special care when matching the cylinder - piston:
  - "Red" piston - cylinder "A";
  - "Green" piston - cylinder "B".

**NOTE** The cylinders size group "A" or "B" is stamped onto the lower side of the actual cylinder in the timing chain compartment area.

M = MOLYKOTE® G-N.

Follow ►



Follow ►

**CAUTION****Use new bent-end gudgeon pin circlips (7) only.**

- ◆ Install the gudgeon pin circlips (7).

**NOTE** Support the piston (3).

Ensure that the two gudgeon pin circlips are inserted perfectly in the groove of the piston and that the hook (8) is inserted in the slot of the piston.

- ◆ Insert the two locating dowels (9) in the cylinder.

**CAUTION****Use a new head gasket.**

- ◆ Fit the head gasket (10) in place.
- ◆ Install the pre-assembled head on the cylinder and tighten the four shouldered screws (11).

**Non-painted cylinder version:**

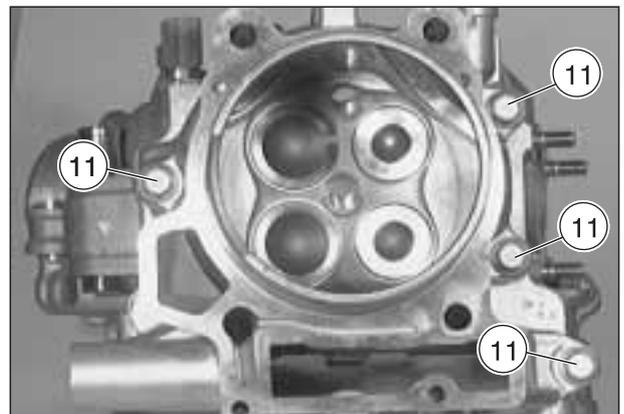
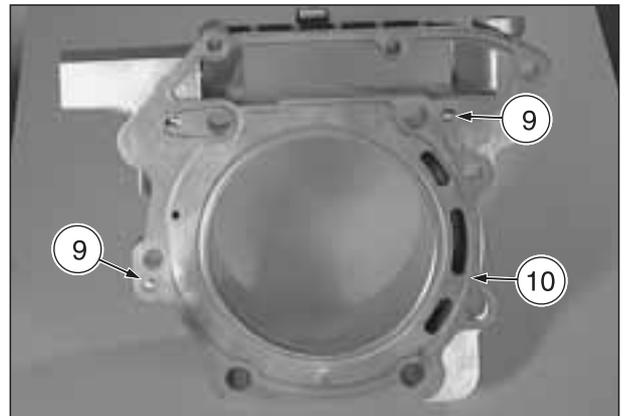
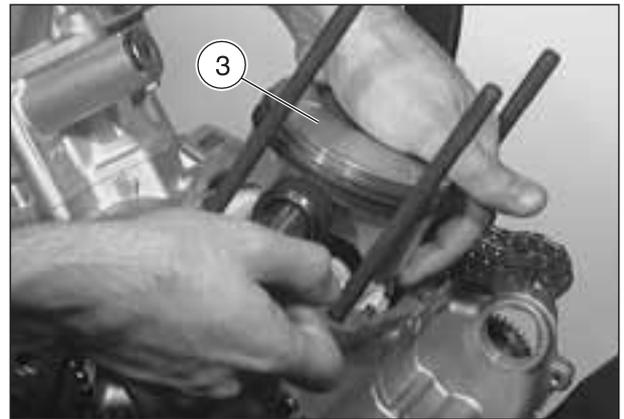
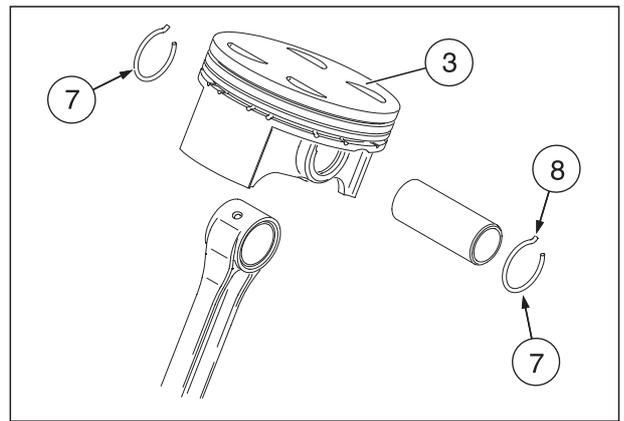
- four shouldered screws (11) tightening torque: 21 ftlb (29 Nm).

**Painted cylinder version:**

- four shouldered screws (11) tightening torque: 19.5 ftlb (27 Nm).

- ◆ Apply a coat of LOCTITE® 574 on the engine case in the area of the parting line of the two halves of the case, on the mating surface between the cylinder and the crankcase.
- ◆ Install the cylinder base gasket on the case.
- ◆ Oil the piston and the piston rings thoroughly using engine oil.
- ◆ Turn the piston rings so that the gaps are staggered by approximately 120°.

Follow ►



Follow ►

**NOTE** Have the appropriate special tool **OPT** available:  
 – **aprilia** part# 8140186 (piston ring compression tool) (12).

- ◆ Compress the rings using the ring compressor (12) or special piston ring pliers.
- ◆ Place the chain tensioner shoe (13) in the chain compartment on the cylinder (14) and push the cylinder down over the piston so that the ring compressor is pushed free of the piston.
- ◆ Remove the ring compressor (12).
- ◆ Insert the timing chain (15) through the chain compartment in the cylinder.

**NOTE** The timing chain can be guided inside using an O-ring or similar device to aid assembly.

- ◆ Install the cylinder (14) on the engine case, pushing it down firmly.
- ◆ Place a drop of engine oil on the threads of the studs (2) and the area of the head where the stud nuts contact it.

**NOTE** Install the M10 nuts (16) and M6 Allen screws (17) evenly and gradually, working in a crisscross pattern.

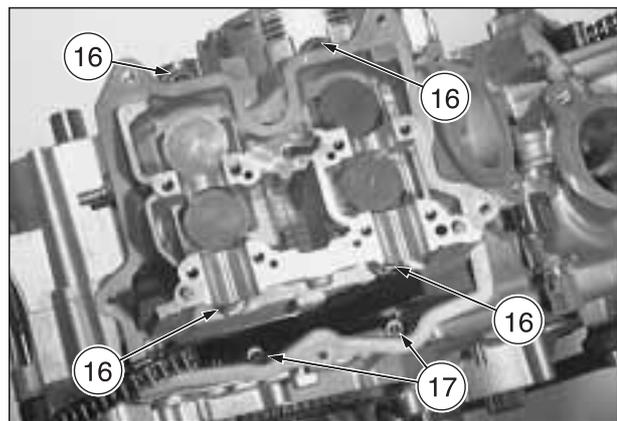
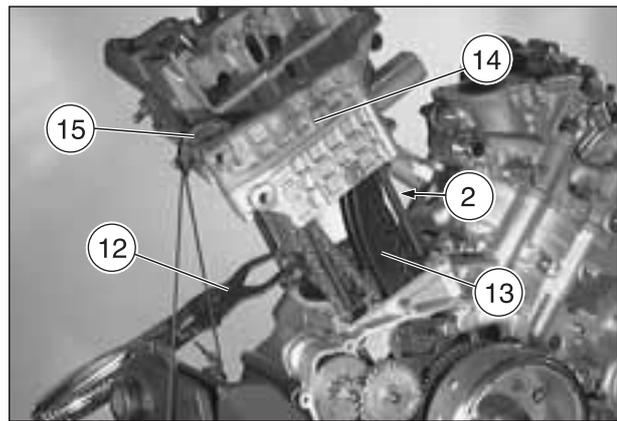
- ◆ Secure the cylinder and head with the four M10 nuts (16) and two M6 Allen screws (17).

**Non-painted head version:**

- four M10 nuts (16), tightening torque 42 ftlb (58 Nm);
- two M6 Allen screws (17), tightening torque 8.7 ftlb (12 Nm).

**Painted head version:**

- two M10 nuts (16), external, tightening torque 38.3 ftlb (53 Nm);
- two M10 nuts (16), chain compartment side, tightening torque 42 ftlb (58 Nm);
- two M6 Allen screws (17), tightening torque 8.7 ftlb (12 Nm).



**6.20 ASSEMBLING HEAD "1" (FRONT) CAMSHAFT**

Carefully read 6.1 (PREFACE).

- ◆ Adjust the valve clearance, see 6.14 (ADJUSTING VALVE CLEARANCE).
- ◆ Oil the housings of the exhaust camshaft (1) and intake camshaft (2).
- ◆ Coat the cams (3) with MOLYKOTE® G-N and insert the camshafts in the head.

**⚠ CAUTION**

Depending of the vehicle model on which the engine is installed, various versions of camshaft are used, see 5.26.1 (CAMSHAFTS FEATURES CLASSIFICATION).

**NOTE** Tighten the camshaft bearing cap gradually, starting from the inside and working in a crisscross pattern.

- ◆ Fasten the camshaft cap (4) with the seven washers (5) and seven M6x30 Allen screws (6).

**Screws tightening torque: 8 ftlb (11 Nm).**

**NOTE** Apply a couple of drops of LOCTITE® 243 to the threads of the two M5 Taptite screws (8).

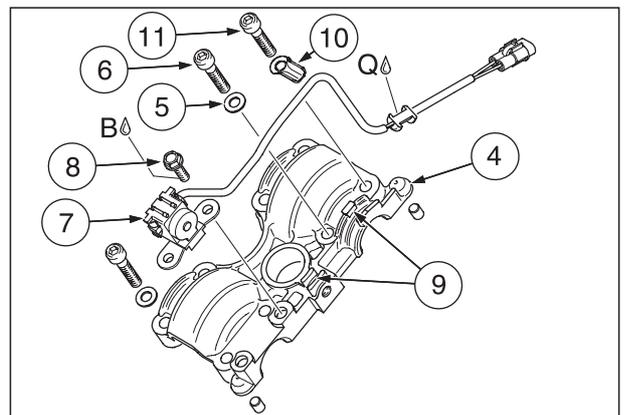
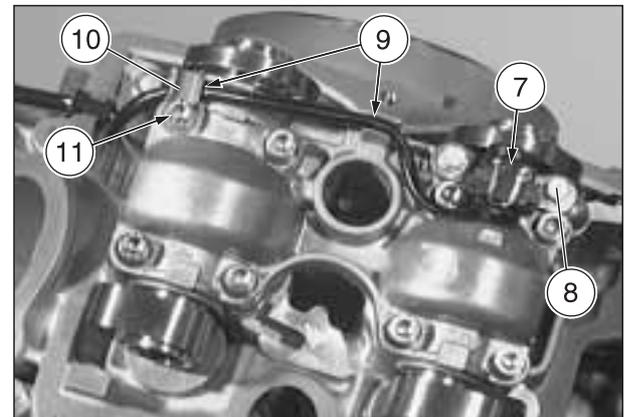
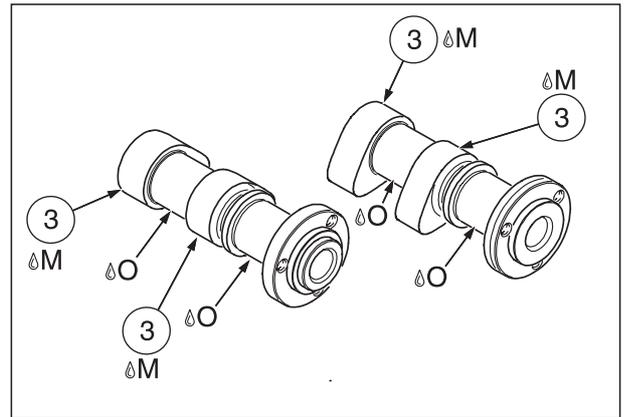
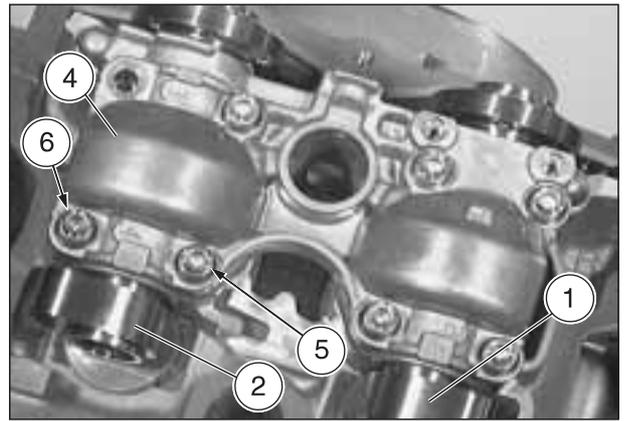
- ◆ Fit the camshaft sensor (7), secure it in place with two M5 Taptite screws (8), and fastening them.

**M5 Taptite screws tightening torque: 2.9 ftlb (4 Nm).**

- ◆ Insert the camshaft sensor cable in the guide (9) and fasten it with the cable clamp (10) and M6X30 Allen screw (11).

**Screw tightening torque: 8 ftlb (11 Nm).**

**B** = LOCTITE® 243.  
**Q** = SILASTIC 732 RTV.



**6.21 ASSEMBLING HEAD "1" (FRONT) TIMING DRIVE ASSEMBLY**

Carefully read 6.1 (PREFACE).

**NOTE** The crankshaft must be locked at Top Dead Center (TDC) on cylinder "1" (front), see 4.9 [DISASSEMBLING CYLINDER "1" (FRONT) TIMING DRIVE ASSEMBLY].

- ◆ Turn the camshaft so the cam lobes (1) face away from each other.
- ◆ Install a camshaft sprocket (2) on the exhaust camshaft and line up the bolt holes.

**NOTE** The exhaust camshaft sprocket (2) incorporates the transducer (4) for the camshaft sensor.

- ◆ Turn the camshaft sprocket (2) and the exhaust camshaft until the "EX" reference mark (5) faces the center of the intake camshaft.
- ◆ Place the timing chain (6) over the timing gear (2).

**NOTE** The timing chain must be taught on the traction side (7).

- ◆ Secure the timing gear with the three M6 Allen screws (8), coating them with LOCTITE® 243.

**Screws tightening torque: 8 ftlb (11 Nm).**

- ◆ Put the intake camshaft sprocket (9) in place, engaging its teeth in the timing gear so that the "IN" reference mark (10) faces the "EX" reference mark (5) on the exhaust camshaft sprocket.
- ◆ Maintaining this position, push the intake camshaft sprocket (9) onto the intake camshaft and line up the holes in the sprocket with those on the camshaft.

**NOTE** Apply a couple of drops of LOCTITE® 243 to the threads of the three Allen screws (11).

- ◆ Secure the timing gear (9) with the three M6 Allen screws (11) and tighten them.

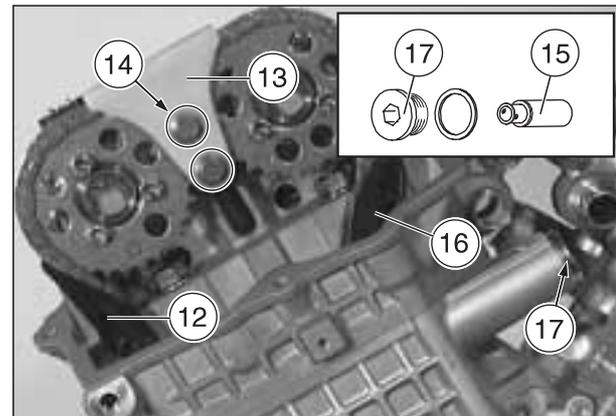
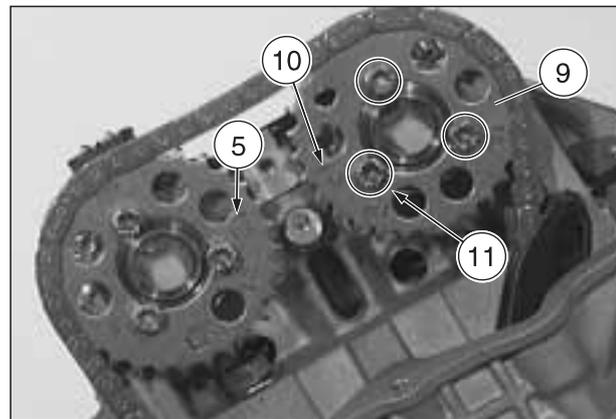
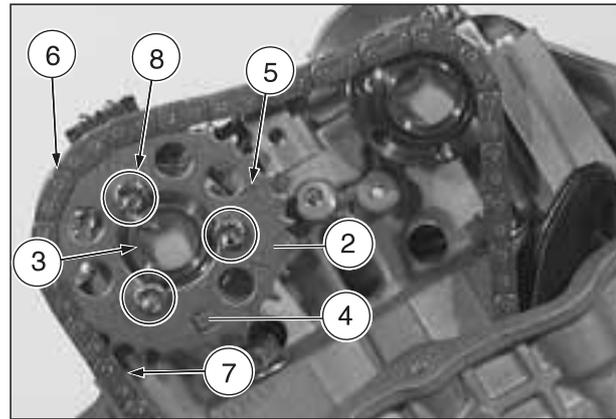
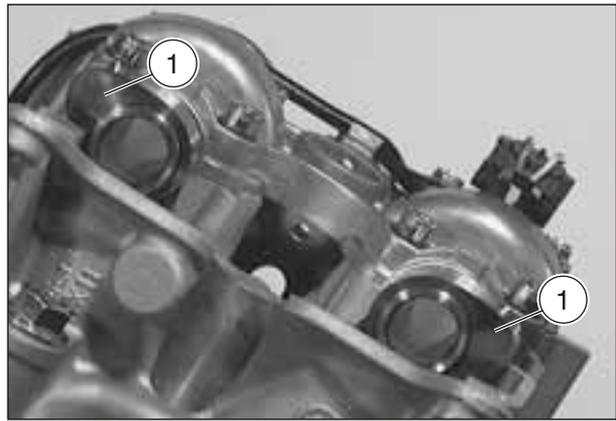
**Screws tightening torque: 8 ftlb (11 Nm).**

- ◆ Insert the chain guide shoe (12) into the cylinder as far as it will go.
- ◆ Fit the chain guide bracket (13) and secure it with the two M6 spacer screws (14).

**Screws tightening torque: 8 ftlb (11 Nm).**

- ◆ Oil the chain tightener (15) and fit it in the cylinder with the closed end facing the chain tensioner shoe (16).
- ◆ Install and tighten the M18x1 screw (17) and seal.

**M8x1 screws tightening torque: 14.5 ftlb (20 Nm).**



**6.22 ASSEMBLING THE VALVE COVER**

Carefully read 6.1 (PREFACE).

- ◆ Coat the cable (1) of the camshaft sensor and grommet (2) with SILASTIC 732 RTV.
- ◆ Apply a thin coat of grease to the valve cover gasket (3) and insert in the groove of the valve cover (4).
- ◆ Place the valve cover (4) on head "1" (front) and on head "2" (rear), securing them with the five M6 special screws (5).

**M6 special screws tightening torque: 6.5 ftlb (9 Nm).**

- ◆ Secure the intake manifold (6) with the two M8 Allen screws (7) and respective washers.

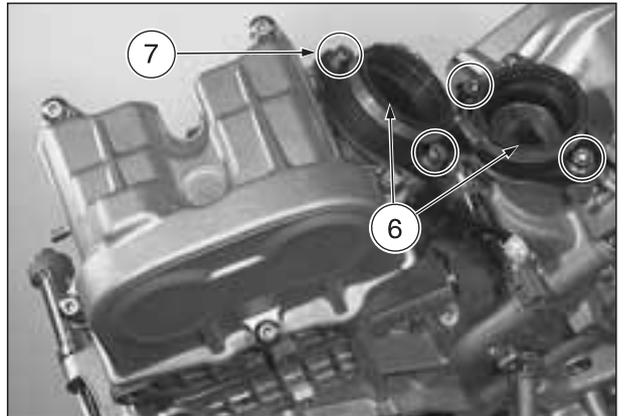
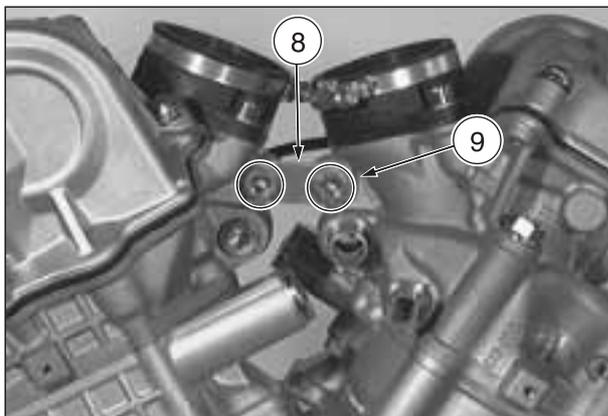
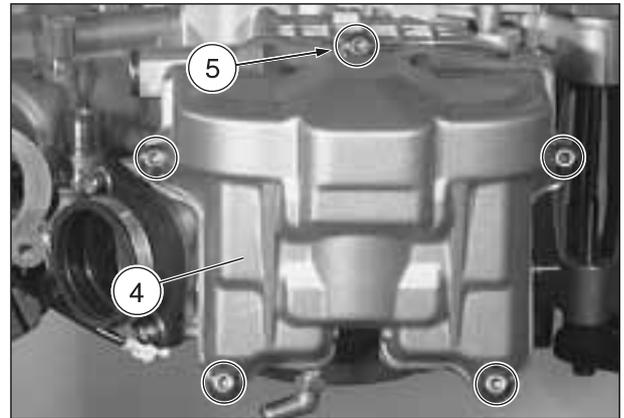
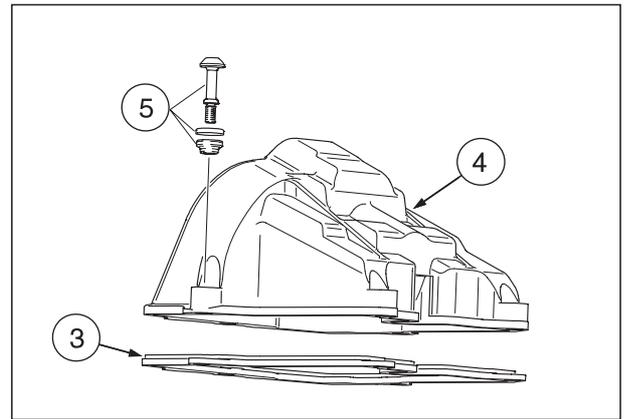
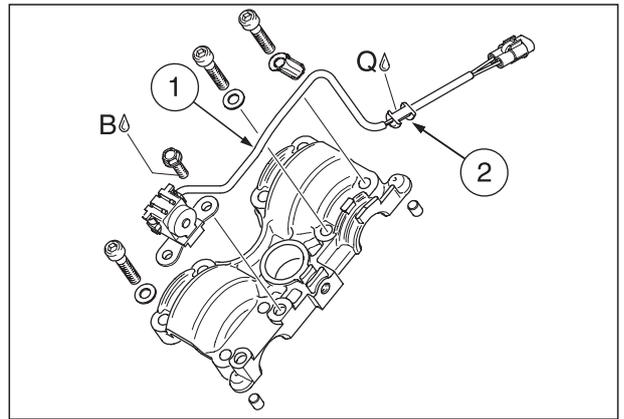
**Screws tightening torque: 13.7 ftlb (19 Nm).**

**NOTE** Apply a couple of drops of LOCTITE® 243 to the threads of the two M10 nuts.

- ◆ Secure the support bracket (8) with the two M10 Allen screws (9), fasten the two M10 nuts.

**M10 screw/nut tightening torque: 29 ftlb (40 Nm).**

**B** = LOCTITE® 243.  
**Q** = SILASTIC 732 RTV.



**6.23 ASSEMBLING THE ALTERNATOR COVER**

Carefully read 6.1 (PREFACE).

- ◆ Where necessary, insert the locating dowel (1).

**NOTE** Use a new gasket (2).

- ◆ Install the gasket (2).

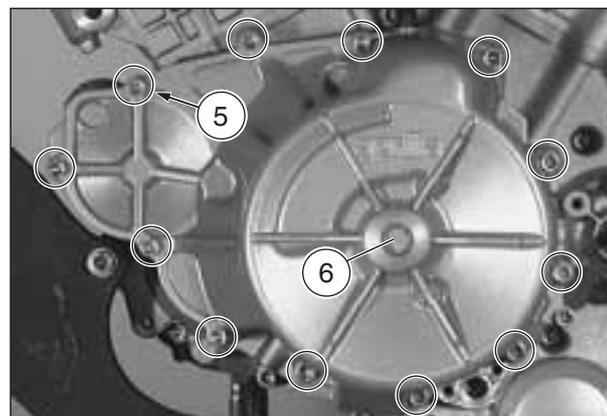
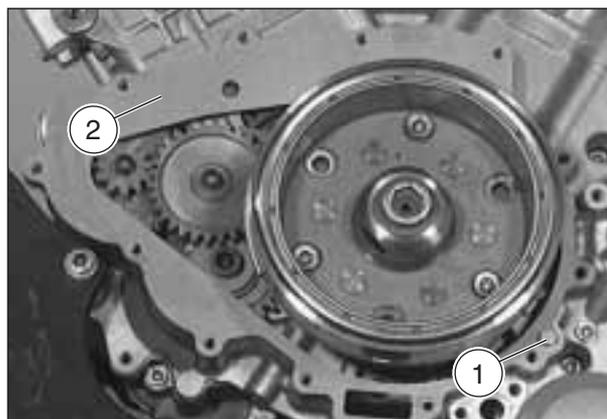
**NOTE** Have the appropriate special tool **OPT** available:  
– **aprilia** part# 0277252 (tool for removal alternator cover) (3).

- ◆ Screw the tool (3) onto the alternator cover.
- ◆ Fit the ignition cover to the engine case and install it with the twelve M6 Allen screws (5).

**Screws tightening torque: 8 ftlb (11 Nm).**

- ◆ Remove the tool (3) and tighten the plug (6) complete with O-ring.
- ◆ Install the four spark plugs in the two heads using the special spark plug wrench.

**Spark plugs tightening torque: 13 ftlb (18 Nm)**  
(with head cold and thread not lubricated).



**6.24 ASSEMBLING THE CLUTCH HOUSING**

Carefully read 6.1 (PREFACE).

- ◆ Remove the threaded bolt (1) for retaining the shaft at TDC.
- ◆ Insert the two locating dowels (2).
- ◆ Fit the gasket (3) in place.

**NOTE** Use a new gasket.

- ◆ Coat the end of the crankshaft (4) and the end of the lower balancshaft (5) with MOLYKOTE® G-N.
- ◆ Install the clutch cover (6), complete with coolant pump on the engine case.

**NOTE** Turn the impeller (8) to enable the teeth of the pump gear (7) to mate with the teeth of the coolant pump idling gear (9).

**NOTE** Fit the seal (13) on the M8x65 Allen screw (12).

Install the:

- eleven M6 x 35 screws (10),
- three M8 x 55 screws (11),
- one M8 x 65 screw (12) with the seal (13),

in the clutch cover and secure them.

**Tightening torque:**

- M6 Allen screws (10) 8 ftlb (11 Nm);
- M8 Allen screws (11 - 12) 13.7 ftlb (19 Nm).

**NOTE** Apply a couple of drops of LOCTITE® 243 to the threads of the M6x55 Allen screw (16) place in the center of the cover.

**NOTE** Fit the seal (18) on the M6x25 Allen screw (17) (coolant drain plug).

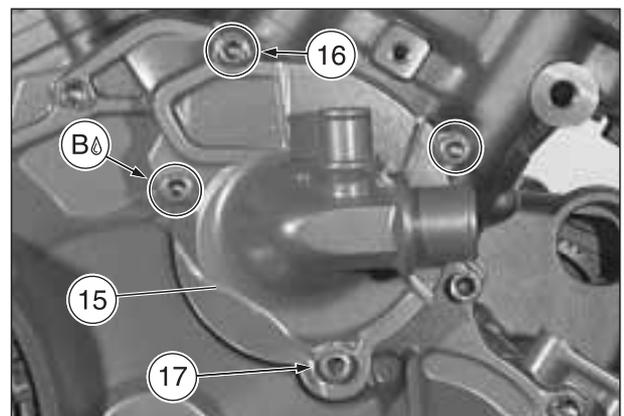
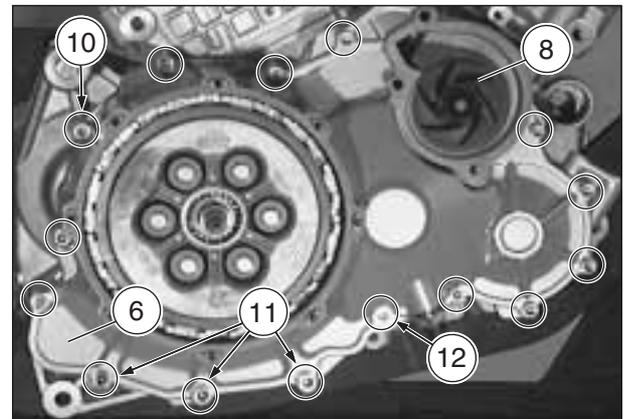
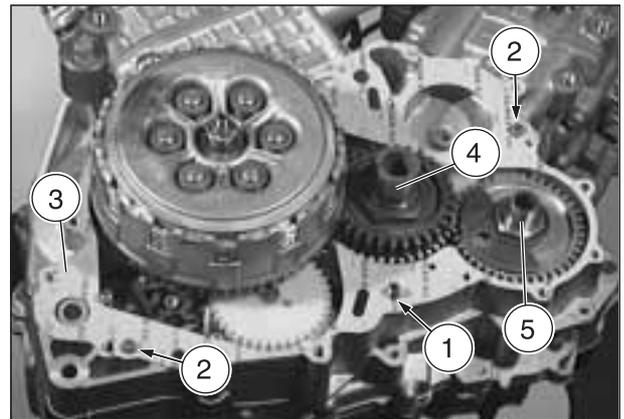
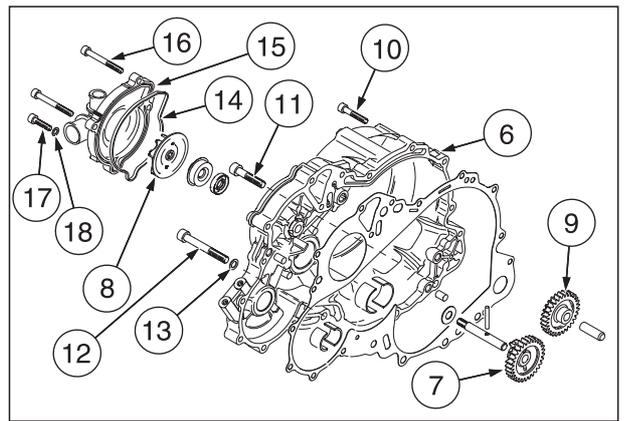
- ◆ Install the specially shaped gasket (14) in the coolant pump case groove (15), and fit it to the clutch cover, securing it with the:

- three M6 x 55 screws (16);
- one M6 x 25 screw (17) with the seal (18).

**Screws tightening torque: 8 ftlb (11 Nm).**

**B** = LOCTITE® 243.

Follow ►



Follow ►

- ◆ Assemble the washer (19), support plate (20), diaphragm (21), pressure plate (22) and spring washer (23) on the clutch disengaging shaft (24).

**NOTE** Apply a couple of drops of LOCTITE® 648 to the threads of the M12 stop nut (25).

Secure these parts to the disengaging shaft with the M12 stop nut (25).

**M12 stop nut tightening torque: 21.7 ftlb (30 Nm).**

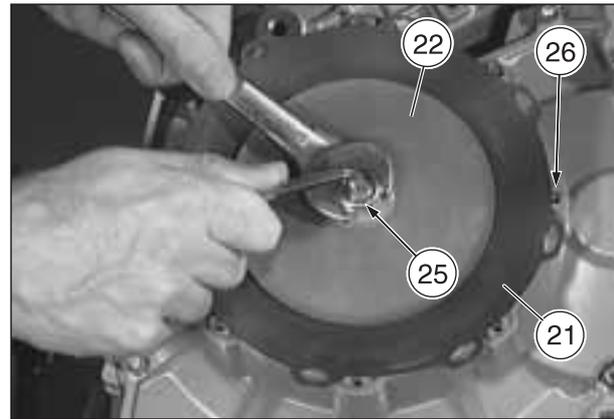
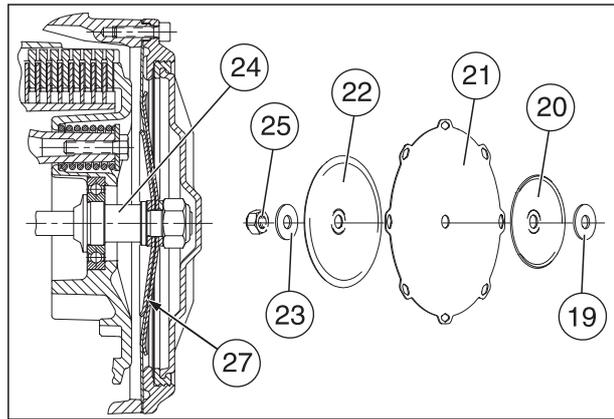
**NOTE** Secure the nut (25) before you install the clutch cover retainers (26).

**NOTE** Fit the support plate (20) and pressure plate (22) on the clutch disengaging shaft with the rounded edge (27) facing out.

**NOTE** Prevent the diaphragm (21) from rotating on the clutch disengaging shaft (24), with an Allen wrench.

- ◆ Rotate the complete clutch disengaging shaft (24) and fasten the diaphragm (21) in the clutch cover retainers (26).
- ◆ Insert the pre-assembled diaphragm disc (28) and secure it with the eight M5 Allen screws (29).

**M5 Allen screws tightening torque: 3.6 ftlb (5 Nm).**

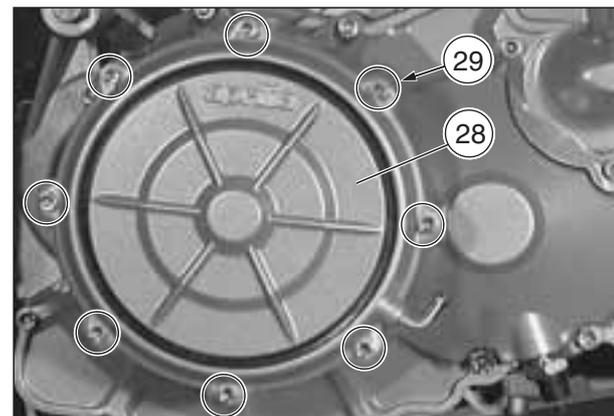
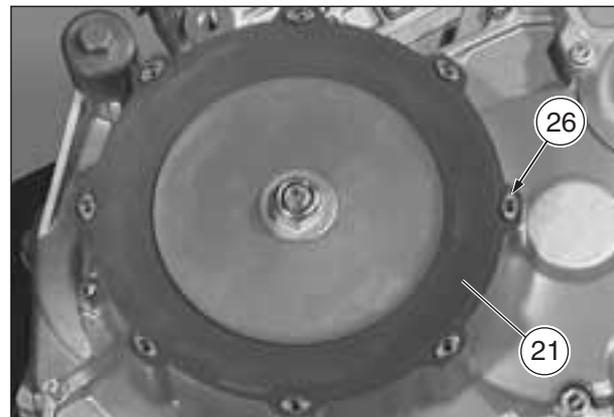


**6.25 ASSEMBLING THE STARTER MOTOR**

Consult the corresponding paragraph in the section 3 (ENGINE) of specific vehicle workshop manual, see 0.4.1 (VEHICLE WORKSHOP MANUAL).

**6.26 ASSEMBLING THE ENGINE OIL FILTER**

Consult the section 2 (SERVICE AND SETTING UP) of specific vehicle workshop manual see 0.4.1 (VEHICLE WORKSHOP MANUAL).







**FUEL SYSTEM, COOLING SYSTEM,  
ELECTRICAL SYSTEM**

**7**



**TROUBLESHOOTING**

**8**



**ANALYTICAL INDEX**



## ANALYTICAL INDEX

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