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MANUALE DI OFFICINA
WORKSHOP MANUAL
MANUEL D'ATELIER
WERKSTATTHANDBUCH

Beta
the play bike

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PREAMBLE

This publication has been written in order to make operations for inspection, maintenance and repairs of the motorcycle engine known and understandable to the user of the motorcycle and to the technical assistance operator.

Read this entire manual with care before operating the engine. Sufficient knowledge of the components that make up the engine and of all the procedures to be followed for inspection and maintenance contribute to lengthen the life of the engine.
The paragraphs have been enhanced with schematic illustrations highlighting each subject in order to make reading immediately understandable.

Informative note

Betamotor S.p.A. is engaged in a policy of ongoing improvement of its products. This is why it could be possible to note slight differences between the contents of this document and the vehicle upon which you are carrying out repairs and/ or maintenance. **Betamotor S.p.A.** models are exported to numerous countries in which there are different standards concerning Highways Codes and procedures for approval of the vehicle. Relying on your understanding, **Betamotor S.p.A.** therefore deems it necessary to reserve the right to modify its products and technical documentation at any time without prior warning.

We respect and defend the environment

*All that we do has an impact on the whole Planet and its resources. **Betamotor S.p.A.**, wishing to safeguard the interests of the entire Community, would like to make customers and technical operators aware of ways of using the vehicle and of disposal of its parts in total compliance with standards in force in terms of environmental pollution, waste disposal and recycling.*

SAFETY

Carbon monoxide

- *Exhaust gasses contain carbon which is poisonous. Carbon monoxide can cause loss of conscience and lead to death. When starting the engine, make sure the place you are is well-ventilated. Never start the engine in a closed place.*
- *Starting the engine closed places can be done only if provided with relevant gas discharge evacuation devices.*

Petrol

- *Petrol is extremely flammable and can be explosive in some conditions.*
- *Keep heat sources, sparks and flames away from the work area.*
- *Always work in a well-ventilated area.*
- *Never use petrol as a solvent for cleaning. Do not handle it unless absolutely necessary.*
- *Never use petrol to clean components by means of compressed air.*
- *Keep out of the reach of children.*

Motor oil

- *Motor oil can cause skin illnesses if carried often and for prolonged periods in contact with skin.*
- *If you touch motor oil, clean parts with soap and water as soon as possible.*
- *In case of contact with the eyes, rinse them abundantly with water and seek medical advice.*
- *If swallowed, do not induce vomiting in order to avoid breathing the product into the lungs; seek immediate medical advice. If you believe the product has been breathed into the lungs, bring the concerned person urgently to the hospital.*
- *Used oil contains dangerous substances which are harmful for the environment. When changing it, you must be equipped to dispose of it in compliance with existing law.*
- *Avoid releasing used oils to the environment.*
- *Keep out of the reach of children.*

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Coolant

- *In some situations, the ethylene glycol contained in the coolant is flammable and its flame is invisible. Should ethylene glycol catch fire, though its flame is invisible, it can cause burns.*
- *Do not bring the coolant in contact with hot parts. These parts could be hot enough to cause the liquid to ignite.*
- *The coolant (ethylene glycol) can irritate skin and is poisonous if swallowed.*
- *Should the coolant come into contact with the skin, immediately remove contaminated clothing or footwear and wash with soap and water. In case of contact with the eyes, rinse them abundantly with clean water and seek medical advice immediately. Should it be swallowed, do not induce vomiting in order to avoid breathing the product into the lungs. Administer clean water and bring the concerned person immediately to the hospital, showing this product to the hospital staff.*
- *In the event of exposure to a high concentration of vapours, bring the concerned person to an uncontaminated atmosphere and seek medical advice if necessary.*
- *Do not remove the radiator cap when the engine is still hot. When coolant is pressurised, it can spurt out violently and cause burns.*
- *Coolant contains dangerous substances which are harmful for the environment. When changing it, you must be equipped to dispose of it in compliance with existing law.*
- *Do not release coolant to the environment.*
- *Keep out of the reach of children.*

Hot parts

- *The engine and the exhaust system get very hot and stay at that temperature for a long time, even after the engine has been turned off. Wait for them to cool off before handling these parts or intervening on areas around them. Use insulated gloves.*

WARNINGS

The information contained in this paragraph is important so that the operations out on the engine can be performed without causing damage.

- *Before disassembling, clean the motorcycle thoroughly.*
- *While you are disassembling it, clean all the parts and place them in containers respecting the order of disassembly exactly.*
- *Always use special tools wherever necessary and when thus prescribed.*
- *Always use glues, sealing and lubricants wherever prescribed. Respect the indications concerning their technical features.*
- *Always replace parts such as gaskets, O-rings and safety washers with newly supplied parts.*
- *When loosening or tightening nuts or screws, always start with the larger ones or from the centre. Always respect the indicated tightening torques.*
- *Use only Betamotor original spare parts.*

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TECHNICAL FEATURES OF ENGINE

Tipo	Monocilindrico a 4tempi raffreddato a liquido con albero bilanciatore e avviamento elettrico			
Bore x stroke RR 350	88x57,4			
Bore x stroke RR 400	95x56,2			
Bore x stroke RR 450	95 x 63,4			
Bore x stroke RR 498	100 x 63,4			
Displacement [cm³] RR 350	349,1			
Displacement [cm³] RR 400	398			
Displacement [cm³] RR 450	449,4			
Displacement [cm³] RR 498	497,9			
Compression ratio RR 400-450-498	13,3:1	12,4:1	11,95	12,0:1
Valve gear	4 valves			

TRANSMISSION				
	RR 350	RR 400	RR 450	RR 498
Primary transmission	28/76	28/76	31/73	31/73
1st gear ratio	12/31	12/31	12/31	12/31
2nd gear ratio	15/28	15/28	15/28	15/28
3rd gear ratio	19/28	19/28	19/28	19/28
4th gear ratio	20/24	20/24	20/24	20/24
5th gear ratio	27/27	27/27	27/27	27/27
6th gear ratio	28/24	28/24	28/24	28/24
SECONDARY TRANSMISSION		CHAIN		

CARBURETTOR				
	RR350	RR400	RR450	RR498
Carburettor type	Keihin FCR-MX39	Keihin FCR-MX 39	Keihin FCR-MX 39	Keihin FCR-MX 39
Carburettor-setting number	006121308 000	006.12.100.8.0	006.12.000.8.0	006.12.200.8.0
Main jet	170	175	175	180
Jet needle	NCVQ	OBDTS	OBDVS	OBDVS
Slow jet	40	45	45	45
Main air jet	x	200	200	200
Idling air jet	100	100	100	100
Needle position	3°	5°	4°	4°
Mixture control screw open	1+1/2	1+1/2	1+1/2	2
Intake jet	40	50	40	40

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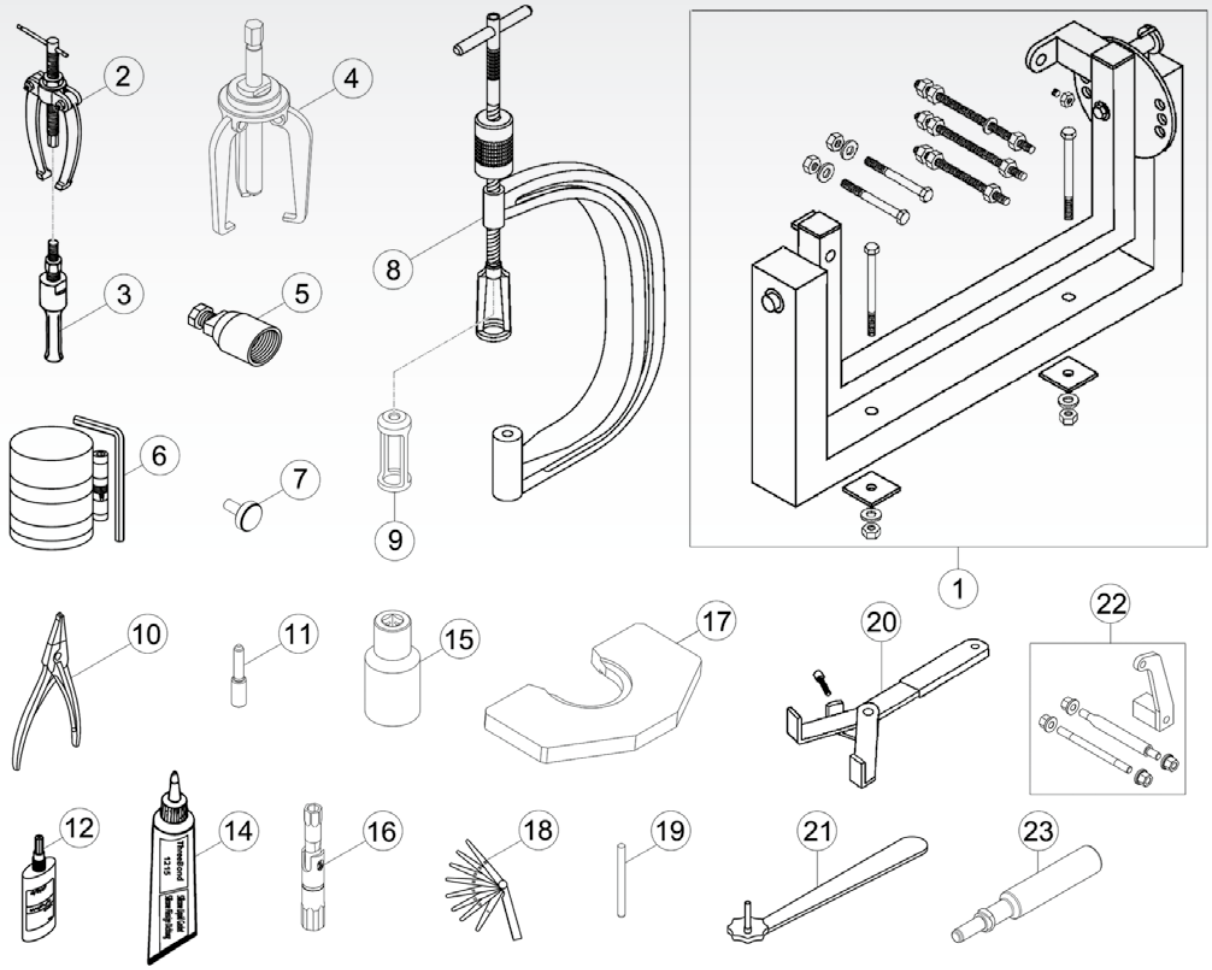
SPECIAL EQUIPMENT



1. *Engine support code 3625132 000;*
2. *Two-leg extractor code 3625081 000;*
3. *Internal bearing puller code 006140160 000;*
4. *Extractor for timing gear code 006140150 000;*
5. *Flywheel Extractor code 3625173 000;*
6. *Piston ring compression band code 006140170 000;*
7. *Chain-tensioner release tool code 006140050 000;*
8. *Valves assembly-disassembly jaw code 0100043 000;*
9. *Tool for valves assembly-disassembly code 006140030 000;*
10. *Special ring pliers code 3625097 000;*
11. *Crankshaft blocking device code 006140110 000;*
12. *Loctite 243 code 3625001 000;*
14. *Silicone paste for gaskets code 3625000 000;*
15. *36mm socket wrench code 3625000 000;*
16. *Spark plug wrench code 020440100 000;*
17. *Connecting rod disassembly tool code 006140070 000;*
18. *Thickness gauge code 006140210 000;*
19. *Valve guide gauge code 006140180 000;*
20. *Clutch cap tool code 006140040 000;*
21. *Carburettor adjustment spanner code 006140200 000;*
22. *Engine fixing code 006140140 000.*
23. *Pin retaining elastic ring tool code 022140200 000 (350cc); code 006140300 000 (400cc, 450cc, 498cc)*

Symbology

6Nm

Value Tightening Torque

Loctite 243/ Sichel 100M

Silicone paste

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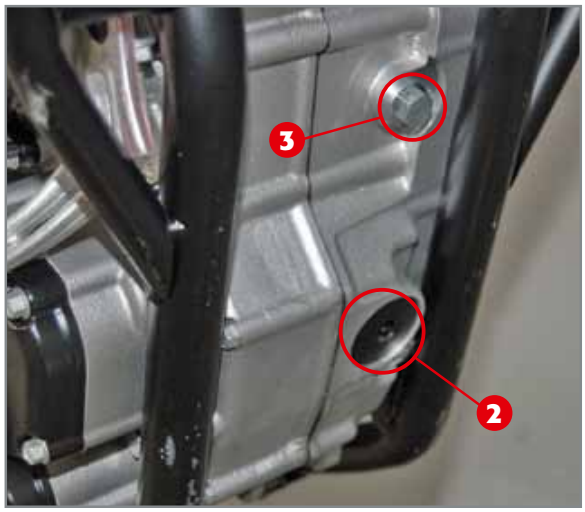
ENGINE DISASSEMBLY

Front engine guard fixing screw.

Back engine guard fixing screws.



Screw 2 for draining motor oil and 3 for draining gear oil.

Before removing the engine from the vehicle, empty the following liquids:

- Motor oil;
- Gear/clutch unit oil;
- Coolant.
-

In order to access the oil drain plug, remove the engine guard connected to the frame by means of the three screws **1**.

Remove the screw **2** to empty the motor oil.
Remove the screw **3** to empty the gear oil.

ATTENTION: *Used oil contains dangerous substances which are harmful for the environment. When changing it, you must be equipped to dispose of it in compliance with existing law.*
Avoid releasing used oils to the environment.

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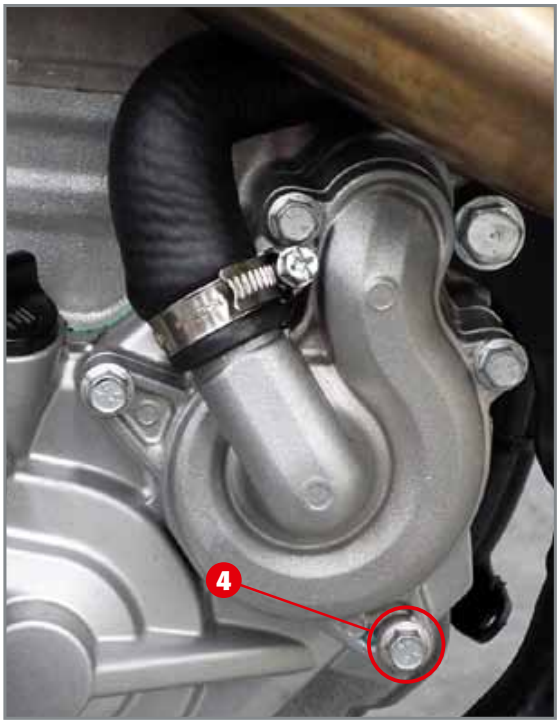
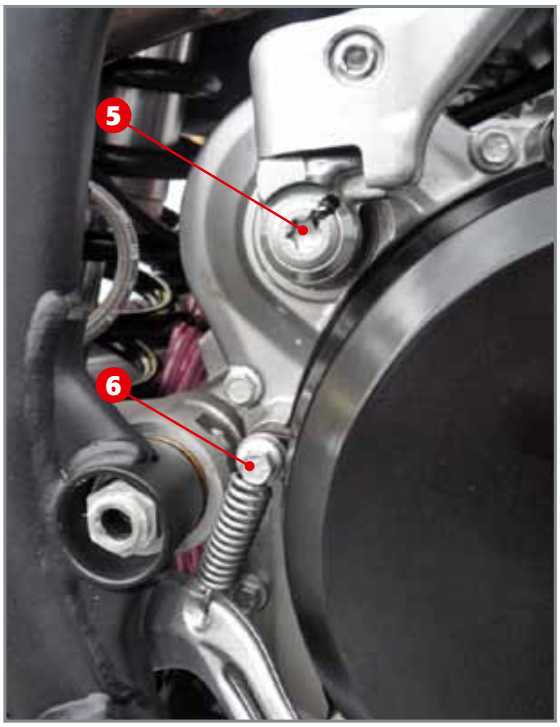


Screw 4 for draining coolant.

In order to empty the cooling circuit, loosen the screw **4** and have the liquid flow out into a recipient (the cooling circuits holds 1.3l of liquid). Remove the radiator cap.

Disconnect the water hoses on the engine side, disconnect the electrical connectors below the tank, the clutch actuator and the exhaust manifold.



Screws 5 and 6.

Loosen the screw **5** that fastens the kickstarter to the kickstarter shaft and the screw **6** which fastens the brake pedal return spring to the engine block.

Once the engine has been unfastened and removed from the frame, connect it to the specific engine support *code 3625132000* by means of the engine fixing devices *code 006140140000*, in order to work in comfort and safety. Then proceed as follows.

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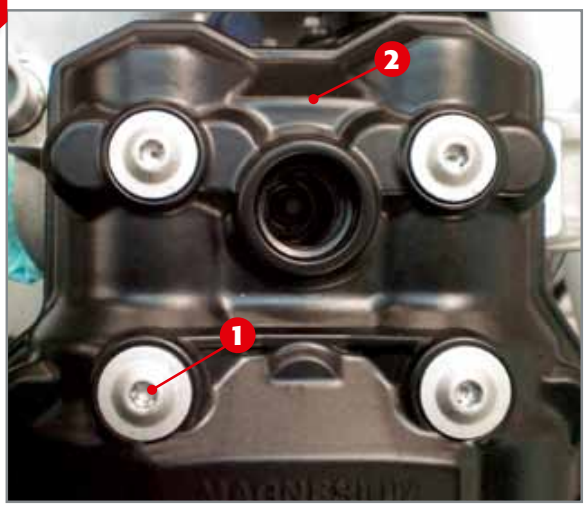


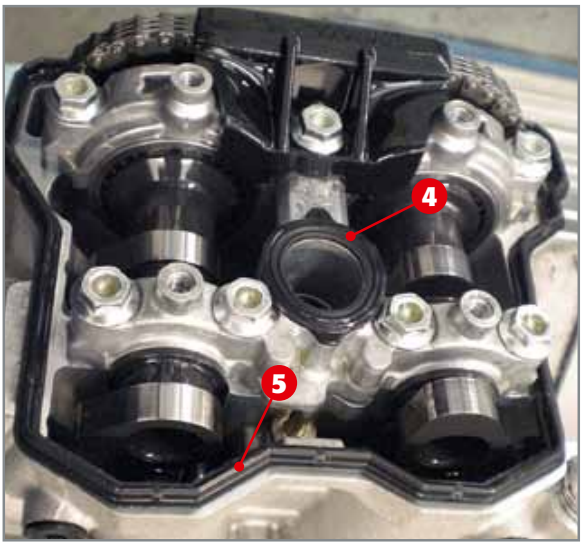
The four screws 1 of the cylinder head cover 2.

1.1 THERMAL UNIT

The thermal unit is made up of the head, cylinder and piston.
Before removing the cylinder head, bring the piston to the TDC and block the crankshaft: Proceed as shown hereafter.

The cylinder head cover 2 and the four gaskets 3.

Remove the **4** screws **1**, the cylinder head cover **2** as well as the **4** screw gaskets **3**.



Spark plug gasket 4 and cylinder head cover gasket 5.

Remove the spark plug gasket **4** and the cover gasket **5**.

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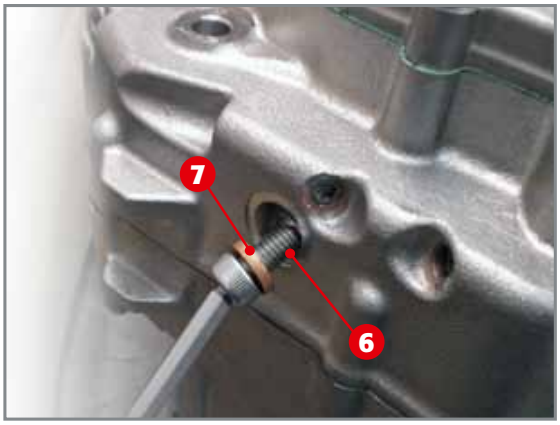
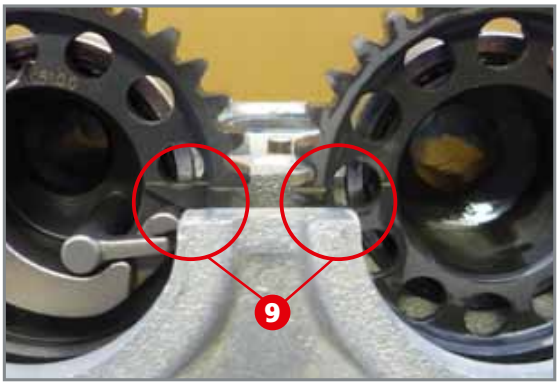


Crankshaft blocking screw 6 with copper washer 7.

Remove the crankshaft blocking screw **6**, remove the copper washer **7** and put the screw (or tool *006140110 000*) back into its seat without tightening it all the way.

Rotation of transmission shaft.

After having engaged the 6th gear, turn the transmission shaft **8** anti-clockwise - using an open-end spanner or the likes, - until the lines **9** on the toothed profiles of the camshafts are aligned.



Alignment of camshafts.

Rotate the transmission shaft in that position and, at the same time, turn the shaft blocking screw **6** by hand until it engages in the seat present on the crankshaft, preventing the crankshaft from turning.

Blocking crankshaft at TDC. Note the blocking screw 6 and the movement set by the transmission shaft with the open-end spanner.

In this way the crankshaft is blocked, by means of the screw **6**, at the Top Dead Centre (TDC) and now all the organs can be disassembled.

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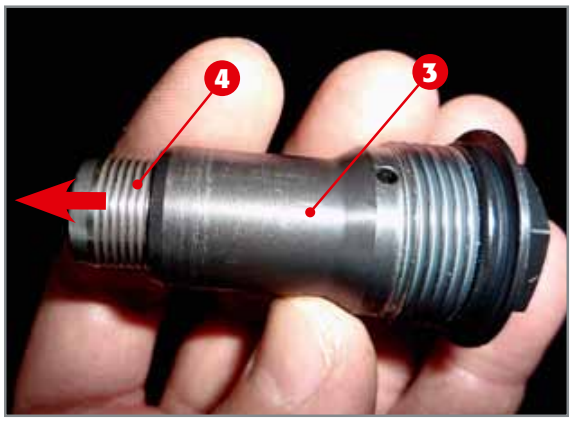
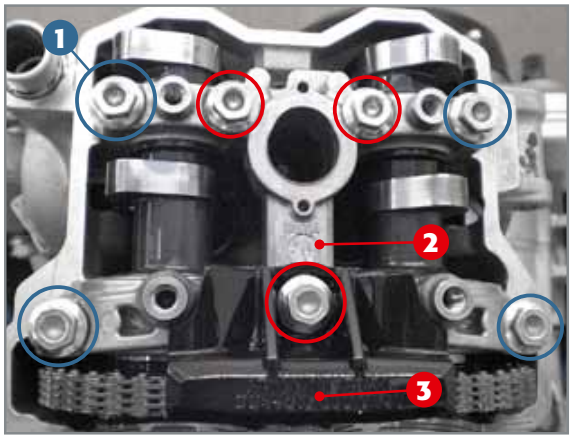
Cap and spring removal.



Tensioner support complete with piston.



Fixing screws 1 camshaft support 2 and chain guide 3 The four outer screws circled blue must be taken off-first.

1.1.1 CYLINDER HEAD: DISASSEMBLING MECHANICAL TENSIONER

A chain which is not well-tensioned can cause:
- excessive vibrations for the chain which could make it jump teeth on the camshafts thus damaging the engine;
- incorrect and premature wear of the support bearings of the camshafts.

The engine is equipped with a hydraulic tensioner in order to provide the chain with proper tensioning.

To remove it, proceed as follows: remove the cap **1** and the spring **2**.

Fully unscrew the tensioner support **3** from the cylinder.
To slip the piston 4 out, just push it out from the tensioner support **3**.

1.1.2 CYLINDER HEAD: DISASSEMBLING CAMSHAFT SUPPORT, CHAIN GUIDE AND SPARK PLUG SEAT O-RING

To remove the camshafts, disassemble the camshaft support **2** and the chain guide **3**. Then loosen the seven screws **1** of the camshaft support, starting with the outer ones (indicated in blue in the figure) and then the inner ones. Remove the chain guide **3**.

Attention: *disassemble the camshafts only after having disassembled the hydraulic tensioner.*

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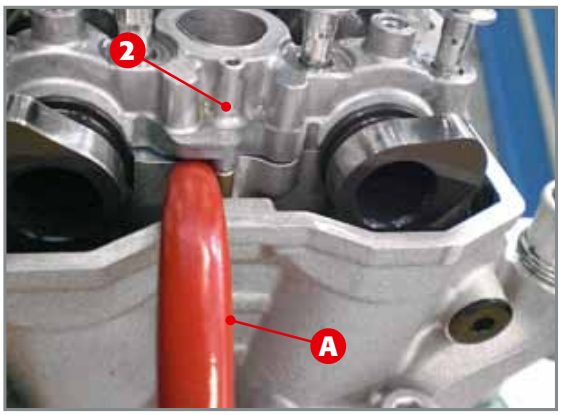
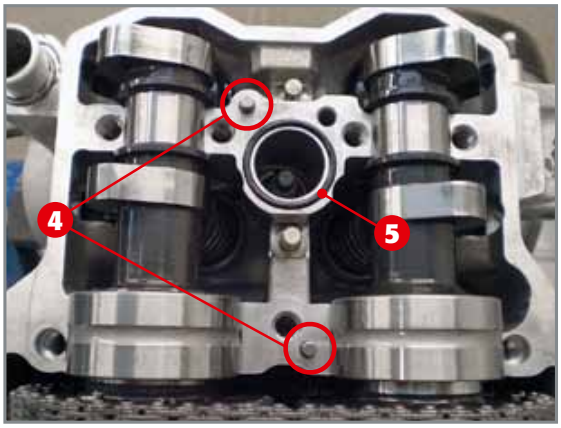


Uncoupling camshaft support 4 from cylinder head.

Using a plastic rod **A** or something similar, lever the head surface and the camshaft support **2** in order to lift it and remove it.



Two centring pins 4 and spark plug housing O-ring 5.

When uncoupling, be careful of the two centring pins **4** the camshaft support Checking camshafts support
Remove the spark plug housing sealing O-ring **5** between the cylinder head and the camshaft support.

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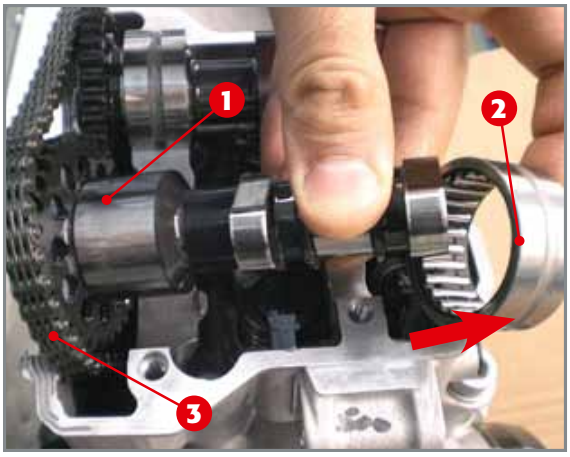
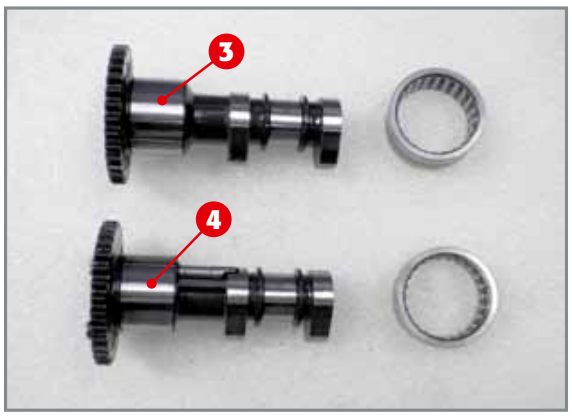
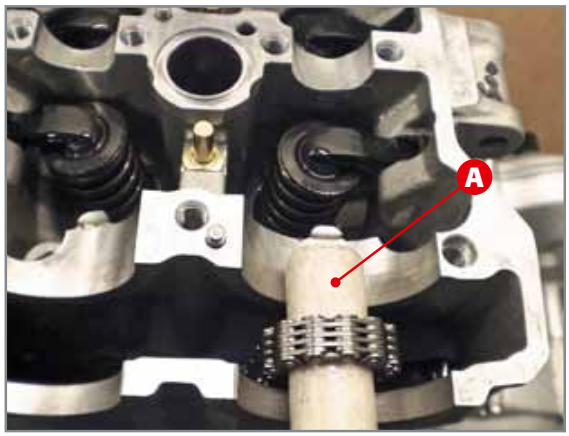


Removal of intake camshaft 1, bearing 2.



Camshafts (G intake, H exhaust) with bearings.



Plastic rod to support chain.

1.1.3 CYLINDER HEAD: REMOVING CAMSHAFTS

Lift the intake camshaft **1**, pull out the bearing **2** and remove the chain **3** from the gear on the shaft.

Attention: *the hydraulic tensioner must already have been removed in order to remove the camshafts.*

In order to remove the exhaust camshaft **4**, repeat the operations described for removal of the intake camshaft.

ATTENTION: *make sure the chain does not fall inside the compartment dedicated to it. For this purpose, it is recommended to interpose a plastic rod (or the likes)* ***A*** *between the chain and the head.*

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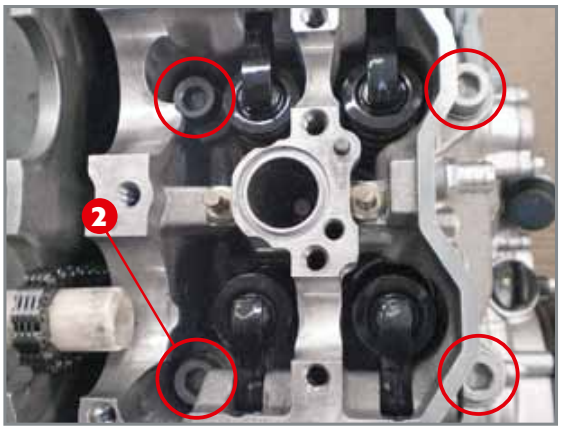
1.1.4 CYLINDER HEAD: UNCOUPLING FROM CYLINDER

Chain-side head fixing screw.

Five screws fasten the head to the cylinder. Remove the cylinder head screw **1** on the outside of the chain-side cylinder head.



Head fixing screws.

Remove the four cylinder head fixing screws **2**, in a criss-cross pattern. Start with one of the two screws outside the cylinder head compartment.
Then remove the respective washers.

Head removal.

Lift the cylinder head **3** with one hand and at the same time with the other hold the chain in tension thus preventing jams during disassembly.
With the cylinder head lifted a few centimetres, drop the chain inside the compartment and pull out the head.

ATTENTION: *should the chain fall inside, place it in tension before lifting the head.*

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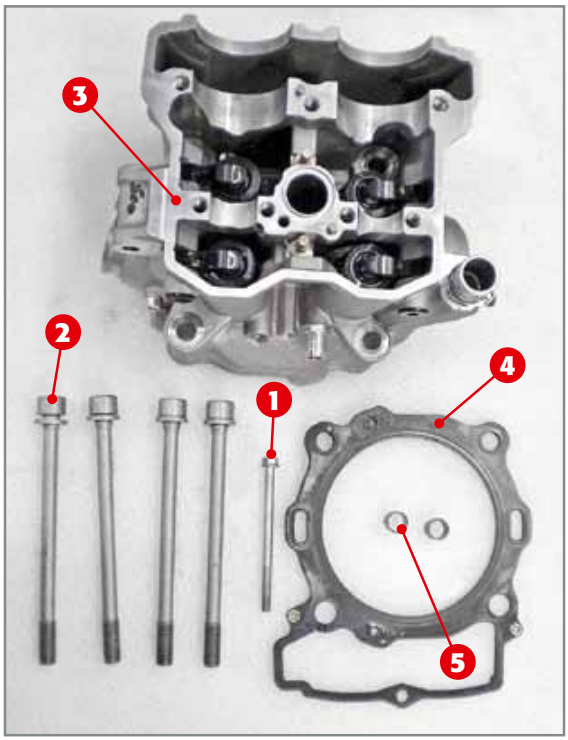

Cylinder head elements:

1) M6x80 screw;
2) M10x1.25 cylinder head screws;
3) Complete cylinder head;
4) Cylinder-head gasket;
5) Centring bushes.

Remove the head gasket **4** and the two centring bushes **5**.

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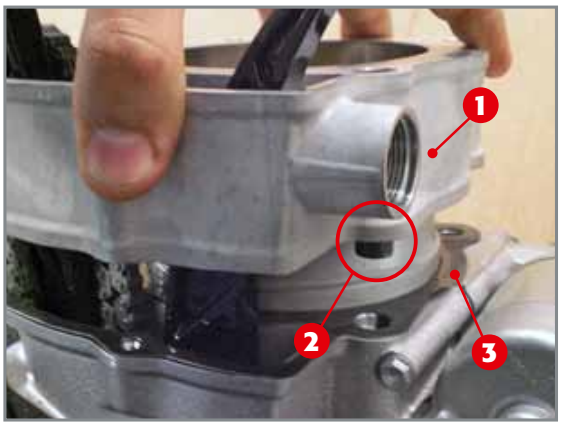
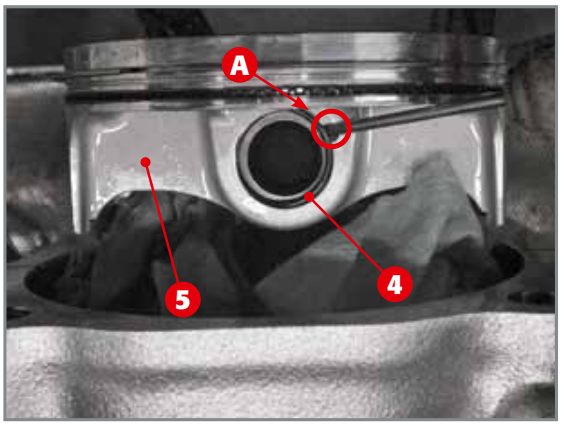
1.1.5 DISASSEMBLING CYLINDER AND PISTON



Cylinder removal.

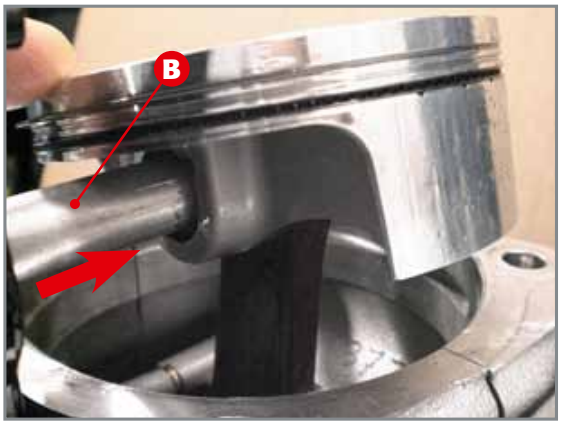
Lift up the cylinder **1** a few centimetres, remove the two centring bushes **2** (both located on the chain side) to prevent them from falling inside the crankcases and continue on removing the cylinder. Remove the cylinder gasket **3**.



Removal of elastic ring 4 from right hand side of piston.

Place a clean cloth between the piston and the crankcase to keep foreign objects or simple residue from falling inside the base. Using a suitable tool to insert the specific seat **A**, remove the elastic ring **4** on the right hand side* of the piston **5**.

ATTENTION: *be careful not to drop the elastic ring inside the engine.*



Pin bolt removal.

From the left hand side of the piston, push the pin bolt with an aluminium cylinder **B** (or the likes), until the pin bolt is freed from the foot of the connecting rod.
Remove the piston.

ATTENTION: *Try pulling out the pin bolt by hand first of all. If it is too tight, hit the pin lightly with a rubber hammer, at the same time holding the piston with your hand in order not to stress the connecting rod.*

* *Referred to normal direction of vehicle.*

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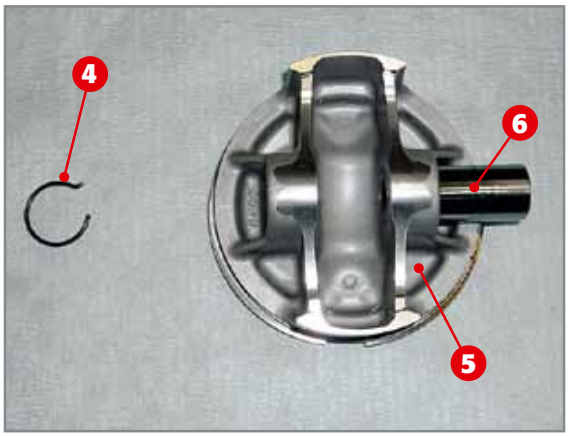


Bottom view of piston 5, elastic ring 4 and pin bolt 6.

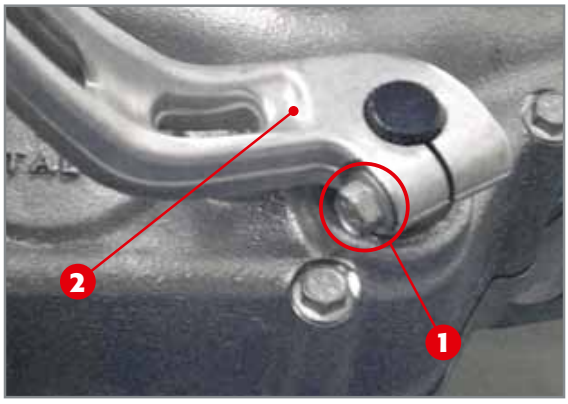
In figure you can see the piston **5** (bottom view), the circlip **4** and the pin bolt **6**.

1.2 DISASSEMBLY OF IGNITION UNIT, TIMING CHAIN AND GUIDES

The ignition unit is made up of the flywheel (or rotor), the pick-up and the stator which is one with the flywheel cover.

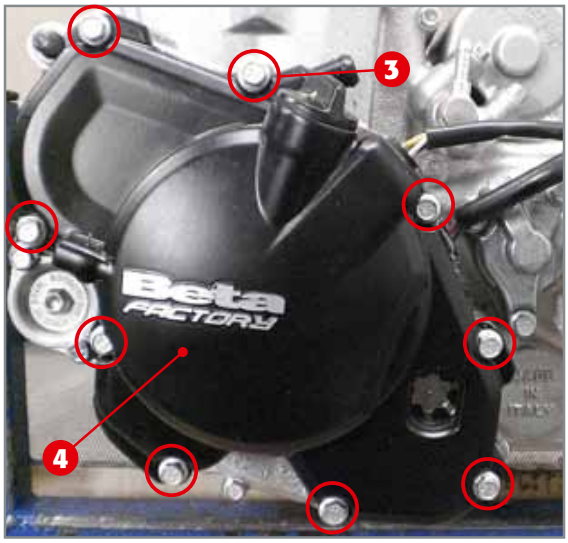
1.2.1 STATOR AND FLYWHEEL

Remove the screw **1** which connects the gear lever 1 to the drive shaft.



Removal of gear lever.

Remove the nine screws **3** which fasten the flywheel cover **4** to the left crankcase half. Remove the flywheel cover and the gasket placed between the casing and the cover.



Fixing screws C of ignition cover D.

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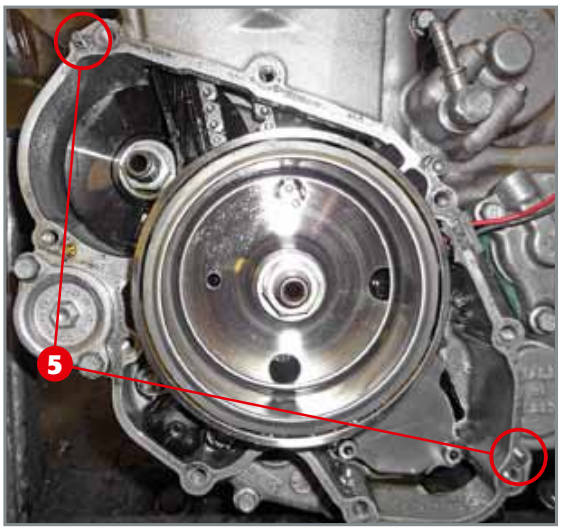
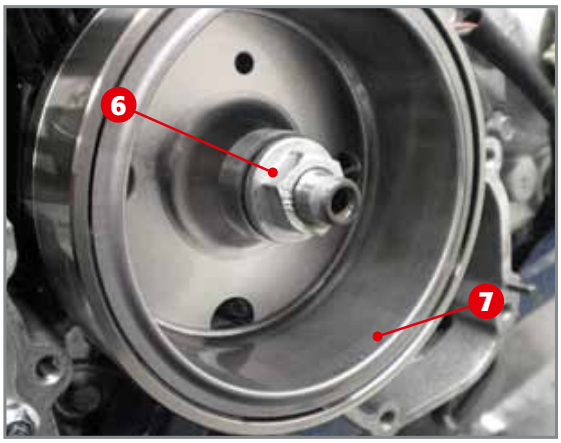


Two centring pins 5 dedicated to the flywheel cover.

Be careful of the two centring pins on the crankcase half.



Nut 6 which fastens the flywheel 7 to the crankshaft.

Remove the tightening nut **6** which fastens the flywheel **7** to the crankshaft.
Once the nut has been unscrewed, pay attention to the special elastic washer (8 shown in the following images) placed between the nut and the flywheel.

Removal of ignition flywheel with relevant extractor A.

To remove the flywheel, screw the relevant extractor **A** *(code 3625173)* onto the threaded segment on the flywheel and, using a box spanner, tighten the screw on the extractor.

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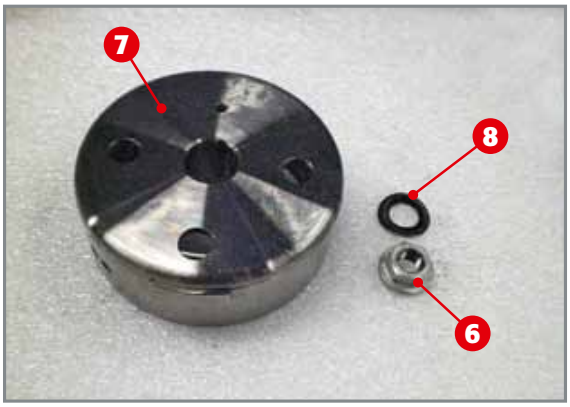
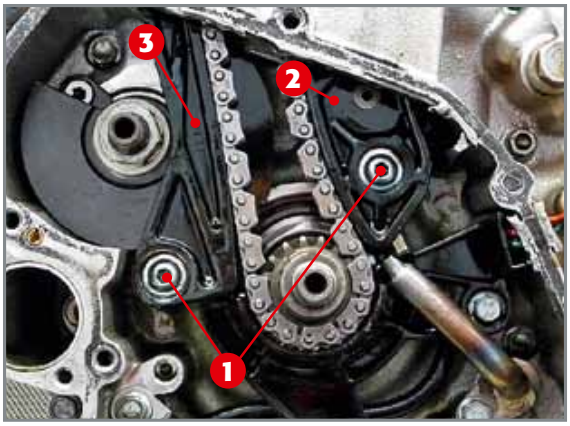


Exploded view of flywheel 7, nut 6 and special elastic washer 8.

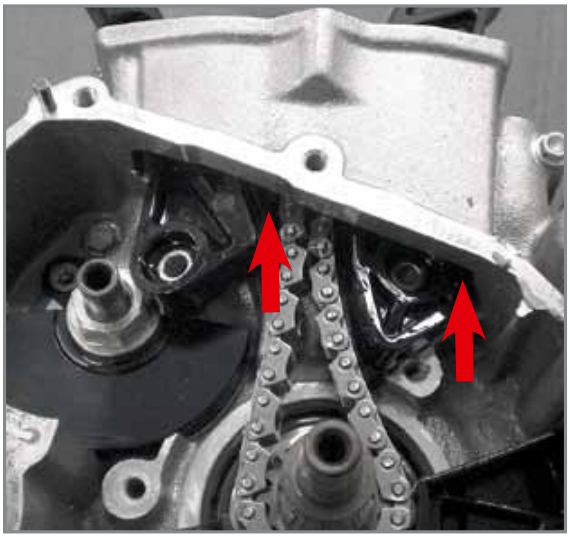
In the image at the side, the flywheel **7** (rear view), the special elastic washer **8** and the tightening nut **6**.



Fixing screws 1 of mobile 2 and fixed pad 3.

1.2.2 TIMING CHAIN AND GUIDES

Remove the fixing screws **1** of the mobile **2** and fixed pad **3**.



Extraction of chain guides.

Extract the two pads, pulling them towards the top part of the engine.

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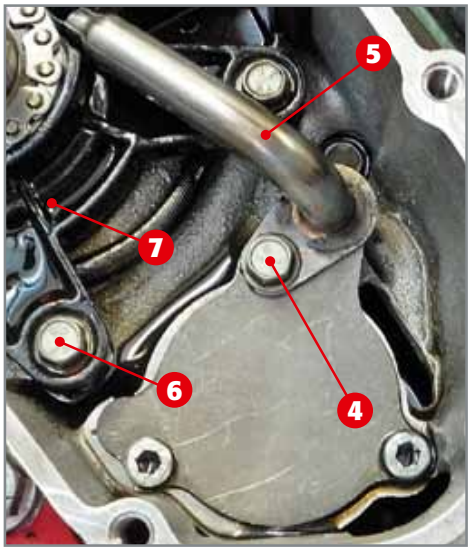
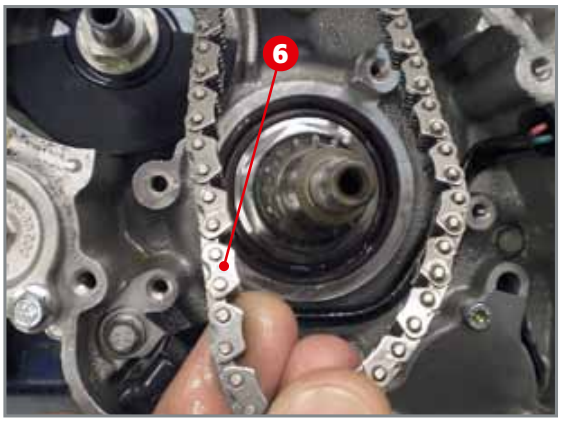


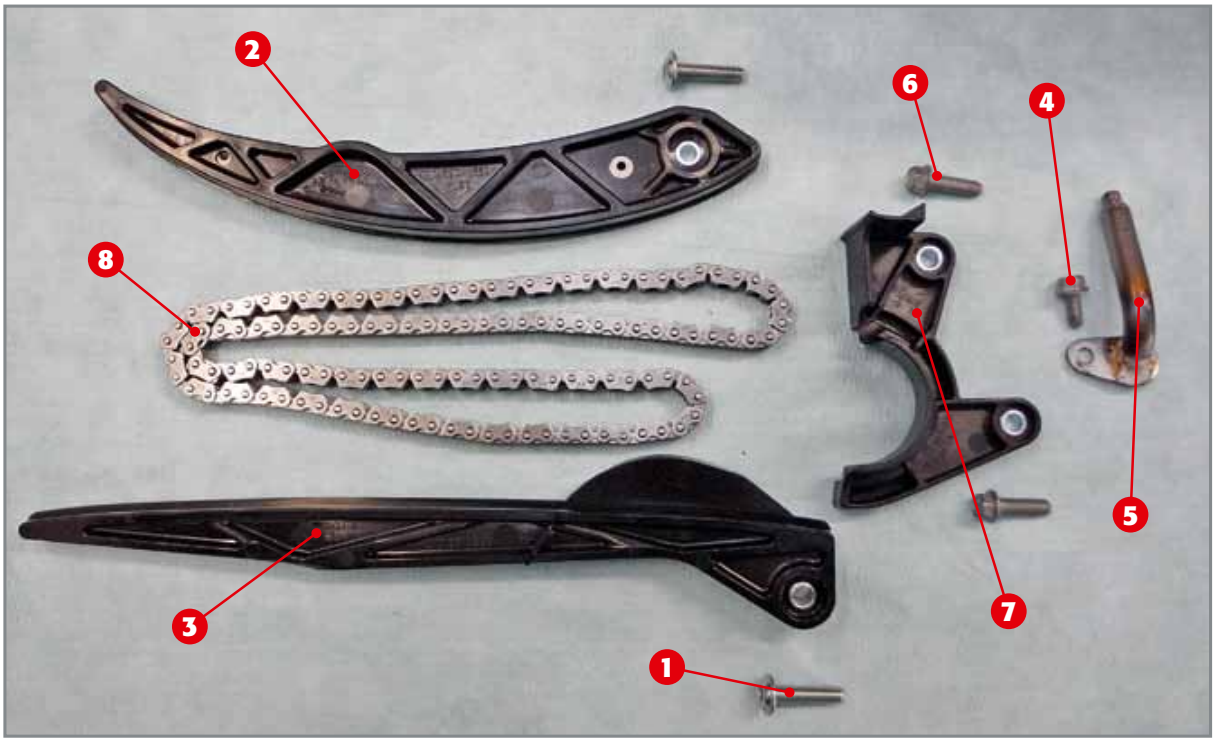
Chain guard and oil jet.

Remove the screw **4** and extract the oil jet **5**. Remove the two screws 6 and then the chain guard **7**.
Pay close attention to the respective bushes while extracting the mobile and fixed pads and the timing chain.



Removal of timing chain.

Pay close attention to the respective bushes while extracting the mobile and fixed guides and the timing chain.



Two pad fixings screws 1; mobile pad 2; fixed pad 3; oil jet fixing screw 4; oil jet 5; chain guard fixings screws 6; chain guard 7; timing chain 8.

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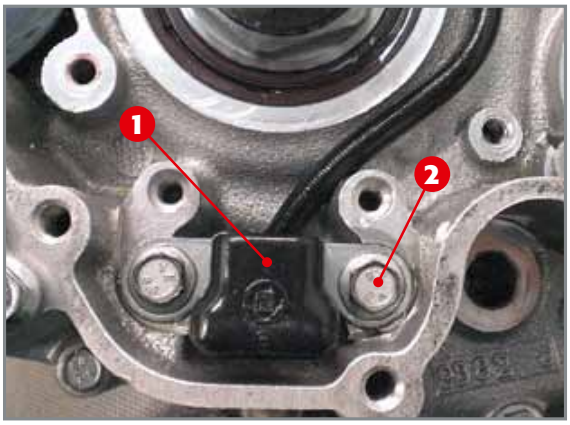
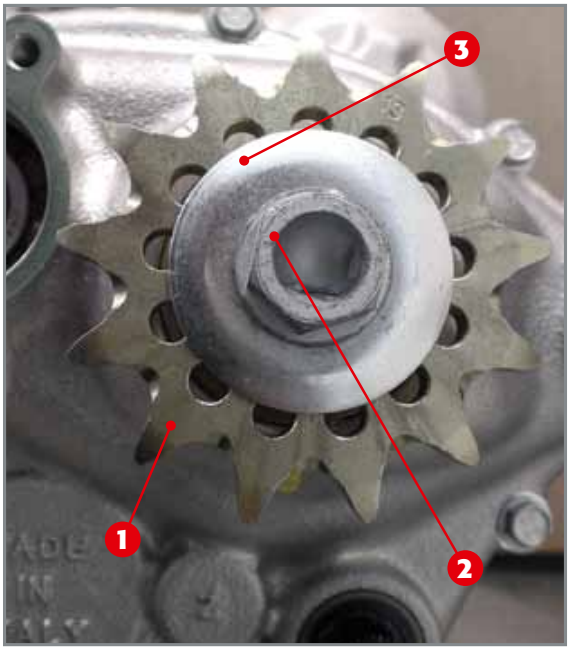


Two screws 2 for fixing pick-up 1.

1.2.3 PICK-UP

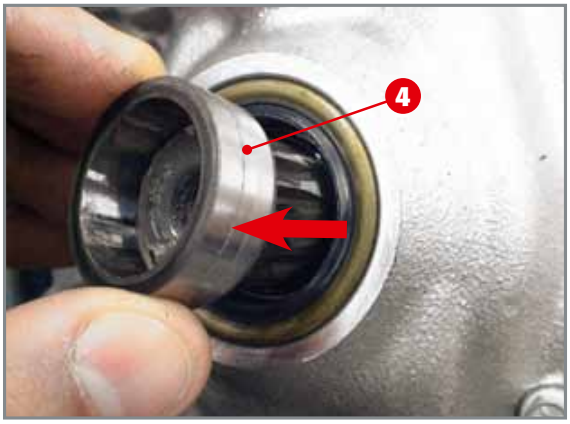
Once the timing chain guard has been removed, the pick-up **1** can be disassembled, by removing the two fixing screws **2**.



Pinion 1, screw 2 and washer 3.

1.3 PINION AND SPACER

In order to remove the pinion **1**, loosen the screw completely **2** and take off the washer **3**.



Pinion spacer 3.

After removing the pinion, pull off the spacer **4**.

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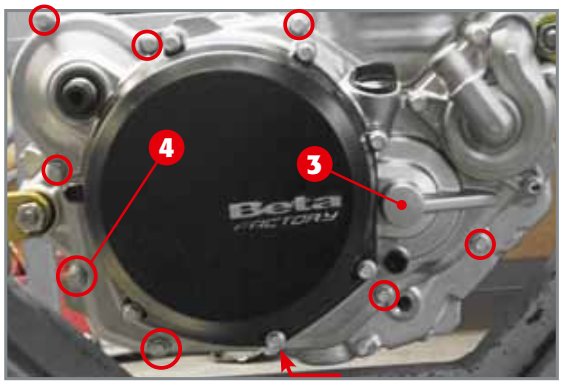
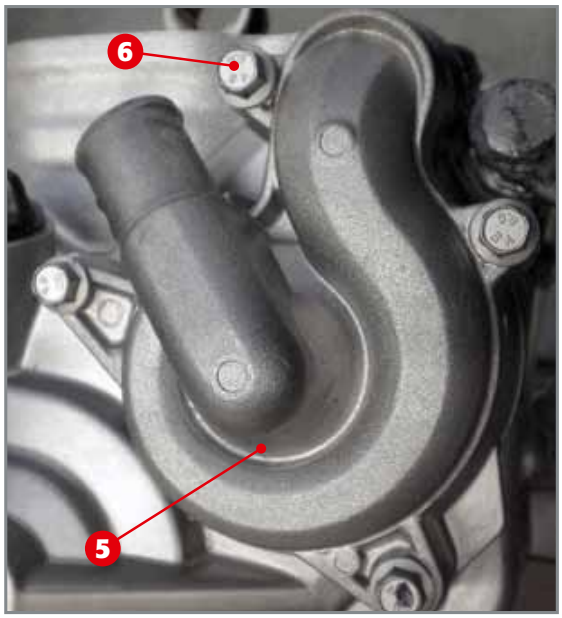
Outer clutch cover 1 and respective screws 2.



Inner clutch cover 3 and respective screws 4.



Pump cover 5 and respective screws 6.

1.4 CLUTCH UNIT AND COOLANT PUMP COVER

In order to access the clutch unit, the outer clutch cover **1** must be removed by loosening the six screws **2**.

On the other hand, when doing a complete overhaul of the clutch unit, of the other elements housed in the outer right side of the crankcase half or of the engine, the inner clutch cover **3** must be removed by loosening the nine screws **4** and the water pump cover **5** loosening the four screws **6**.

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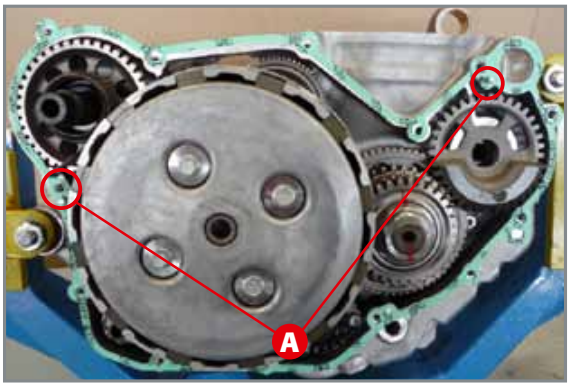
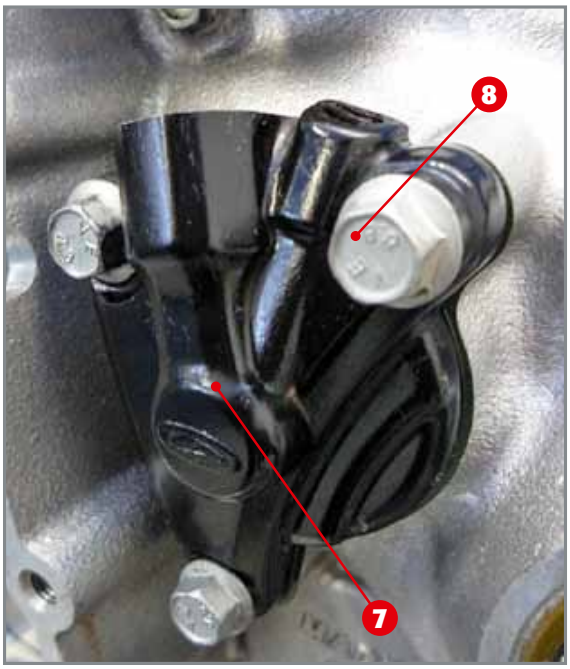


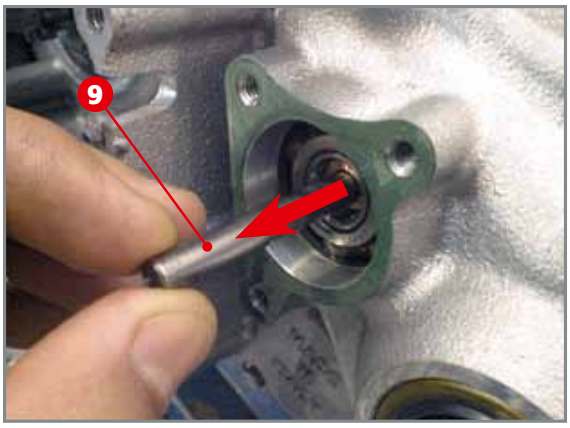
Two centring pins A for cover coupling Inner clutch.

Pay attention to the two reference pins **A** placed between the right crankcase half and the inner clutch cover while disassembling.



Hydraulic actuator 7 and three screws 8 coupling it to crankcase half.

Remove the complete hydraulic actuator **7** -if the tube was disconnect from the actuator- outer left side crankcase half by loosening the three screws 8 which fasten it to the crankcase half. Remove the gasket in between the actuator and the crankcase half.



Extraction of clutch rod 9.

Extract the clutch control rod **9**.

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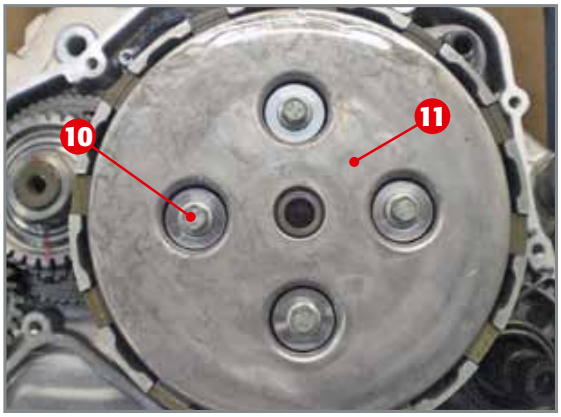
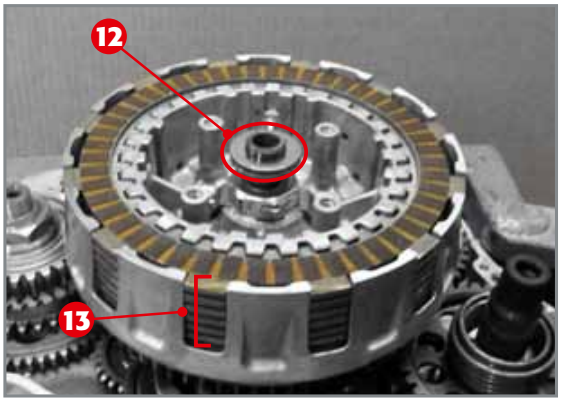


Clutch cap 11 and four screws 10.

Remove the **4** screws **10** which fasten the clutch cap **11** to the inner hub.
Remove the clutch cap together with the four washers and relative springs.

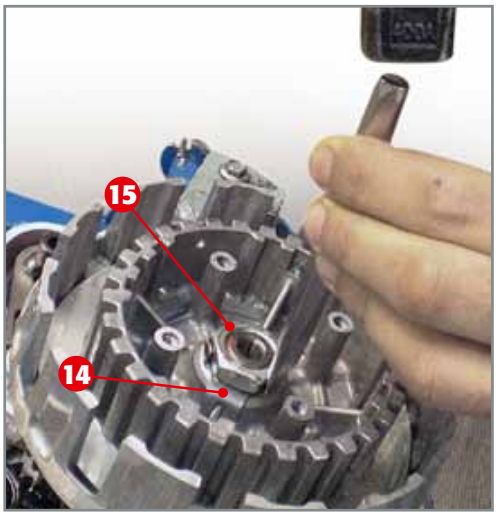


Pressure plate unit 12 and clutch disc pack 13.

Extract the whole pressure plate unit **12** and the clutch disc pack **13**.

Removal of disc spring assembly.

Remove special driven disc and the disc spring assembly.



Opening safety washer with chisel.

In order to complete the disassembly of the clutch unit, open the safety washer **14** using a chisel or similar tool and remove the nut **15**.

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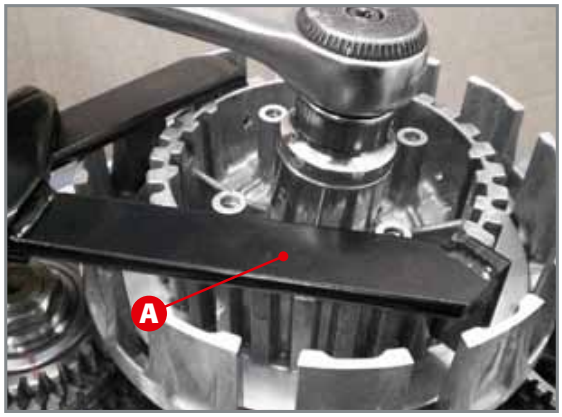
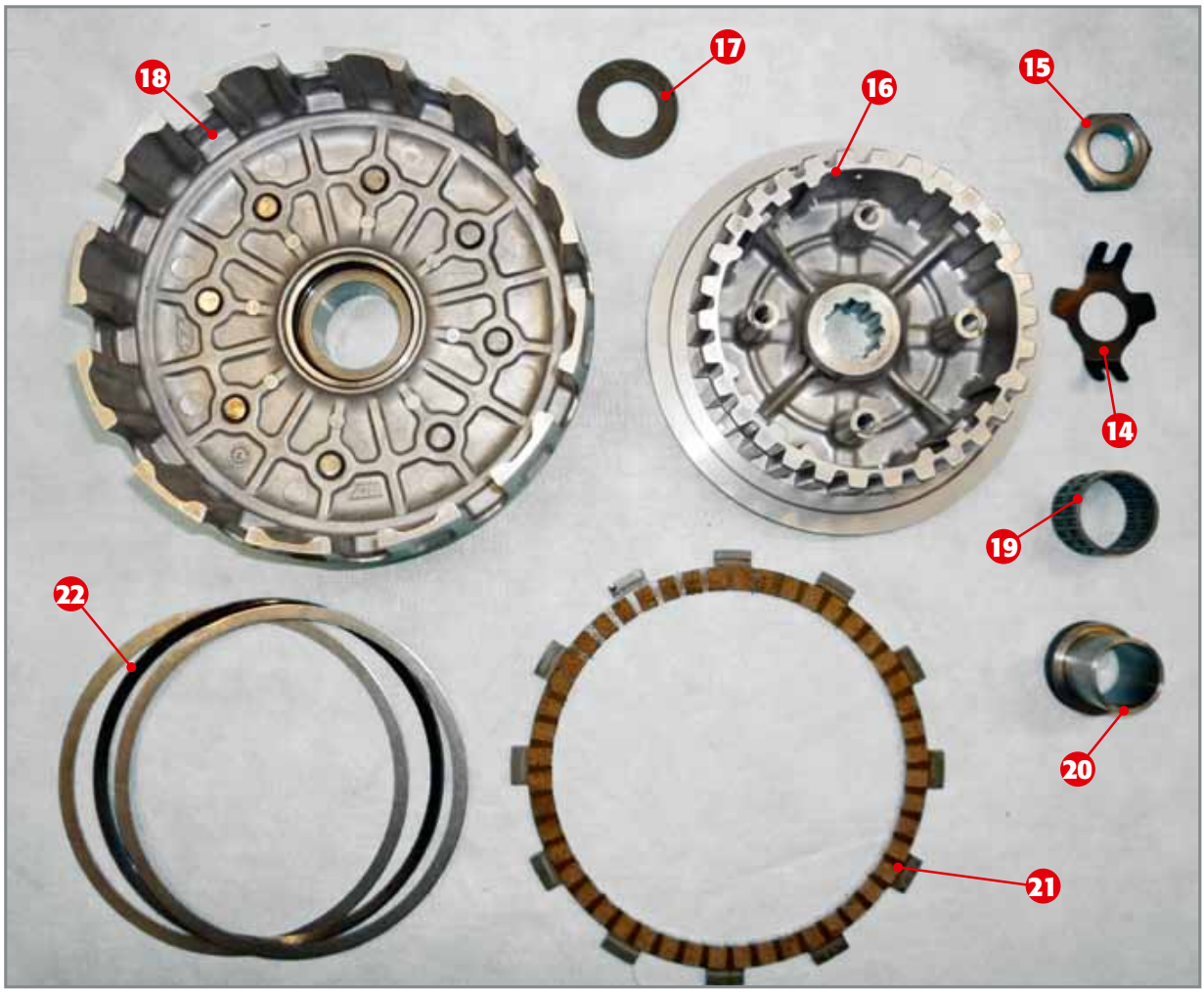


Removal of inner hub nut with relevant tool G.

To unscrew the nut **15**, the inner hub must be blocked with a relevant tool **A** *(code 006140040000)*.
Then remove the nut and relative safety washer.

ATTENTION: *don't use pneumatic wrench*

Extract the inner hub **16**, the washer **17**, the basket **18**, the roller cage **19** and the centre bearing **20**.



Safety washer 14, nut 15, inner hub 16, washer 17, basket 18, roller cage 19 and bush 20, special fiction disc 21, judder spring 22.

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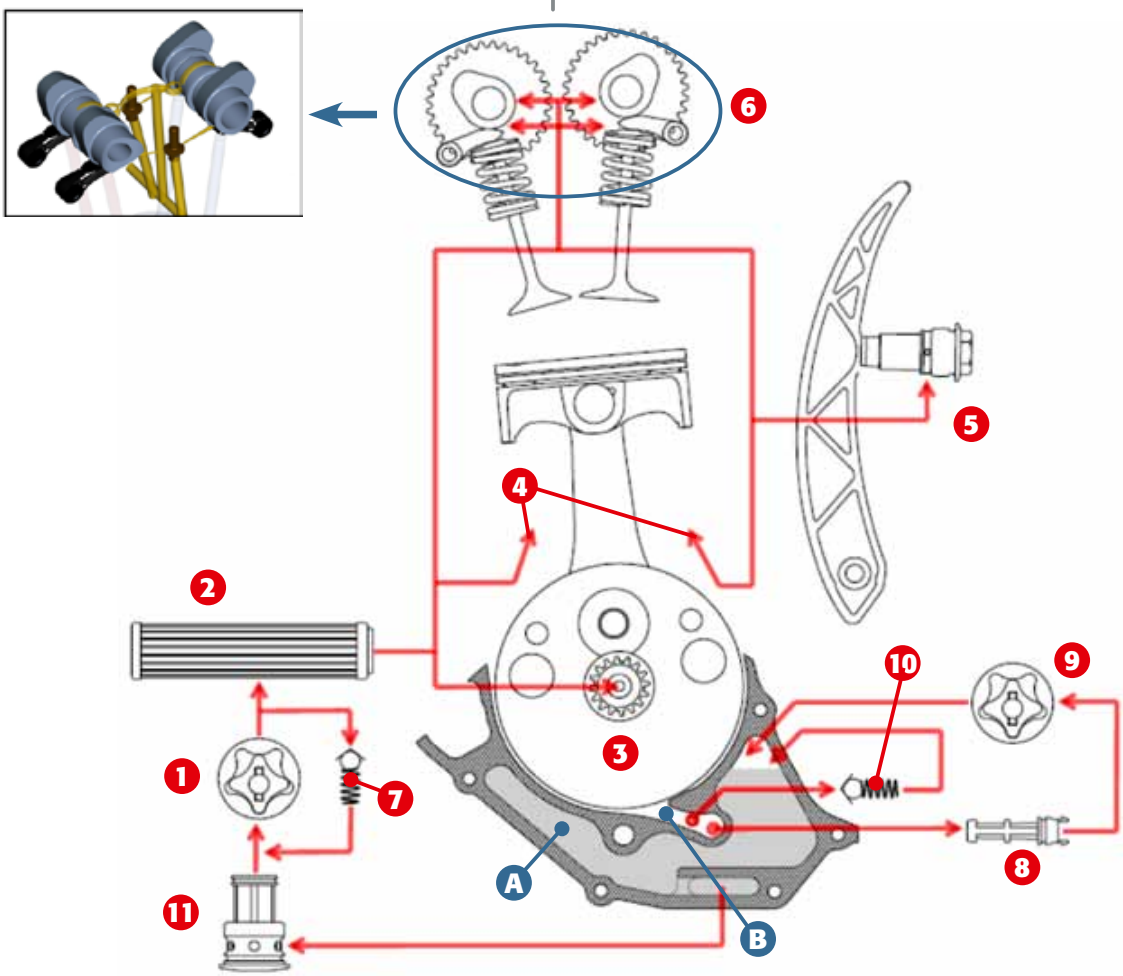
1.5 ENGINE LUBRICATION CIRCUIT

The high-pressure pump (or delivery) **1** - with less displacement - sends the oil purified by the paper filter **2**, to the crank mechanism **3**, to the piston oil jets **4**, to the tensioner **5** and to the cylinder head jets and camshafts* **6**. The valve **7** controls the pressure.
When oil has lubricated the cylinder head and has seeped through the tensioner, it flows along the timing chain to the ignition unit compartment **A**. When oil has lubricated the crank mechanism and the piston-cylinder coupling, it goes to the crank mechanism compartment **B** from which it is sucked by a low-pressure pump (or recovery) **9** - with higher displacement -, passing through the oil filter **8** and sent to the ignition unit compartment **A**. There it is sucked once again by the pump **1** after being filtered through the wire metal filter **11**.
The one-way valve **10** controls the pressure between the external casing on the ignition unit side and the crank mechanism compartment.

ENGINE LUBRICATION CIRCUIT:

1) High-pressure pump;
2) Paper oil filter;
3) Crank mechanism;
4) Piston oil jets;
5) Hydraulic tensioner;
6) Cylinder head oil jets;
7) High-pressure valve;
8) Internal filter;
9) Low-pressure pump;
10) By-pass valve;
11) Wire metal filter;
A) Ignition unit compartment;
B) Crank mechanism compartment.



** Part of the lubricant sent to the cylinder head is used for the hydrodynamic support of the camshafts.*

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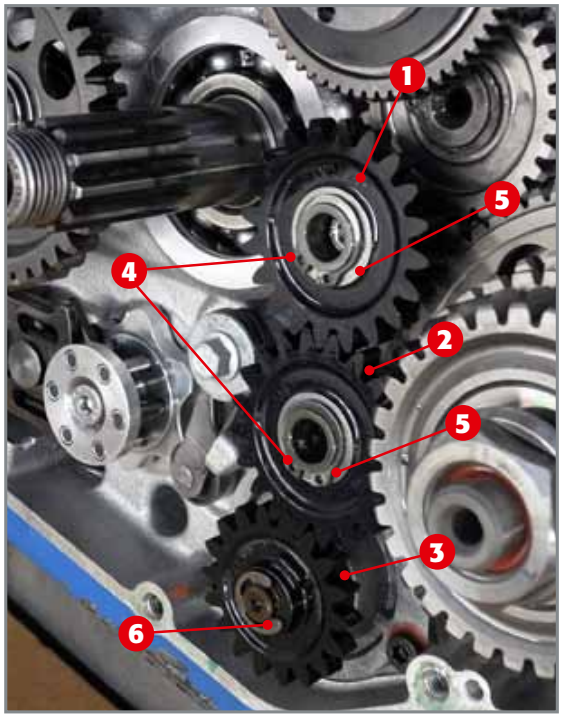
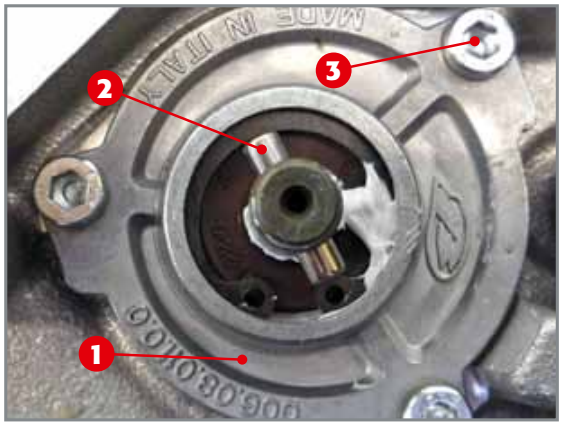


Gear unit for oil pump control.
1) Gear meshing with clutch gear;
2) Idler wheel
3) Oil pumps control gear;
4) Circlip;
5) Thrust washer;
6) Benzing ring

1.5.1 OIL PUMPS CONTROL GEARS

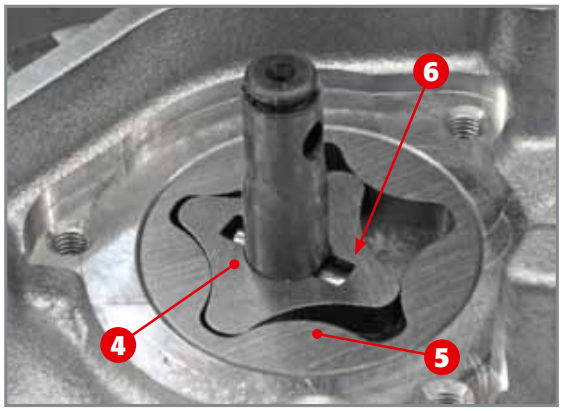
The two oil pumps are controlled by a gear unit driven by the clutch gear.
In detail, the gear **1** meshes with the clutch gear, **2** it is the idler wheel and **3** it is the oil pumps control gear.
In order to disassemble the gears **1** and **2**, the respective circlips **4** and thrust washers **5**.
In order to disassemble the gear **3**, just remove the Benzing ring **6**.



Disassembly of high-pressure pump cover.

1.5.2 HIGH-PRESSURE OIL PUMP

The high-pressure pump, located in the external right-hand side crankcase, is enclosed under the cover **1** which can be disassembled by removing the roller **2** and the three screws **3**.
Having removed the cover, extract the internal rotor **4**, the external rotor **5** and the roller **6**.



High-pressure pump. 4) Internal rotor; 5) External rotor; 6) Roller.

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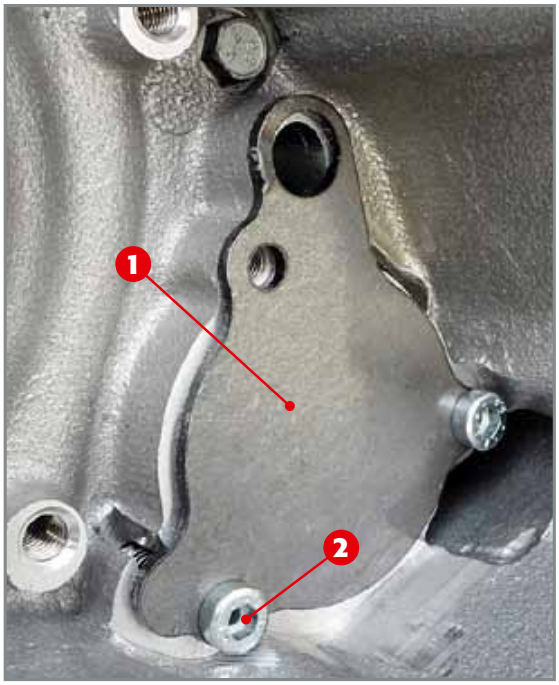
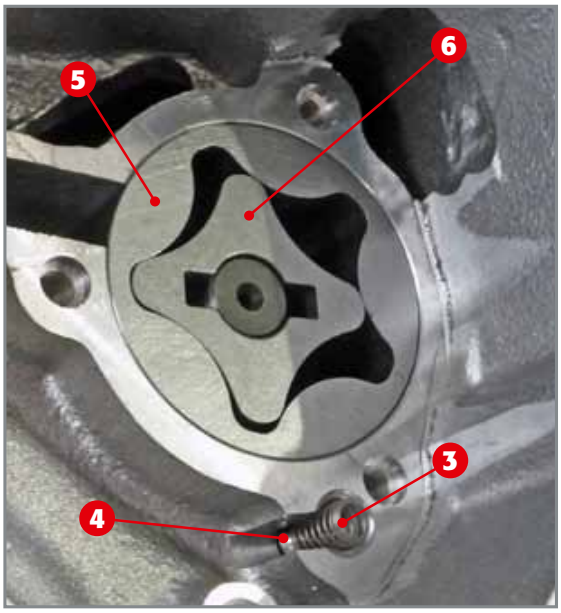
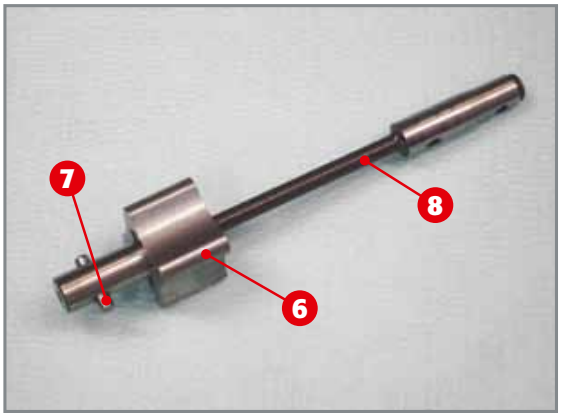


Cover and screws of low-pressure pump.



Low-pressure oil pump and by-pass valve.



Internal rotor 6, roller 7 and drive shaft 8.

1.5.3 LOW-PRESSURE OIL PUMP AND BY-PASS VALVE

The low-pressure pump and the one-way valve are located in the left-hand side crankcase (on the outside) inside the ignition unit compartment. They are enclosed under the cover **1**, which removed by extracting the three screws **2**.

Extract the one-way valve consisting in the spring **3** and the ball **4**.
Then extract the external rotor **5** and the internal rotor **6** together with the roller **7** and the drive shaft **8**.

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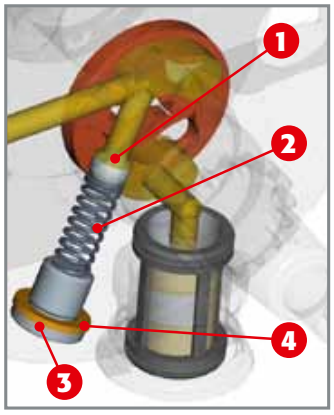
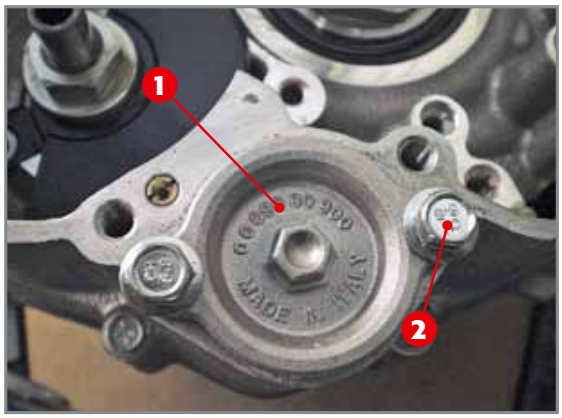
Location of pressure control valve.



Pressure control valve layout.



Paper oil filter cap 1 and relative fixing screws 2.

Extraction of filter with pliers A.

1.5.4 OIL PRESSURE CONTROL VALVE

The pressure control valve is located in the bottom of the right-hand side crankcase near the motor oil drain plug.
The valve consists of the ball **1** and the spring **2** kept in place by the screw **3** and washer **4**.
In order to disassemble the valve, remove the screw, pull out the washer, the spring and the ball.

1.5.5 PAPER OIL FILTER

In order to extract the paper oil filter, remove the cover **1** by loosening the two screws **2** completely. Once the cover has been removed, use a pair of opening pliers **A** to extract the filter.
While extracting the cover, be careful of the specific O-ring applied onto the cover.

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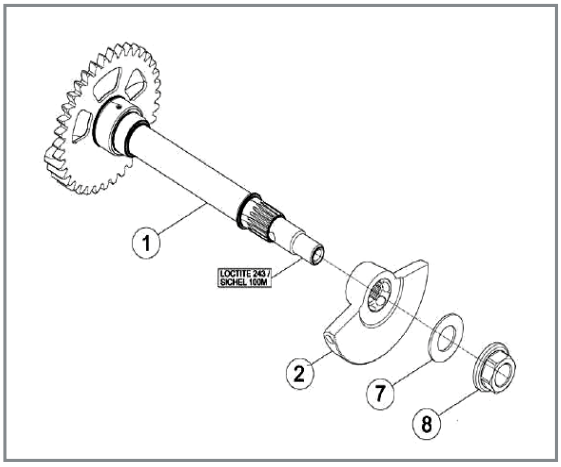

Exploded view of countershaft.
1) Shaft;
2) Counterweight; Elastic washer
8) Nut M12x1

1.6 COUNTERSHAFT

The countershaft has the task of balancing a part of the inertial forces produced by the crank mechanism.
The countershaft is mainly made up of the shaft **1** and counterweight **2**. The elastic washer **7** and nut **8** have the task of assuring coupling of the complete shaft to the base.

ATTENTION: *don't use pneumatic wrench*

Extraction of countershaft.

In order to disassemble the shaft, remove the nut **8** which can be accessed through the ignition unit compartment. Extract the elastic washer **7** and the counterweight.
Pull the countershaft out through the right-hand side crankcase1.

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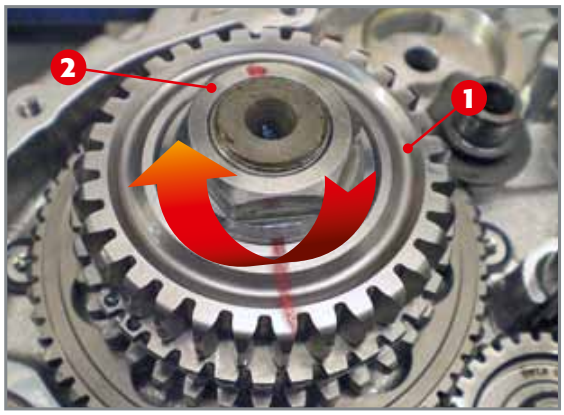
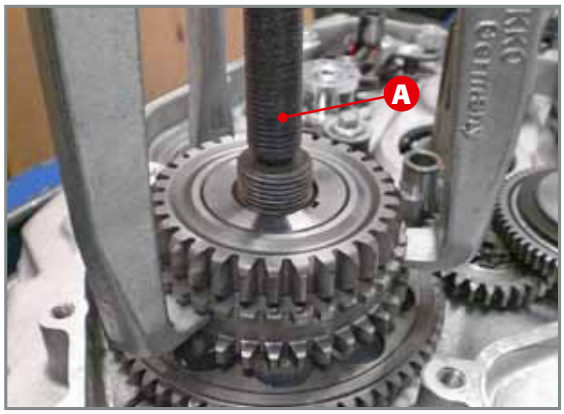


Primary gear 1 and relative nut 2.

1.7 PRIMARY GEAR

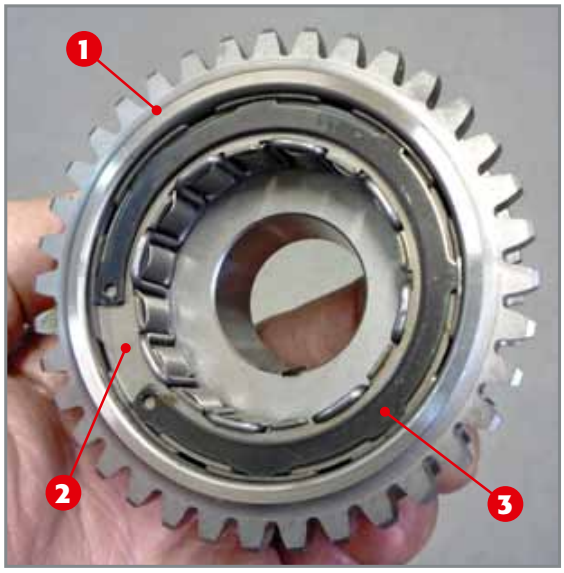
The primary gear **1**, located in the right crankcase, is fastened to the crankshaft. In order to disassemble it, remove the nut **2** which must first be previously heated using a blow-dryer or similar instrument.

ATTENTION!
The nut 1 must be turned clockwise to be unscrewed.



Extraction of primary gear with appropriate extractor A.

Extract the primary gear using the relevant extractor **A** *(code 006140150000)*.



Primary gear 1, complete with free wheel 2 and specific circlip 3.

Notice that the primary gear houses the free wheel device **2** inside of it, which can be removed by taking out the circlip **3**.

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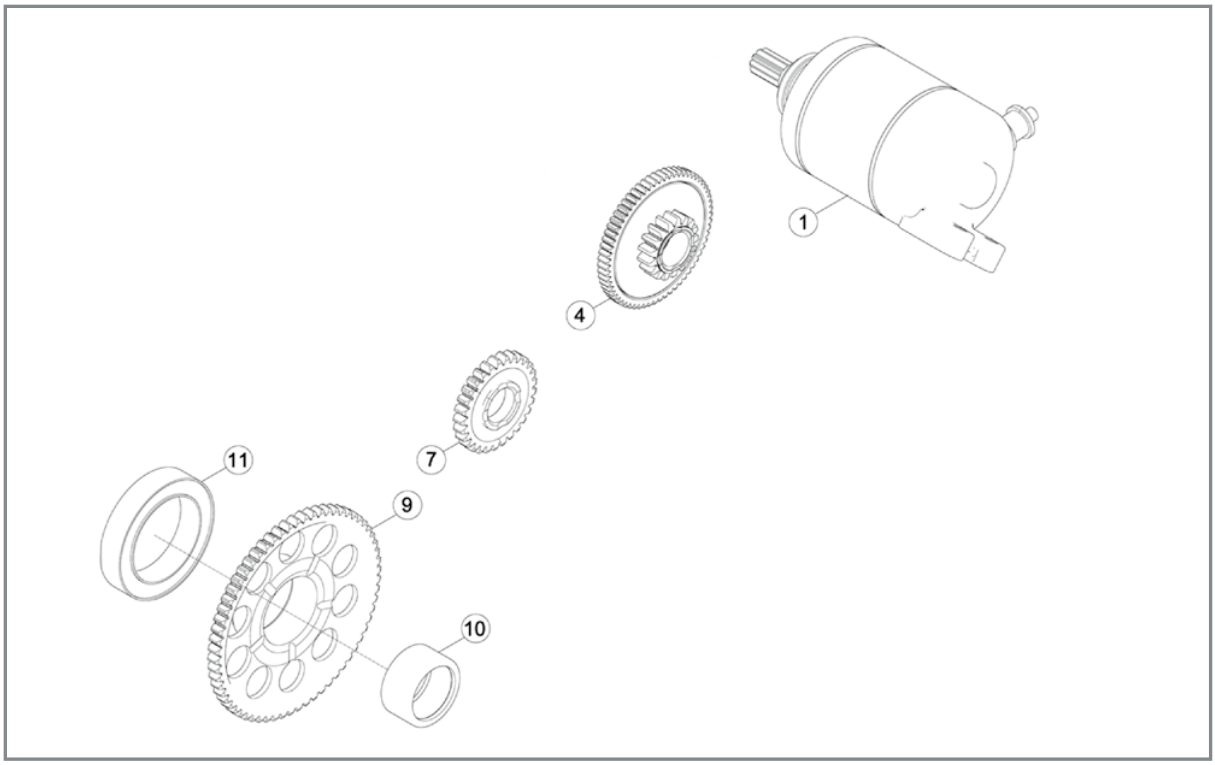
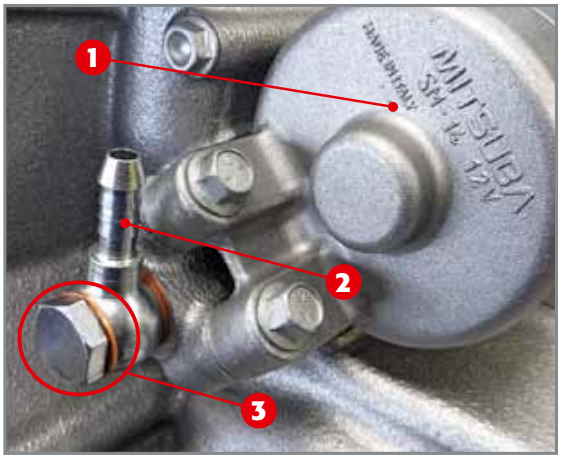
1.8 ELECTRIC IGNITION

Electric ignition can be carried out by means of the start motor **1** which meshes on the gearwheel **4** with the function of torque limiter.
The gearwheel 4 (torque limiter) transmits motion to the idler wheel **7**, which will then mesh with the starter gear **9**.
The roller bearing **10** supports the starter wheel **9**, while the free wheel **11** is internally engaged on the starter wheel **9** and externally on the main gear, thus allowing it, depending on rotation direction, to pull the crankshaft.

EXPLODED VIEW OF ELECTRICAL STARTER.
1) Start motor;
4) Torque limiter;
7) Idler wheel;
9) Ignition gear;
10) Roller bearing HK2516;
11) Free wheel.





Start motor 1 and the gearbox breather nozzle.

1.8.1 START MOTOR

In order to easily disassemble the start motor **1**, the breather nozzle **2** must be removed, by taking off its screw **3** along with the two copper washers.

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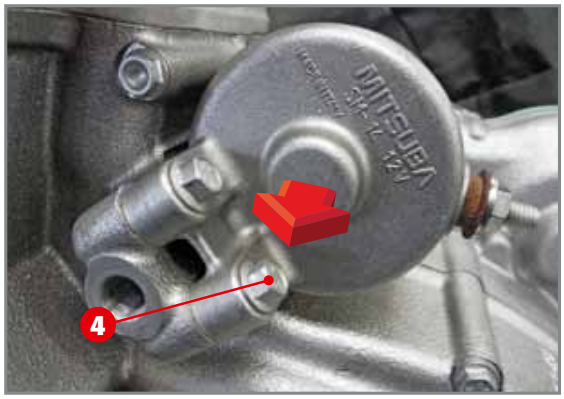
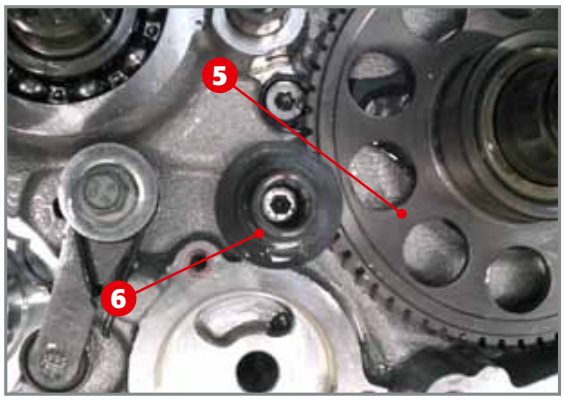


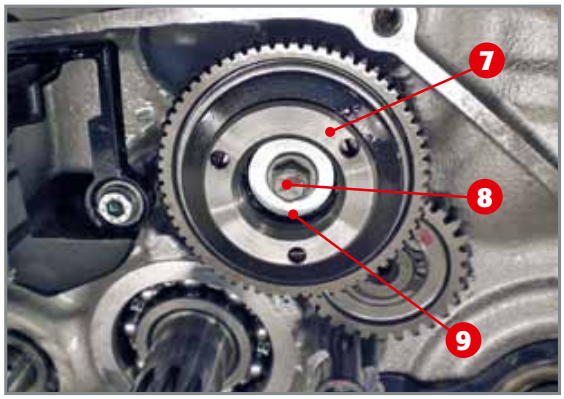
Screws 4 fixing start motor to crankcase.

Remove the two screws **4** which fasten the start motor to the crankcase and pull out the start motor.



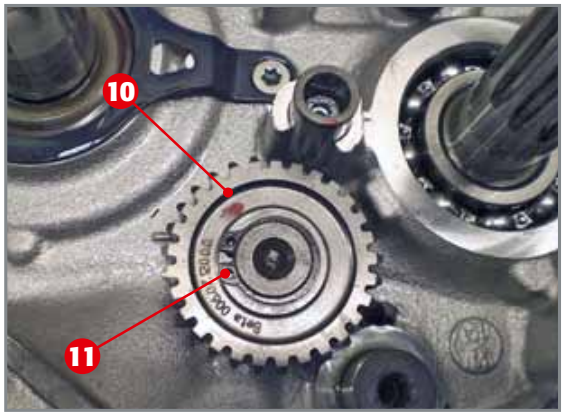
Removal of pin 6.

In order to extract the kick-start gear **5**, disassemble the primary gear (see par. 1.7) and the pin **6** which supports the idler wheel for oil pump control (see par. 1.5.1). The kickstart gear is pulled out by hand.



Torque limiter 8, screw 7 and washer 9.

In order to disassemble the torque limiter **7**, completely loosen the screw **8** which fastens the torque limiter to the crankcase. Pull out the washer **9** together with the limiter itself.



Idler wheel 10 of electrical ignition device.

In order to remove the idler wheel **10**, just remove the circlip **11** and pull the gear off.

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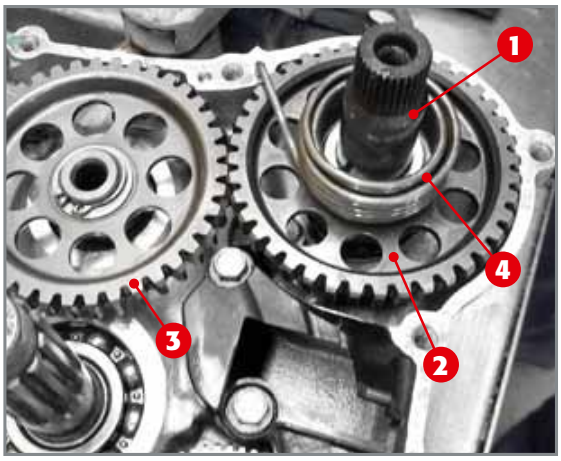
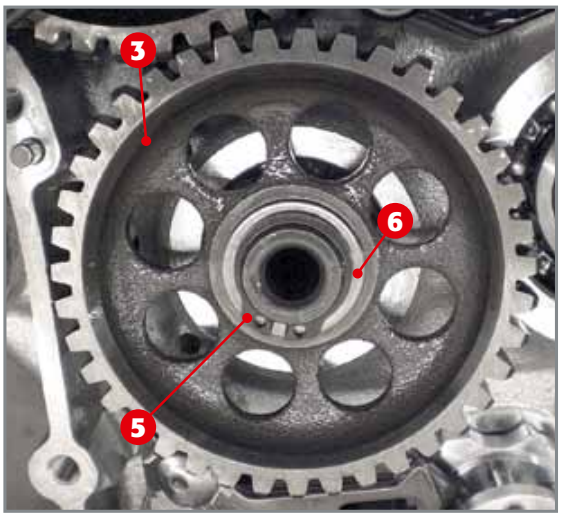
1.9 KICKSTARTER



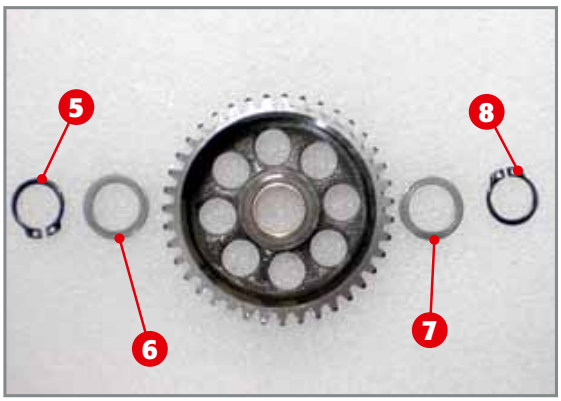
Kickstarter mechanism.

The kickstarter is made up of the pedal which, attached to the kickstarter shaft **1**, moves the kickstarter gear **2**. This gear moves the idler wheel **3** which then meshes with the clutch gear.
The device moves back thanks to the spring **4**.



Removal of circlip 5 of idler gear 3.

Remove the external circlip **5** and pull off the external thrust washer **6**, the idler gear **3**, the internal thrust washer **7** and the second circlip **8**. The circlips and thrust washers are interchangeable.



Two circlips 5 and 8 and thrust washers 6 and 7.

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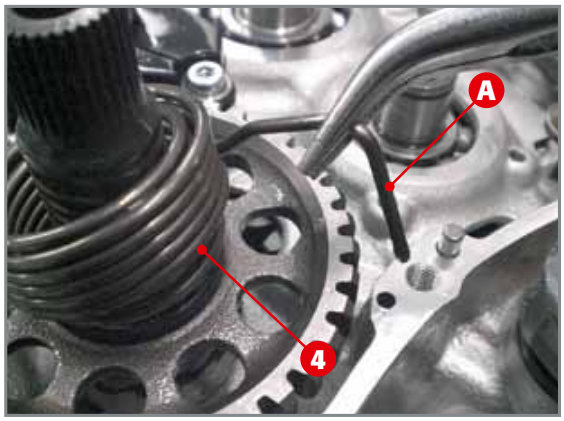
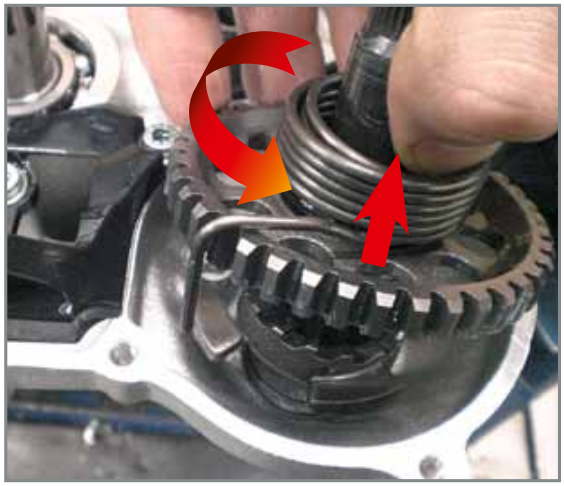


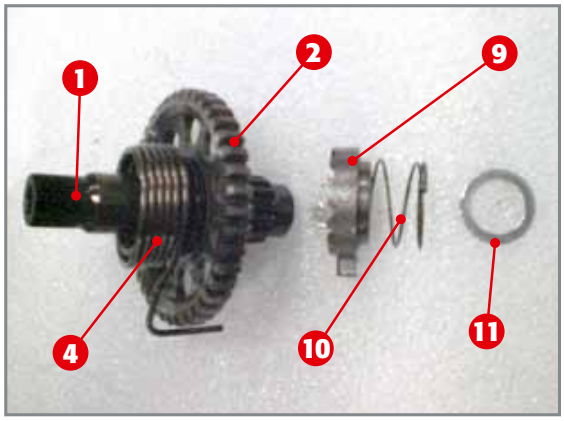
Releasing spring from crankcase.

Using a pair of pliers, pull the end **A** of the spring **4** from the hole on the crankcase and bring it to a rest position having it turn anti-clockwise.



Extraction of shaft from crankcase.

Turn the shaft anti-clockwise and pull it off together with the sleeve **9**, the spring **10** and the thrust washer **11**.



Complete manual kickstart shaft.

Note: *Be careful of the reference pins for centring the inner clutch cover (par. 1.4)*

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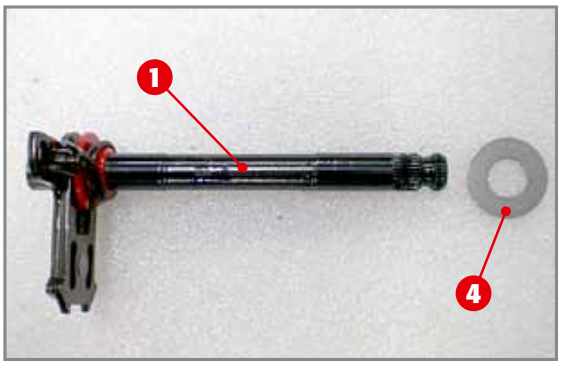
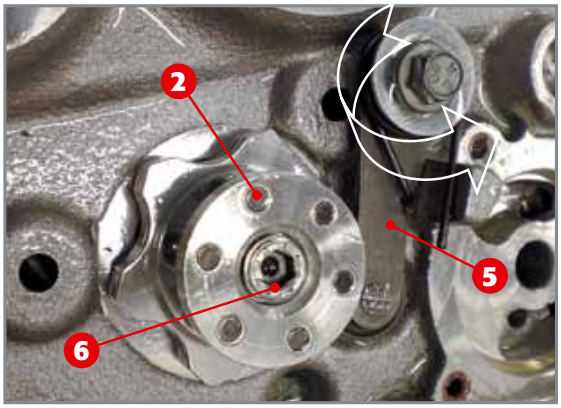
1.10 EXTERNAL GEARSHIFT UNIT

Disassembly of drive shaft.

The external gearshift is made up of the drive shaft **1** upon which the movable and fixed pawls are applied. The fixed pawl constitutes the drive of the movable pawl which then has the task of engaging the stop cam **2**. This in its turn is fastened to the internal gearshift and is kept in the fixed position by the cam stop lever.
In order to disassemble the drive shaft, just keep the movable pawl return spring **3** pressed and extract the shaft together with specific washer **4**.

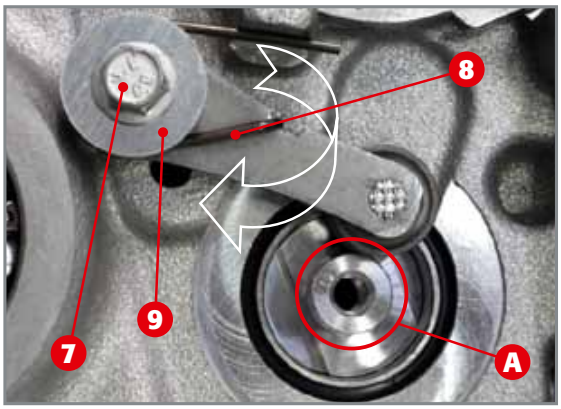


Gearshift with washer.



Disassembly of stop cam.

In order to disassemble the stop cam **2**, keep the cam stop lever moved **5**, loosen the screw **6** and pull out the stop cam.



Disassembly of cam stop lever.

In order to disassemble the stop lever, loosen the screw **7** enough to allow the lever to move axially and overcome the cylinder segment **A** of the desmodromic device. Bring the return spring **8** to the rest position and remove the screw, the washer **9**, the spring together with the spacer (not shown in the image) and finally the cam stop lever.

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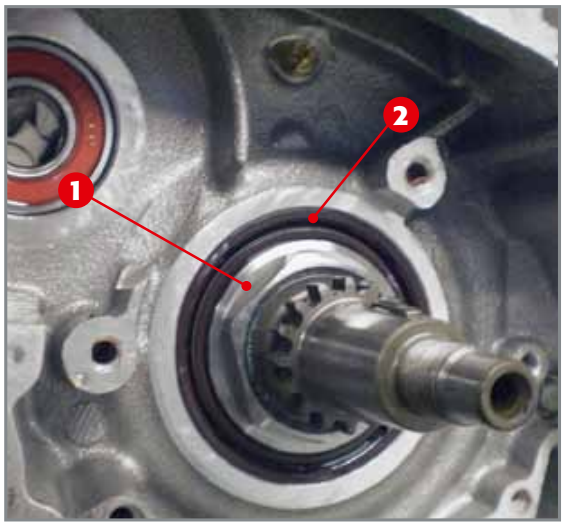
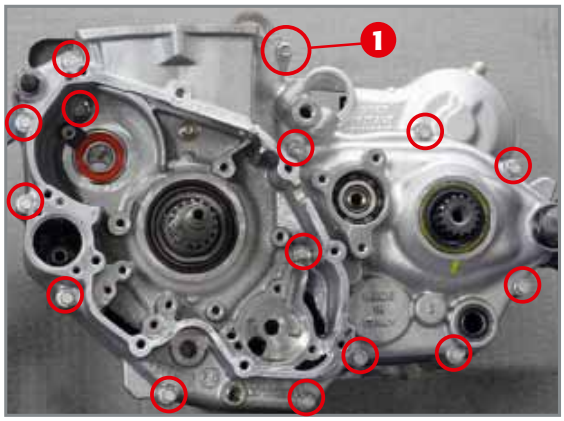


Nut B blocking crankshaft.

Removal of crankshaft nut with special socket wrench A.



Crankcase blocking screws 1.

1.11 CRANKSHAFT, GEARBOX UNIT AND INTERNAL GEARSHIFT

To access the crankshaft, gearbox unit and internal gearshift, the left and right crankcases must be detached. Here are the needed instructions.

1.11.1 NUT ON LEFT SIDE OF CRANKSHAFT

In order to loosen the nut **1** on the left-hand side of the crankshaft, heat it with a blow-dryer or similar instrument. Then loosen the nut with a special socket wrench **A** *(code 006140020000)* and remove it.

> ***ATTENTION**: When re-assembling, the oil seal must be replaced2 since the heating required for disassembly damages it.*

1.11.2 OPENING CRANKCASE

Remove the **15** screws **1** which close the crankcase.

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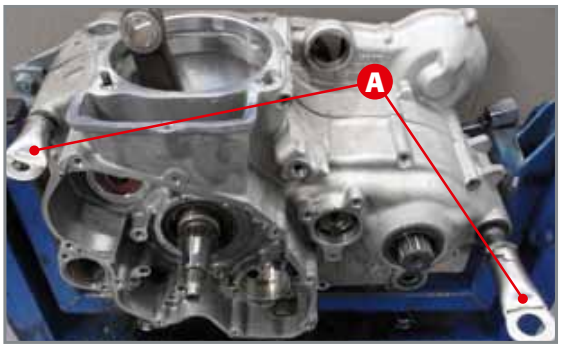
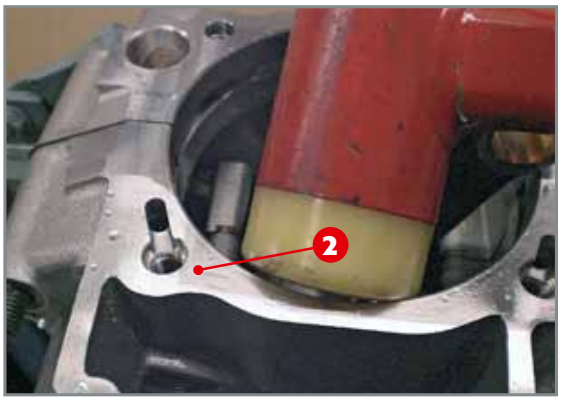


Two screws A blocking engine to engine support stand.

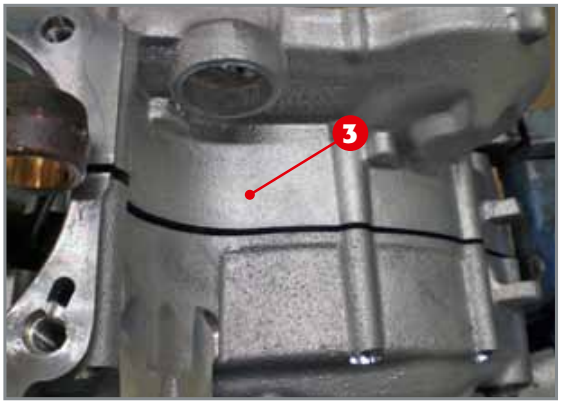
Loosen the two screws **A** which fasten the engine to the support stand.



Disassembly of crankcase.

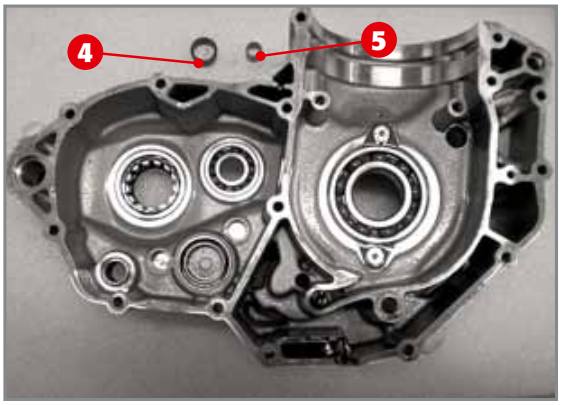
Hit the left crankcase half **2** lightly with a rubber or plastic hammer until it detaches from the right crankcase half **3**. Remove the two screws blocking the engine to the equipment and disassemble the crankcase by hand.

> ***ATTENTION:*** *The gearbox unit and the crankshaft must remain inside the right crankcase half.*



Detaching crankcase halves.

Remove the back **4** and front reference bushes **5** to position the crankcase correctly. Remove the gasket between the two crankcase halves.



The left crankcase half (inside) with references pins 4 and 5.

The right crankcase half (inside) with crankshaft and gearbox unit.

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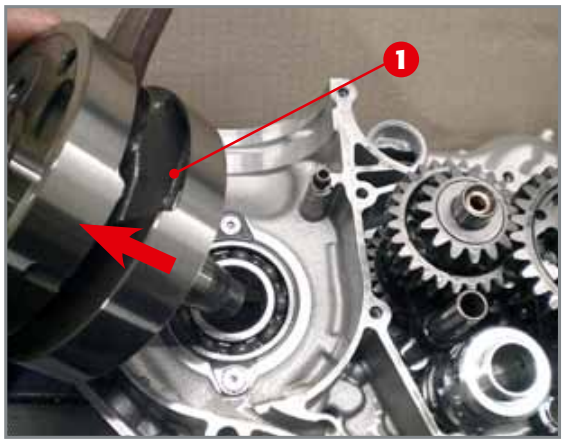
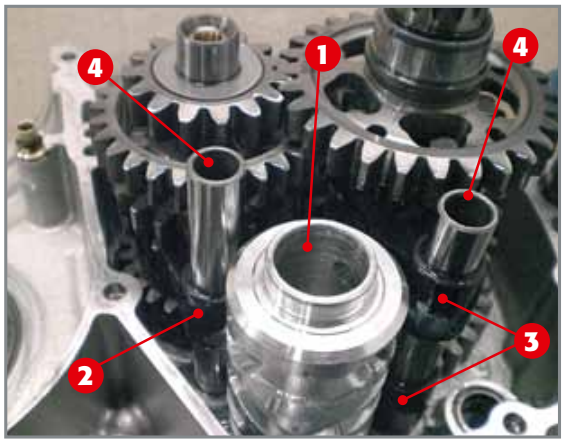


Extraction of crankshaft.

1.11.3 CRANKSHAFT

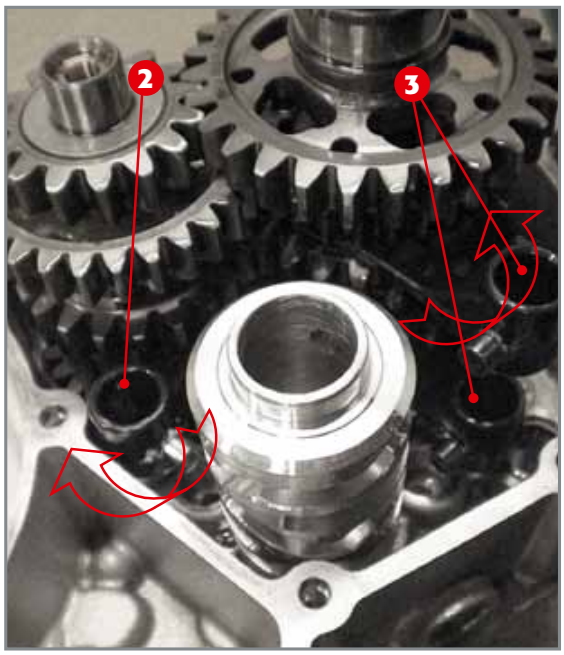
The crankshaft **1** can be pulled out by hand. Should there be resistance, tap the right end of the crankshaft lightly with a plastic or rubber hammer.



Removal of fork support pins 4.

1.11.4 INTERNAL GEARSHIFT UNIT AND COMPLETE GEARBOX

The internal gearshift unit is made up of the desmodromic device **1** upon which the fork **2** and two forks **3** are engaged. The forks, supported by the pins **4**, drive the sliding wheels of the gearbox, allowing engagement of the desired ratio. The desmodromic device is controlled by the stop cam present in the external gearshift unit (par.1.10)
Extract the two pins **4** by hand so that the forks can be released and removed.



Disengagement of control forks from desmodromic device.

Turn the fork **2** which drives the sliding gear on the primary unit clockwise, to free it from the desmodromic control.
Do the same operation, though in the opposite direction, on the forks **3** driving the sliding gears on the secondary shaft.
Extract the desmodromic device.

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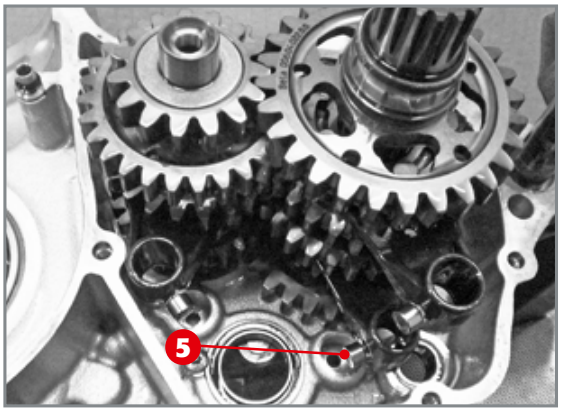
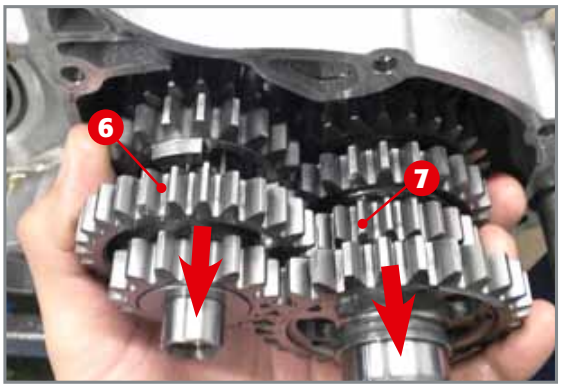


Extraction of forks from gearbox unit.

Extract the forks together with the drive bushes **5**.



Extraction of complete gearbox unit: 6 primary unit, 7 Secondary unit.

Proceed to extract the complete gearbox unit including the primary **6** and secondary unit **7**.

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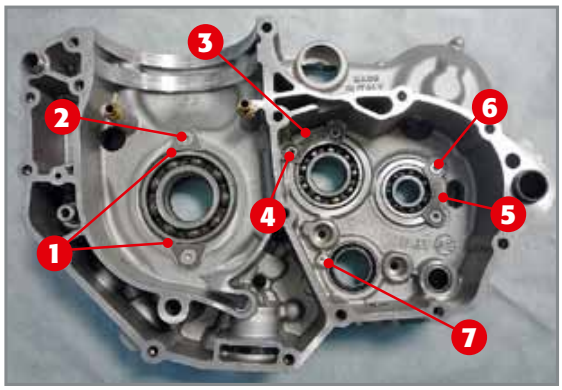
1.12 DISASSEMBLY OF PARTS FROM CRANKCASES

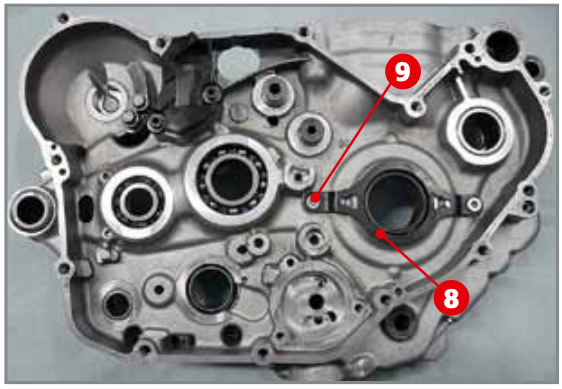
Once the crankcases have been detached, it is necessary to remove the various components attached to it.
The correct positioning of some bearings applied to the crankcase halves is ensured by locking devices such as plates or simple screws. In order to disassembly these bearings, the safety devices must be disassembled as well.

1.12.1 RIGHT CRANKCASE HALF



Safety devices present on the inside of the right crankcase half.

On the inside, the plates **1** are those which assure the correct positioning of the support bearing of the crankshaft. All you need to do is remove the two screws **2** to disassemble them.
The plate **3** is the one relative to the mainshaft support bearing of the gearbox. It can be disassembled by removing the two screws **4**.
The plate **5** holds the bearing of the secondary shaft of the gearbox in place. It can be disassembled by removing the two screws **6**.
The screw 7holds the support bearing of the desmodromic device in place.



The oil seal blocking plate **8** is applied on the outside. It can be removed by taking off the two screws **9**.

1.12.1.1 PISTON OIL JETS

Location of piston oil jets.

It is recommended to remove the piston oil jets **1** and relative O-rings in order to check and clean the lubrication circuit.
The oil jets are located inside of the right crankcase half.

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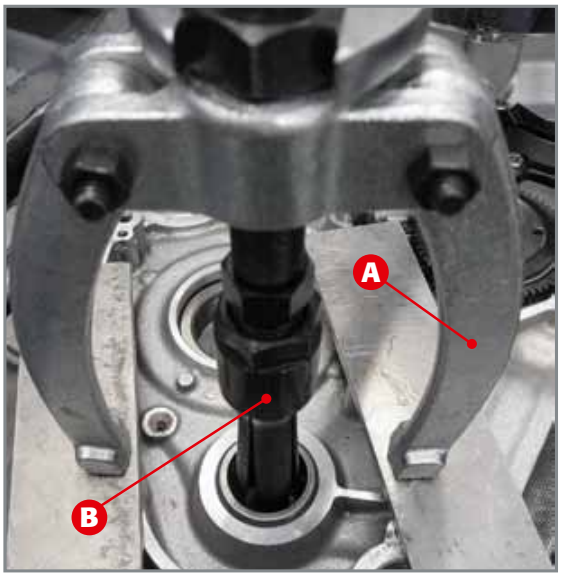
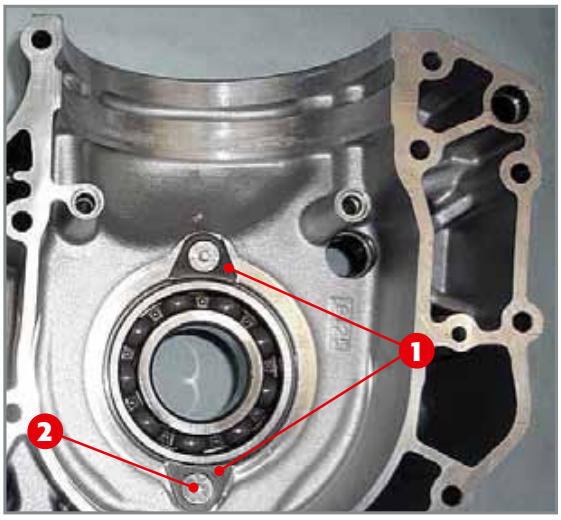


Extraction of countershaft bearing.

1.12.1.2 EXTRACTION OF COUNTERSHAFT SUPPORT BEARING

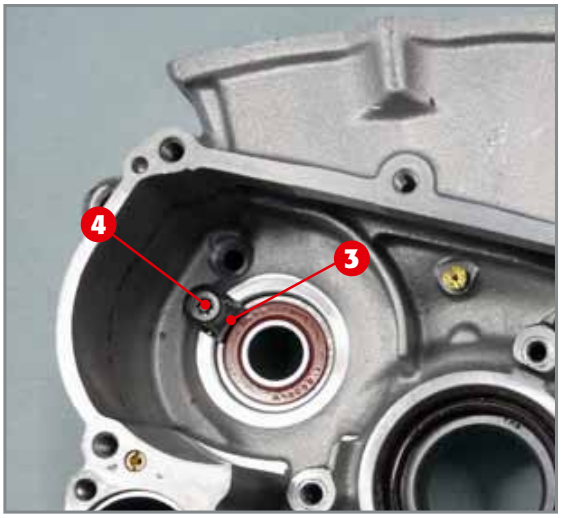
To extract the countershaft bearing, use the extractor **A** *(code 3625081)* together with extractor **B** *(code 006140160000)*. It is recommended to apply the two aluminium plates to be placed between the legs of the extractor and the crankcase half.



Inside safety plates of left crankshaft half.

1.12.2 LEFT CRANKCASE HALF

Three safety plates are present on the left crankcase half. Two are applied on the inside and one on the outside.
The plates **1** on the inside are the ones relative to the crankshaft support bearing of the gearbox. They can be disassembled by removing the two screws **2**.



Outside safety plate of left crankshaft half countershaft.

The plate **3** is the one relative to the bearing which supports the countershaft. It can be disassembled by removing the screw **4**.

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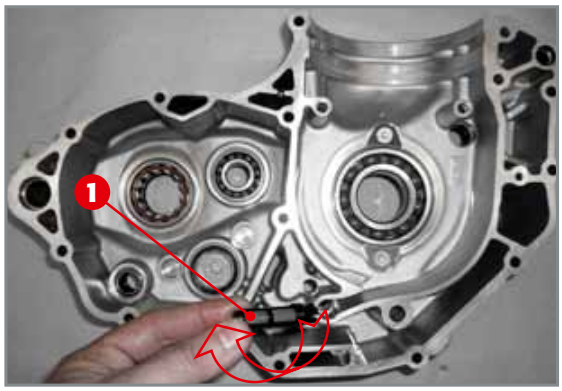
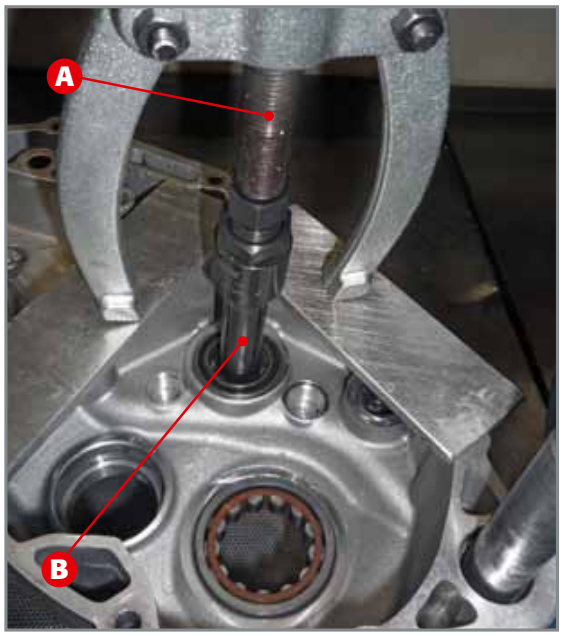


Disassembly of inner filter.

Removal from low pressure oil pump side.

1.12.2.1 INNER OIL FILTER

The inner oil filter **1** must be pulled out from the inside of the left crankcase. Its removal can be aided by using a soft pin to push it from the outside towards the inside, tapping with a small hammer.



Extraction of desmodromic device bearing.

1.12.2.2 EXTRACTION OF DESMODROMIC DEVICE BEARING

Removal of bearing dedicated to the device present inside left crankcase half.
Its removal entails use of the extractor **A** *(code 3625081)* together with extractor **B** *(code 006140160000)*.
To carry out this operation, it is recommended to apply two aluminium plates between the legs of the extractor and the crankcase half.

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Before reassembling the engine, a series of important controls must be carried out to ensure correct functioning of the engine. The bearings must be replaced if they play or get jammed during rotation. It is however recommended to refer to the periodical maintenance table.
In order to insert the bearings in the crankcase halves, bring the crankcase halves to a temperature of 150°C and keep them at that temperature for 20 minutes.
Place the crankcase halves on a large surface where their whole seal surface can rest. When the bearings cool off, they drop into their seats on their own.

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EXPLODED VIEW OF ENGINE CRANKCASE HALF

1) Complete engine block;
4) Crankcase gasket;
5) Back reference bush;
6) Front reference bush;
7) Bush 17x21x19;
8) Inner oil filter;
9) O-ring;
15 Piston oil jet;
16) O-ring;
17) Lubrication jet;
18) Lubrication jet;
19) Centring pin;
20) Centring pin;
21) Cap;
22) Cap;
23) Plate;
24) Screw M5x10;
30) Screw M5x10;
31) Bush;
32) Oil incline; Copper gasket;
34) Gearbox oil vapour breather fitting;
35) Fitting screw;
37) Copper washer;
38) Oil pressure control valve screw;
39) Cable gland.

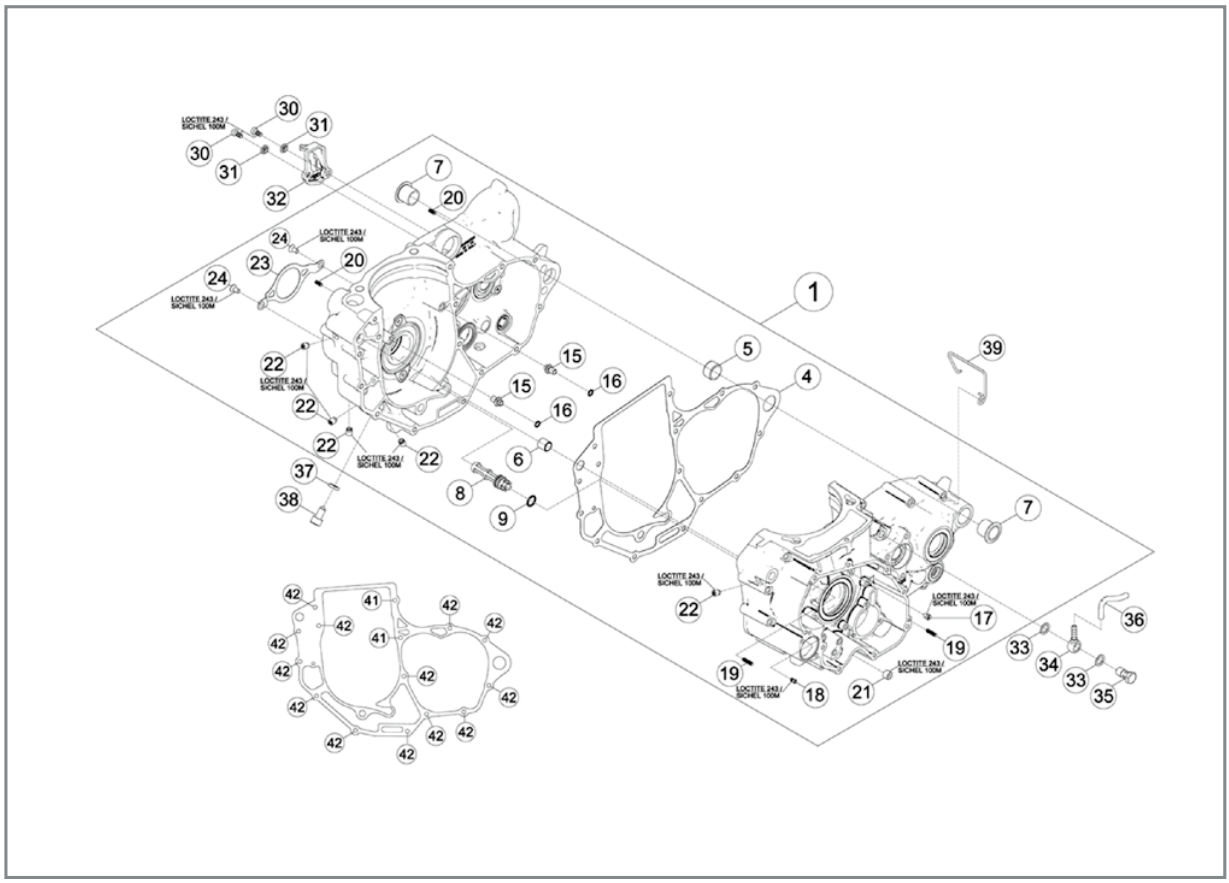
2.1 CRANKCASE HALVES

The crankcase halves have some elements that need to have their integrity and use status checked. Hereafter the controls and assembly operations of the individual elements coupled to the crankcase halves will be described. Clean the threading and oil passages thoroughly using a degreaser and compressed air.

ATTENTION! *It is absolutely necessary to replace the crankshaft oil seals present on the outside of the left and right crankcase halves. This is due to the extreme heating they undergo when being disassembled.*

In general, the crankcase halves must be replaced when:

- the oil pump crankcases show scratches or meshing signs (see their location in detail);
- once the new bearings are inserted and the crankcase half is left to cool off, they do not fit into their seats.



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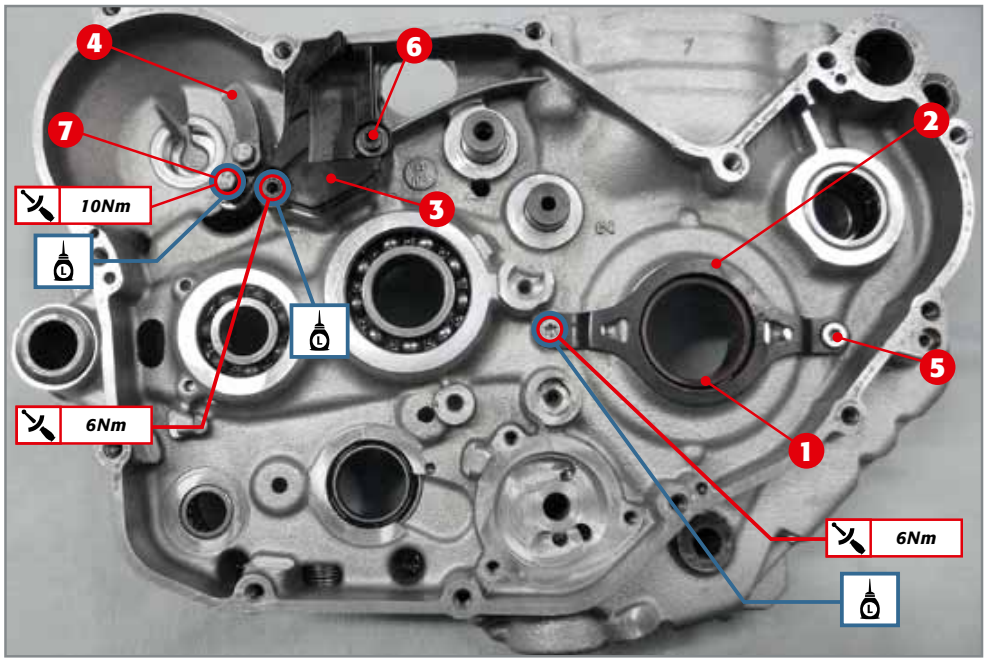
2.1.1 EXTERNAL RIGHT SIDE

Pull out the crankshaft oil seal **1** and replace it. Check that the oil seal fixing plate **2** is not bent. If so, have it replaced.
Control the integrity of the oil incline **3**. Should it be worn, have it replaced.
Check the state of use of the kickstart ramp **4**. It must be replaced if it shows signs of meshing or chipping.
The table below contains indications for fixing the screws of the above-mentioned elements.

Screw number	Screw dimensions		Threadlocker application	Tightening torque [Nm]
	Threading diameter [mm]	Threading length [mm]		
5	M5	10	Loctite 243/ Sichel 100M	6
6	M5	10	Loctite 243/ Sichel 100M	6
7	M6	20	Loctite 243/ Sichel 100M	10
29	M6	20	Loctite 243/ Sichel 100M	10



Elements present on outside right crankcase half.

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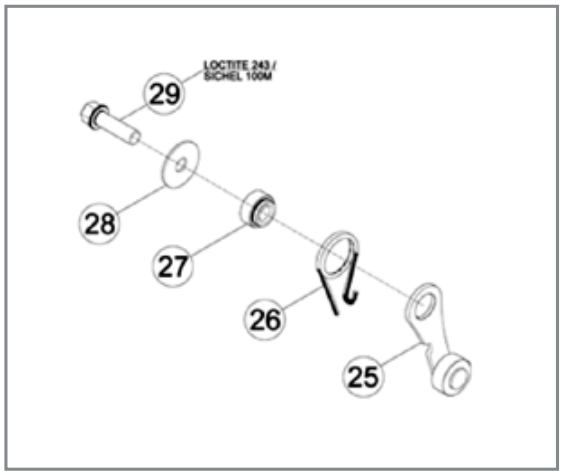
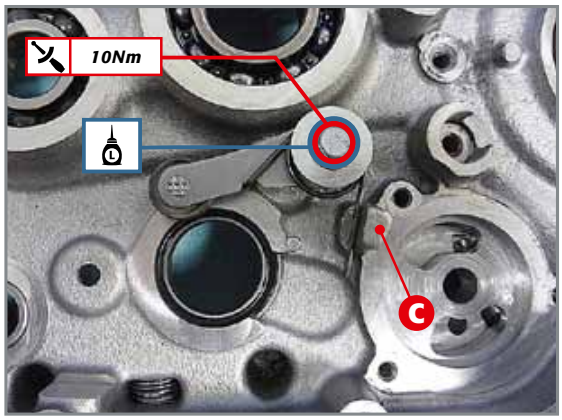


EXPLODED VIEW OF STOPPING DEVICE

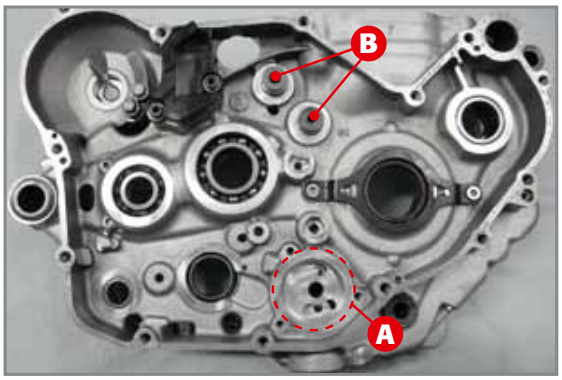
25) Lever;
26) Spring;
27) Spacer;
28) Washer 6x20x1;
29) Screw M6x20.

Keeping the tightener on the lever **25** facing towards the crankcase half, apply the spacer **27** onto it, by inserting the smaller diameter segment in the lever. Apply the spring **26** so that the hook inserts into the groove present on the lever **25** and then apply the washer **28** and the screw **29** M6x20 whose threading must be spread with medium strength threadlocker.



Stopping device coupled with the crankcase half.

Apply the entire device on the crankcase half so that the straight segment of the spring rests on the stop **C**. Tighten the screw at 10Nm.



The crankcase half will definitely need to be replaced when:

the oil pump crankcase **A** shows deep scratches or meshing signs;

- the two pins **B** for the idler wheel and torque limiter show traces of abnormal wear or meshing;

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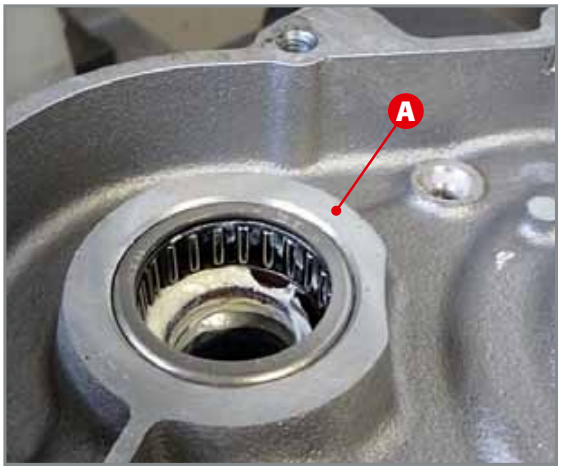
Application of oil seal 1.

Insertion of bearing 2.



Oil seal and bearing unit coupled to the left crankcase half.

2.1.1.1 INSERTION OF OIL SEAL AND COUNTERSHAFT SUPPORT BEARING

In order to insert the oil seal and countershaft support bearing proceed as follows. Grease the oil seal and bearing housing. Insert the new oil seal **1** greasing the inside of it.

Apply the new bearing **2** paying close attention that it is aligned in its seat.

Use a press or similar instrument to push the bearing until the outside surface is flush with the surface **A**.

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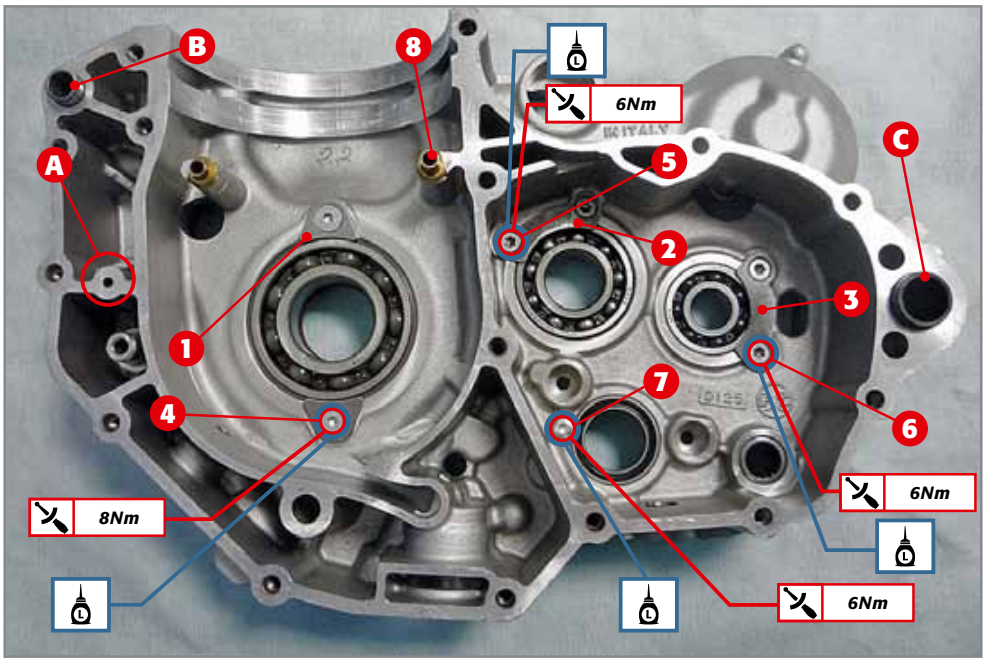
2.1.2 INTERNAL RIGHT SIDE

Check the flatness of the crankshaft bearing retaining plate **1**, of the mainshaft bearing retaining plate **2** and of the secondary shaft bearing retaining plate **3**.
The table below carries the indications for application of the fixing screws of these plates and for fixing the desmodromic device support bearing.

Screw number	Screw dimensions		Threadlocker application	Tightening torque [Nm]
	Threading diameter	Threading length		
4	M6	14	Loctite 243/ Sichel 100M	8
5	M5	10	Loctite 243/ Sichel 100M	6
6	M5	10	Loctite 243/ Sichel 100M	6
7	M5	8	Loctite 243/ Sichel 100M	6



Elementi presenti nel carter destro lato interno.

Blow compressed air into the hole **A** making sure the passage is free from any type of impurity.Insert the two reference bushes **B** and **C** in their respective housings

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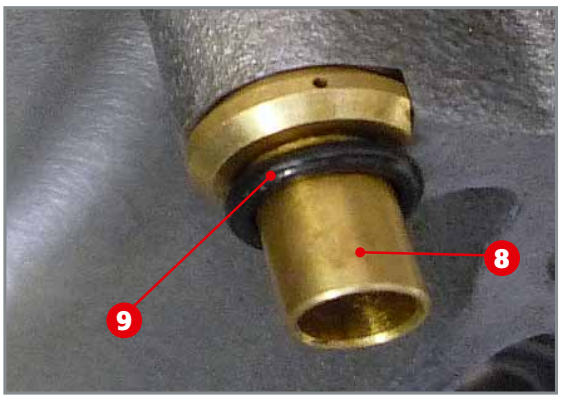


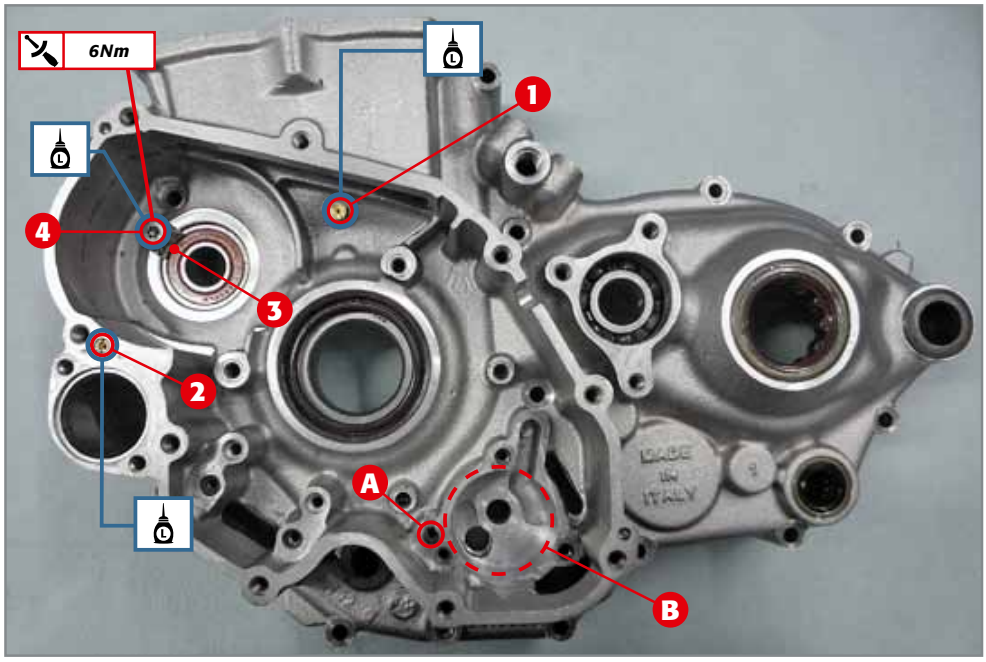
Piston oil jet O-ring and detail of passage hole.

Make sure the piston oil jets **7** are positioned correctly and free of obstructions.
Make sure the O-rings **8** are positioned correctly, checking their status. Should the O-rings have cracks or deformations, they must be replaced.

2.1.3 EXTERNAL LEFT SIDE

Make sure the calibrated screw **1** and the jet **2** are not obstructed. Should they have been replaced, couple them to the crankcase using a small amount of medium strength threadlocker, being careful that the threadlocker does not block the holes. Then tighten them all the way.
Make sure that the oil passage **A** is cleaned well. Make sure that the countershaft bearing retaining plate **3** is not deformed. If it is, replace it.
The table below carries the indications for application of the screw for the plate **3**.
The crankcase half will definitely have to be replaced if the oil pump crankcase **B** has deep scratches or signs of meshing

Screw number	Screw dimensions		Threadlocker application	Tightening torque [Nm]
	Threading diameter	Threading length		
4	M5	10	Loctite 243/ Sichel 100M	6



Elements present on outside left crankcase half.

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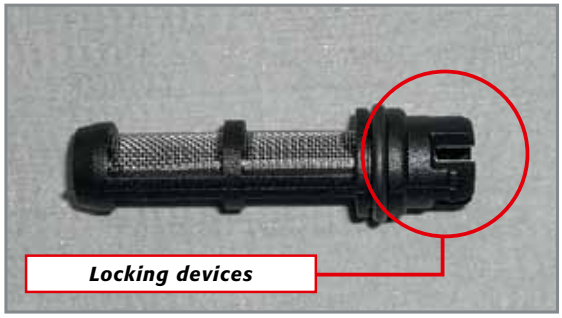
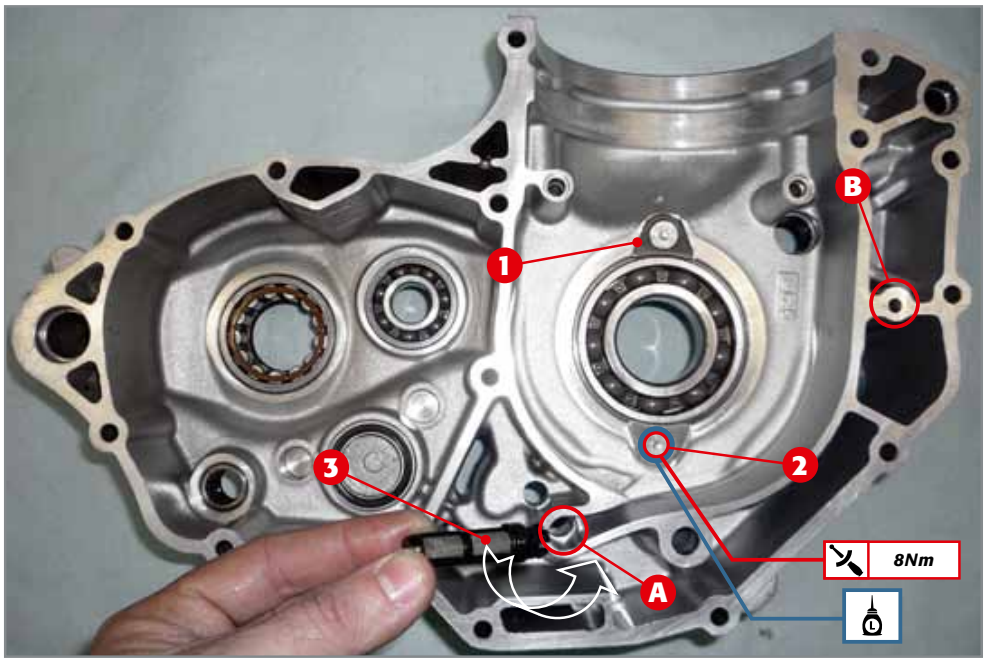


2.1.4 INTERNAL LEFT SIDE

Clean the inner filter thoroughly and check the integrity both of the wire metal and the hooking device. Should the filter be deteriorated in any of these parts, replace it.

Check the state of the two crankshaft bearing retaining plates **1**. If they are deformed, have them replaced.
The table below carries the indications for application of the screws for the plates **1**.
Insert the inner filter **3** in its seat A present in the crankcase and push it all the way down until you hear the hooking device click.
Blow compressed air in the hole B making sure it is not obstructed.

Screw number	Screw dimensions		Threadlocker application	Tightening torque [Nm]
	Threading diameter	Threading length		
2	M6	14	Media intensità	8



Elements present on inside left crankcase half.

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2.2 CHECKING CRANKSHAFT AND CONNECTING ROD

Deflection/Off-centring of crankshaft.

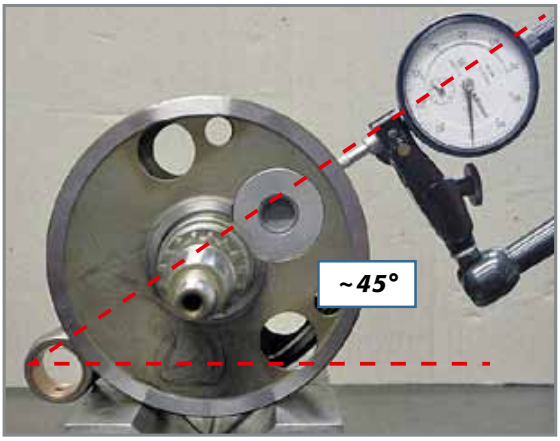
After having checked the state of wear of the coupling surfaces, check the offset of the half shaft axes by placing the crankshaft in between two tailstocks or similar instrument. Control the maximum measurement variation during a complete turn, using comparators positioned on the coupling surfaces with the crankshaft bearings.

Allowed limited: 0.12mm

Connecting rod axial play.

Check the axial play between the connecting rod head and the half shafts.

Recommended play:
0.4÷0.7mm



Connecting rod radial play.

Check the radial play of the connecting rod head bearing placing the crankshaft on a stable support, with the axis of the connecting rod inclined about 45° respect to the horizontal position. Then position a comparator in axis and, pressing lightly in the direction of the crank lever, check that the measurement detected does not exceed the service limit.

Maximum play 0.05mm

If play is greater replace the connecting rod.

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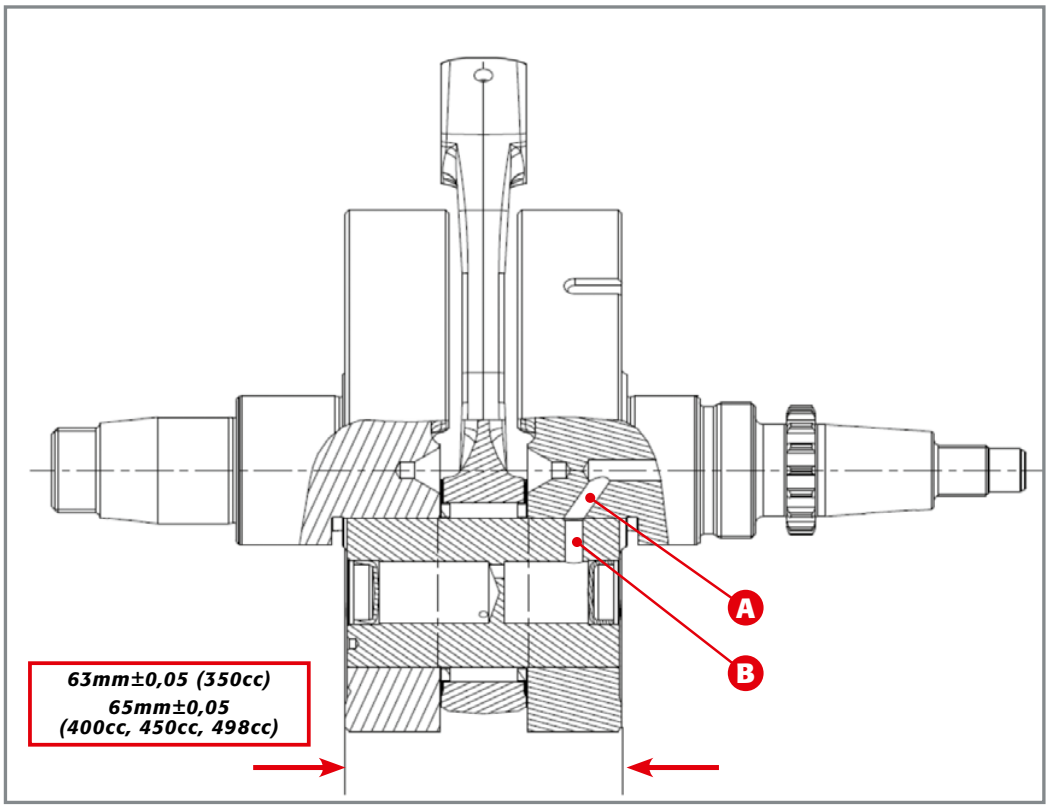
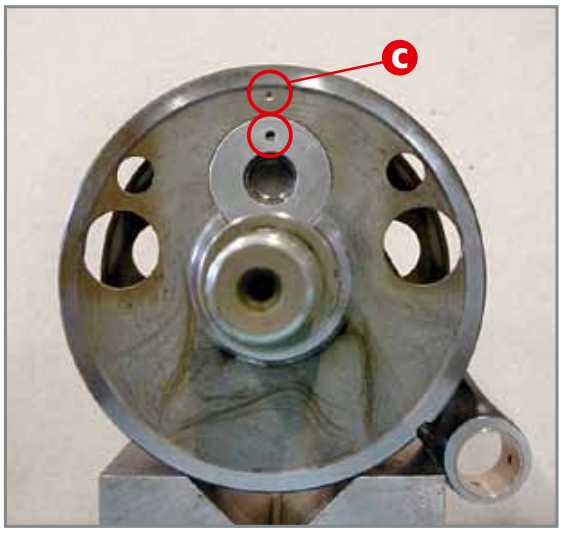
Make sure that the chain control gear is free of chipping or signs of abnormal wear. Replace the crankshaft should it be deteriorated.

The distance between the two opposite sides of the half shafts must be:

63mm±0,05 (350cc)
65mm±0,05 (400cc, 450cc, 498cc)



Crankshaft oil passages.



Half shaft and crank lever pin bolt references C.

If the two half shafts are detached for replacement of the connecting rod, pay close attention when repositioning the crank lever respect to the half shafts. The holes for oil passage **A** on the half shaft must coincide with those present on the crank lever **B**.
Incorrect positioning would cause an irregular oil flow rate thus damaging the connecting rod head bearing.
The references **C** which must be aligned are found on the half shaft on the flywheel side and on the crank lever of the pin bolt.

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Bore meter verification of inside diameter of connecting rod foot.

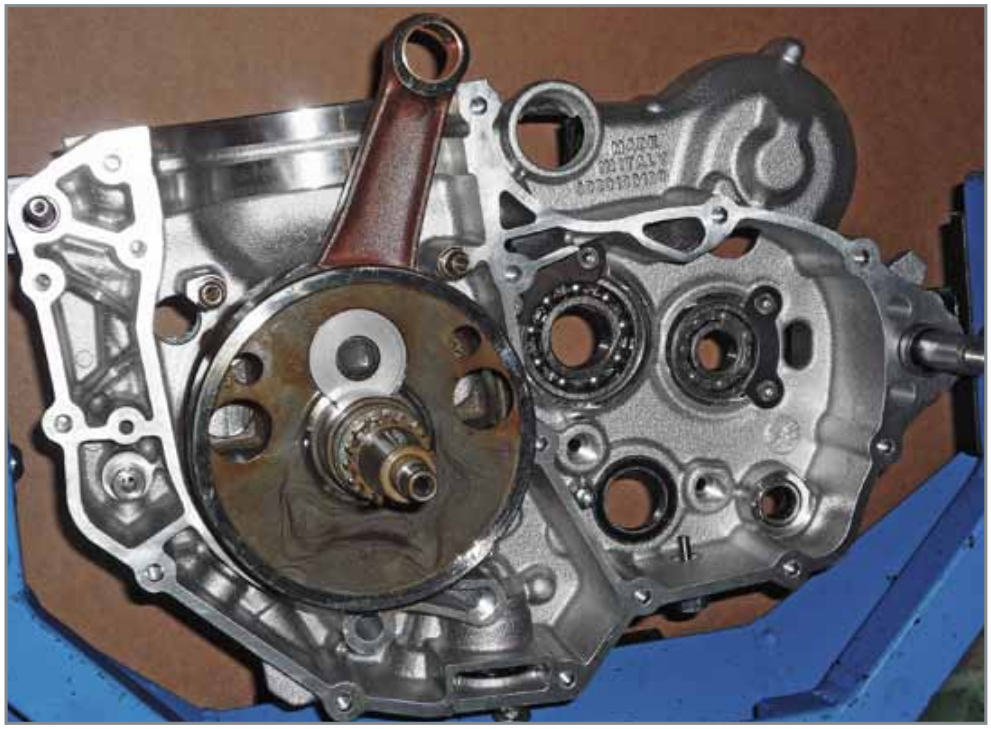
Use a bore meter to check the inside diameter of the connecting rod foot which must not exceed the following service limit:

limite di servizio 18,04mm (350cc)
20,03mm (400cc, 450cc, 498cc)

Remember that the measurement must be made placing the axis of the feeler in parallel with the axis of the connecting rod.

2.3 ASSEMBLING COMPLETE CRANKSHAFT

When all the aforementioned controls have been carried out and the worn parts replaced, grease the crankshaft oil seal on the right crankcase half and couple the crankshaft to the left crankcase half. Keep the gear present on the crankshaft towards the left. In order to carry out this operation, you must just push the shaft axially towards the crankcase.



Insertion of crankshaft in right crankcase: note the position of the gear.

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Checking wear of forks and gearwheels.

2.4 GEARBOX UNIT: CONTROLS AND REASSEMBLY

The gearbox unit is made up of the gearshift and of the gearbox itself. The gearshift is then divided into external and internal gearshift.
The following are the verifications and procedures for checking and reassembling these units to the engine.

2.4.1 CHECKING GEARBOX UNIT

Use protective jaws to clamp the primary and secondary shaft.
Use a thickness gauge to check the axial play between the gearshift forks and the gearwheels. The play detected must not exceed the service limit indicated below:

service limit: 0,5mm

If the detected axial play is greater, before replacing either the gearwheels or the forks, check their state of wear (par. 2.4.4).

Remove the various elements and check that:

· The support surfaces of the primary and secondary shafts are free of abnormal wear or signs of seizure.

· the sides of the teeth are free from chipping or abnormal wear;

· the sliding areas of the gearwheels are free from abnormal wear or traces of seizure

· the front claw clutches of the gearwheels are not chipped or rounded;

· the roller bearings are intact and efficient;

· none of the thrust washers show traces of abnormal wear or meshing.

Should any of these defects present themselves, replaced the concerned parts.

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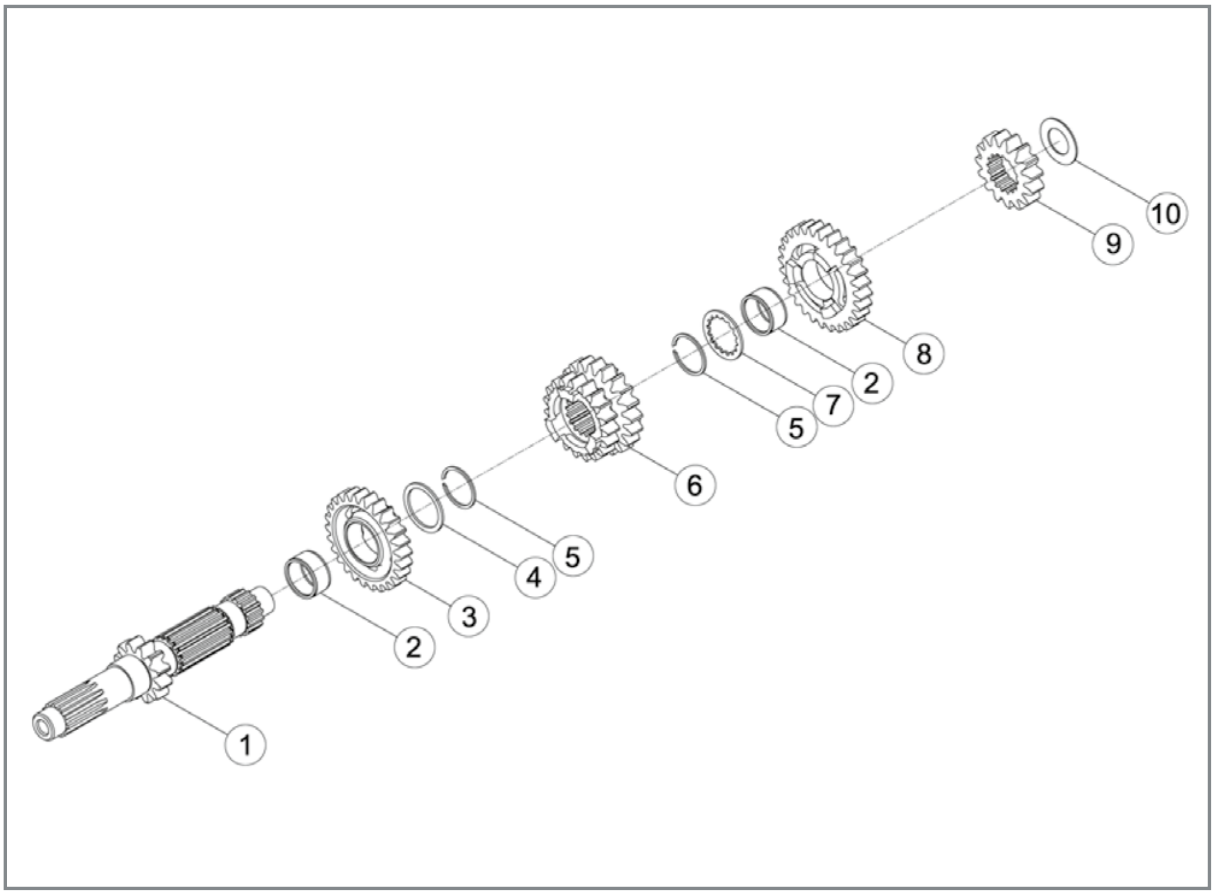
2.4.2 PRIMARY UNIT ASSEMBLY

Before proceeding with reassembly, clean all the elements thoroughly and oil them with gear oil. Always replace the circlips.
Clamp the mainshaft **1** (using protective jaws), so that the grooved end faces downwards.
Insert onto the lower cylinder part of the shaft: the roller cage **2**, the 5th gear (**3**) (turning the front claw clutches upwards), the 26x32x1.5 thrust washer **4** and the circlip **5**.
Insert the III - IV sliding gear (**6**) so that the smaller gear faces downwards, and then insert the circlip **5**.
Insert the 23x32x1.5 thrust washer **7**, the roller cage **2**, the 6th gear (**8**) (with the front claw clutch facing downwards), the 2nd gear (**9**) (with the cavity facing upwards) and finally the 17x30x1 thrust washer **10**.

EXPLODED VIEW OF PRIMARY UNIT:

1) Mainshaft;
2) Roller cage 22x26x13;
3) Fifth gear on mainshaft;
4) Thrust washer;
5) Circlip sw15;
6) Third and fourth gear on mainshaft;
7) Thrust washer;
8) Sixth gear on mainshaft;
9) Second gear on mainshaft;
10) Thrust washer 17x30x1



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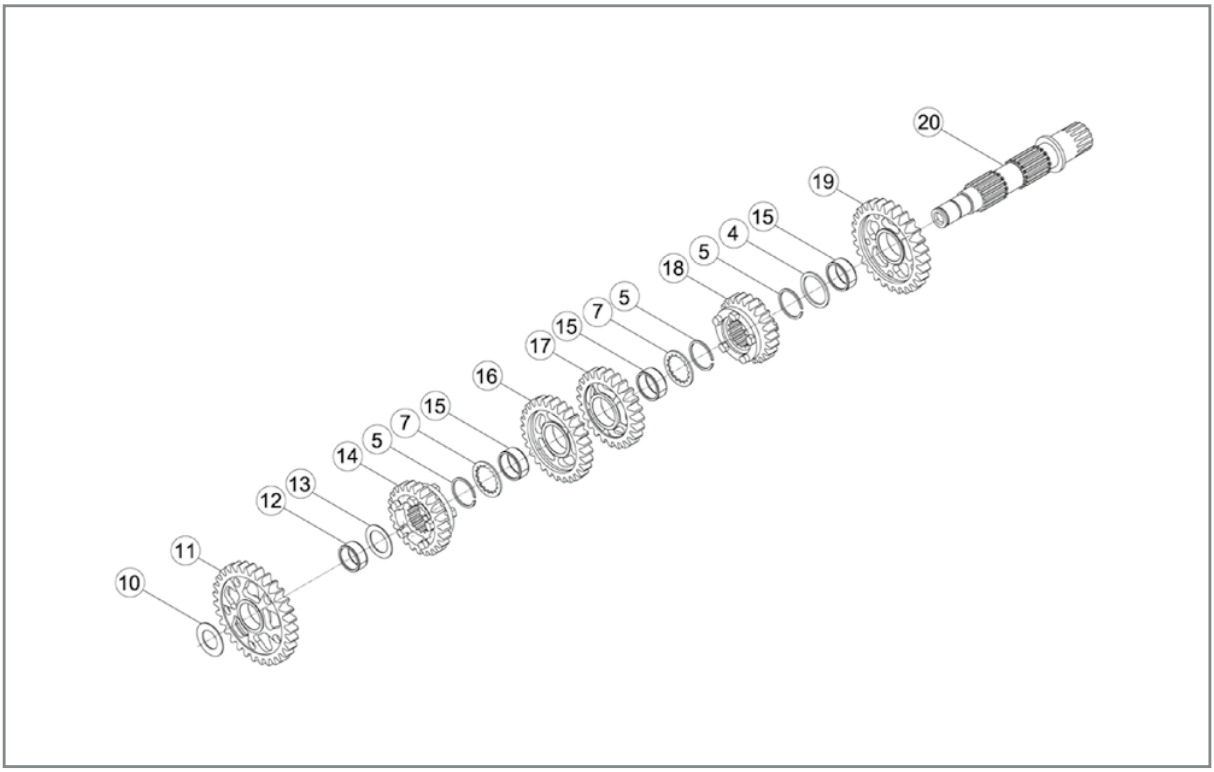
2.4.3 SECONDARY UNIT ASSEMBLY

Before proceeding with reassembly, clean all the elements thoroughly and oil them with gear oil. Always replace the circlips.
Clamp the secondary shaft **20** (using protective jaws), so that the grooved end faces downwards.



EXPLODED VIEW OF SECONDARY UNIT

4) Thrust washer;
5) Circlip sw15;
7) Thrust washer;
10) Thrust washer 17x30x1;
11) First gear on secondary;
12) Roller cage 20x24x10;
13) Thrust washer 20x30x1;
14) Fifth gear on secondary;
15) Roller cage;
16) Third gear on secondary;
17) Fourth gear on secondary;
18) Sixth gear on secondary;
19) Second gear on secondary;
20) Secondary shaft

Insert onto the lower cylinder part: the roller cage **15**, the 2nd gear (**19**) (so that the front claw clutches face downwards), the 26x32x1.5 thrust washer **4** and the circlip **5**.
Insert the 6th gear (**18**) (so that the fork seat faces upwards) and the circlip **5**.
Insert the 23x32x1.5 thrust washer **7**, the two roller cages **15**, the 4th gear (**17**) (with the front claw clutches facing upwards), the 3rd gear (**16**) (with the front claw clutches facing downwards), the 23x32x1.5 thrust washer **7** and the circlip **5**.
Insert the 5th gear (**14**) (with the fork seat facing downwards) the 20x30x1 thrust washer **13** the roller cage **12**, the 1st gear (**11**) (with the front claw clutches facing upwards) and finally the 17x30x1 thrust washer **10**.

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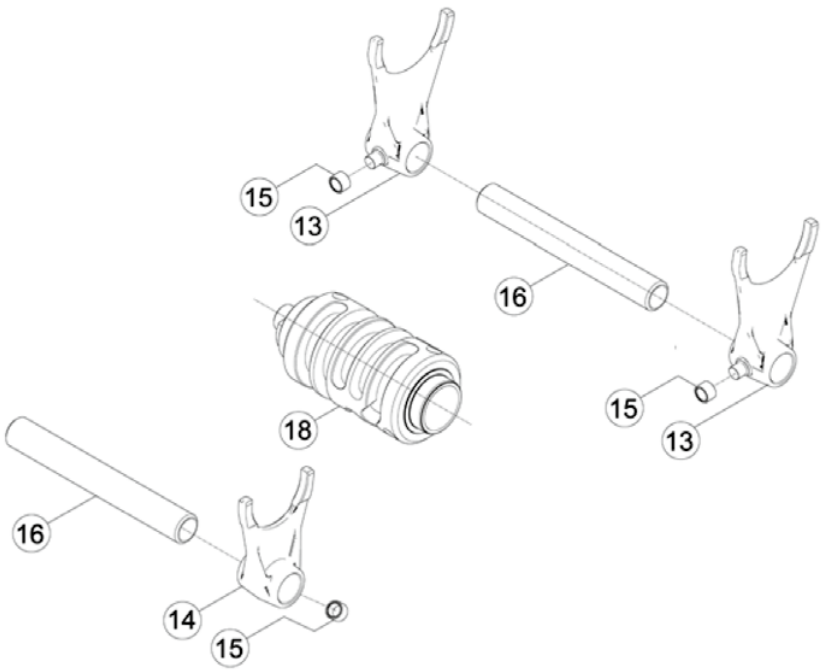
2.4.4 CHECKING THE FORKS, FORK PINS AND DESMODROMIC DEVICE

The internal gearshift is made up of:

- two forks **13** which drive two gears on the secondary unit;
- one fork **14** which drives one gear on the primary unit;
- three drive pin bushes **15**;
- two fork pins **16**;
- desmodromic gearshift **18** through whose rotation the forks are driven thus selecting the desired gear.



EXPLODED VIEW OF INTERNAL GEARBOX CONTROL UNIT:

13) ¼ fork;
14) 5/6 fork;
15) bush;
16) fork pin;
18) desmodromic control

Check to make sure that the drive pins which support the bushes **15** have no traces of meshing or abnormal wear and that the bushes themselves are not worn.

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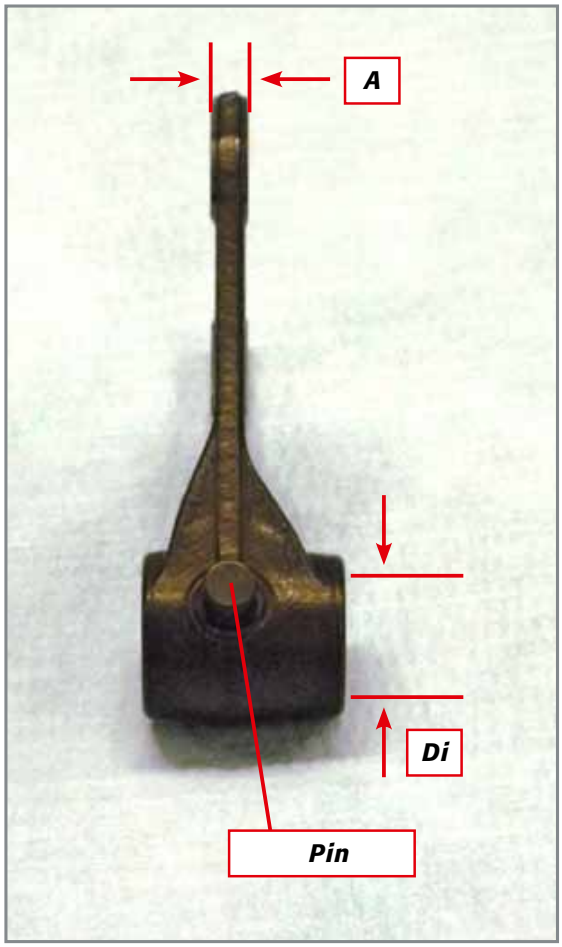

Make sure the distance **A** between the outer faces of the fork is not less than that indicated below:

Minimum acceptable distance: 4.25mm

Check to make sure that the inside diameter **D** of the fork pin seats is below the limit:

Fork inside diameter limit: 13,83mm

Make sure that the fork pins upon which they slide have an outside diameter above the limit (to be measured in the sliding areas of the forks and in the housing areas of the crankcases):

Fork pin outside diameter limit: 13,75mm

Make sure that the desmodromic control device has no corroded or worn areas especially in the grooves in which the drive pins of the forks are engaged.

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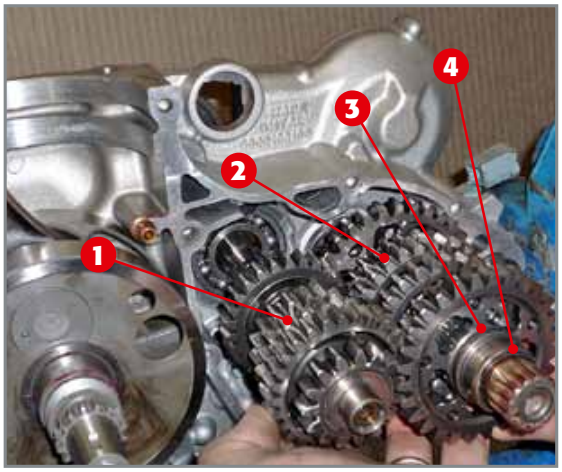
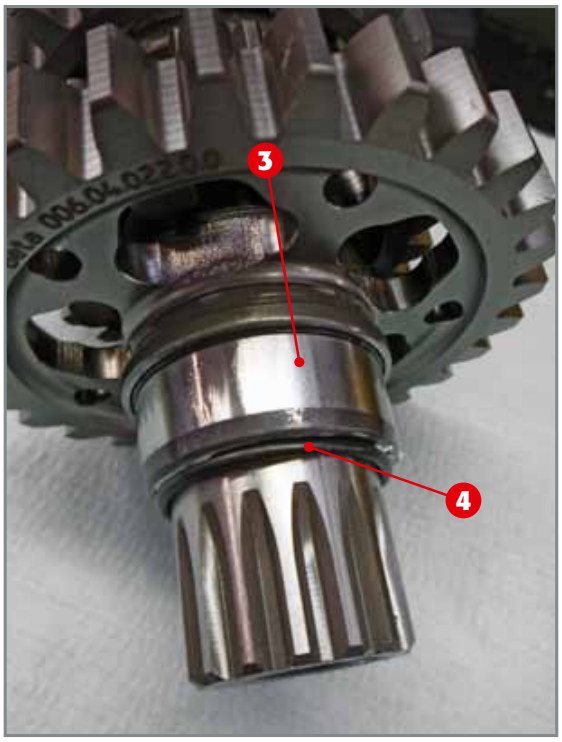


Insertion of gearbox in left crankcase.

2.5 ASSEMBLY OF INTERNAL GEARBOX AND GEARSHIFT

Insert the entire primary **1** and secondary unit **2** into the respective seats on the left crankcase half simultaneously. Remember to oil the gears abundantly with gear oil and to grease the shafts supporting them in the areas where they are coupled with the bearing with graphitic grease. Make sure that all the parts slide properly.



Detail of centre bearing 3 and O-ring 4 coupled to the secondary shaft.

Insert the centre bearing **3** and the O-ring **4** on the secondary unit.

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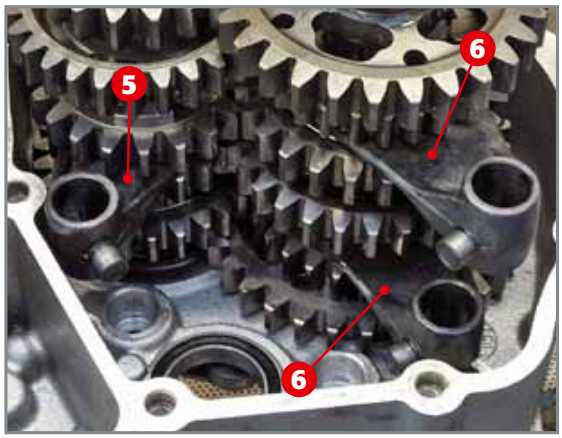
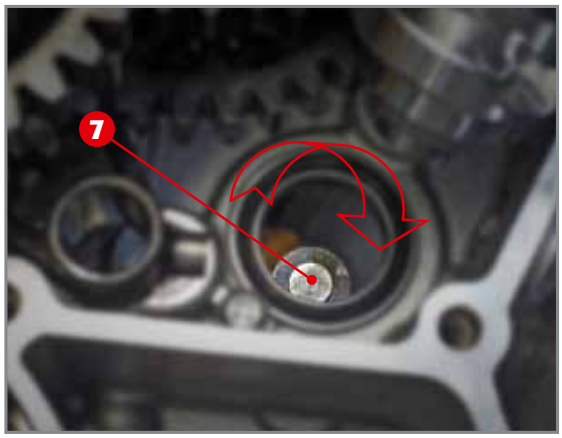


Application of forks to gearwheels.

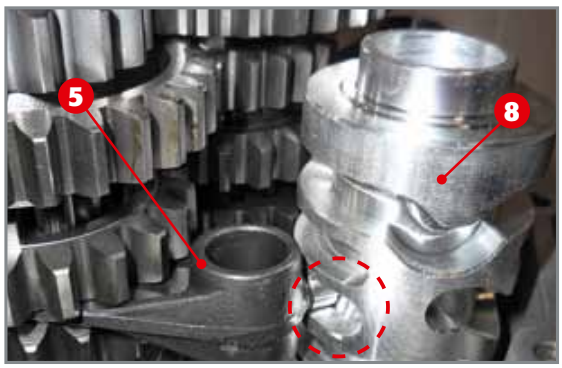
Introduce the forks together with the drive bushes on the gear tracks. To be precise; the smaller fork **5** drives the sliding gear on the primary unit, while the other two (**6**) drive the sliding gears on the secondary unit.

Note: *the two forks **6** are interchangeable and their positioning is univocal, since the drive pin must face the desmodromic device. If none of the components in question is replaced, it is recommended to reposition the forks in their original positions.*



Insertion of desmodromic device in specific bearing. Note the rotation of the stop lever.

Insert the desmodromic device in the specific bearing. In order to do this, it is necessary to rotate cam stop lever **7** towards the bottom part of the engine.



Positioning of primary unit fork 5 in central guide of desmodromic device 8.

Position the fork **5** of the primary unit in the central guide of the desmodromic device **8**, insert the fork pin inside the fork itself and insert the pin in its proper seat in the crankcase half.

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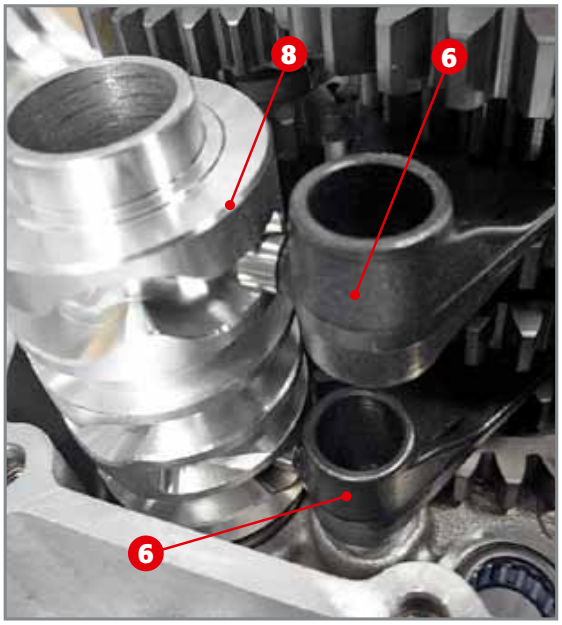

Positioning of the secondary unit forks 6 in the external guides of desmodromic device 8.

Position the two forks **6** of the secondary unit in the external guides of the desmodromic device **8** and, just like the primary unit fork, insert the fork pin first in the pins and then in its proper seat.
Remember to oil the shafts, forks and the desmodromic device abundantly with gear oil.

Position the new crankcase gasket.

View inside the right crankcase with crankshaft, oil jets, gearbox shafts complete with gearwheels, internal gearshift and gasket.

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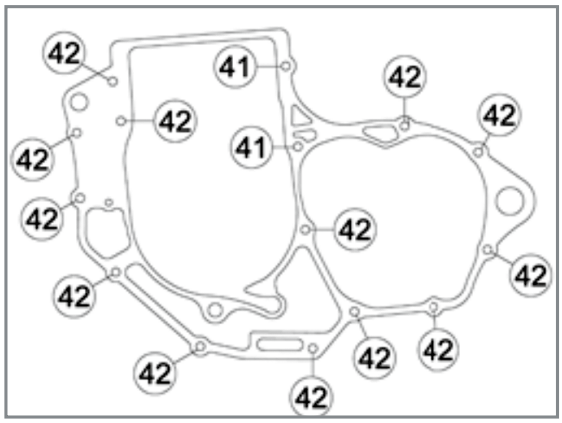
2.6 CLOSING ENGINE BLOCK

Press the right crankcase half towards the left, being careful that the shafts and pins on the crankcase fit into the respective housings and that the crankcase half is not upside-down. To facilitate progressive nearing and aligning of the two crankcase halves, connect two screws on opposite sides and tighten them bit by bit. If the crankcase halves tend to capsize, do not insist tightening them. Rather loosen the screws and reposition the crankcase correctly.

Make sure that the two crankcase halves match perfectly one with the other. Assemble the screws according to their length as indicated in the figure.
The table below contains indications for applying these screws.
It is recommended to tighten them in a criss-cross pattern using a torque of 10Nm.



Positioning of screws to fasten crankcase.

Screw number	Screw dimensions		Threadlocker application	Tightening torque [Nm]
	Threading diameter	Threading length		
41	M6	75	NO	10
42	M6	65	NO	10

Cutting extra piece of gasket between engine crankcase halves.

Cut the extra piece of gasket in between the two crankcase halves in the area of the cylinder.
This can be done easily by bending the gasket several times.

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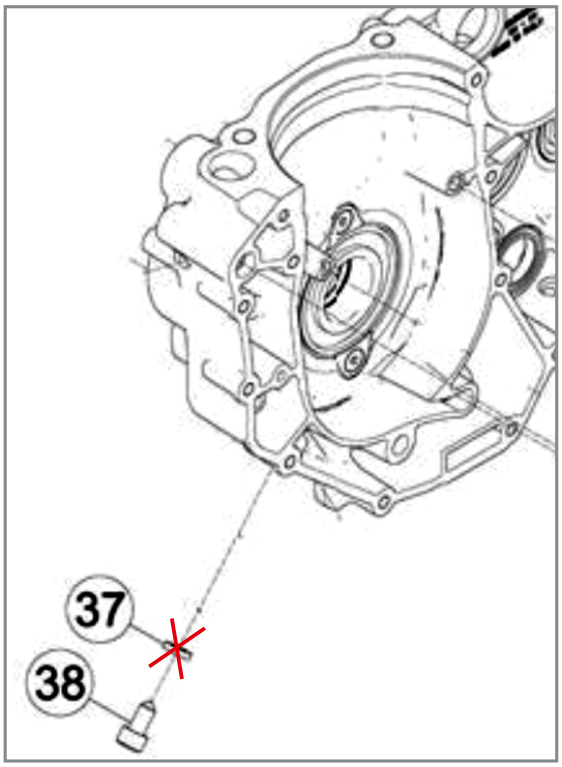
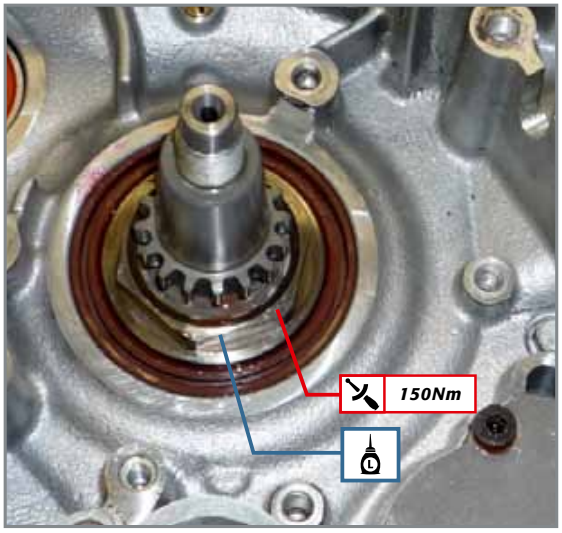


To block the crankshaft, apply only the screw 38 to the crankcase.



Nut on left side of crankshaft.

2.7 BLOCKING THE CRANKSHAFT AT THE TOP DEAD CENTRE AND TIGHTENING THE NUT ON THE LEFT SIDE OF THE CRANKSHAFT

In order to block the crankshaft at the Top Dead Centre, the specific conical-end screw **38** *(or tool 006140110 000)* must be introduced in its seat on the right crankcase half without applying the washer **37**. Once the crankshaft is positioned at the Top Dead Centre, tighten the screw all the way.

Spread the threading on the left-hand side of the crankshaft with medium strength threadlocker. Tighten the nut using the special socket wrench **A** *(code 006140020000)* at a torque of 150Nm.

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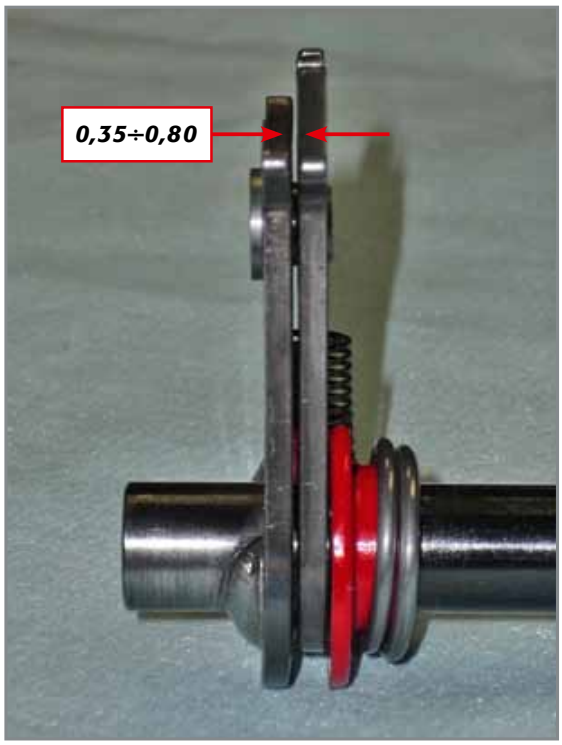
2.8 EXTERNAL GEARSHIFT

Before reassembling the external gearshift, check its state of use. While for the stop cam it is enough to make sure it's free from abnormal wear or meshing, the gearshift drive shaft needs more in-depth inspections.

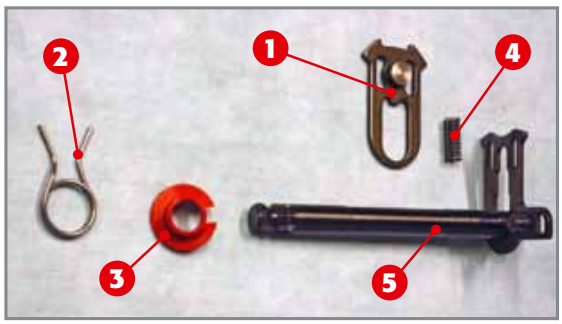
2.8.1 CHECKING THE COMPLETE DRIVE SHAFT

With the device complete, make sure that the distance between the movable pawl and the drive shaft is between **0.35÷0.80mm**. Should the distance be greater, replace the movable pawl.



Allowed distance between shaft and pawl.

In order to replace the movable pawl **1**, disassemble the return spring of the gearshift **2**, the spring guide **3**, the spring **4** (which must be compressed and pulled out of its seat) and the pawl, moving it completely towards the shaft **5**.



Complete drive shaft: 1) Movable pawl; 2) Gearshift return spring; 3) Spring guide; 4) Spring; 5) Gearshift drive shaft.

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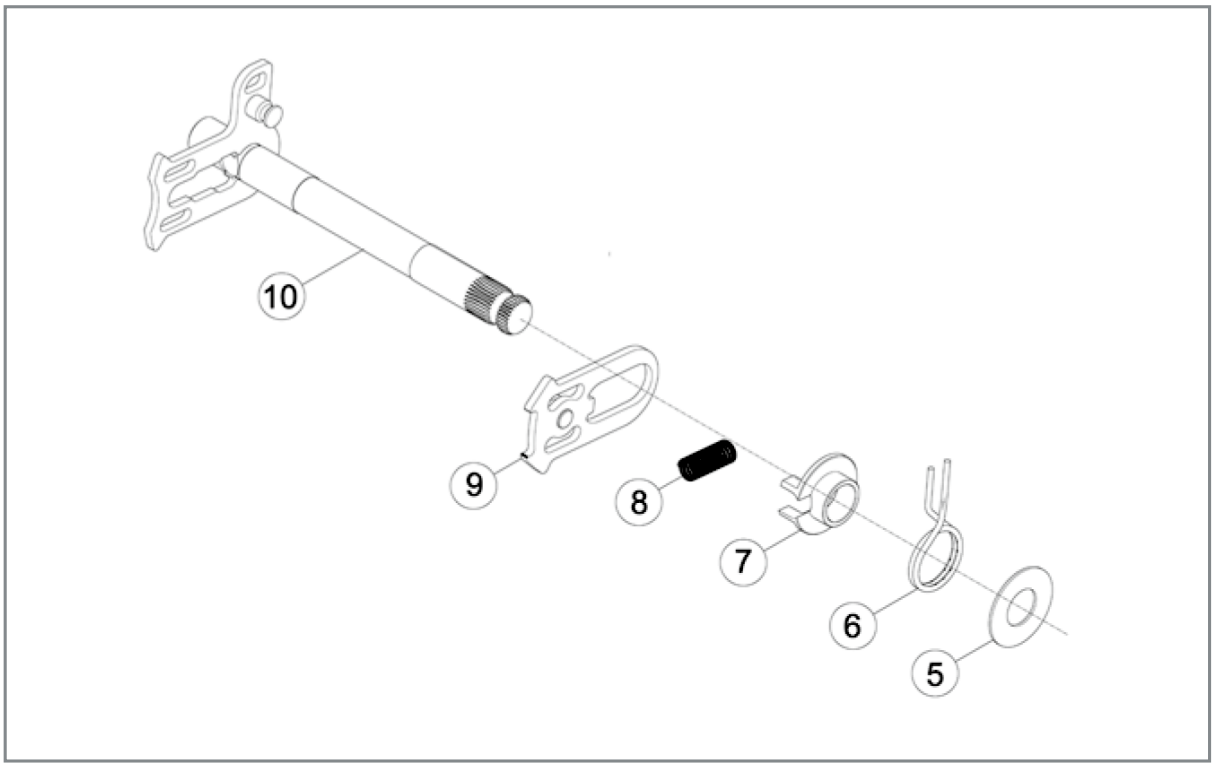

EXPLODED VIEW OF GEARSHIFT

5) Thrust washer 14x30x1;
6) Gearshift return spring;
7) Spring guide;
8) Pawl return spring;
9) Movable pawl;
10) Gearshift drive shaft.

For reassembly, couple the movable pawl **9** to the drive shaft **10** and, while compressing it, insert the spring **8** between the movable pawl and the drive shaft. Then apply the spring guide **7**, the gearshift return spring **6** and finally the 14x30x1 thrust washer **5**.

The gearshift return spring must be positioned as in the figure to be able to carry out its function.

Gearshift drive shaft: note the positioning of the gearshift return spring.

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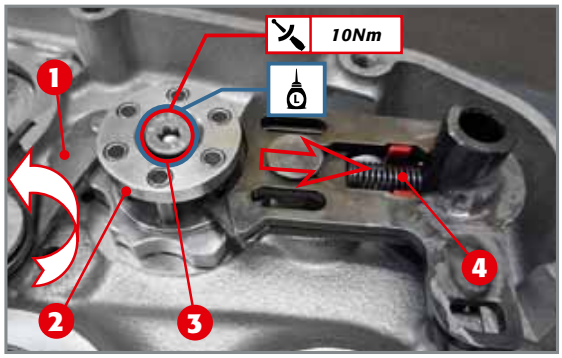

POSITIONING OF STOP CAM ON DESMODROMIC DEVICE

1) Stop lever;
2) Stop cam;
3) Screw M6x30;
4) Movable pawl return spring.

2.8.2 ASSEMBLY OF EXTERNAL GEAR-SHIFT

Keeping the stop lever moved **1** in such a way that the spring is compressed, position the stop cam **2** on the protruding end of the desmodromic gearshift (external right crankcase). The stop cam has only one correct position which is determined by the particular shape of the end of the desmodromic device and of the bottom part of the stop cam.
Proceed mounting the tightening screw **3** M6x30 between the stop cam and the desmodromic gearshift, after having applied medium-resistance sealant: tighten it at 10Nm.
Insert the drive shaft together with the washer in its seat keeping the return spring **4** of the movable pawl pressed.
Wishing to test the correct functioning of the entire unit, you just need to temporarily couple the external gearshift lever and to simulate the operation of changing gears, by lifting and lowering the gearshift lever and having the mainshaft of the gear unit rotate. The whole device works properly if abnormal jamming does not occur.
If the unit runs without oil, the device makes more noise than usual.

2.9 KICK STARTER

Before coupling the kickstarter to the crankcase half, some controls must be carried out.

2.9.1 CHECKING KICKSTARTER SHAFT UNIT AND ASSEMBLY

In order to disassemble all the parts of the kickstart shaft, pull off the washer **11** at the end of the shaft (on the side of the spring **16**), the spring **16**, the kickstart sleeve **14**, and the lever return spring **8**, which to be unfastened from the shaft must be pulled in the radial direction so that it is extracted from its hole. Pull out the kickstart spacer **9**.

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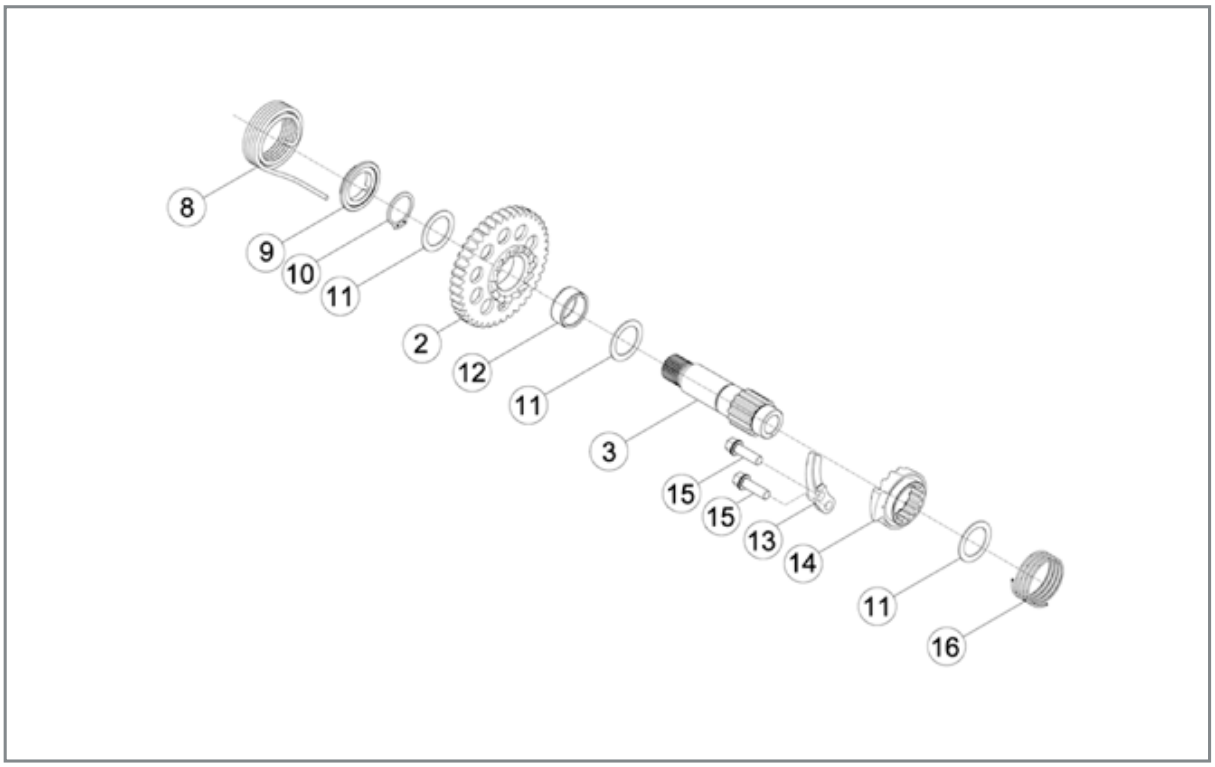
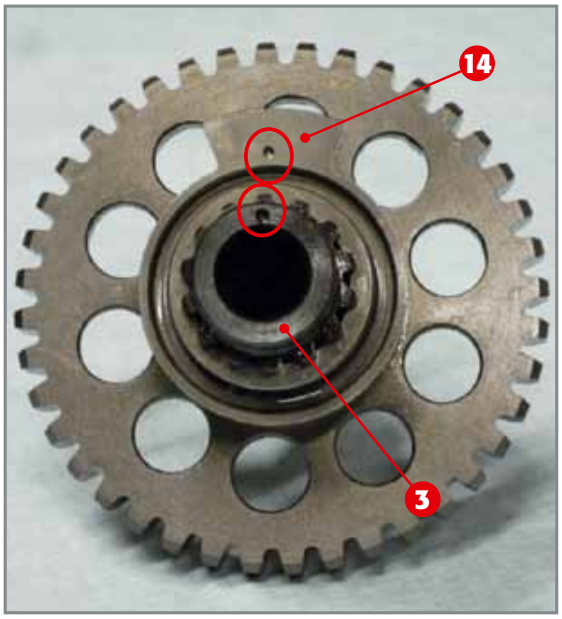


EXPLODED VIEW OF COMPLETE KICKSTART SHAFT

2) Kickstart gear;
3) Kickstart shaft;
8) Kickstart return spring;
9) Kickstart spacer;
10) Circlip 20E;
11) 20x28x1 washer DIN 988;
12) Roller bearing K20x24x10;
14) Kickstart sleeve; 16) Spring



Positioning of sleeve on small shaft.

Widen the circlip **10**, thus slipping off the washer **11**, and the kickstart gear **2** as well the roller bearing **12** and the washer **11**. This frees the kickstart shaft **3** from all other elements.
Make sure that the side of the kickstart gear teeth **2** have no signs of meshing or superficial wear. Make sure that the front teeth (sleeve side **14**) are not chipped. Replace any element that has the aforementioned defects.
Make sure that the front teeth of the sleeve **14** are not chipped and that the spring **16** is capable of putting enough pressure on the sleeve **14** so that it can to pull the gear **2**.
Also check to make sure that the washers have no abnormal or excessive wear. If so, have them replaced. Make sure that the spring **8** has no cracks or abnormal deformation. Have it replaced if it is not able to bring the external kickstart lever back to the rest position.
For reassembly, proceed inversely compared to the previously-described disassembly procedures.
Pay attention to the correct positioning of the sleeve **14** respect to the shaft **3**. The front of the shaft has a reference sign, just as the sleeve does**14**: the two references must match.

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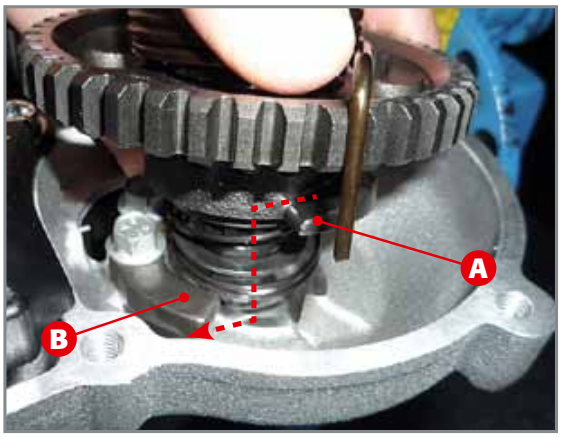
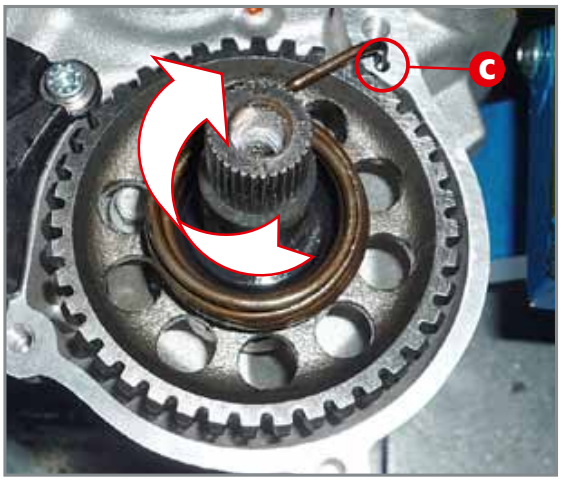


Positioning of sleeve A below ramp B.

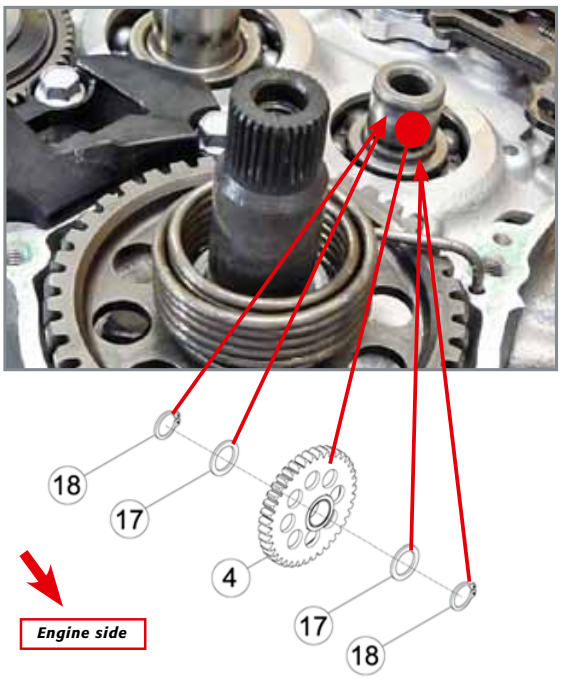
2.9.2 ASSEMBLY OF KICKSTART DEVICE

Insert the complete kickstart shaft in its housing keeping the thin-striped facing outwards and making sure that the ramp **A** on the kickstart sleeve is positioned below the ramp **B** bolted onto the right crankcase (external side).



Insertion of kickstart return spring.

Turn the spring clockwise until it fits into the specific hole **C**.



Kickstart device unit coupled to the crankcase

Insert in the slot on the protruding segment of the secondary shaft: the circlip **18**, the washer **17**, the idler wheel **4** followed by the washer **17** and the circlip **18** as shown in the figure.

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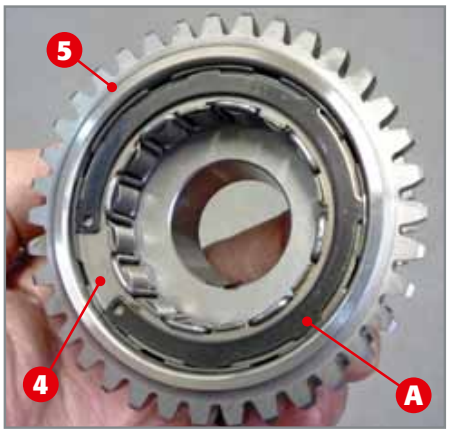
Idler wheel 1.

Torque limiter 2.



Free wheel coupled to main gear.

Main gear complete with free wheel coupled to ignition gear.

2.10 ELECTRICAL STARTER UNIT AND MAIN GEAR

Carry out the following controls before assembly.

2.10.1 CHECKING ELECTRICAL STARTER DEVICE ELEMENTS

Make sure that the teeth of all the gearwheels of the device are intact, free from chipping or signs or abnormal wear.
Pay attention to the teeth of the idler wheels **1** and torque limiter **2** and between the gears and respective support pins. Replace them if they show signs of meshing or seizure.

Make sure there are no traces of meshing on the housing of the roller bearing on the starter gear **3**. Mount the starter gear temporarily on the crankshaft, together with the roller bearing and check to see if there is excessive play.
To check the correct functioning of the free wheel **4** proceed as follows.
Insert the starter gear **3** on the free wheel **4** and main gear unit **5**. Keeping the main gear blocked **5** and turning the kickstart gear **3** clockwise, it must run freely. Turning the kickstart gear **3** anti-clockwise, it must be blocked without idling.

To replace the free wheel, disassemble the special circlip **A** and remove the free wheel.
During disassembly make sure that the lugs on the outer edge of the special circlip **A** are coupled in the slots of the free wheel and in the groove inside the main gear.

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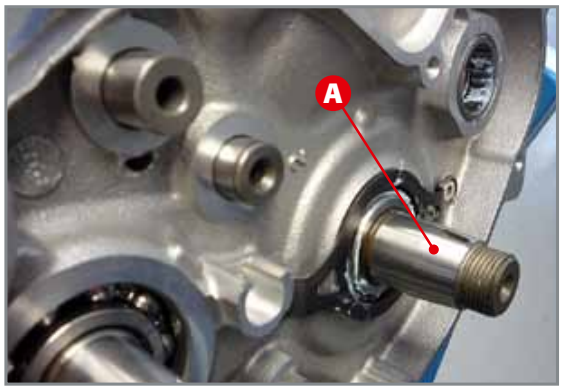
2.10.2 COUPLING IGNITION AND PRIMARY GEARS TO THE MOTOR

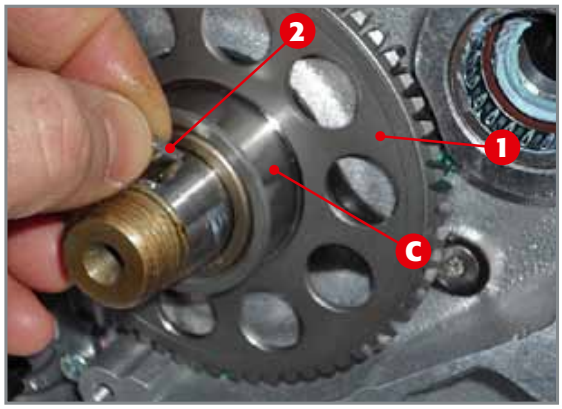
Thoroughly degrease the conical part **A** on the right side of the crankshaft and **B** of the primary gear.



Conical segment A on right side of crankshaft.

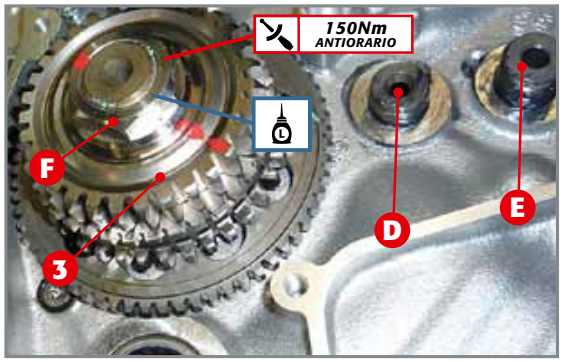
Conical segment B main gear.

Lubricate the segment **C** of the starter gear **1** with motor oil and couple it to the crankshaft.
Insert the Woodruff key **2** in the specific seat.



Positioning Woodruff key in specific seat.

Apply the main gear **3** to the crankshaft and while turning the gear clockwise, push it towards the crankcase half until you perceive meshing between the gear and the Woodruff key.
Insert the locking nut **F** applying the threading with a medium strength threadlocker and tighten at a torque of 150Nm.



Coupling main gear to crankshaft.

> ***Attention:***
> *it must be tightened **anti-clockwise**.*

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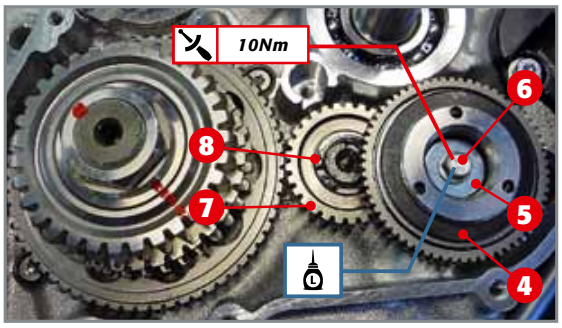
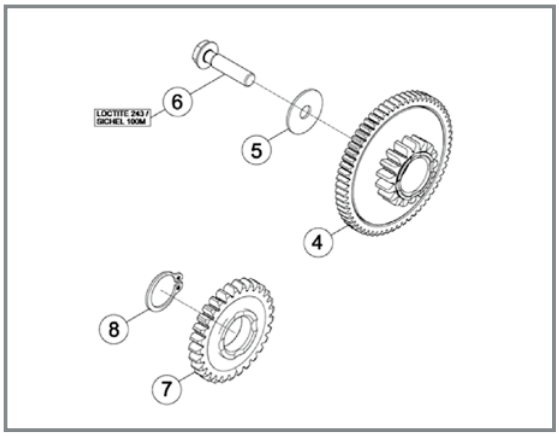
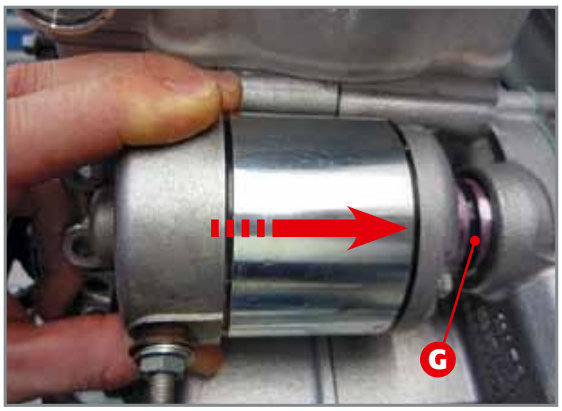


Coupling electrical starter gear unit.

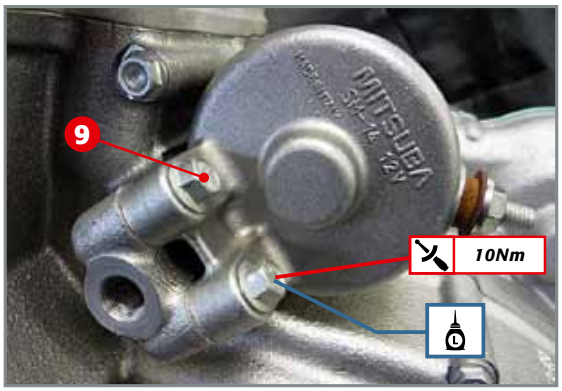
Grease the two pins **D** and **E** with graphitic grease.
Couple the idler wheel **7** to the pin **D** and apply the circlip **8**.
Couple the torque limiter **4** to the pin **E** turning the gearwheel with the smaller diameter towards the crankcase half. Insert the washer **5** and the screw 6 after having spread the threading with medium strength threadlocker. Tighten the screw at a torque of 10Nm.





Insertion of start motor in crankcase half.
Note zone G to be greased.

Apply a light layer of grease in the area **G** of the start motor and insert the motor in its housing.



The two fixing screws 9 of the start motor.

Apply medium strength threadlocker on the two screws **9** and tighten them with a torque of 10Nm.

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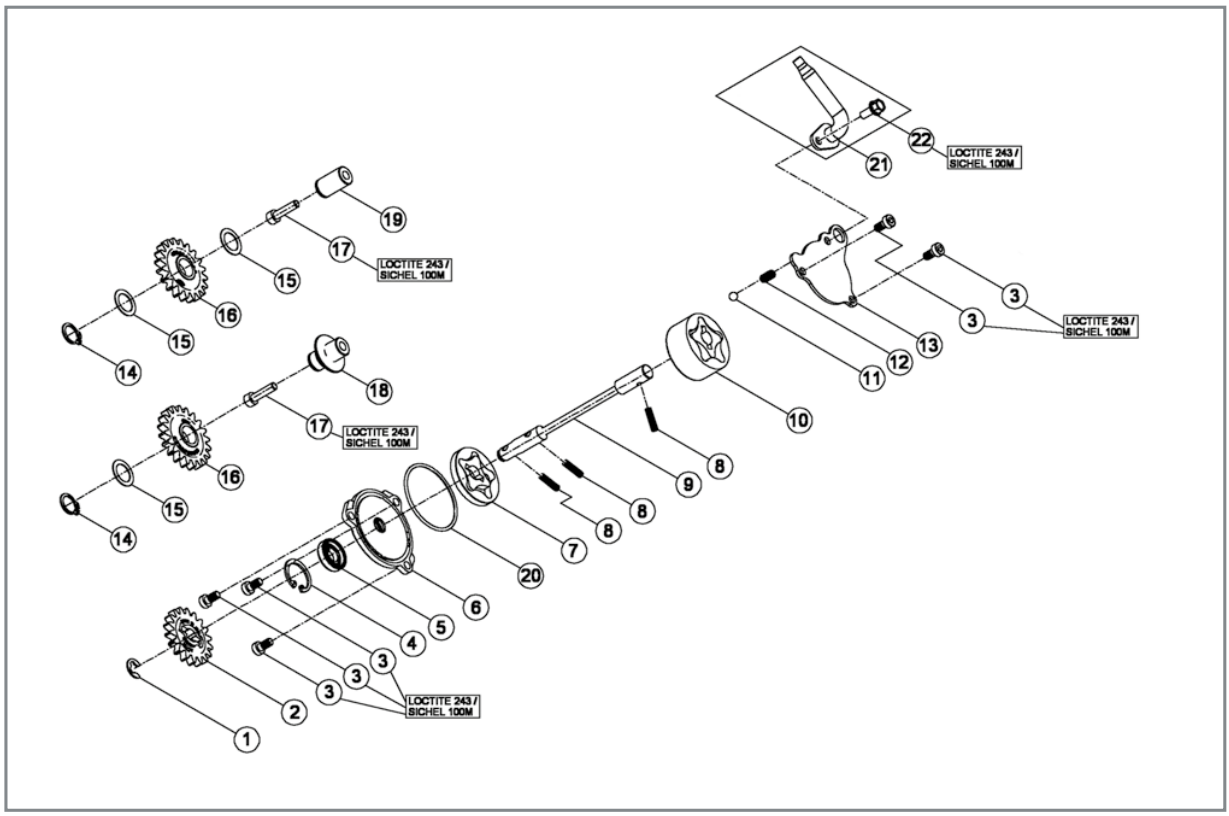
2.11 OIL PUMPS: CONTROL AND REASSEMBLY

As shown in paragraph 1.5, the motor is equipped with two oil pumps: one is the low pressure (suction) pump (higher displacement) located in the outside of the left crankcase half and the other high-pressure pump (lower displacement) located on the outside of the right crankcase half. The two pumps are driven by a gear cascade meshing with the clutch gear.



EXPLODED VIEW OF OIL PUMP UNIT

1) Benzing ring;
2) Oil pump gear;
3) Screw M5x10;
4) Circlip JS24;
5) Oil seal;
6) High-pressure oil pump cover;
7) High-pressure (or delivery) oil pump;
8) Roller;
9) Pump control shaft;
10) Low-pressure (or intake) oil pump;
11) Ball;
12) Spring;
13) Low-pressure oil pump cover;
14) Circlip A13;
15) Thrust washer 13x19x0,5;
16) Oil pump transmission gear;
17) Screw M5x20;
18) Pin;
19) Pin;
21) Lubrication plate;
22) Head Flanged bolt M5x12.

Proper operation of the pump depends:

- On the sliding surface with the rotors;
- On the radial play between the two rotors and between the external rotor and the crankcase;
- On the axial play of the rotors respect to the sliding surfaces;
- On the O-ring seal and the oil seal (on the high-pressure pump cover).

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Low pressure pump: note the dot on the two rotors. The dot must face the inside of the engine.

Should the sliding surfaces with the rotors present deep or evident traces of corrosion, replace the deteriorated part (in this case, the crankcase). To measure the radial play between the internal and external rotor and between the external rotor and the crankcase, proceed as follows:
Insert the two rotors in their specific seat with the reference dot facing the inside of the engine.

Using a thickness gauge, check that the play does not exceed that allowed, equal to:

Maximum radial play: 0,20mm

Take a thickness gauge again and a rectified reference surface and verify that the axial play does not exceed the maximum allowed amount:

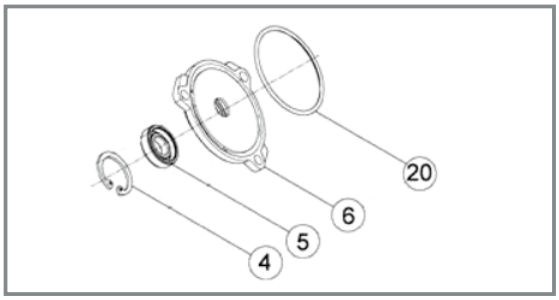
Maximum axial play: 0,1mm

Should play be greater, replace the rotors.

Assessment of radial play between and internal and external rotor.

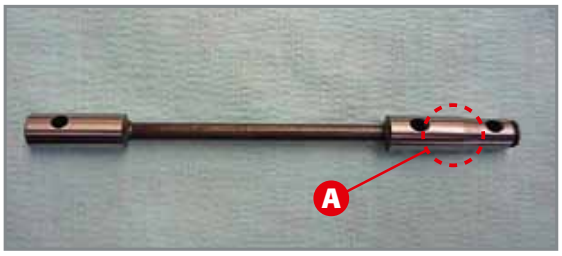
Assessment of radial play between external rotor and crankcase.

Assessment of radial play between rotors sliding surfaces.



Exploded view of high-pressure pump cover. 4) Circlip JS24; 5) Oil seal 10x22.6; 6) Oil pump cover; 20) O-ring 45x2.

As to the high-pressure pump (located in the outside right crankcase half), one must check that the oil seal **5** is not worn (it is recommended to replace it). In order to disassembly it, the circlip **4** must be removed. Check the state of use of the O-ring **20** and replace it if needed.



Checking oil pump control shaft.

Also check that the drive shaft is not too marked in the zone **A** where the oil seal slides.

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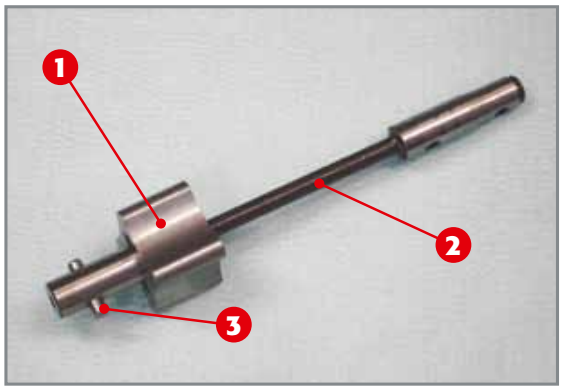
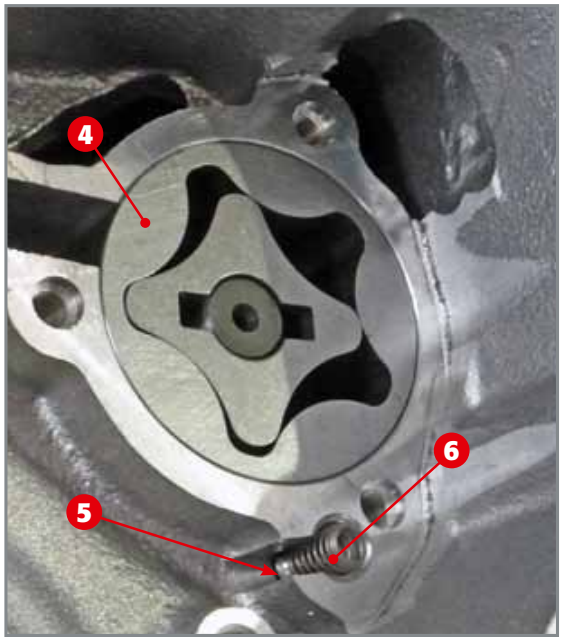
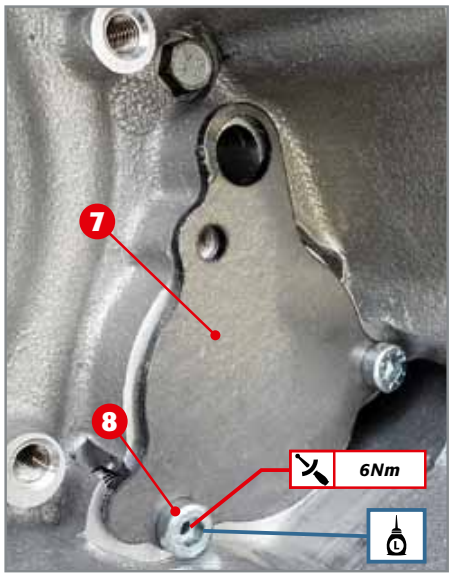


Shaft, low pressure pump, internal rotor and roller unit.



Complete low pressure pump coupled to the crankcase.



Coupling low pressure pump cover to crankcase.

2.11.1 ASSEMBLY OF LOW PRESSURE PUMP

Insert the internal rotor **1** on the shaft **2** so that the dot on the face of the rotor faces inwards. Then insert the roller **3** on the shaft.

Use motor oil to lubricate the seat of the rotors on the outside of the crankcase half, insert the external rotor **4** and the internal shaft-rotor unit in its proper seat.
Insert the ball **5** (diameter 5.5mm) and the respective compression spring **6**.
Lubricate with motor oil and, while rotating the protruding segment of the drive shaft (from the outside of the right crankcase half), make sure it rotates freely and does not jam.

Fasten the cover **7** to the crankcase with the three screws **8**, which must first be spread with medium strength threadlocker. These screws must be tightened at a torque of 6Nm.

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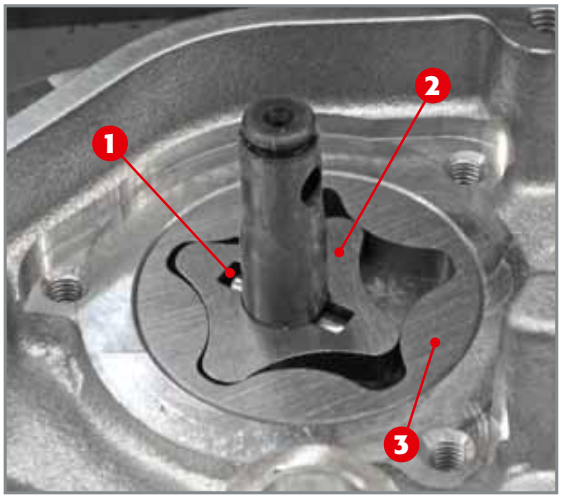
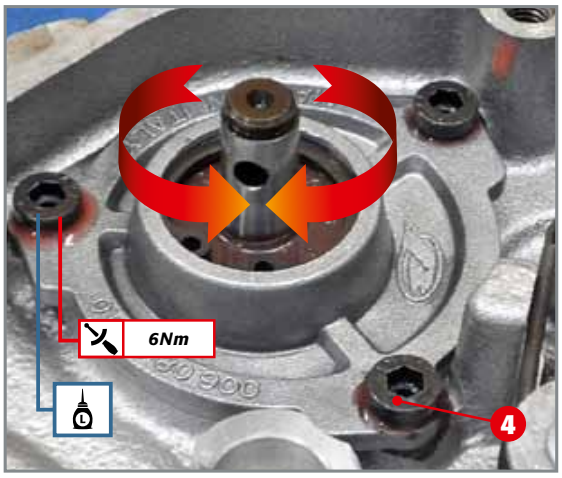


Coupling high-pressure pump rotors to drive shaft.

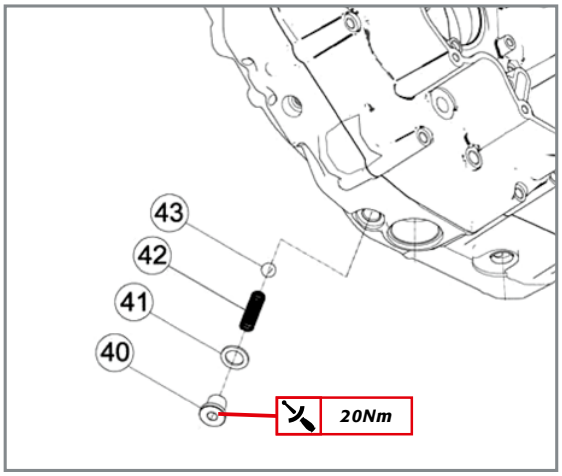
2.11.2 ASSEMBLY OF HIGH-PRESSURE PUMP AND CONTROL GEAR

Lubricate the area where the pump is housed (outside right crankcase half), and insert the roller in its hole **1**. Then insert the internal rotor **2** and the external rotor **3**, making sure to position them with the reference dot facing the inside of the engine. Lubricate the pump body with motor oil.



Coupling high-pressure pump cover to crankcase.

Grease the oil seal, insert the cover in the end of the shaft and press towards the crankcase carefully (pay attention to the oil seal). Insert the three screws **4** after having applied them with spread medium strength threadlocker. Tighten them at a torque of 6Nm.
Turn the shaft holding on to the protruding end and make sure it rotates freely without getting jammed.



PRESSURE CONTROL VALVE

40) Screw;
41) Thrust washer;
42) Spring;
43) Ball

2.11.3 CHECKING AND ASSEMBLY OF PRESSURE CONTROL VALVE

The pressure control valve is made up of a ball **43**, spring **42**, calibrated washer **41** and screw **40**.
Check the length of the free spring on this component:

Service limit: 29.5mm

Tighten the screw at a torque of 20Nm.

Attention: *If one of these elements making up the control valve is not inserted, engine functioning will be jeopardised.*

Attention: *always restore the original thickness value of the washer **41**. If this should be replaced, have it changed with one having the same original thickness.*

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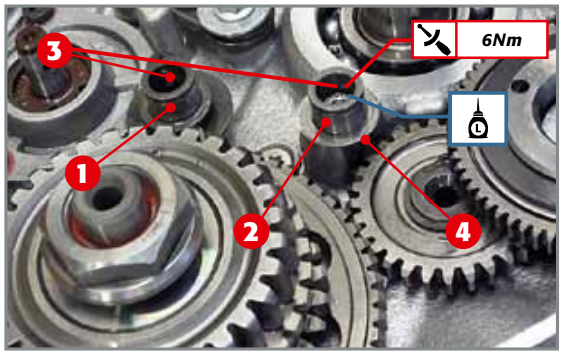
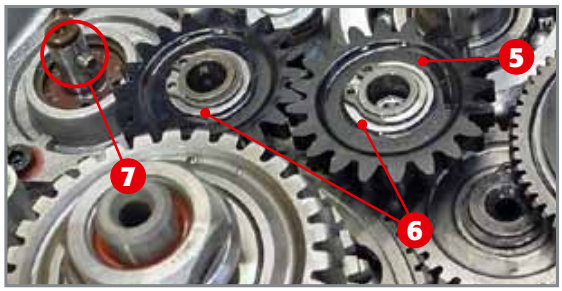
2.11.4 CHECKING AND ASSEMBLY OF OIL PUMPS CONTROL GEARS

The oil pumps are controlled by a gear cascade driven by the clutch gear.
The gearwheels, being made of plastic, must not have chips, grains or signs of abnormal wear.



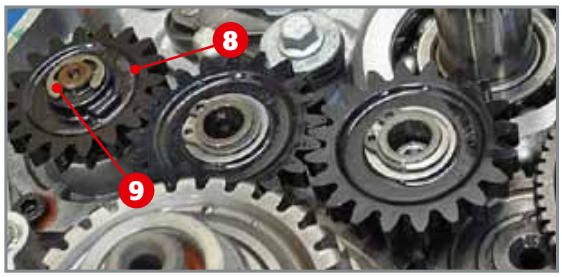
Oil pumps control gearwheels support pins.

Should the pins **1** and **2** which support the two pump control idler wheels be disassembled, they must be refastened to the crankcase half. These are connected to the crankcase half by means of two screws **3** (after they are applied with medium strength threadlocker) and tightened at a torque of 6Nm. Couple the thrust washer **4** to the pin **2** and lubricate it with gear oil.



Coupling pump control gearwheels to crankcase.

Couple the two pump control idler wheels **5** to the two pins so that the most protruding segment faces the crankcase.
Then insert the thrust washers **6** and circlips to keep the wheels from coming off the pins.
Insert the roller **7** to the end of the pump control shaft.



Coupling pump control wheel.

Couple the oil pump control wheel **8** to the end of the shaft so that the groove on the gear inserts into the roller. Then apply the benzing ring **9**, so that the gear does not slip off.

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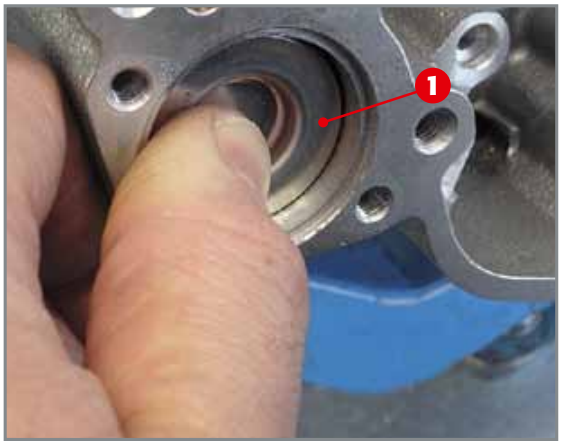
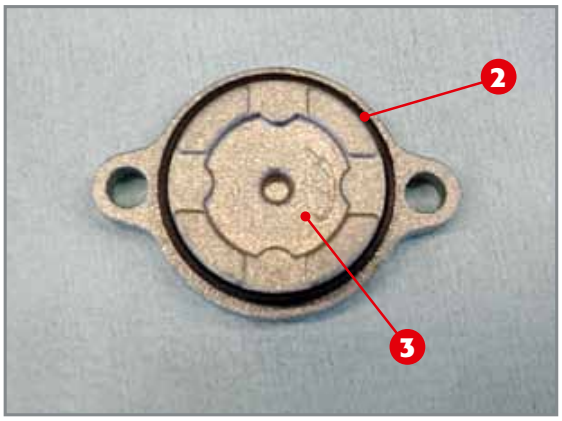
2.11.5 PAPER OIL FILTER INSERTION



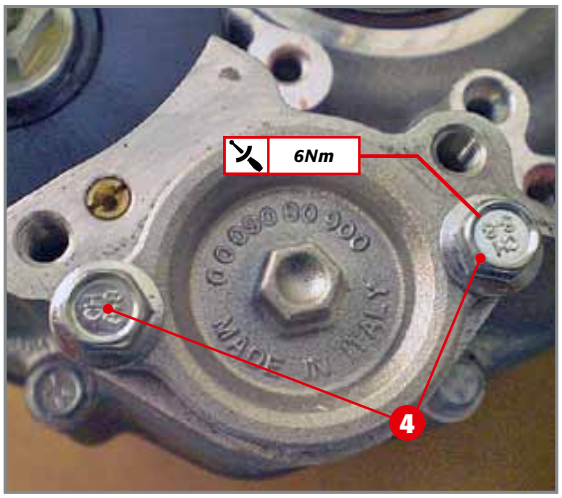
Application of paper oil filter.

Lubricate the rubber gasket on the filter. Insert the filter **1** into its housing and push it towards the inside of the engine as far as it can go.



Paper oil filter cover complete with O-ring.

Insert the O-ring **2** onto the oil filter cover **3** and apply the unit to the crankcase.



Two fixing screws of paper oil filter cover.

Apply the two screws **4** M5x16 to be tightened at a torque of 6Nm.

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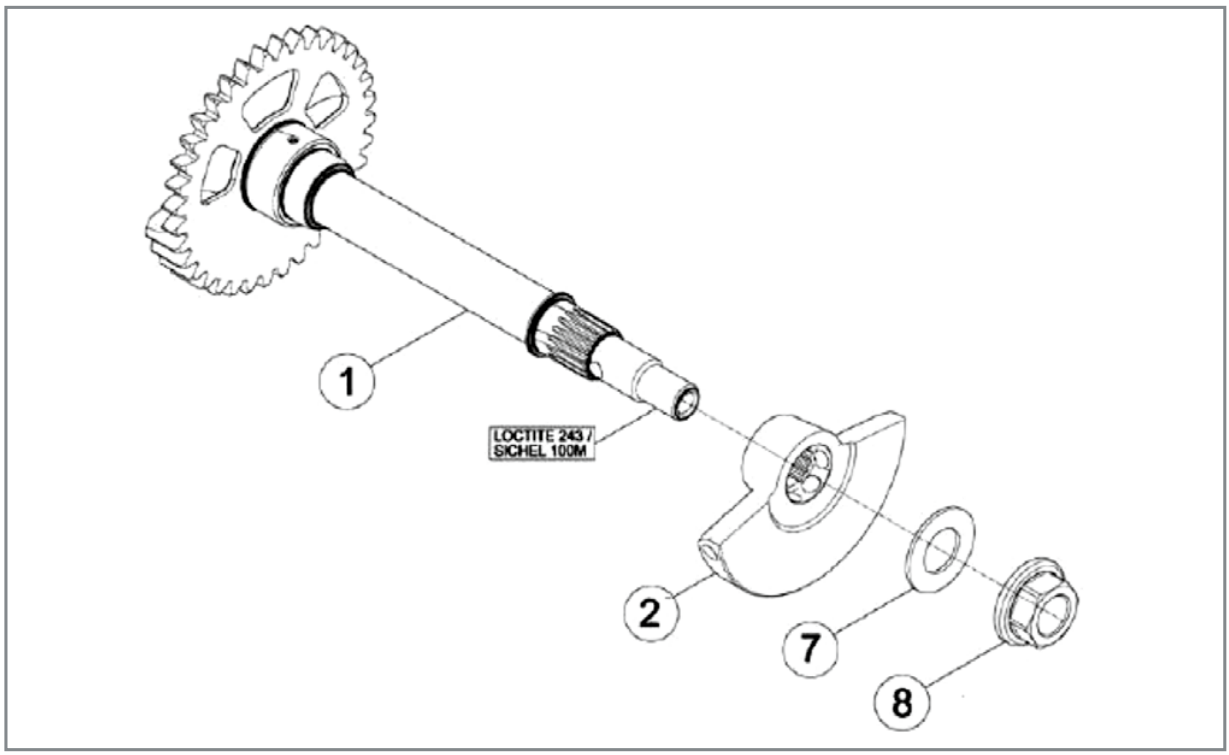
2.11.6 CHECKING AND COUPLING COUNTERSHAFT

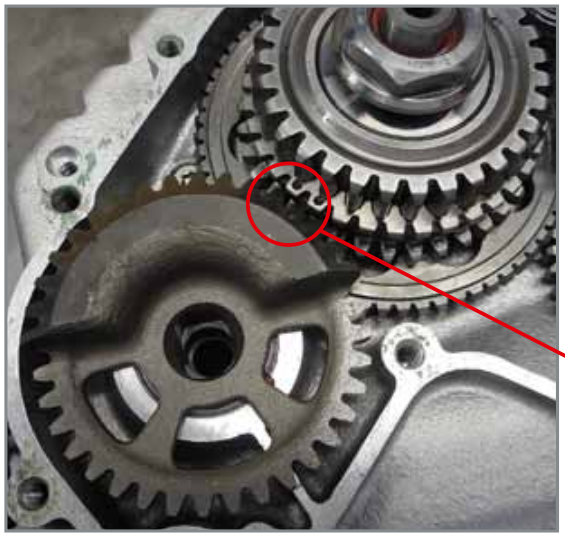
Check the state of use of the areas where the shaft rests on the bearing. Should they show signs of abnormal wear, have the shaft replaced. Make sure that the toothed segment of the shaft does not have traces of abnormal wear.

EXPLODED VIEW OF COUNTERSHAFT

1) Shaft;
2) Counterweight;
7) Elastic washer;
8) Nut M12x1



Grease the oil seal and insert the countershaft in its seat. Position it so that the reference sign on the shaft is between the two reference signs on the main gear.



Coupling countershaft to crankcase.

Enlargement of references.

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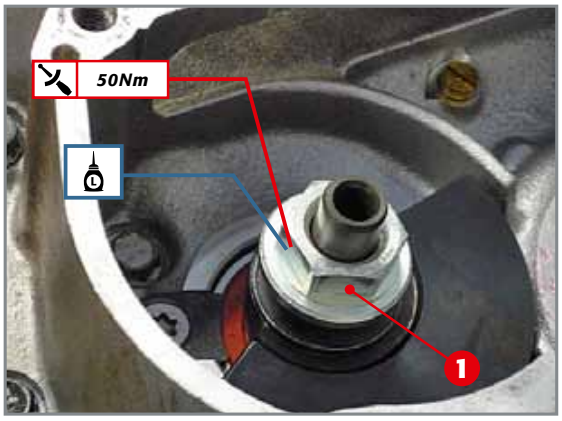
Coupling counterweight to countershaft.

Detail of grooved profiles for coupling.



Countershaft nut.

While keeping the countershaft in place, insert the counterweight on the left side depending on the position set by the grooved shaft.

Then couple the elastic washer and the nut **1** after having applied medium strength threadlocker on their threading. The nut must be tightened at a torque of 50Nm.

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2.12 CLUTCH UNIT

Before reassembling the clutch unit, carry out some controls on the various components described below.

2.12.1 CHECKING CLUTCH BASKET, ROLLER BEARING AND INTERNAL CENTRE BEARING

Before reassembling the clutch basket, make sure that the sides of the teeth **A**, dedicated to main transmission and **B** dedicated to meshing with the kickstart idler gear and oil pumps, have no superficial nicks or abnormal wear.
Also closely check that the teeth **C**, upon which the driving discs engage, are not chipped or deeply cut.
Make sure that the centre bearing **D** with the roller bearing has no traces of meshing or abnormal wear.
If any damage is found, have the piece replaced.

CLUTCH BASKET:
A) Teeth meshing with main gear;
B) Teeth meshing with kickstart idler gear;
C) Teeth meshing with driving discs;
D) External centre bearing.

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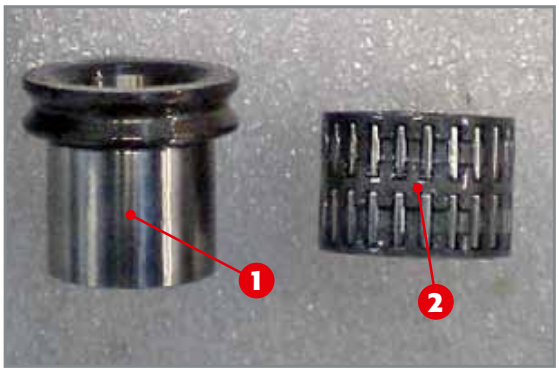
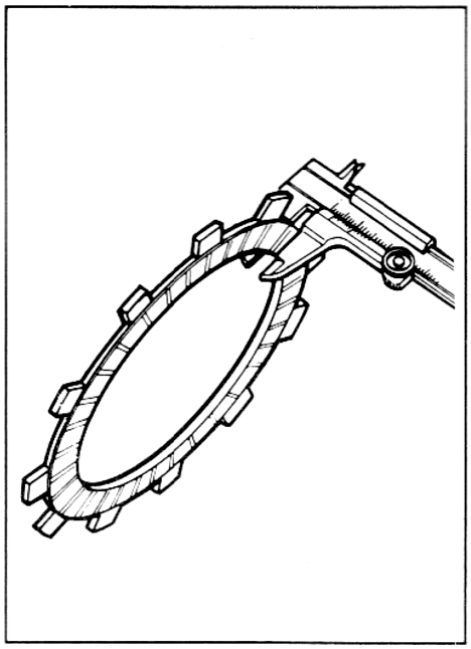


Internal centre bearing and roller bearing of clutch gear.

Check the state of use of the silent-blocks as follows. Clamp the gear **B** intended to mesh with kickstart idler gear, using protective elements. Rotate the clutch basket. If there is play between the basket and the gear unit, replace the clutch basket.
Check the state of use of the centre bearing **1** which must have no traces of meshing or abnormal wear.
Check the state of use of the roller bearing **2**. If it is worn, have it replaced.

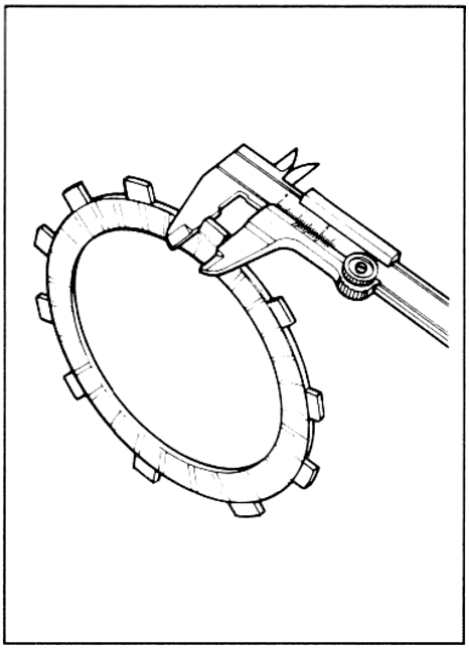


Minimum thickness.

2.12.2 CHECKING CLUTCH DISCS

The clutch discs are divided into friction discs and steel discs: there are eight friction discs and seven steel discs.
The friction discs have friction material applied on both sides which wear out due to the steel discs sliding on them.
Make sure that the thickness of each friction disc is not below the minimum value fixed at:

minimum thickness: 2,8mm



Minimum disc tooth thickness.

The other value that needs to be checked is the thickness of the teeth of each friction disc. They must not be less than the minimum value fixed at:

minimum friction disc tooth thickness: 13,3mm

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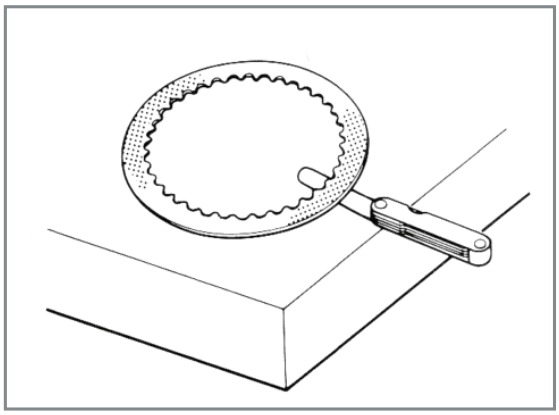
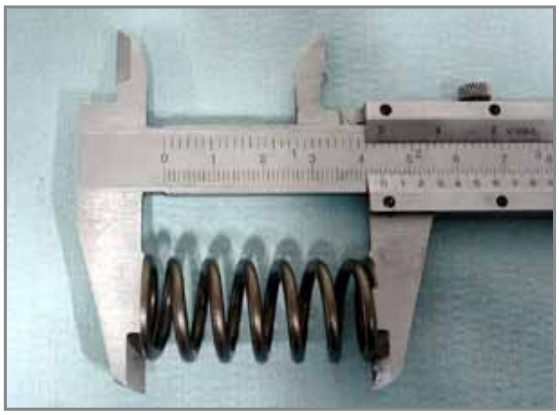


Measuring steel disc distortion.

Also check the distortion of the steel discs. This operation is done by placing the steel discs on a perfectly flat surface and using a thickness gauge to check that the clearance between the disc and the surface is not greater than:

allowable distortion
steel discs: 0.10mm

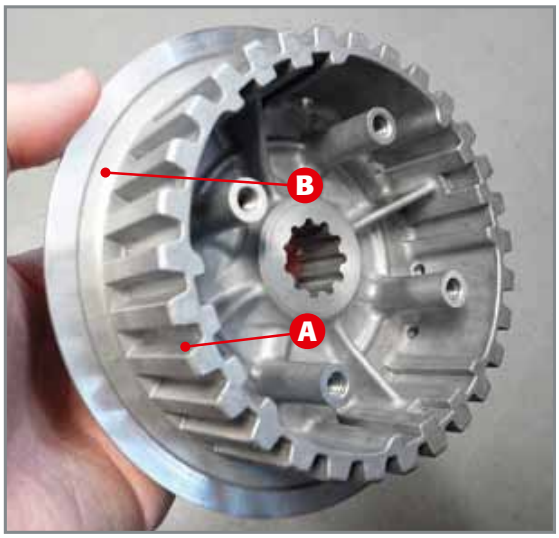


Clutch spring length measurement.

2.12.3 CHECKING SPRINGS

To ensure the correct pressure between the clutch discs, the state of the springs must be checked. The minimum acceptable length must be:

minimum clutch spring length:
42 mm



Checking inner hub teeth.

2.12.4 CHECKING INNER HUB

The inner hub meshes with the steel clutch discs by means of the teeth **A**: Make sure these teeth are not meshed or shaped by abnormal wear. If so, replace the inner hub. Make sure that the seat **B** where the support washer of the disc spring slides shows no traces of meshing. If so, replace the drum.
Also control that the radial holes present on the inner hub are not obstructed and are free from sediments.

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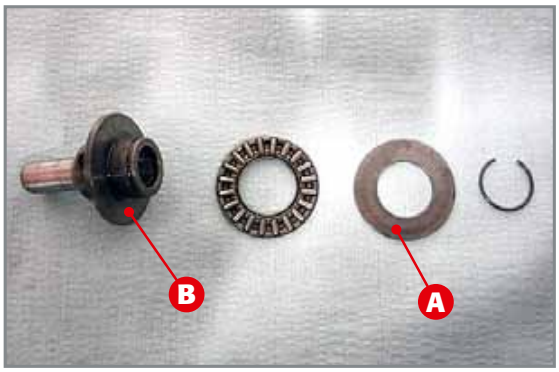


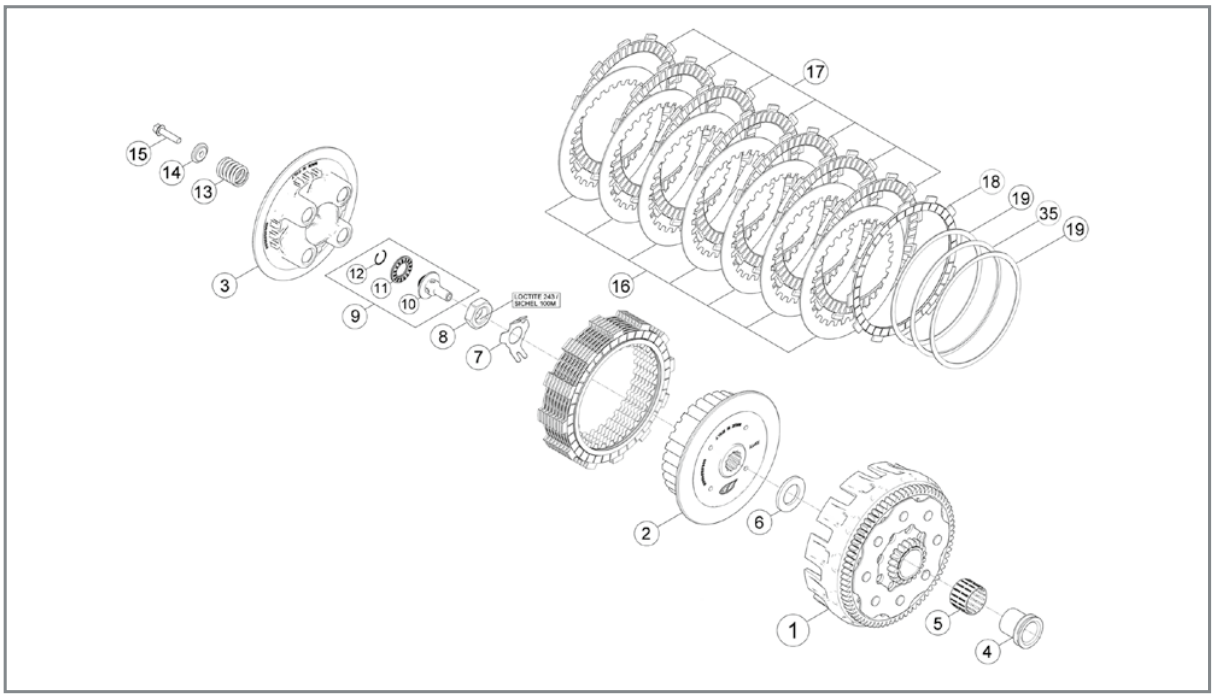
Thrust bearing device.

2.12.5 CHECKING THRUST BEARING DEVICE

Check the state of use of the thrust bearing and the surfaces upon which it rests. In order to check the thrusting bearing, just see if it slides. When the device is assembled, simulate rotation of the front centre bearing **A** respect to the rear one **B**.
Be careful for presence traces of meshing or wear on the sliding surfaces.

2.12.6 ASSEMBLY OF CLUTCH UNIT

After having lubricated the end of the main transmission shaft, insert the internal centre bearing **4** to which the roller bearing must be coupled **5**.
Insert the clutch basket **1** followed by the 21.7x38x3 washer **6**, upon which the inner hub will rest **2**. Put on the safety washer **7** and after having applied medium strength threadlocker, couple the lock nut **8**. In order to facilitate insertion of the clutch basket, lightly turn the kickstart idler gear, the idler gear for oil pump control and the basket itself, thus helping meshing of the various gears.



EXPLODED VIEW OF CLUTCH UNIT 1) Complete basket; 2) inner hub; 3) Clutch pressure cap; 4) Internal centre bearing; 5) Roller bearing 26x30x22; 6) Washer; 7) Safety washer; 8) Nut M18x1,5; 9) Overall thrust bearing; 10) Clutch body rod coupling; 11) Thrust bearing; 12) Circlip RB14; 13) Clutch spring; 14) Clutch spring retainer; 15) Screw M6x25; 16) Steel discs; 17) Friction discs; 18) special fiction disc; 19) washer; 35) judder spring.

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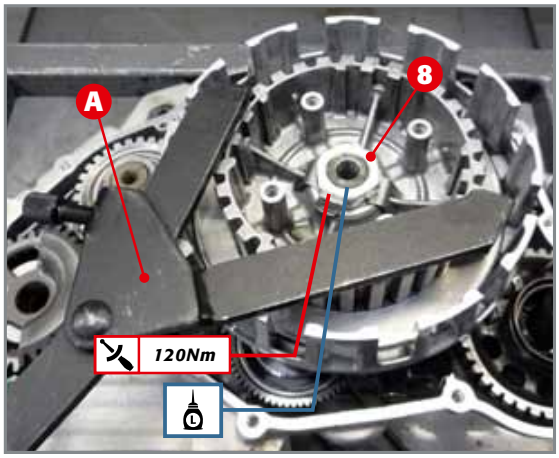
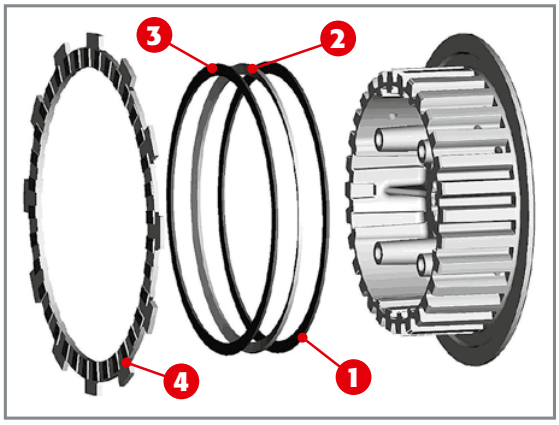


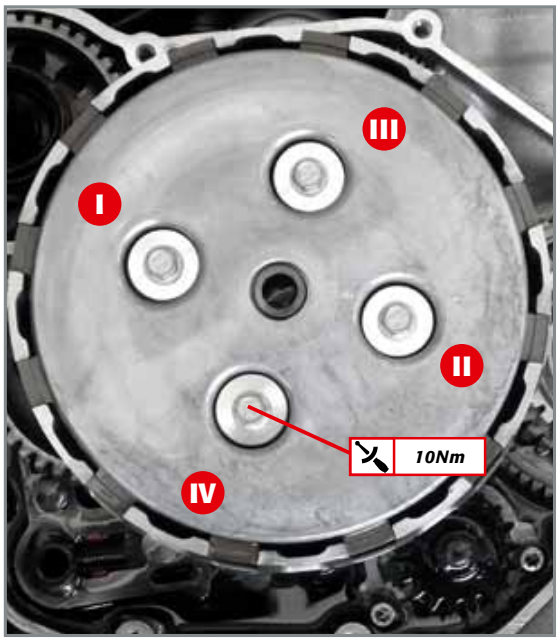
Blocking inner hub with specific tool Code 0061400400.

To unscrew the nut **8**, the inner hub must be blocked with a relevant tool **A** *(code 0061400400)*; the tightening torque is fixed at 120Nm after having applied medium strength threadlocker.
Having tightened the nut, bend to two blocking flaps on the safety plate.



Juddere spring assembling.

Lubricate the clutch disc with gearbox oil and apply the washer 1 in the seat on the drum, the disc* spring 2 so that the concave part faces the washer 1, the washer 3, the special disc 4, a driven disc and then the other discs alternating a driving disc and a driven disc.



Complete clutch and recommended tightening order.

Insert the overall thrust bearing **9** (after having lubricated it with gear oil) in the hole on the main gearbox shaft and check its free axial sliding. Close the clutch unit by means of the clutch pressure cap **3**, the four springs **13**, the fours spring retainers **14** and the four screws **15**, to be tightened with a torque of 10Nm, in a criss-cross pattern.

** Refer to the exploded view of the clutch unit for assembly.*

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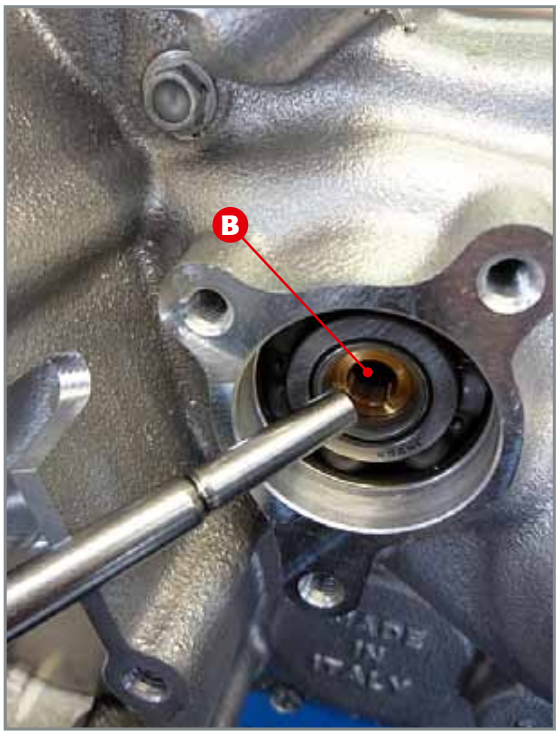
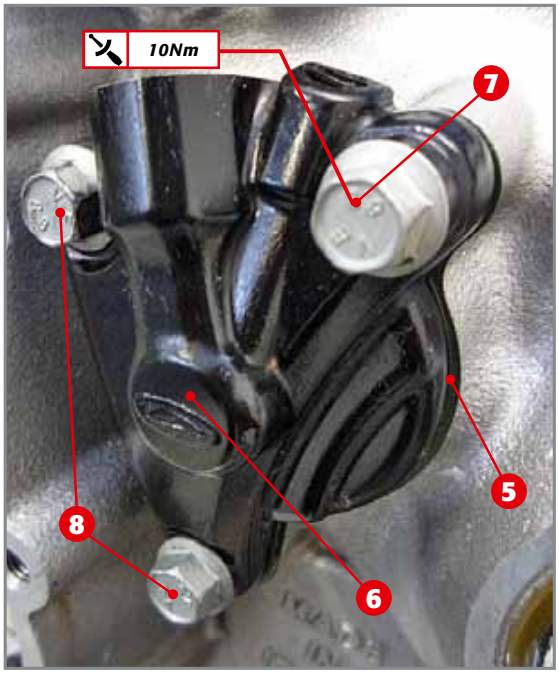


Insertion of clutch rod in housing B.

Insert the clutch rod in the seat **B** from the left side of the engine, turning the smaller section towards the inside of the engine.



Application of gasket 5, actuator 6, screw 7 M6x30 and two screws M6x20.

Apply the gasket **5**, the complete hydraulic actuator **6** the M6x30 screw **7** and the two M6x20 screws **8** to the left crankcase half. Tighten the three screws at a torque of 10Nm.

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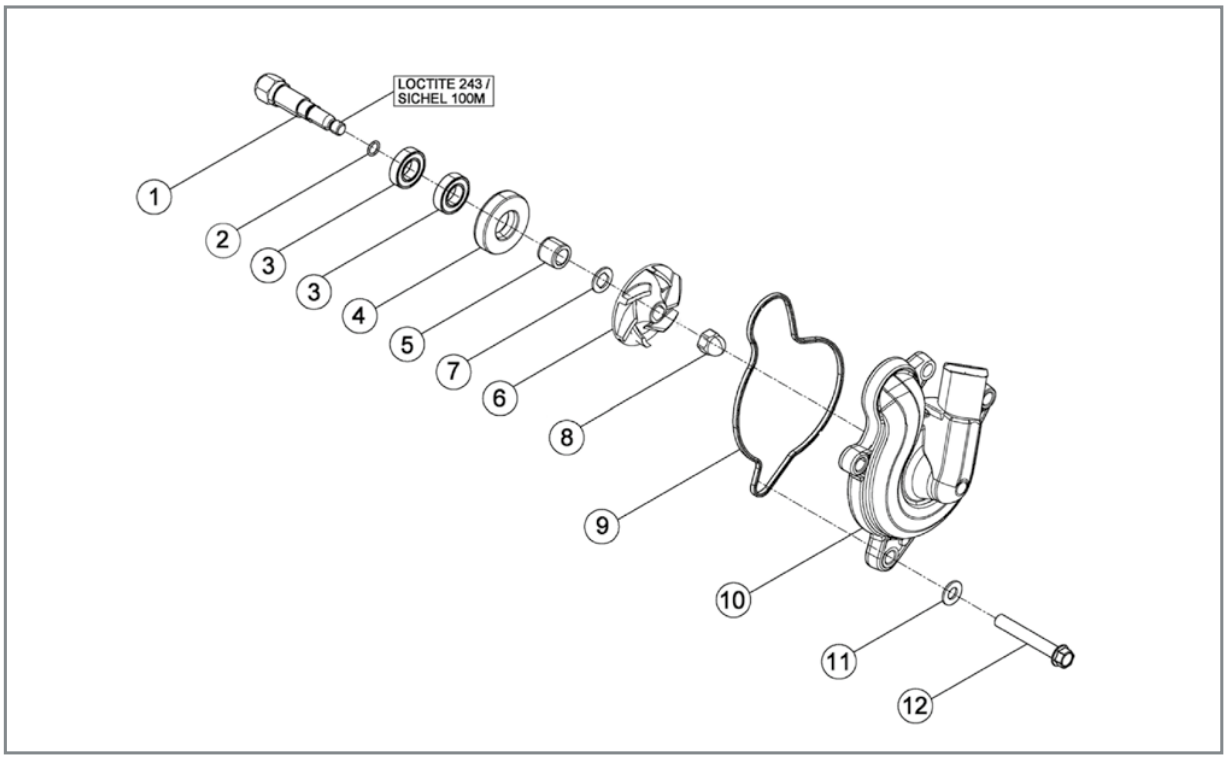
2.13 COOLANT PUMP

The water pump must guarantee, depending on the set rotation speed, the correct flow rate of the coolant in order to extract the needed amount of heat from the thermal unit.
The shaft **1** is supported by two bearings **3** and sealing of coolant and gear oil is ensured by the O-ring **2** and oil seal **4**.
The impeller 6 is fastened to the shaft **1** and the coupling is ensured by tightening the nut **8** onto the shaft **1**.

EXPLODED VIEW OF WATER PUMP

1) Drive shaft
2) O-ring 5.5x1;
3) Bearing 10x19x5;
4) Oil seal 12x30x7;
5) Bush 8x12x10;
6) Impeller;
7) Washer;
8) Blind nut M6x1;
9) Gasket;
10) Gasket cover;
11) Washer;
12) Screw M6x40.



Complete internal clutch cove of water pump.

2.13.1 CHECKING PUMP UNIT AND DISASSEMBLY

Disassembly of the entire pump unit can be done only with the entire clutch cover removed.
Disassembly of the pump unit is performed by removing the nut **8** which allows you to extract the impeller **6**, the washer **7**, and the shaft **1**. This can be removed by pressing the threaded part of shaft **1** towards the inside of the clutch cover.
Extract the oil seal **4** and, heating the bearings **3**, remove them.
Once the shaft is pulled off 1 from the crankcase, it is recommended to replace the O-ring **2**.
Replace the oil seal **4** every time and if the bush **5** is marked in the area of contact with the oil seal, replace it as well.

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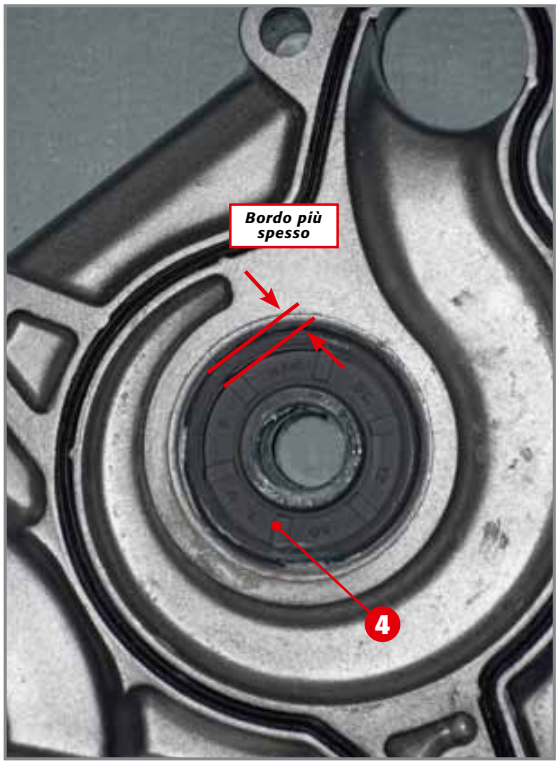
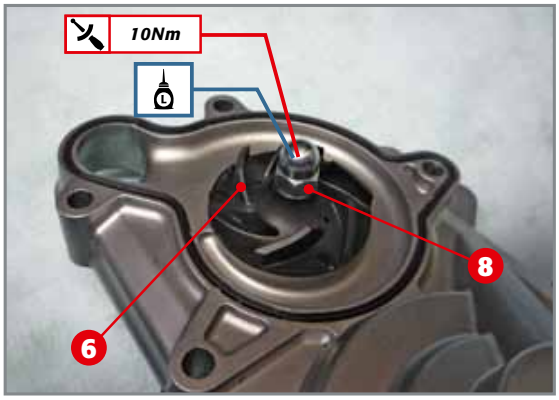
2.13.2 ASSEMBLY OF PUMP UNIT



Application of oil seal on inner clutch cover.

Heat the concerned area to couple the bearings **3** to the inner clutch cover. They must be pushed until they are flush with the shoulders on the pump body.
Grease the oil seal housing. Position the oil seal **4** so that the thicker edge faces the outside of the cover. Insert the oil seal in the inner clutch cover, having it enter the seat very slowly to keep it from deteriorating.



Complete coolant pump unit.

Couple the shaft **1** with the O-ring **2** to the inner clutch cover and then insert the bush **5**, the washer **7** and the impeller **6**.
Then couple the blind nut 8 to the threaded segment of the shaft after having applied medium strength threadlocker. Tighten it at a torque of 10Nm.

When coupling is complete, check that the pump unit turns freely without meshing or friction.
Check the axial play of the pump unit. Make sure it is not beyond 0.3 mm.
It is recommended to replace the gasket in between the inner clutch cover and the pump cover.

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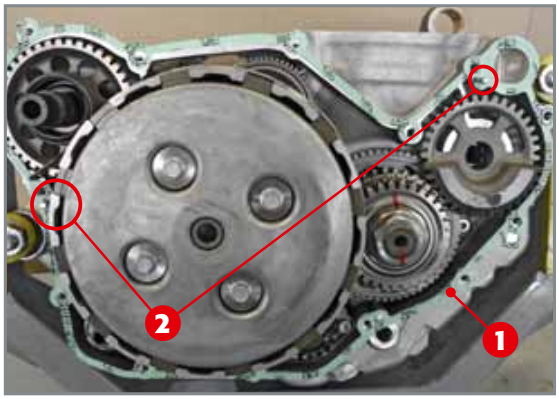
2.14 ASSEMBLY OF COMPLETE CLUTCH COVER

Apply a new gasket **1** placed between the right crankcase half and the inner clutch cover using the two reference pins **2** to keep it in place.

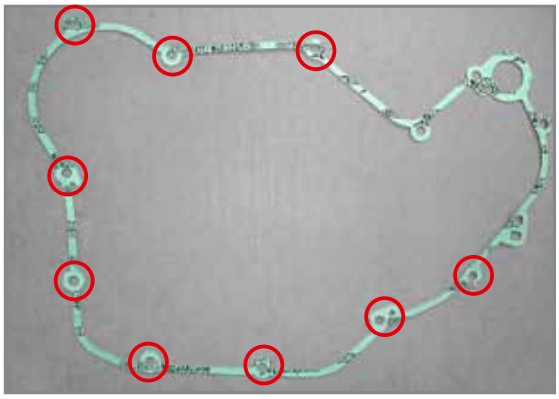


Positioning of gasket 1 and centring pins 2.

Couple the inner clutch cover to the right crankcase half and turn the water pump impeller until the pump shaft inserts perfectly in the housing on the countershaft which drives it.

Application of complete inner clutch cover to right crankcase half.

Apply the nine M6x25 screws as shown in the figure, tightening them by hand until they are flush.



Positioning of M6x25 screws.

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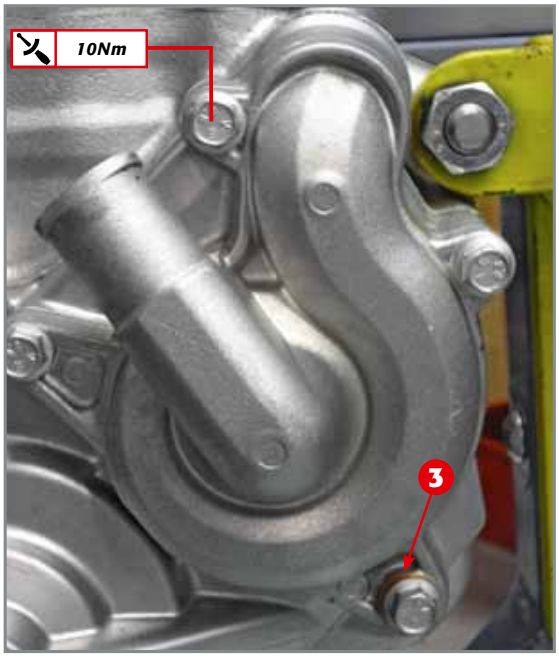
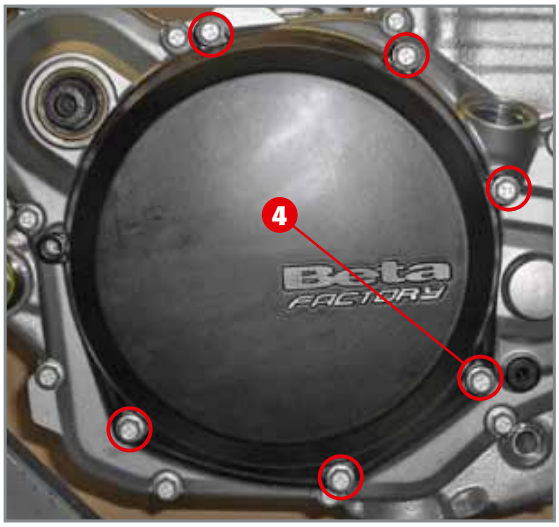


Coolant pump cover: pay attention to washer 3.

Couple the water pump cover to the inner clutch cover applying the four M6x40 screws, making sure to apply the copper washer **3** to the lower screw of the pump cover.
Tighten all thirteen screws at a torque of 10Nm following a criss-cross pattern.



4 screws that fasten the outer clutch cover to the inner cover.

If only the outer clutch cover was removed, put it back on the inner cover and fasten the six M6x25 screws as shown in the figure.

Detail of screw 5 to be applied with the engine coupled to a vehicle.

The M6x30 screw **5**, not present in the figure, is coupled to the engine applied to the vehicle because this maintains a spacer in position upon which the brake pedal return spring in engaged.

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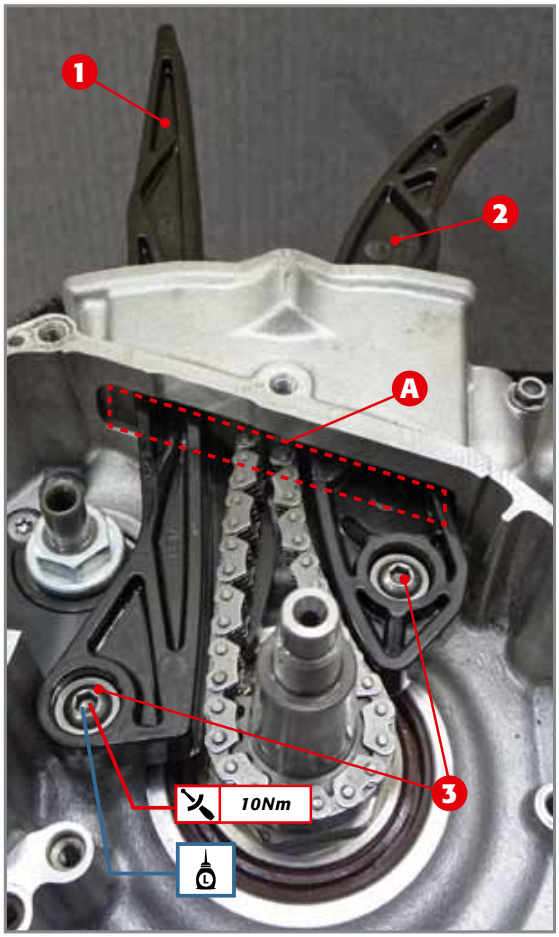
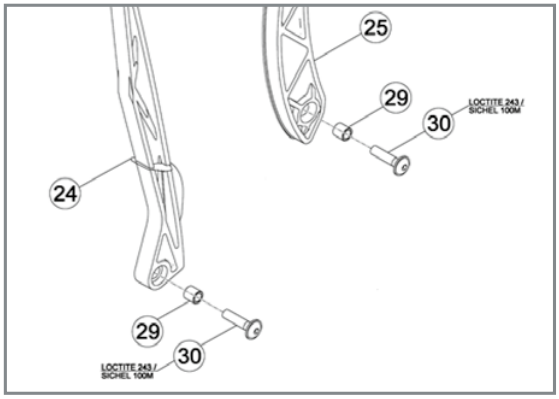


Timing chain with relative fixed and movable guides.



Mounting bushes in lower eyelets of guides.

2.15 CHECKING AND COUPLING OF TIMING CHAIN, FIXED AND MOBILE GUIDES

The chain has the task of transmitting motion from the crankshaft to the camshafts present on the cylinder head. The links must be checked to make sure there is no excessive radial or axial play between them.
The fixed and movable guides guarantee a correct movement of the chain. The hydraulic chain tensioner ensures correct tensioning.
Make sure that the guides do not have deep traces caused by the rotation of the chain.
In order to assemble the chain to the engine, just introduce it in the vertical passage compartment A on the left crankcase and insert it in the gear on the crankshaft.
Insert the fixed guide **1** and the movable guide **2** inside the compartment **A**. Insert the specific 6.2x9x9 bushes inside the lower eyelets of the guides. After having applied medium strength threadlocker, tighten the relative screws **3** at a torque of 10Nm.

2.16 IGNITION SYSTEM

Before reassembling the ignition system, it is recommended to check its correct functioning.
The ignition system is made up of the magnetic pick-up, the stator unit and the flywheel. The system is completed by the electronic control unit, the ignition coil and the spark plug, which are not dealt with in this text.

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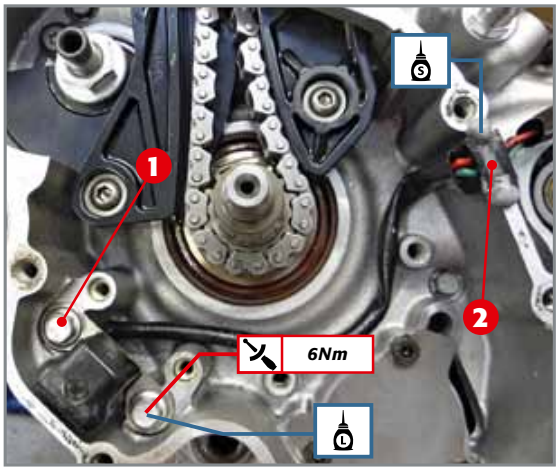
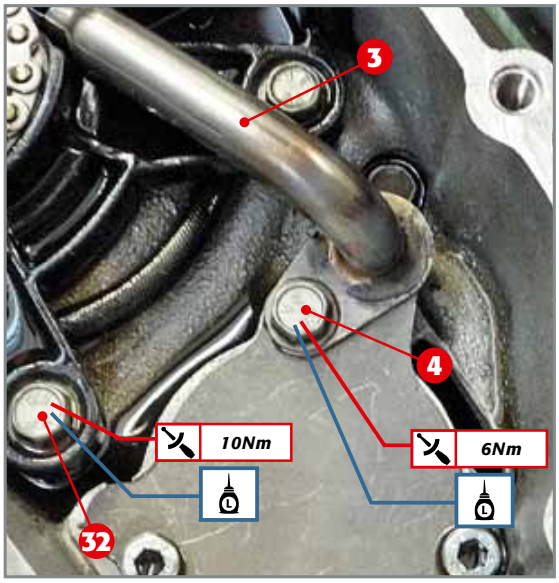
2.16.1 CHECKING IGNITION SYSTEM

Degrease the various elements and carry on with the controls.
The main control is the one concerning the electrical verification which can be done by using a standard tester. The resistance values detected at the terminal heads must respect those carried in the table (at 20°C).

Element	Cables	Resistance values
Pick-up	Red – Green	100Ω ± 20%
Stator	Red/Black – White/Red	14,7Ω ±15%
	Yellow – Mass	0.61Ω ±15%
	Yellow – White	0.18Ω ±15%



Coupling pick up to crankcase.



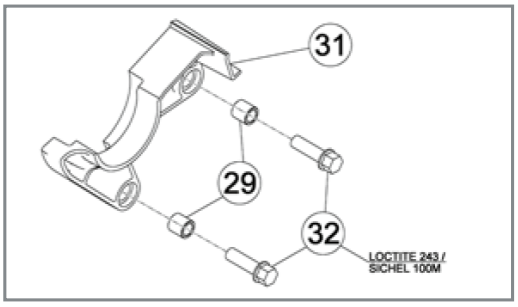
Coupling chain guard to crankcase.

2.16.2 COUPLING IGNITION SYSTEM TO CRANKCASE

Set the pick-up on the crankcase so that the two holes on its support coincide with the two outer holes on the crankcase.
Apply the threading of the two screws **1** with medium strength threadlocker and tighten them at a torque of 6Nm.
Lay the cable on the crankcase, apply the groove of the cable gland **2** with gasket paste *(code 3625000000)* and insert it in the specific housing n the crankcase, removing excess paste.
Couple the chain guard to the crankcase, insert the two 6.2x9x9 bushes in the lower eyelets and couple the two screws **1** after having applied them with medium strength threadlocker. Then tighten them at a torque of 10Nm.

Attention: *pay close attention so that the cables are well fastened to the wall of the crankcase halves near the cable gland.*

Apply the oil jet **3** so that the bottom edge enters the hole of the cover. Insert the screw **4** previously spread with medium strength threadlocker. Tighten the screws at a torque of 6Nm.



Mounting bushes in lower eyelets of chain guard.

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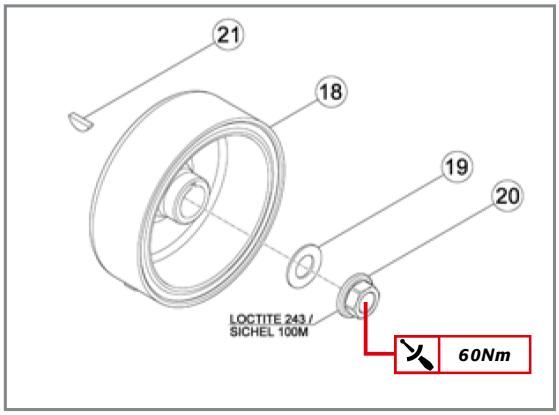
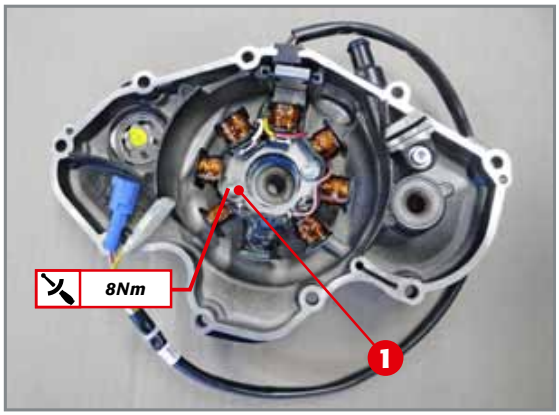


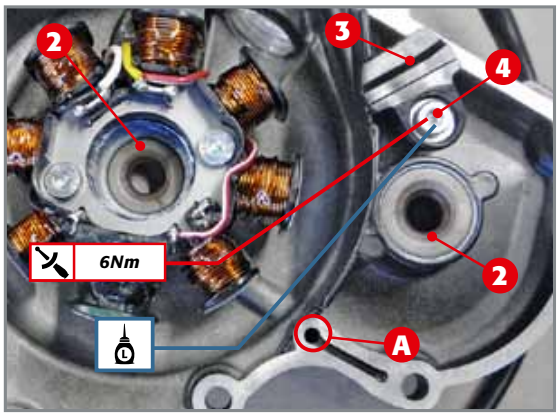
EXPLODED VIEW OF FLYWHEEL
18) Flywheel; 19) Elastic washer; 20) Nut M12x1; 21) Woodruff key.

Degrease the conical segment of the crankshaft, apply the Woodruff key **21** in the appropriate groove on the crankshaft, couple the flywheel **18**, the elastic washer **19** and the nut **20**, after having applied the threading with Loctite 243 / Sichel 100M medium strength threadlocker. Tighten the nut at a torque of 60Nm.



Coupling stator to flywheel cover.

Couple the stator to the flywheel cover by means of the two screws **1**. Apply the threading with medium strength threadlocker and tighten them at a torque of 8Nm.
Insert the cable gland in its specific seat and check its perfect sealing.



Detail of flywheel cover.

Check the state of use of the two oil seals **2**. If they are deteriorated, they must be replaced.
Blow compressed air in the hole **A** making sure the lubrication pipe is perfectly clean. Also check the state of use of the chain guide **3**. If it is deteriorated, it must be replaced. In that case, before putting on the screw **4**, apply it with medium strength threadlocker and tighten it at a torque of 6Nm.

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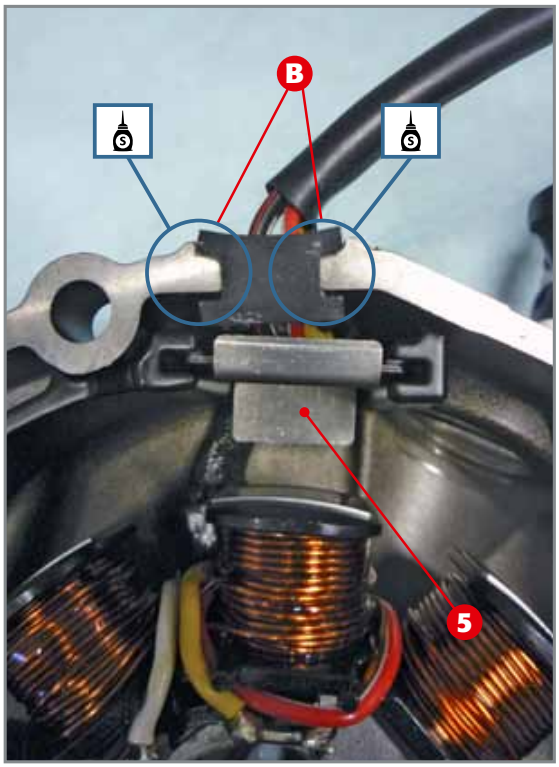
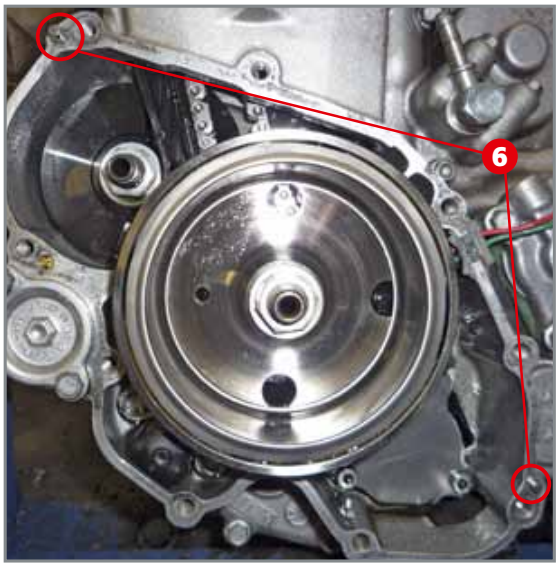


Application of cable protection plate 5. Note the two zones A where a drop of gasket paste must be applied.

Reposition the plate **5** which must be inserted in the relevant guides and pressed towards the outside of the cover.
When coupling it to the left crankcase half, apply a drop of gasket paste *(code 3625000000)* in the two zones **B**, in order to ensure perfect sealing between the cover and the crankcase half in the concerned zone.



Application of centring pins on left crankcase half for coupling with flywheel cover.

Insert the centring pins **3** on the crankcase and fasten a new gasket. Grease the oil seal on the flywheel cover and couple it to the left crankcase with the nine M6x25 screws **4**.

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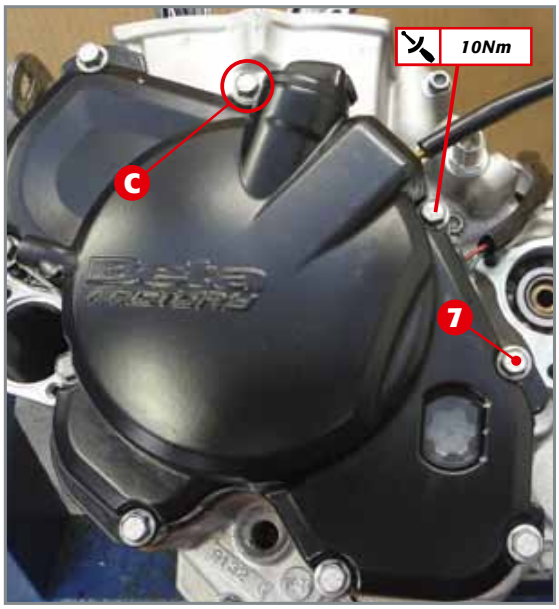

Flywheel cover coupled to crankcase.

Notice that a 12x6.3x1 copper washer **4** must be applied to the screw.

Tighten the screws at a torque of 10Nm.

2.17 THERMAL UNIT

Before assembling the thermal unit, thorough controls must be carried out on the cylinder, piston, pin bolt, piston rings, cylinder head and the timing unit described hereafter.

Quota at which to measure the outside diameter of the piston.

2.17.1 CHECKING PISTON, PIN BOLT, AND PISTON RINGS

Eliminate carbonaceous sediment from the top of the piston and wash the entire piston with specific degreasing agent.
Do not use sharp points or tools for cleaning.
Then carry out a careful analysis of the piston which must be free from forcing, scratches, cracks or any type of damage.
Analyse the outside diameter of the piston whose service limit is carried in the table below concerning their specific class. The diameter must be measured at a distance X from the inner edge of the skirt perpendicularly to the axis of the pin bolt.

Displacement [cm³]	Quota X [mm]	Service limits based on relevant class [mm]	
		1	2
350	6	88,90	88,91
400	7	94,915	94,925
450	7	94,915	94,925
498	7	99,905	99,915

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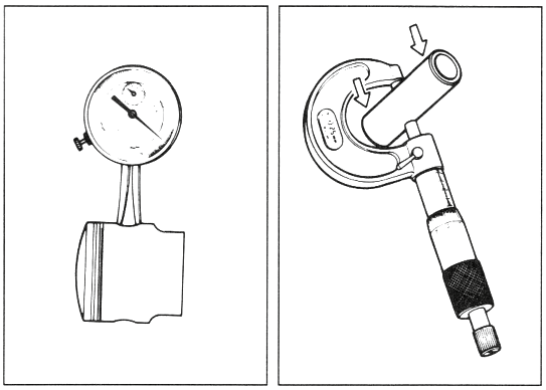
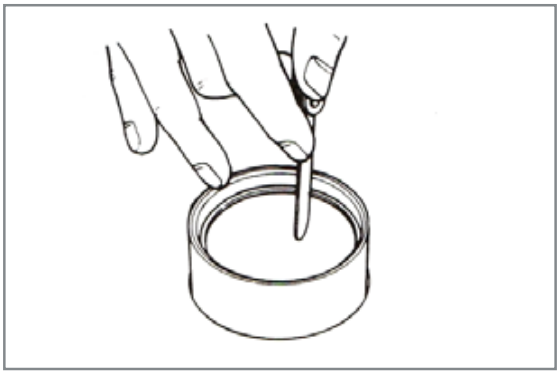


Measuring pin bolt seat and pin bolt.



Checking the wear limit of the elastic band.

Check the size of the pin bolt seat located on the piston and the size of the pin bolt. This last control must be made at the end of the pin bolt itself in the area where it is engaged with the piston.

Displacement [cm³]	Size [mm]	
	Pin bolt seat	Pin bolt
350	18,03	17,98
400-450-498	20,03	19,98

See the relative chapter regarding crankshaft and connecting rod controls for controls on connecting rod foot (par. 1.2).

In order to check the state of use of the piston ring and oil-scraper ring, the ring must be inserted in the cylinder so that its axis is aligned with the axis of the cylinder. Then measure the distance between the two opposite edges.
The respective service limits are carried in the table below.

Displacement [cm³]	Service limit of compression ring [mm]	Service limits of upper and lower oil-scraper ring [mm]
350 - 400 450 - 498	0,8	1,0

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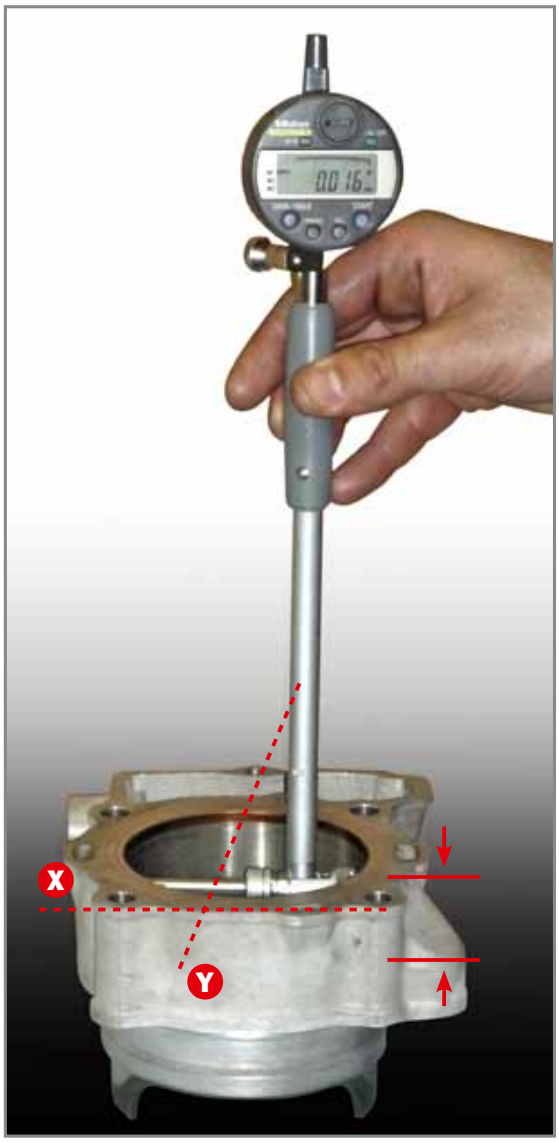

2.17.2 CHECKING THE CYLINDER

Make sure the bore is within the service limits of the relevant class carried in the table below.
Carry out measurement at a distance **A** from the top face of the cylinder (surface between cylinder and cylinder head). To measure it correctly, it must be done according to the **X** and **Y** directions orthogonal between them. Consider the maximum measurement to determine the cylinder wear.
The difference between the two measurements is the ovalization.

This measurement must be carried out by placing the bore meter in such a way that its axis is perpendicular to the axis of the crankshaft.

Displacement [cm³]	Quota A [mm]	Service limits based on relevant class [mm]		
		1	2	Ovalization [mm]
350	35	88,022	88,034	0,015
400	40	95,022	95,034	0,015
450	40	95,022	95,034	0,01
498	40	100,022	100,035	0,01

2.17.2.1 ASSEMBLY CLEARANCE

The following table carries the coupling play between the cylinder and piston.
In order to calculate the coupling play between the cylinder and the piston, a subtraction must be carried out between the diameter of the cylinder and that of the piston.

Displacement [cm³]	Coupling play based on relevant class [mm]				Coupling play limit based on relevant class [mm]	
	Class 1		Class 2		Class 1	Class 2
	Min	Max	Min	Max		
350	0,035	0,057	0,037	0,060	0,10	0,10
400	0,035	0,057	0,037	0,060	0,10	0,10
450	0,035	0,057	0,037	0,060	0,10	0,10
498	0,045	0,067	0,047	0,070	0,12	0,12

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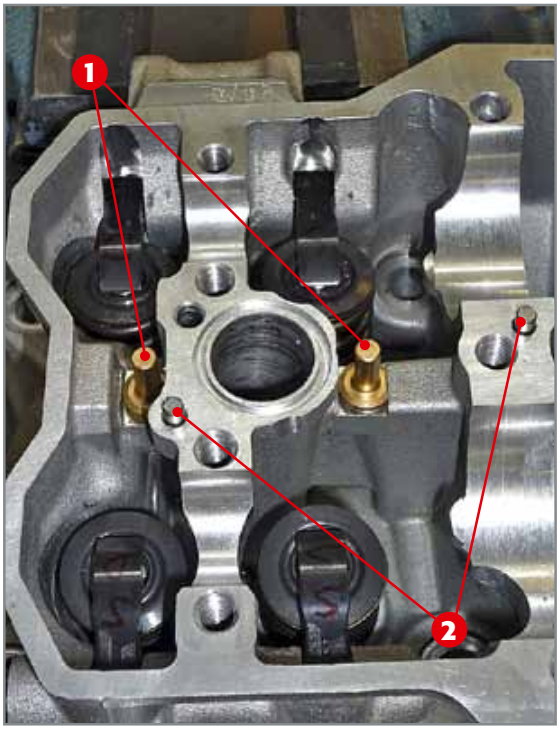
Blocking cylinder head on vice.



Oil jets 1 for lubrication of cylinder head and two centring pins 2.

Detail of oil jet lubrication 1.

2.17.3 CYLINDER HEAD: DISASSEMBLY AND CHECKING AUXILIARY DEVICES

Before disassembling the cylinder head, clean the entire unit thoroughly. The various elements must be cleaned and named bit by bit as they are disassembled.
Proceed as follows for disassembly and inspection of the cylinder head.
Clamp the cylinder head using protective jaws, gripping it at the head connection **A**.
Disassemble the spark plug using the special spark plug wrench *(code 020440100 000).*

2.17.3.1 LUBRICATION JETS AND CENTRING PINS

Pull out the two oil jets 1 for lubricating the cylinder head and make sure the holes are free from any impurity. Take off the O-rings- If damaged, replace them.

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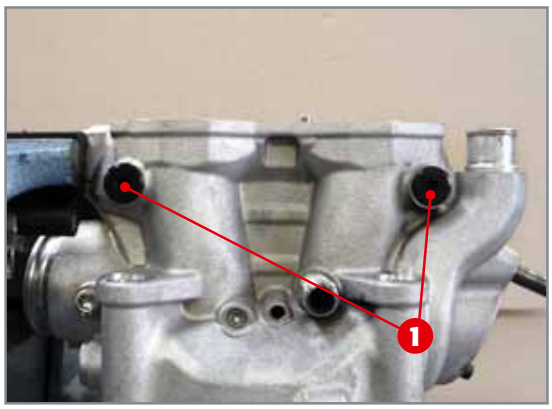
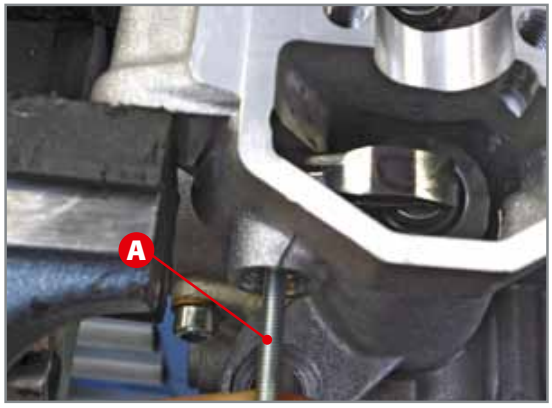


Closing caps for finger follower support shaft seats.

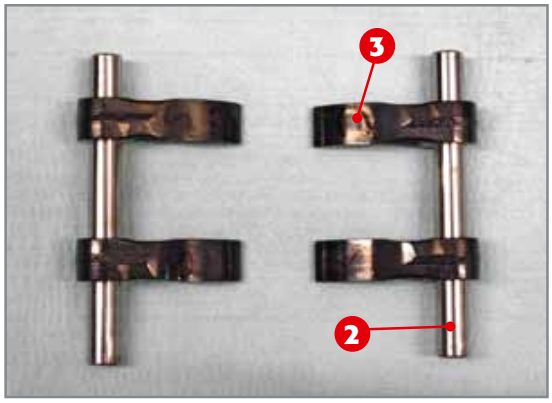
2.17.3.2 FINGER FOLLOWER/SHAFTS UNIT

Disassemble the two caps **1** which keep the finger follower shafts in place.
Make sure the face of the cap facing the shaft does not have deep traces or signs of wear. If so, replace the caps.
Check the state of use of the two O-rings between the caps and the cylinder head. We recommend they be replaced.



Application of M4 screw to allow pulling out the finger follower support shafts with your fingers.

The finger follower shafts have a threaded hole (M4) at the end so that they can be extracted. To pull them out, just screw a sufficiently long M4 screw **A** in this hole and pull out. In this way, the finger followers can be extracted.



finger follower /shafts unit.

Make sure the outside diameters of the shafts **2** and the inside diameters of the holes on the finger followers **3** respect the following service limits:

Shaft service limit: 6.98mm
finger follower service limit: 7.03mm
Play limit: 0.05mm

Check to see that the contact areas between the finger followers and the calibrated discs, and between the finger followers and the cams are not chipped or particularly worn. If so, replace the finger follower.

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Removal of calibrated discs from seats.

Measure shim.

2.17.3.3 SHIMS (CALIBRATED DISCS) FOR VALVE PLAY ADJUSTMENT

Using a magnet, pull out the calibrated discs **1** from the seats in the cups.
Once the calibrated discs are extracted, measure them with a thickness gauge.

The calibrated discs range from 2.00 to 3.30 according to the intervals carried in the table below.

Intervallo spessori[mm]	*Step [mm]*
2,000 ÷ 2,300	***0,050***
2,325 ÷ 3,000	***0,025***
3,050 ÷ 3,200	***0,050***

Once you have done the measurement, take note and mark the calibrated disc depending on its original position.
Should the calibrated discs be deteriorated, replace them with others having the same dimensions. Thus you can know whether to replace it with a thicker or thinner calibrated disc when determining the valve play.

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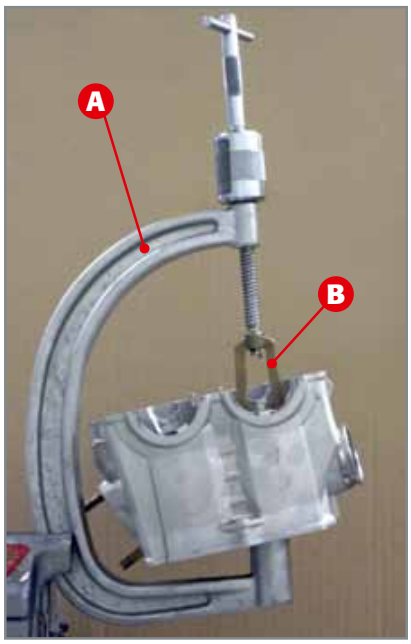


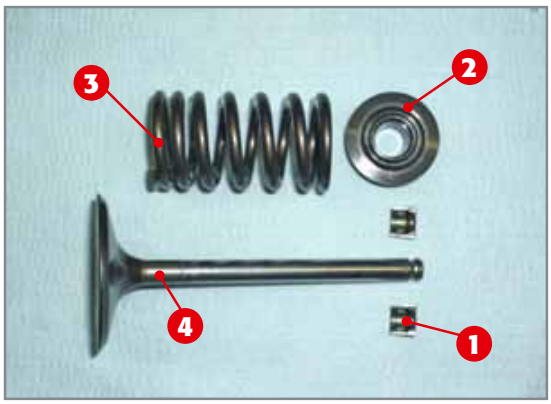
Placing cylinder head on device for disassembling valve springs.

2.17.4 CYLINDER HEAD: DISASSEMBLING AND CHECKING VALVE UNITS

Clamp the spring removal jaw **A** *(code 0100043 000)* and apply the spring removal tool onto it **B** *(code 006140030 000)*. Then position the cylinder head and disassemble the springs.

Extraction of half-cones.

Compress the spring as much as necessary to extract the half-cones **1**.



Valve unit.

Having extracted the half-cones, release the spring and extract the cup **2**, the spring **3** and the valve **4**.

ATTENTION! *Mark all the pieces you disassemble. Pay particular attention to the valves.*

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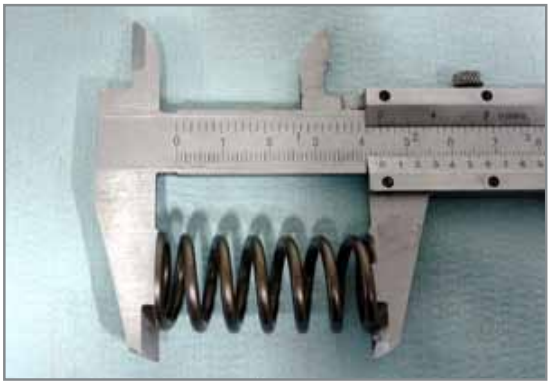


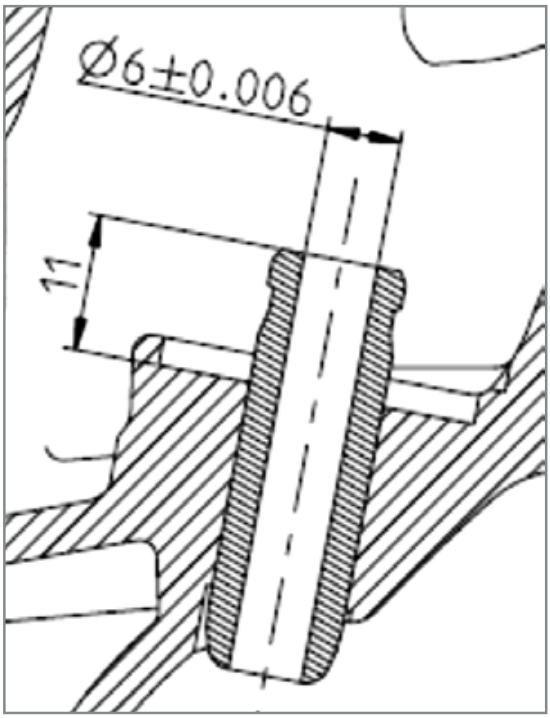
Measuring length of free spring.

2.17.4.1 SPRINGS

Each valve is retained by a spring. The length of these springs must be checked while they are loose:

service limit = 42,5mm

Should the springs be shorter, have them replaced.



Reference dimensions for processing and fitting valve guide.

2.17.4.2 VALVE GUIDES, VALVES AND SEATS

Make sure that the valve guides are free from scratches or any type of nicks. To check the correct diameter, introduce the gauge in the valve guides from the side of the combustion chamber (code *006140180 000)*. If the gauge can enter, the valve guide must be replaced at a rectification workshop.
To this purpose, keep to the data carried in the drawing.
Remember that if replacing the valve guides, the seats of the valves must be repassed as described later on.
Brush the valve mushroom head thoroughly and degrease the entire valve.
Make sure that the valve stems are free from scratches or any type of nicks. Measure the diameter of the valve stems, making sure it is not less than the service limit:

Valve stem diameter service limit: 5,95mm

If it is, replace the valve. Play between the valve and the valve guide must not be greater than the limit carried below:

Play limit between valve and valve guide: 0,08mm

If play is greater, first try to replace the valve. Should play still not be within the aforementioned limits, intervene on the valve guide.Check the valve mushroom head zone, making sure that the area of contact with the seat is not dented: if so, replace the valve.
Check the state of wear of the valve seats and the sealing surface. In order to do this, apply a light layer of Prussian blue paint on the contact zone of the valve with the seat. Then insert the guide valve until you press it against the seat and turn it on its own axis.

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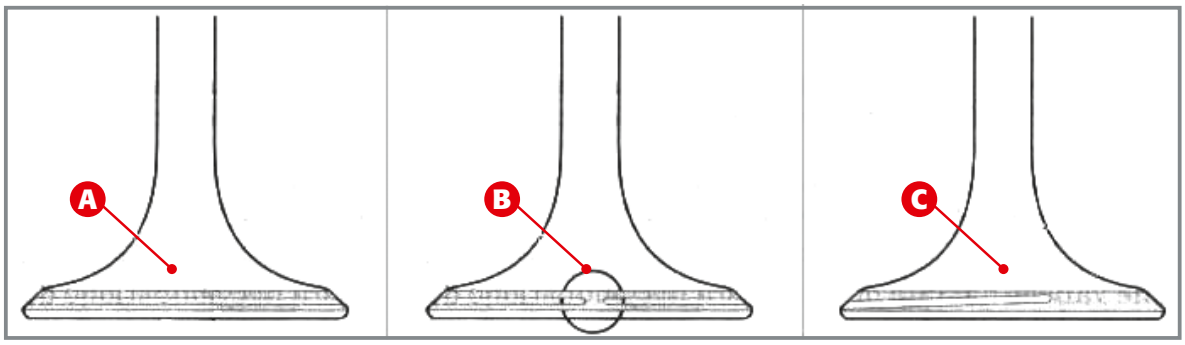
Taking the valve out, the paint will be missing in the contact zone. Its width must not be greater than the following service limit:

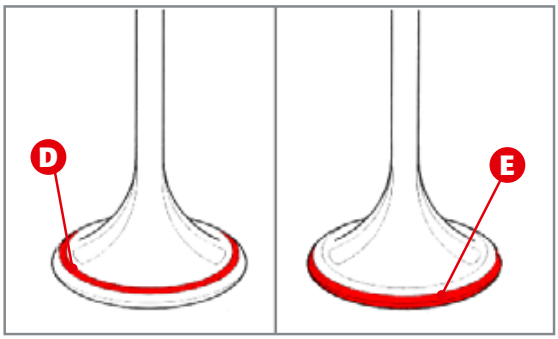
Width service limit of valve seat contact zone: 1,9 mm.

The contact zone can principally take on three different appearances, as shown in the figure:

A - correct;
B - incorrect (contact face damaged);
C - incorrect (uneven seat width).

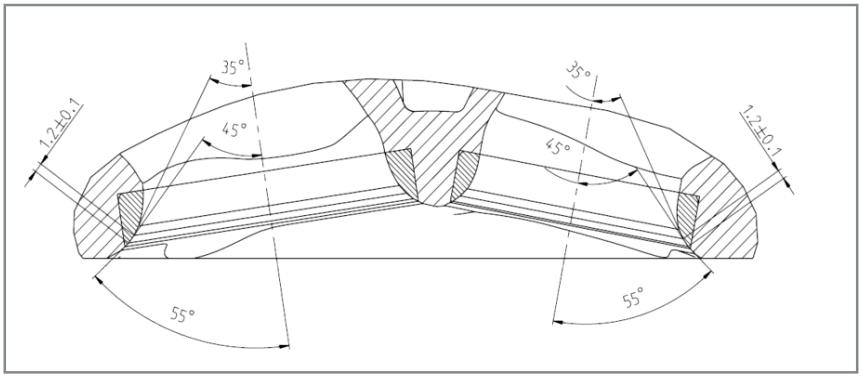


Valve-seat contact conditions: A) Correct; B) Incorrect - contact face damaged-; C) Incorrect - uneven width-.



Positioning of contact area: D) too high; E) too low

Also check the correct positioning of the contact area. It must be neither higher (case **D**) or lower (case **E**).
Should the incorrect conditions described above occur, the valve seats must be rectified, respecting the conditions carried in the following drawing.



Geometric features of valves seats.

If the valve seats are beyond recovery, replace the cylinder head.

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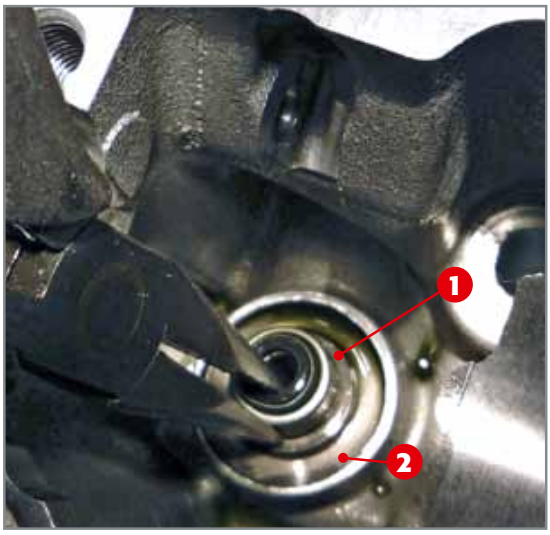
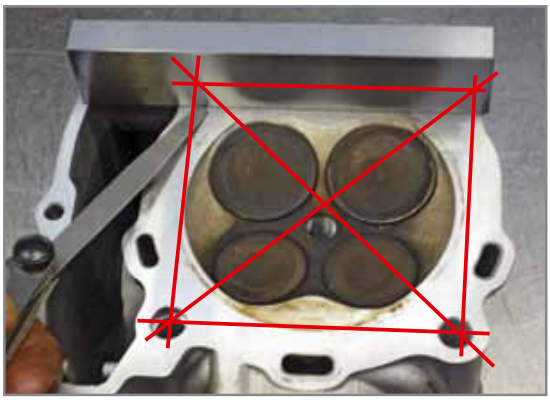


Extraction of valve stem seals from valve stems.

2.17.4.3 VALVE STEM SEAL AND LOWER STOP WASHER

Should there be excessive oil consumption or a white-like exhaust smoke which cannot be blamed on the oil-scraper rings on the piston, replace the valve stem seals **1**, intended to prevent excess oil leakage.
It is recommended to replace them every time the cylinder head is overhauled.
In order to replace them, use needle-nose pliers to pull them out, being careful not to nick the valve guide.
Once the valve stem seal is extracted, the lower cup can be pulled out **2**.



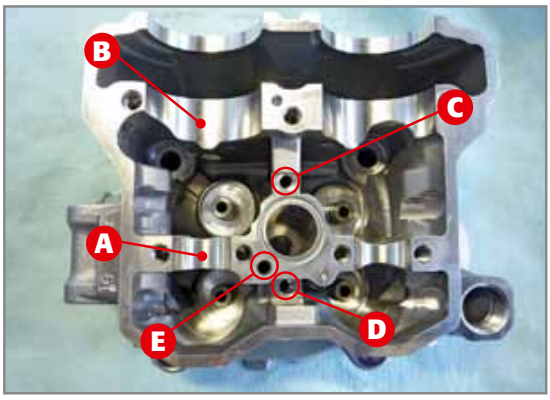
Checking flatness of cylinder head.

2.17.5 CYLINDER HEAD: CHECKING CYLINDER HEAD BODY

Check the flatness between the head and cylinder coupling surfaces.
This can be done using a rectified block and a thickness gauge by positioning the block according to the directions shown in the figure.

The service limit is:

cylinder head flatness service limit: 0.05mm



Check that the state of use of the sliding zones **A** with the camshafts and **B** of the camshaft support bearing housing are free of scratches or signs of meshing.
Clean the oil passages for lubricating the cylinder head by blowing compressed air into the holes **C**, **D** and **E**.

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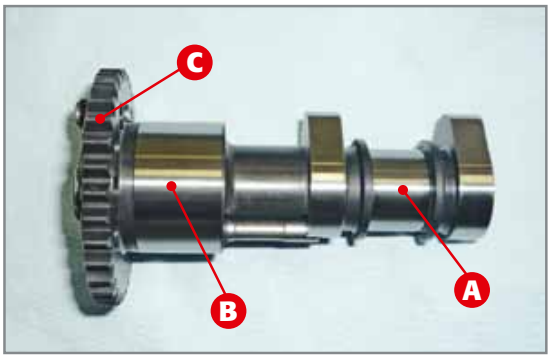


Cam zone to be checked.

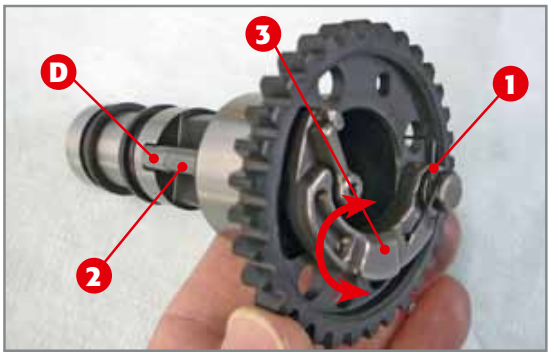
2.17.6 CHECKING CAMSHAFTS

Verify the zones **A** and **B** on the camshafts making sure they have no traces of meshing or abnormal wear. Make sure the sides of the teeth **C** are not chipped or have no trace of abnormal wear.
The zone **A** comes into contact with the cylinder head becoming part of a hydrodynamic support bearing. Zone **B** on the other hand supports the roller bearing.
Make sure that the shafts in the cam zones are free of abnormal colouring which is typical when working without oil.

Cam height measurement.

Use a thickness gauge to check the wear limit of the cams referring to the values carried in the table.
Sometimes the cams show small run marks. This can be accepted, if the finger followers are without wear and the cam height is inside the tolerance.

	Intake		Exhaust	
Displacement [cm³]	Nominal size [mm]	Size limit [mm]	Nominal size [mm]	Size limit [mm]
350	34,1	34,0	33,75	33,65
400	34,1	34,0	33,75	33,65
450	33,75	33,65	33,75	33,65
498	33,75	33,65	33,75	33,65



Check on the exhaust camshaft that the spring **1** of the centrifugal decompressor recalls the rest of the device so that the cylinder segment **D** of the rod **2** protrudes completely without any play.
Turn the lever **3** all the way to make sure the device is not jammed.

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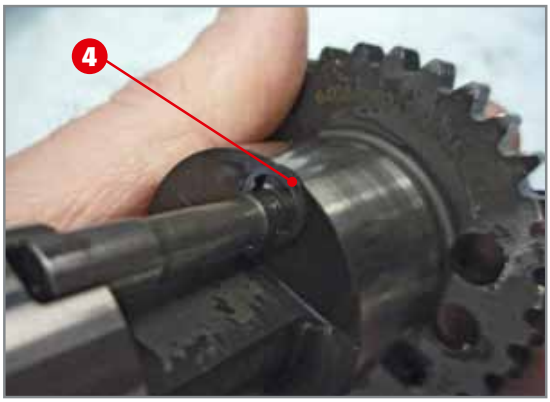
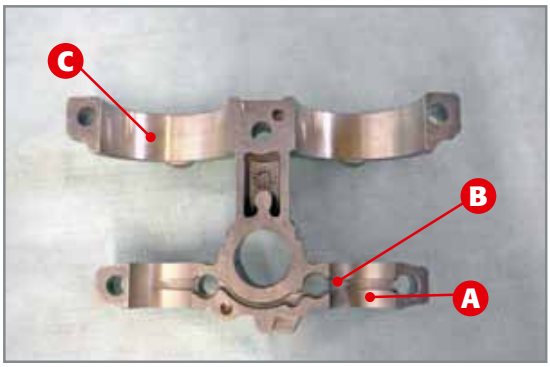


Extraction of Benzing ring from decompressor shaft.

Make sure that the cylinder segment **D** of the decompressor is not worn or chipped. Should it be deteriorated, replace the decompressor shaft. In order to extract it, remove the Benzing ring **4** and pull the shaft out. Operate inversely to reassemble it. If replacing the decompressor shaft, replace the Benzing ring as well.



2.17.7 CHECKING CAMSHAFTS SUPPORT

The camshafts supports fasten the shafts so they maintain the correct position while operating. The support in the zone **A** has a channel **B** intended to lubricate the camshaft to allow the hydrodynamic support of the shaft itself. Therefore you must make sure that the zones **A** are free from scratches or traces of corrosion.
Make sure the zones **C** for housing the roller bearings have no traces of meshing or scratches.

Attention: *If the support needs to be replaced, the cylinder head must be replaced as well.*

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Insertion of lower cup.

Insertion of valve stem seal.

2.17.8 CYLINDER HEAD: INSERTION OF INNER CUP AND VALVE STEM SEAL

If the lower cups and valve stem seals were disassembled*, reassemble them as follows. First insert the lower cup **1** facing the flat part downwards. Lubricate the upper part of the valve guide lightly and insert the valve stem seal **2**. Pay close attention that while inserting the valve stem seal, its axis is aligned with that of the valve guide. The valve stem seal must be pressed towards the bottom of the cylinder head until it is flush with the valve guide.

* *Remember the valve stem seals must be replaced once they have been taken off.*

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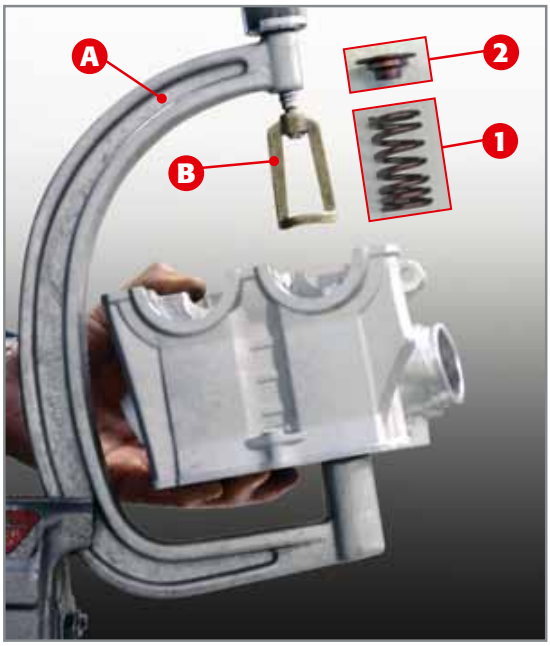

Placing cylinder head on device for disassembling valve springs.

2.17.9 CYLINDER HEAD: ASSEMBLY OF VALVE UNIT

Clamp the spring removal jaw **A** *(code 0100043 000)* and apply the spring removal tool onto it **B** *(code 006140030 000)*.
Insert the valve stem in the valve guide* from the combustion chamber side.
Place the valve in the specific lower housing of the jaw and introduce:

- The spring **1**, being careful to insert it so that the segment with the smaller pitch faces downwards;
- The upper cup **2**, turning the flatter part upwards.

Spring compression, half-cones insertion. Note the application of grease on the upper part of the stem.

Compress the spring as much as necessary to extract the two half-cones **3**. To facilitate their insertion, apply a small amount of grease on the stem in the half-cone housing zone.

** If the valves, valves guides and their seats have not been replaced, the valves must be put back in their original positions.*

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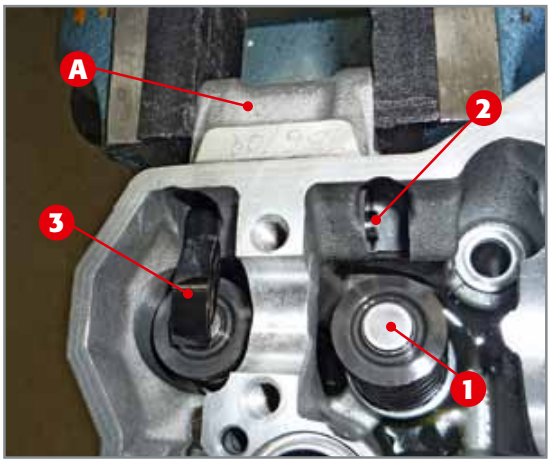
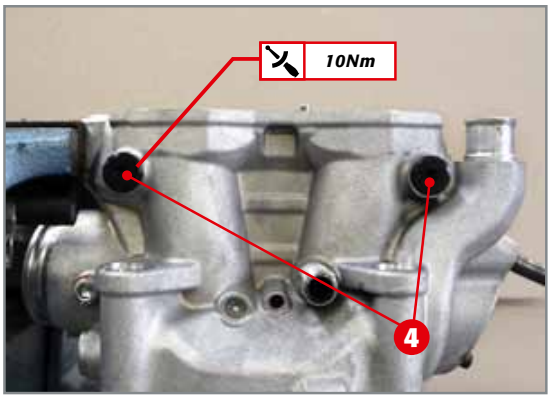
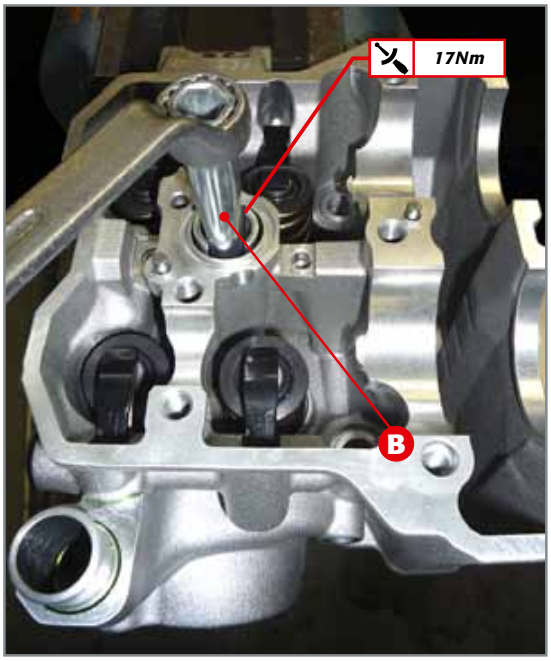


Insertion of shaft 1 on outermost finger follower 2.



Application of two finger follower shaft caps.



2.17.10 CYLINDER HEAD: REPOSITIONING CALIBRATED DISCS, ASSEMBLY OF FINGER FOLLOWER SHAFTS AND FINGER FOLLOWERS AND COUPLING THE SPARK PLUG

Clamp the cylinder head using protective jaws, gripping it at the head connection **A**.
Put the calibrated discs **1** back in place in their original positions (if not deteriorated see par.1.17.3.3).
Insert the finger follower shaft **2** partly in the specific seat as much as needed to be able to insert the outermost finger follower into the cylinder head first **3**. Having fastened the outermost finger follower to the shaft, push the shaft further until it reaches the seat of the innermost finger follower. Having coupled the innermost finger follower to the shaft push it all the way into the cylinder head.

Couple the two caps **4** with the O-rings to the cylinder head. They must be tightened at a torque of 10Nm.

Apply the spark plug on the special wrench **B** *(code 020440100 000)*, introduce the unit in the specific housing and tighten at a torque of 17Nm.

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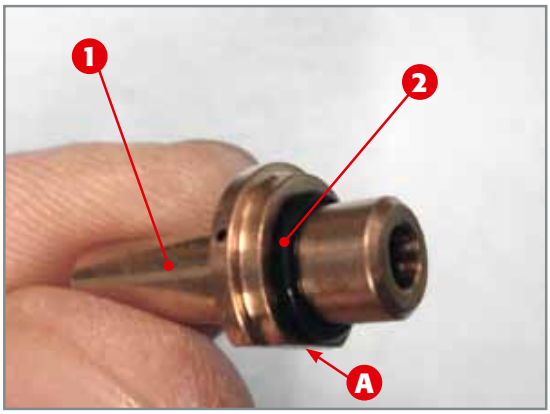
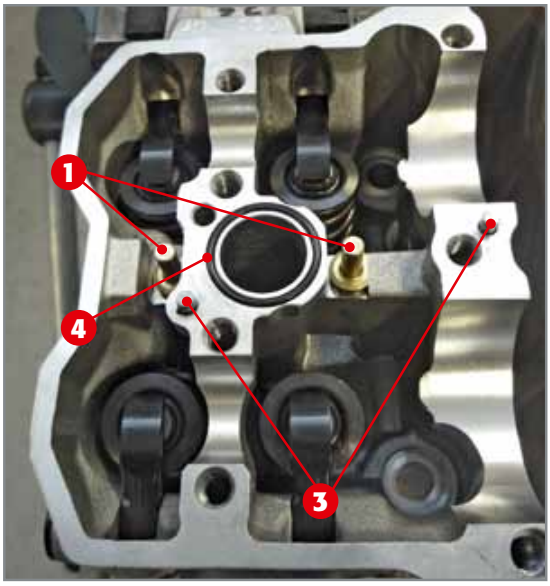


Oil jet with O-ring. Note the flat part A for reference on the side of the jet.

2.17.11 CYLINDER HEAD: INSERTION OF OIL JETS, CENTRING PINS AND SPARK PLUG O-RING

Insert the oil jets **1** with the O-rings **2** in their specific seats on the cylinder head.



Overhead view of complete cylinder head.

The positioning of the jets is univocal thanks to the specific flat side.
Apply the centring pins **3** to the cylinder head and the spark plug seal O-ring **4** between the cylinder head and the camshaft support.

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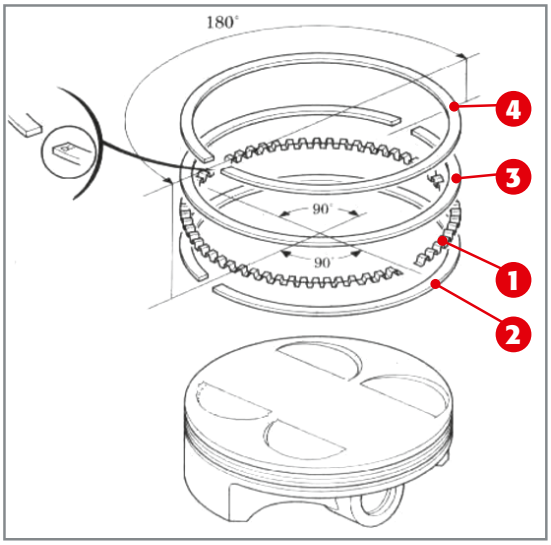
Application of central oil-scraper band.

Detail of positioning of two edges.

2.17.12 PISTON: APPLICATION OF PISTON RINGS AND OIL-SCRAPER RINGS

Oil the ring seats abundantly and apply the central oil-scraper ring in the lower seat of the piston **1** paying close attention that the two ends face one another but do NOT overlap.
The two ends must be aligned in axis with the pin bolt.



Application of piston rings.

Apply the two lower **2** and upper oil-scraper rings **3** and then the compression ring **4**.
The two oil-scraper rings must be placed so that their openings face the higher segment of the skirt and at 180° between them. Assembly of the compression ring **4** must be done keeping the reference (letter or number) facing upwards and the opening must face the some way as the opening of the lower oil-scraper ring **2**.

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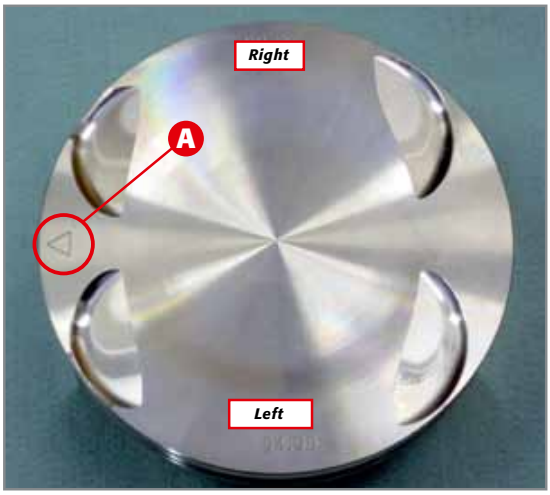
Application of circlip 5 to piston.

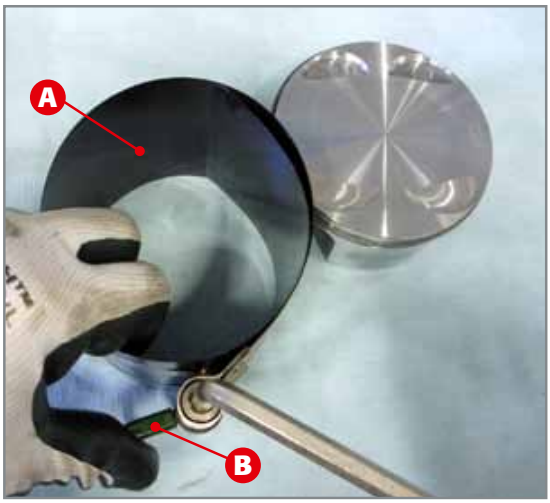
Abundantly lubricate the seats for the pin bolt with motor oil and the circlip **5** in the left pin bolt seat, being careful to position it so that the lug on the circlip inserts itself in the specific seat on the piston.



Identification of piston right and left side.

In order to identify the right and left side of the piston, just use as a reference the arrow **A** stamped on the piston crown which must face the exhaust manifold.

2.17.13 APPLICATION OF PISTON TO CYLINDER



Preparation of ring compression band A.

To couple the piston to the cylinder, place the cylinder while keeping the top facing upwards. Oil the cylinder with plenty of motor oil.
Prepare the ring compression band **A** *(code 006140170000)* as shown in the figure.
Press the green locking lever **B** and turn the hex key anti-clockwise until the band reaches a dimension near that of the piston. Oil the inside of the band abundantly and insert the piston with all its rings inside of it. Press the green locking lever again and turn the hex key clockwise to tighten the rings and piston well.

Attention: *the compression band has edges which could be sharp. Be very careful when handling it.*

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Application of the complete piston band on cylinder.

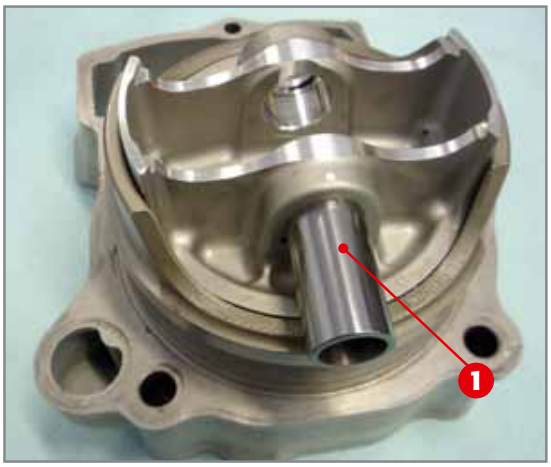
Press the piston downwards having the higher segment of the skirt protrude a bit from the band. Rest the unit on the cylinder, making sure that the contact zones of the band rest correctly on the cylinder surface. For this purpose, make sure that the upper edge **C** of the band is perfectly aligned with the contact surface of the cylinder.

> ***Note:*** *When positioning the complete band-piston unit on the cylinder, be careful to place them so that the arrow stamped on the crown of the piston faces the exhaust manifold.*

Insertion of piston in cylinder.

Holding the band firm with one hand, push the piston inside the cylinder, making sure that the axis of the piston is aligned with that of the cylinder. Towards the end of insertion it might be necessary to use the wooden handle of a hammer or a similar tool to lightly tap the piston crown in order to facilitate its complete insertion in the cylinder.

> ***Attenzione:*** *Attention: during the whole operation, hold the band firm with one hand without moving it. Make sure that the piston rings insert themselves correctly in the cylinder when passing through the band. Should there be excessive resistance when inserting the piston into the cylinder, do not insist in order not to deteriorate the parts. Find out the cause.*



Application of pin bolt to piston.

When the piston has been inserted into the cylinder and the band has been removed, press the piston towards the bottom of the cylinder so that the pin bolt seats come out from the lower edge. Apply the pin bolt **1** into the right-hand seat as much as needed to allow it to be coupled with the connecting rod.

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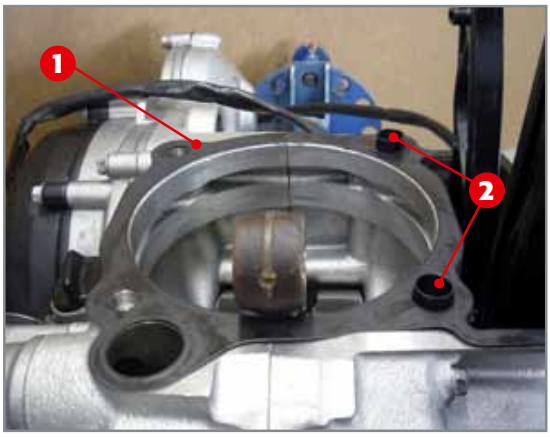

Application of cylinder/crankcase gasket and of centring bushes.

2.17.14 APPLICATION OF PISTON-CYLINDER COUPLING TO CRANKCASE

Apply a new piston-cylinder gasket **1** to the crankcase and couple the two centring bushes to the left crankcase **2**.
Lubricate the foot of the connecting rod abundantly with motor oil.

Passage of chain in cylinder.

Insert the timing chain in the proper compartment in the cylinder and bring the piston/cylinder unit close to the connecting rod.

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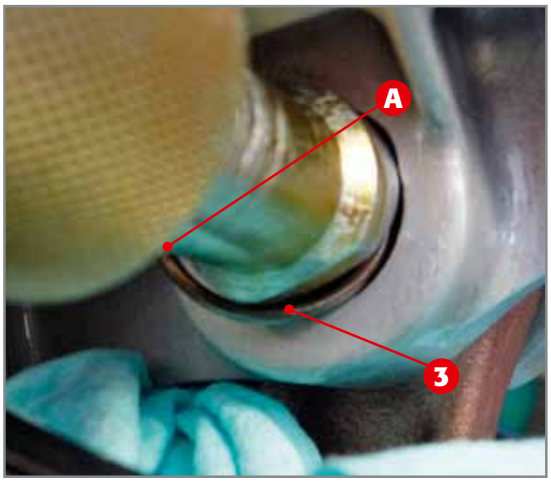


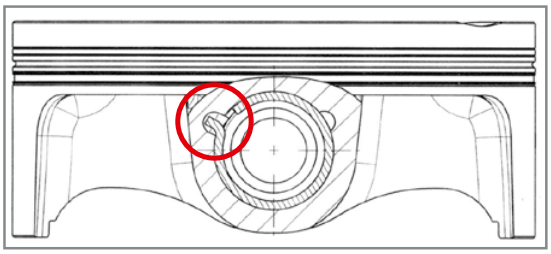
Added seeger.

Once the pin bolt reaches its housing in the foot of the connecting rod, push the pin bolt inside until it is inserted all the way. Apply the lug to the circlip **3** in the pin bolt seat. Insert the cylindrical part of the special tool **A** into the pin bolt and, having one of the two flat surfaces of the tool coincide with the part of the circlip to be inserted, turn and push the special tool towards the engine until the circlip is fully inserted into a seat.

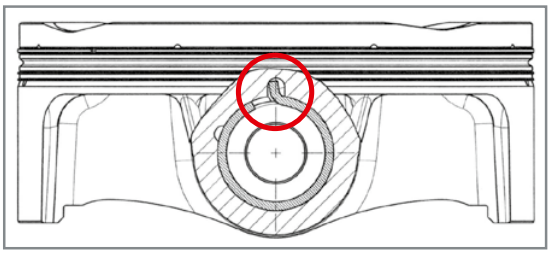
Coupling cylinder to crankcase.

Push the cylinder towards the crankcase making sure the two centring bushes on the left crankcase are correctly inserted in the seats in the lower part of the cylinder.

Attention: *the seeger nib seat is different between the 350cc and 400cc, 450cc, 498cc.*



The 400cc, 450cc, 498cc seeger nib seat.



The 350cc seeger nib seat.

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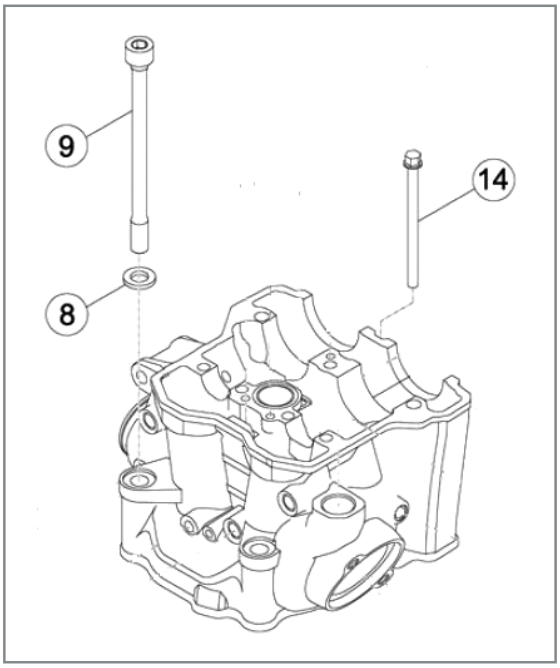
Application of guide bushes 4 and gasket 5 to cylinder.

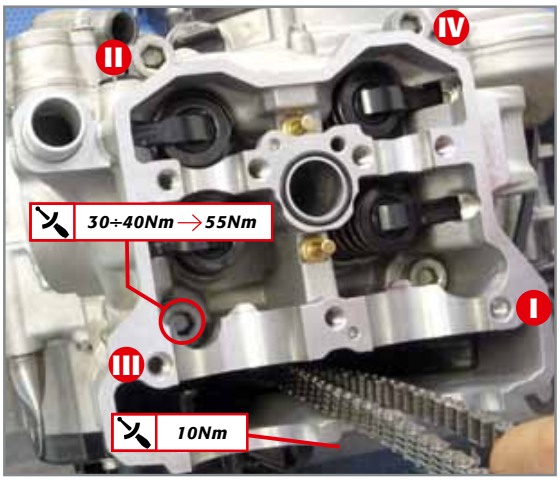
Apply to the cylinder the two guide bushes **4** and the gasket **5** coupling with the cylinder head.



Application of components for coupling cylinder head and cylinder to crankcase.

2.17.15 COUPLING HEAD TO CYLINDER

Introduce the timing chain in the compartment on the cylinder head. Keeping the chain tight, place the head on the gasket making sure it inserts perfectly into the two centring bushes on the cylinder.
Lubricate the four washers **8** and insert them into their specific seats on the outside and inside of the cylinder head. Then insert the four M10x1.25 screws **9** - after having lubricated them- and the M6x80 screw **14** which connect the head and cylinder to the crankcase.



Tightening order of screws coupling the head and cylinder to crankcase.

In two moments, proceed tightening the four screws in a criss-cross pattern. Start with one of the two screws inside the cylinder head.
The first tightening can be done at 30÷40Nm, while the second and last one is fixed at 55Nm.
The screw **14** must be tightened at a torque of 10Nm.
Keep the chain lifted so that it does not fall inside the chain compartment.

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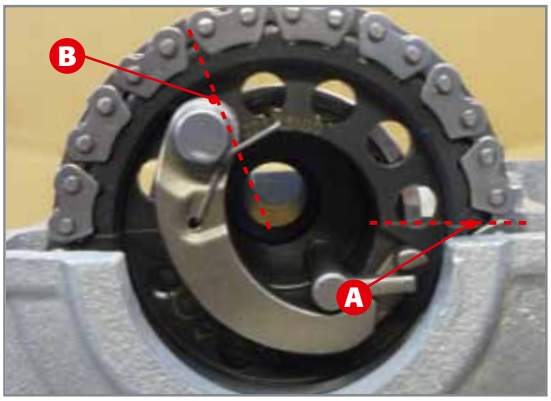
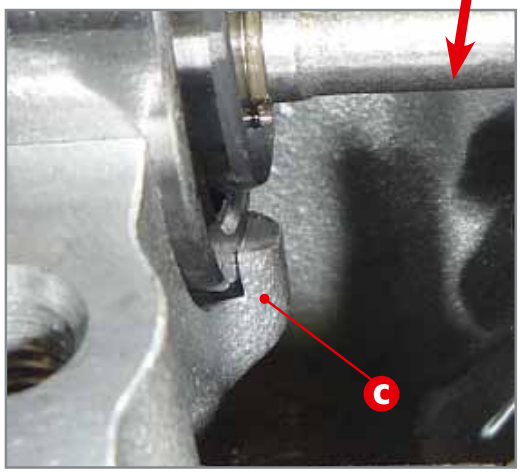


Positioning camshaft.

Positioning camshaft bearing.



Detail of positioning bearing against shoulder C.

2.17.16 COUPLING CAMSHAFTS TO CYLINDER HEAD AND PHASING

Couple the bearings to the camshafts and lubricate them with motor oil.
Widening the timing chain, insert the exhaust camshaft upon whose gearwheel the timing chain must be placed. It is advisable already in this phase to position the shaft so that the reference notches **A** are horizontal with the cams facing upwards according to the approximate direction **B**.

Lift the camshaft slightly and move the bearing so that it is flush with the shoulder **C**. Having carried out the above-mentioned positioning, rest the camshaft on the cylinder head.

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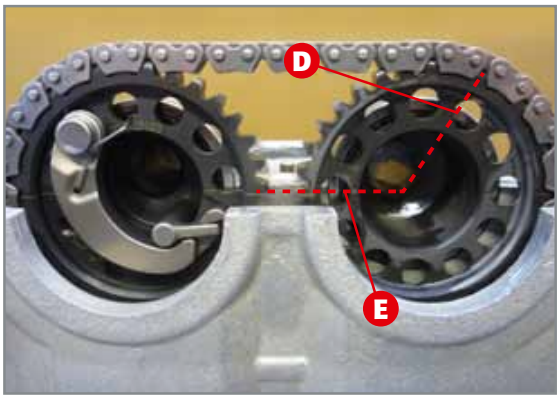
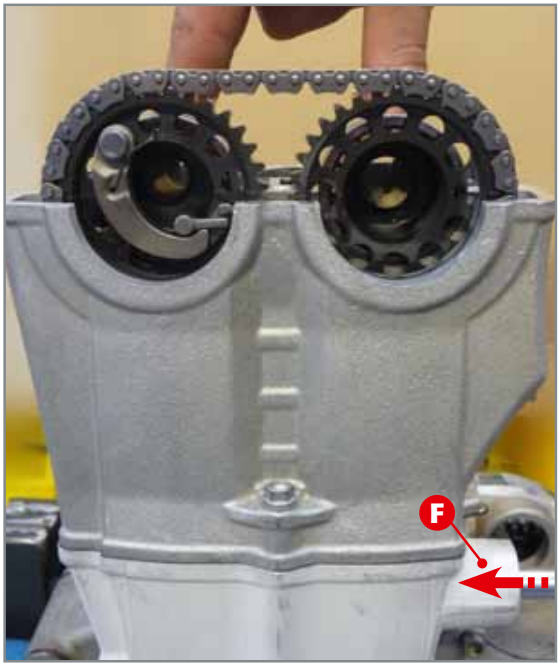


Positioning intake camshaft.

Lift the chain again and insert the intake camshaft placing the chain on the gearwheel. Place the shaft so that the cams face upwards according to the approximate direction **D** and the references **E** carved on the gear are horizontal.
Position the bearing in the same way as for the exhaust camshaft.



Phasing check. Note the pressure that the cylinder B exercises on the chain.

Holding the camshaft still with one hand, insert an aluminium cylinder **F** in the housing of the hydraulic tensioner as far as needed to be able to push the movable guide against the timing chain. Make sure that the notches engraved on the two wheels are aligned one with the other. Is so, the phasing is correct. If not, release the cylinder **F**, lift the timing chain so that the gearwheels disengage allowing the needed rotation to obtain correct phasing.
Having checked phasing, extract the cylinder **F**.

Detail of correct alignment of engraved notches on gearwheels of camshafts.

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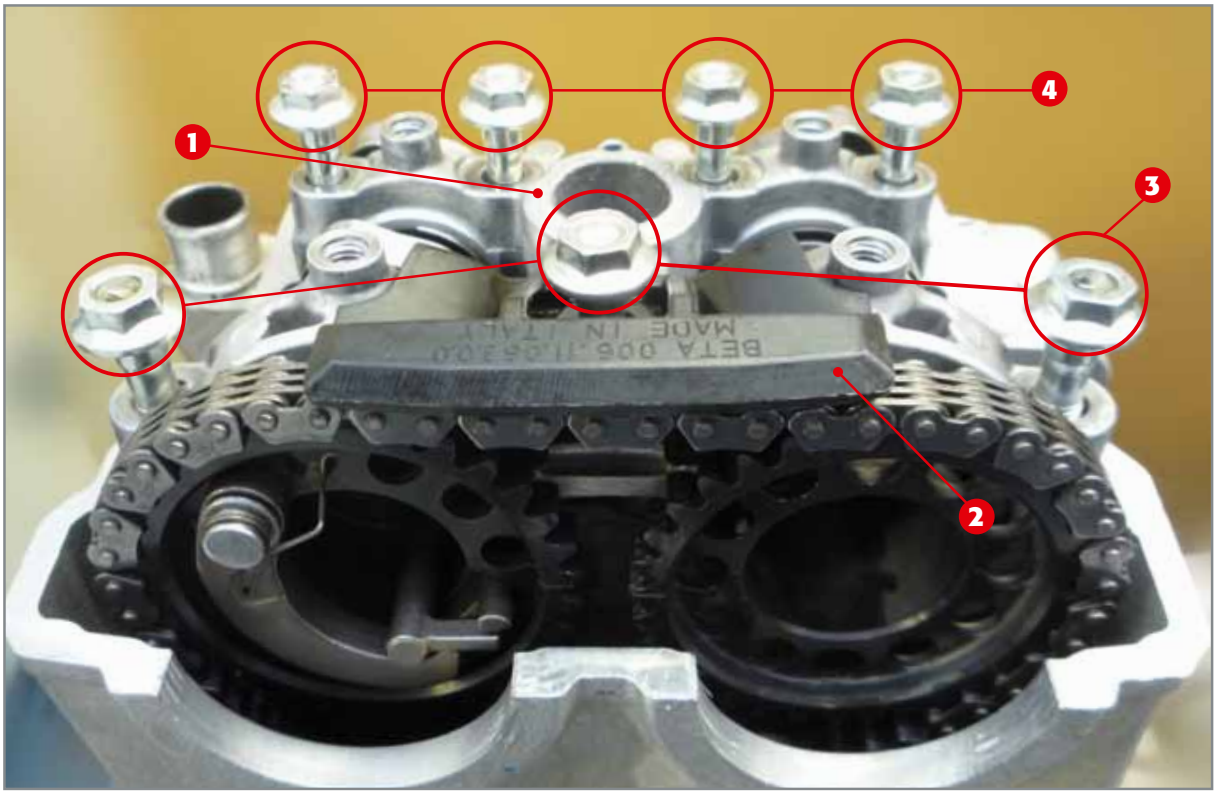
Lubricate the entire camshaft unit with motor oil and apply the support **1**, making sure it is perfectly engaged both on the shafts and on the centring pins.

Note: *check the presence of the oil jets (par 1.17.11).*

Apply the chain guide **2** and insert the three M7x38 screws **3** in the holes on the chain side and the four M7x33 screws **4** in the four remaining holes.



Application of camshaft support 1, chain guide 2, three M7x38 screws 3 and four M7x33 screws 4.

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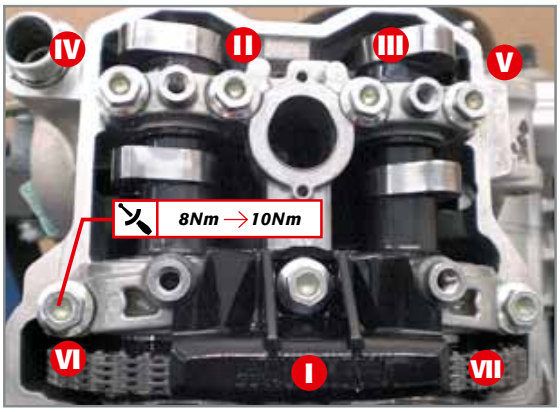

Tightening order of camshaft support screws.

Tighten the seven screws by hand until they are flush. Check the correct position of the camshaft bearings once more (page 116).
Proceed with tightening in two moments, following the order indicated in the figure. Carry out the first tightening operation at a torque of 8Nm and the second at 10Nm. At the end of this operation, make sure the camshaft moves freely.

Checking valve play with thickness gauge.

2.17.17 VALVE PLAY

Checking for valve play must be carried out by placing a thickness gauge **A** *(code 006140210000)* in between the cam and the finger follower. This control can be done even without the hydraulic tensioner coupled to the engine.

Attention:
The piston must be positioned at the Top Dead Centre (par 1.7)! Following the order of this text, this position is already fixed.

Play must be within the values carried on the table below.

Side	Minimum [mm]	Maximum [mm]
Intake	0,10	0,175
Exhaust	0,125	0,20

If the play measured is greater than that indicated, the calibrated disc must be replaced with a thicker one. On the contrary, if the valve play is less than that indicated, replace the calibrated disc with a thinner one. The value of the needed thickness can easily be assessed by calculating the difference between the detected play value and the one required.
The following is a layout for calibrated disc replacement.

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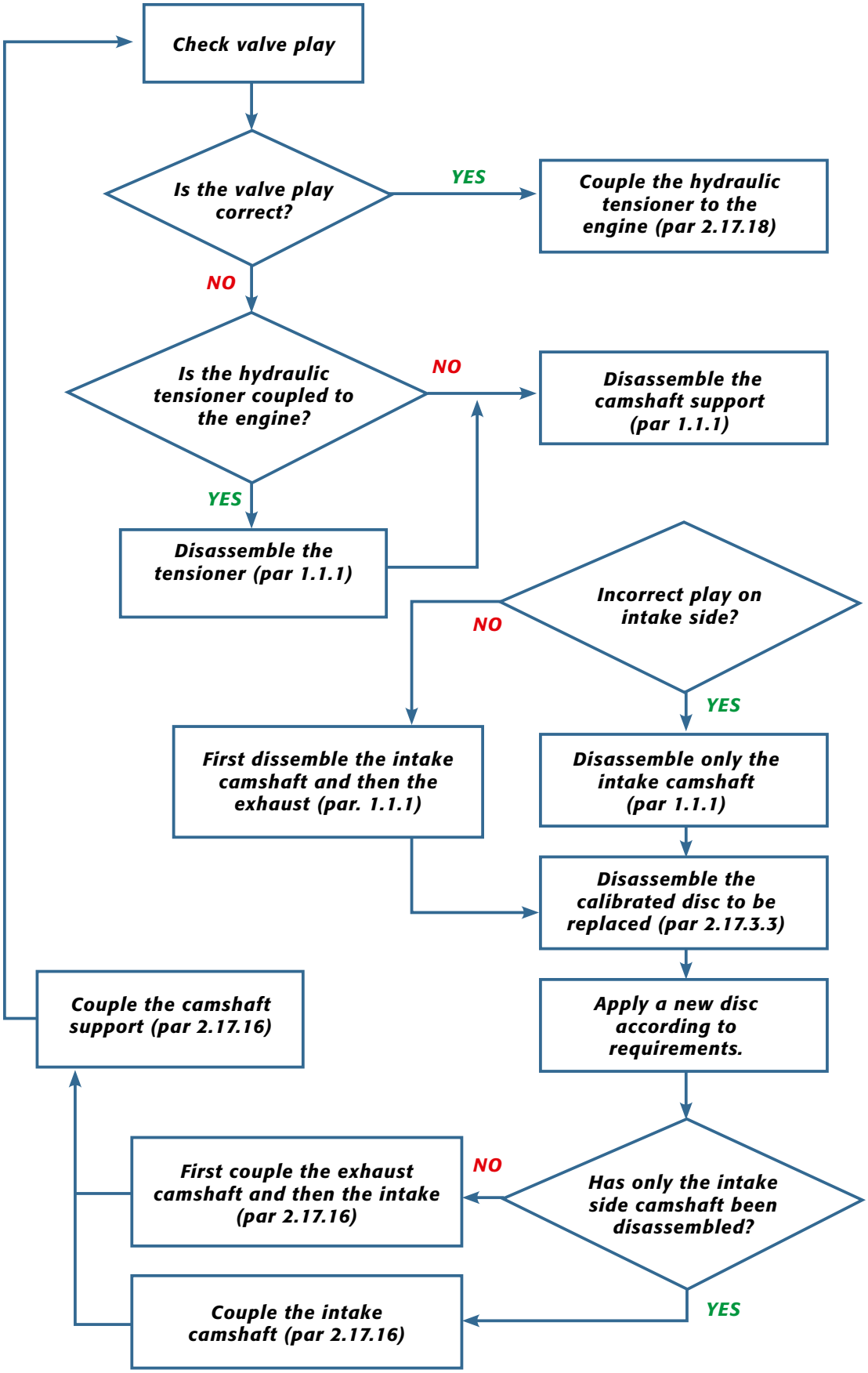

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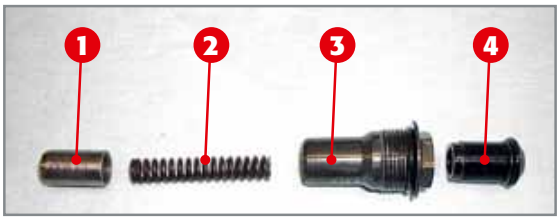
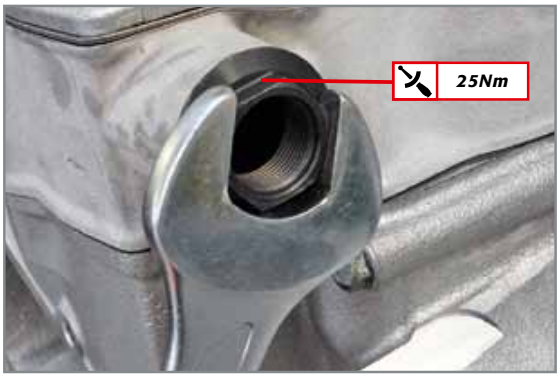


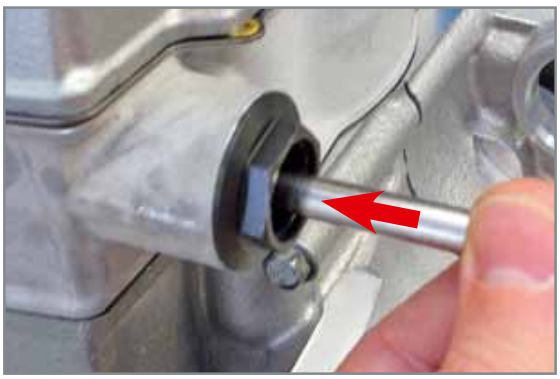
2.17.18 CHECKING AND COUPLING OF MECHANICAL TENSIONER TO ENGINE

The mechanical tensioner consists in:
1. a piston;
2. a spring;
3. a support;
4. a cap

Make sure the piston shows no signs of abnormal meshing.
Insert the piston into the support and push it until it sticks out of the edge of the support by approximately 1 millimetre.



Insert the tensioner support in the specific seat on the cylinder, tightening it at a torque of 25Nm and push the piston towards the front of the engine.



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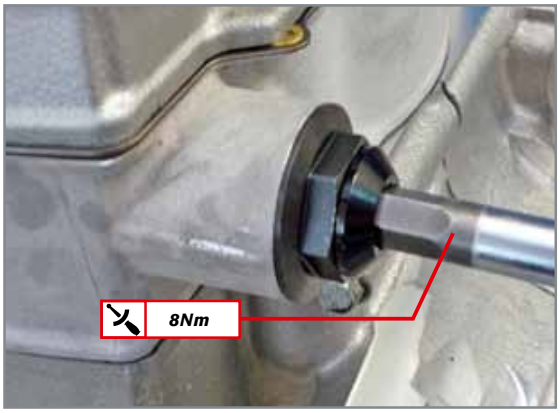

Insert the spring in the support and apply the cap to be tightened at a torque of 8Nm.

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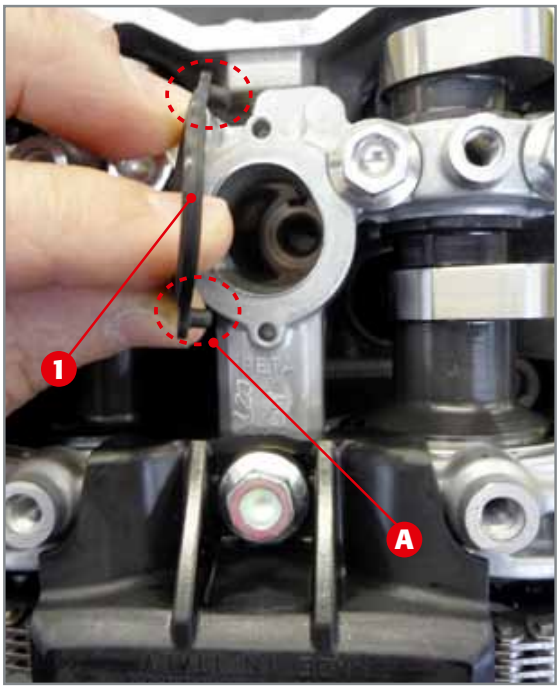
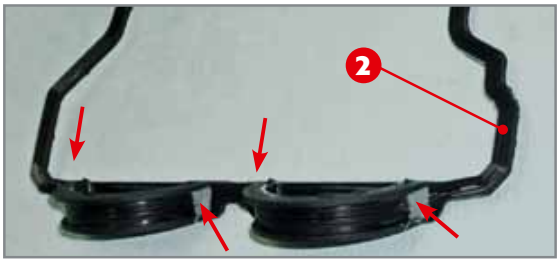
2.17.19 COUPLING CYLINDER HEAD COVER GASKETS AND CYLINDER HEAD COVER



Application of spark plug gasket.

Apply the spark plug gasket **1** to the camshaft support inserting the two pegs **A** in the specific seats and positioning it so that it recopies the shape on the support.



Edges where the gasket paste must be applied.

Apply a few drops of gasket paste in the edges of the cylinder head cover gasket **2**.

Insertion of gasket in groove on cylinder head cover.

Insert the gasket in the cylinder head cover so that the protruding part fits perfectly into the groove in the cover.

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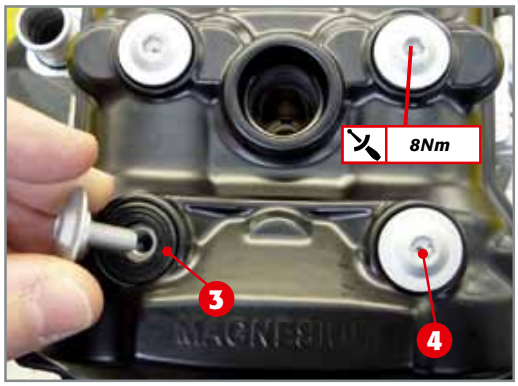
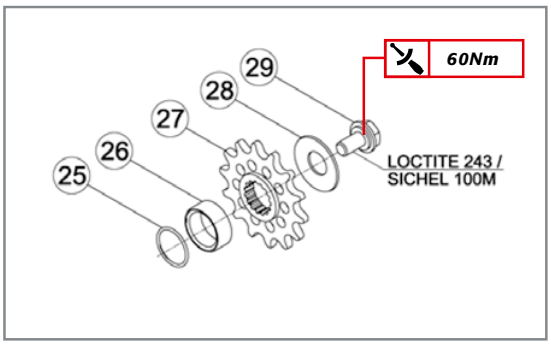


Application of rubber rings 3 and fixing screws 4.

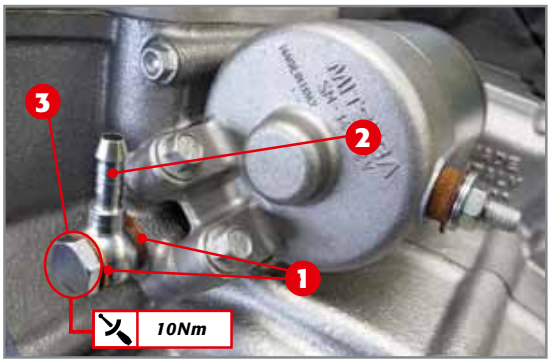
Place the complete cover on the cylinder head making sure that the gasket covers the surface correctly.
Apply the four rubber rings **3** to the cover and insert the four screws **4** which fasten the cover to the cylinder head. Tighten the screws in a criss-cross pattern at a torque of 8Nm.



Exploded view of pinion. 25) O-ring 25x12x1.78; 26) Spacer 27) Pinion; 28) Washer; 29) Screw.

2.18 COUPLING PINION AND BREATHER NOZZLE

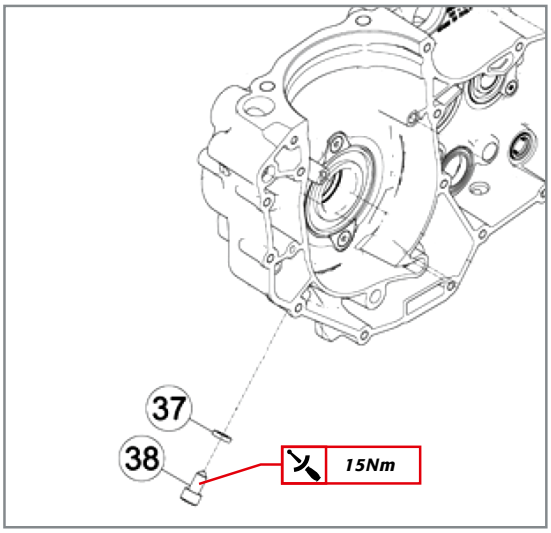
If the O-ring **25** is not coupled to the secondary shaft (par 1.5), insert it followed by the spacer **26**.
Then apply the pinion **27**, the washer **28** and the screw 29 which must be spread with medium strength threadlocker: tighten at a torque of 60Nm.



Gear oil vapour breather device.

Attention: *do not use pneumatic devices!*

Apply the breather nozzle to the left crankcase half, first coupling the copper washer **1**, then the breather nozzle **2**, the copper washer **1** and the bored screw **3** to be tightened at a torque of 10Nm.



2.19 RELEASING CRANKSHAFT

Remember that according to the order of this text, the crankshaft is blocked at the Top Dead Centre.
It must be released by removing the screw **38** *(respectively tool 006140110 000)* and applying the copper washer **37** to screw **38**. Therefore reapply the screw-washer unit, tightened at a torque of 15Nm.

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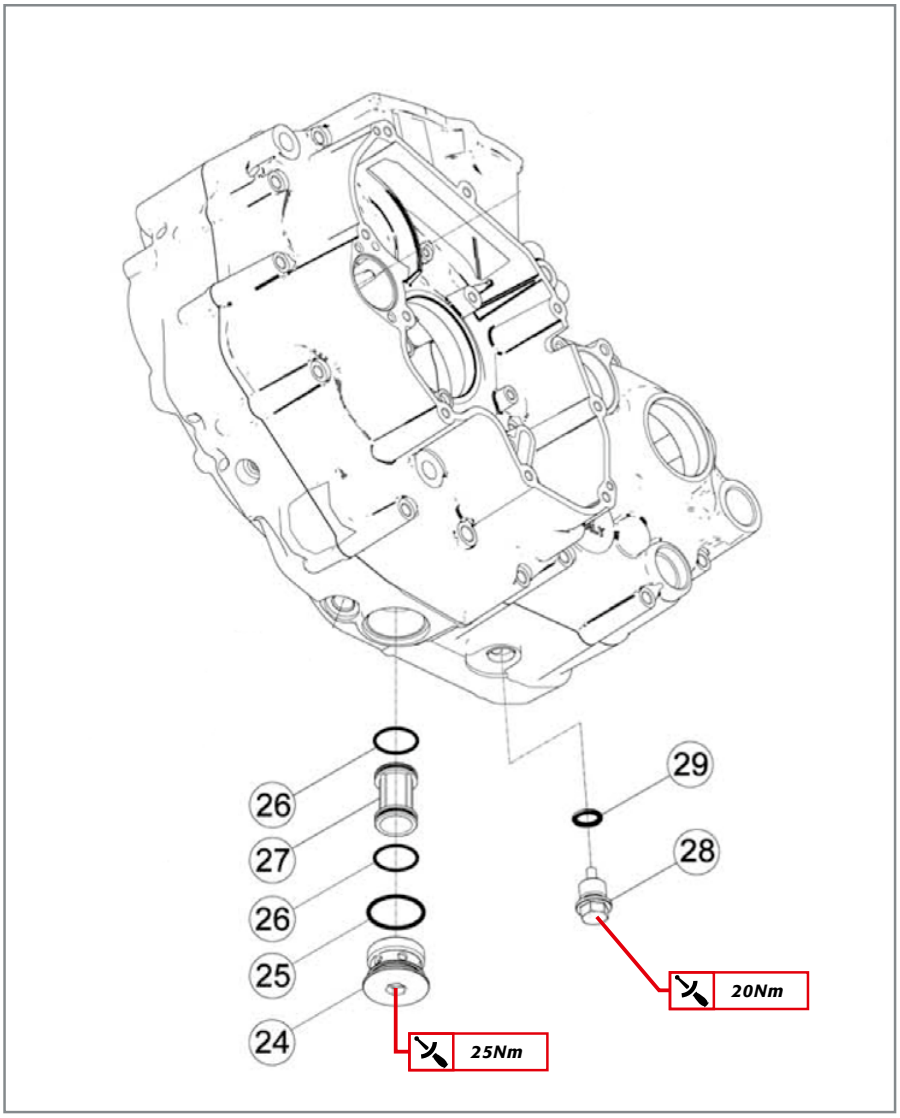
2.20 COUPLING OIL CAPS

Couple the motor oil plug **24** with the O-ring **25** in the bottom part of the right crankcase half. Before inserting it in the drain hole, apply the wire metal filter **27** with the O-ring **26**. Tighten at a torque of 25Nm.
Apply the magnetic screw **28** with the O-ring **29** to the gear oil drain hole: tighten at a torque of 20Nm.



EXPLODED VIEW OF OIL DRAIN CAPS.
24) Motor oil drain plug;
25) O-ring 27x2;
26) O-ring 20x1.5;
27) Metal filter;
28) Magnetic screw;
29) O-ring 11x2.5

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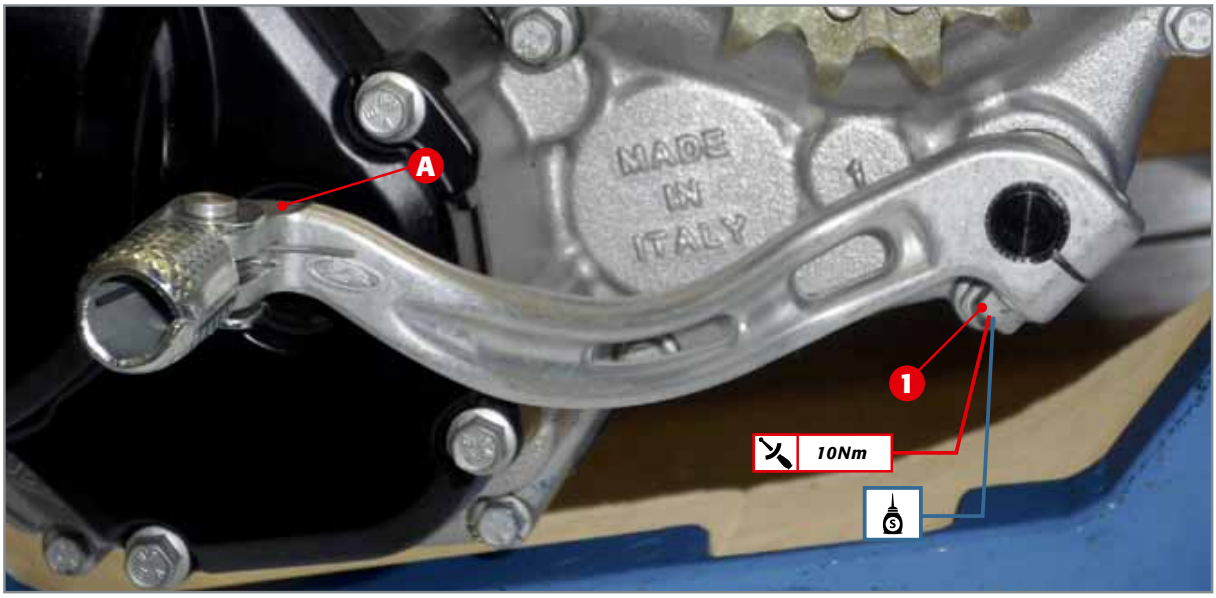
2.21 COUPLING GEARSHIFT LEVER

Couple the gearshift lever to the drive shaft by positioning it so that the part **A** of the lever coincides with the upper edge of the oil level inspection window.
Tighten the screw **1** at a torque of 10Nm after having applied medium strength threadlocker.



Positioning of gearshift lever.

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TABLE OF TIGHTENING TORQUES OF ENGINE COMPONENTS

Fixing	Threading diameter x length [mm]	Quantity	Threadlocker	Torque [Nm]	Notes
Outside right crankcase half					
Oil seal fixing plate	M5 x 10	2	Loctite 243/ Sichel 100M	6	
Oil incline	M5 x 10	2	Loctite 243/ Sichel 100M	6	
Kickstart ramp	M6 x 20	2	Loctite 243/ Sichel 100M	10	
Inside right crankcase half					
Crankshaft bearing fixing plates	M6 x 14	2	Loctite 243/ Sichel 100M	8	
Main gearbox shaft bearing fixing plate	M5 x 10	2	Loctite 243/ Sichel 100M	6	
Secondary gearbox shaft bearing fixing plate	M5 x 10	2	Loctite 243/ Sichel 100M	6	
Desmodromic gearshift bearing fixing	M5 x 8	1	Loctite 243/ Sichel 100M	6	
Outside left crankcase half					
Countershaft bearing fixing	M5 x 10	10	Loctite 243/ Sichel 100M	6	
Calibrated screw	M5	1	Loctite 243/ Sichel 100M		Tighten all the way
Oil jet	M4	1	Loctite 243/ Sichel 100M		Tighten all the way
Inside left crankcase half					
Crankshaft bearing fixing plates	M6 x 14	2	Loctite 243/ Sichel 100M	8	
Crankcase half coupling	M6 x 75	2		10	
Crankcase half coupling	M6 x 65	13		10	
Crankshaft					
Left-hand side nut	M32	1	Loctite 243/ Sichel 100M	150	
Right-hand side nut	M20	1	Loctite 243/ Sichel 100M	150	Left threading
Crankshaft blocking	M8x16	1		15	
Gearshift					
Stop cam	M6 x 30	1	Loctite 243/ Sichel 100M	10	
Stopping device lever	M6 x 20	1	Loctite 243/ Sichel 100M	10	
Gearshift lever	M6 x 25	1	Loctite 243/ Sichel 100M	10	
Electrical starter device					
Torque limiter	M6 x 25	1	Loctite 243/ Sichel 100M	10	
Start motor	M6 x 20	2	Loctite 243/ Sichel 100M	10	

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Fixing	Threading diameter x length [mm]	Quantity	Threadlocker	Torque [Nm]	Notes
Engine lubrication					
Oil pump covers	M5 x 10	5	Loctite 243/ Sichel 100M	6	
Chain oil jet	M5 x 12	1	Loctite 243/ Sichel 100M		
Oil pump control idler gears support pins	M5 x 20	2	Loctite 243/ Sichel 100M	6	
Oil pressure control screw	M12 x 10	1		20	
Paper oil filter cap	M5 x 16	2		6	
Countershaft					
Locking nut	M12	1	Loctite 243/ Sichel 100M	50	Attention! Don't use pneumatic wrench
Clutch					
Inner hub / clutch basket	M18	1	Loctite 243/ Sichel 100M	120	Attention! Don't use pneumatic wrench
Clutch pressure cap	M6 x 25	4		10	
Clutch actuator	M6 x 20	2		10	
Clutch actuator	M6 x 30	1		10	
Outer clutch cover	M6 x 25	6		10	
Outer clutch cover	M6 x 30	1		10	
Inner clutch cover	M6 x 25	9		10	See water pump cover screws as well
Water pump					
Impeller blind nut	M6	1	Loctite 243/ Sichel 100M	10	
Cover	M6 x 40	4		10	
Timing chain guards					
Fixed and movable guides	M6 x 25	2	Loctite 243/ Sichel 100M	10	
Chain guide on flywheel cover	M5 x 10	1	Loctite 243/ Sichel 100M	6	
Chain guard	M6 x 20	2	Loctite 243/ Sichel 100M	10	
Ignition system					
Pick-up	M5 x 12	2	Loctite 243/ Sichel 100M	6	
Stator winding	M6 x 25	2	Loctite 243/ Sichel 100M	8	
Flyweel	M12	1	Loctite 243/ Sichel 100M	60	
Spark plug	M12	1		17	
Cover	M6x25	9		10	

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Fixing	Threading diameter x length [mm]	Quantity	Threadlocker	Torque [Nm]	Notes
Cylinder head					
Finger follower shaft caps	M10	2		10	
Cylinder head	M10	4		40->55	Lubricate threading and washers. Follow a criss-cross pattern
Cylinder head	M6	1		10	
Camshaft support	M7 x 38	3		8->10	Follow a criss-cross pattern
Camshaft support	M7 x 33	4		8->10	Follow a criss-cross pattern
Exhaust flange stud	M8 x 30	2	Loctite 243/ Sichel 100M		
Electric fan sensor	M12	1		20	
AIS valve fitting	M10	1		10	
Cover	M6 x 12	4		8	
Mechanical tensioner					
Tensioner cap	M24	1		25	
Small tensioner cap	M16	1		8	
Chain pinion					
Pinion	M10 x 18	1	Loctite 243/ Sichel 100M	60	Do not use pneumatic devices!
Gearbox oil vapour breather					
Bored screw	M10	1		10	
Oil drains					
Motor oil plug	M30	1		25	
Magnetic screw gearbox oil plug	M14	1		20	
Kickstarter					
Kickstart lever	M8 x 26	1	Loctite 243/ Sichel 100M	25	Do not use pneumatic devices!

ENGINE/FRAME TABLE OF TIGHTENING TORQUES

Fixing	Threading diameter x worm [mm]	Quantity	Threadlocker	Torque [Nm]	Notes
Front engine pin	M10x1,25	1		60	
Lower engine pin	M10x1,25	1		60	
Swingarm pivot	M16x1,5	1		125	

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RECOMMENDED ENGINE MAINTENANCE

The required engine maintenance is strongly depending on the level of use and on the accordingly done periodic checks and service. The below mentioned maintenance intervals are for standard competition use, subject to the condition that the engine was never running under extraordinary conditions and the periodic service was done accurately.

	30h 200l	60h 400l	90h 600l	120h 600l	150h 800l	180h 1200l
Clutch disc wear	I	I	S	I	I	S
Clutch springs length	I	I	S	I	I	S
Gearbox bearing (crankcase side)	-	-	S	-	-	S
Clutch hub/basket wear	I	I	I	I	I	I
Cylinder wear	-	-	I	-	-	I
Piston and segments	-	-	S	-	-	S
Camshaft wear	-	-	I	-	-	I
Valve springs	-	-	I	-	-	S
Valves 400-450-498	-	-	I	-	-	I
Valves 350	-	-	I	I	-	S
Valve guide wear	-	-	I	-	-	I
Connecting rod	-	-	S	-	-	S
Countershaft bearings	-	-	S	-	-	S
Crankshaft bearings	-	-	S	-	-	S
Wear of complete gearbox including gearshift	-	-	I	-	-	I
Pressure control valve spring length	-	-	I	-	-	I
Water pump oil seals	-	-	S	I	-	S
Oil pumps control gearwheels	-	-	I	I	-	S

I = INSPECT AND REPLACE IN CASE OF NECESSARY *S = REPLACE*

RECOMMENDED LUBRICANTS AND LIQUIDS

APPLICATION	PRODUCT	QUANTITY
Gearbox and clutch	PANOLIN OFF ROAD 4T SYNT 10W/50	850 ml*
Engine	PANOLIN OFF ROAD 4T RACE 10W/40	850 ml*
COOLANT	PANOLIN ANTI FROST MT 325	1,300ml*

** Refer to Use and Maintenance Manual for levels*

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Beta
the play bike

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