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# WORKSHOP MANUAL

**LDW 422 engines-**
**4 Speed - EURO 2 Version**
**code 1-5302-662**

# LDW 422

**1st Edition**

LOMBARDINI
SERVICE



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## FOREWORD

We have done all in our power to give up to date and accurate technical information in this manual. Lombardini engines are, however, constantly developing thus the data in this publication may be liable to modification without prior notice.

The information in this manual is the exclusive property of Lombardini. Neither partial nor total duplications or reprints are therefore permitted without the express authorization of Lombardini.

The information in this manual is given on the assumption that:

1- the persons who service Lombardini engines have been adequately trained and outfitted to safely and professionally carry out the necessary tasks;

2- the persons who service Lombardini engines possess the necessary skills and special Lombardini tools to safely and professionally carry out the necessary tasks;

3- the persons who service Lombardini engines have read the specific information concerning the above mentioned Service operations and that they have clearly understood the operations required.

## GENERAL SERVICE NOTES

1 - Only use genuine Lombardini spare parts. Use of spurious spares may lead to incorrect performance and shorten the life of the engines.
2 - The metric system is used to express all data, i.e. the dimensions are given in millimeters (mm), torque is expressed in Newton-meters (Nm), weight in kilograms (Kg), volume in liters or cubic centimeters (cc) and pressure in barometric units (bar).

SERVICE



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# INDEX

This manual contains pertinent information regarding the repair of LOMBARDINI air-cooled, indirect injection Diesel engines type **LDW 422:** updated October 18, 2004.

## TABLE OF CONTENTS


**SAFETY DECALS - SAFETY INSTRUCTIONS ..... Pag. 8-9**

**I TROUBLESHOOTING ..... " 10-11**

**II MAINTENANCE ..... " 12**

**III MAINTENANCE- RECOMMENDED OIL TYPE - REFILLING ..... " 13**

**IV MODEL NUMBER AND IDENTIFICATION ..... " 14**

**V TECHNICAL DATA ..... " 15**

**VI LUBRICATION SYSTEM ..... " 16-17**

**VII COOLING SYSTEM ..... " 18-21**

Cooling liquid features ..... 19
Cooling liquid circulating pump ..... 20
Checks on water pump ..... 20
Checks on thermostat valve ..... 20
Check of the coolant temperature switch. ..... 21
FORCED LIQUID COOLING SYSTEM WITH AXIAL FAN ..... 19
Thermostatic valve ..... 20
Sensor for cooling liquid temperature indicator light ..... 21
WATER COOLED SYSTEM DESCRIPTION ..... 18

**VIII FUEL SYSTEM ..... " 22-24**

FUEL SUPPLY CIRCUIT WITH QUICK STOP DEVICE ( QSD ) ..... 22
Fuel circuit air bleeding ..... 24
QSD behaviour with excited electromagnet ..... 22
QSD behaviour with de-excited electromagnet ..... 23
QSD WIRING DIAGRAM ..... 24
Running engine (excited electromagnet) ..... 23
Running engine (excited electromagnet) ..... 22

**IX TIMING DIAGRAM ..... " 25**

**X PREHEATING SYSTEM ..... " 26-27**

Distraction time diagram ..... 27
Preheating system ..... 26
Preheating time diagram according to ambient temperature ( 11V ) ..... 27
Post heating time diagram ..... 27

**IX DISASSEMBLY / REASSEMBLY**

Internal alternator ..... 32
Internal alternator - features ..... 33
Adjustment of pump control rod ..... 103
Air shroud, Cooling fan - Disassembly ..... 30
Air shroud, cooling fan – Radiator shroud - Assembly ..... 106
Assembly play - Cylinder-Piston ..... 63




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Assembly play - Piston rings ..... 63
Assembly play - Piston - Piston pin ..... 64
Assembly play - Piston slots - piston rings ..... 64
Assembly play - Small end bush - wrist pin ..... 64
Assembly play - Connecting rod small end bush ..... 64
Assembly play - Crankshaft - big end ..... 65
Assembly play - Valve guide - valve stim ..... 65
Assembly play - Valve seat ..... 65
Assembly play - Tappet ..... 66
Assembly play - Valves - spring ..... 66
Assembly play - Valves caps ..... 66
Battery recharge curve ..... 33
Belt tightener - Disassembly ..... 45
Camshaft - Reassembly ..... 92
Camshaft and tappet support ..... 91
Camshaft extraction ..... 46
Camshaft oil seal and timing pulley ..... 92
Camshaft support - Disassembly ..... 47
Camshaft timing ..... 37
Camshaft: control of size ..... 92
Caption Gearbox shaft 4th speed gear ..... 77
Centrifugal weights assembly - Assembling ..... 97
Clearance Check ..... 100
Clutch assembly ..... 88
Clutch cover, clutch pack - Disassembly ..... 36
Clutch-side housing half ..... 84
Clutch-side housing half – Gearbox shaft roller case and multiple gear ball bearing - Disassembling. ..... 53
Complete governor assembly - Disassembly ..... 44
Connecting rod ..... 76
Cooling fan support - Disassembly ..... 31
Cooling liquid circulating pump - Assembly ..... 96
CRANCKCASE - BEARINGS - CLUTCH SIDE MULTIPLE GEAR BALL BEARING ..... 67
CRANCKCASE - BEARINGS - CRANKSHAFT - CRANKCASE - BEARING HOUSING ..... 67
CRANCKCASE - BEARINGS - DIFFERENTIAL HOUSING ..... 67
CRANCKCASE - BEARINGS - NEEDLE BEARING HOUSING ..... 67
CRANCKCASE - BEARINGS - REVERSE GEAR ..... 67
Crankcase, half, flywheel side ..... 84
Crankshaft – Reverse shaft – Gearbox shaft – Multiple gear – Differential gear assembly ..... 52
Crankshaft timing ..... 38
Cylinder – Piston – Wrist pin - Disassembly ..... 51
Cylinder head ..... 70
Cylinder head - Disassembly ..... 47
Cylinder head installation - Reassembly ..... 91
Cylinder-cylinder head securing studs ..... 91
Delivery governor assembly ..... 97
Delivery regulator – reassembly ..... 59
Delivery regulator - Disassembly ..... 58
Description of the injection advance regulator ..... 98
Differential case ..... 81
Differential gear box ..... 81
Dismantling values ..... 70
Drive shaft and connecting rod ..... 76
Drive shaft, reverse gear shaft, multiple gear, gearbox shaft and differential gear ..... 85
Driving shaft gear ..... 49
ELECTRICAL DIAGRAM ..... 82
Engine gear ..... 87
Feeding pump ..... 104
Fireproof bulkhead and injector - Assembly ..... 101
Flywheel - disassembly ..... 31
Flywheel and cooling fan support - Assembly ..... 106
Flywheel-side air shroud - Disassembly ..... 30
Flywheel-side housing half – Roller case, multiple gear and roller case, gear - Disassembly ..... 53
Fuel exhaust pipe - Assembly ..... 105
FUEL FLOW GOVERNOR DESCRIPTION ..... 56



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# INDEX

Fuel pump - Disassembly ..... 47
Fuel pump – Characteristics and components ..... 104
Fuel pump - Reassembling ..... 104
Gear assembly measure check ..... 78
Gear cluster ball bearing and drive shaft d.c. roller bearing ..... 84
Gearbox ..... 80
Gearbox shaft ..... 77
Glow plug - Disassembly ..... 42
Glow plug - Check ..... 42
Glow plug - Assembling ..... 102
GOVERNOR'S WORKING DESCRIPTION - ENGINE AT FULL LOAD ..... 61
GOVERNOR'S WORKING DESCRIPTION - ENGINE AT IDLE SPEED ..... 60
GOVERNOR'S WORKING DESCRIPTION - ENGINE AT MAX SPEED ..... 62
GOVERNOR'S WORKING DESCRIPTION - ENGINE AT PARTIAL LOAD ..... 61
GOVERNOR'S WORKING DESCRIPTION - ENGINE STANDING OR AT STARTING ..... 60
Injection static advance timing ..... 108
Injection advance dynamic control - B ..... 113
Injection advance variator ..... 98
Injection advance variator - Disassembly ..... 44
INJECTION EQUIPMENT DESCRIPTION AND FUNTIONING - FUEL FLOW CONTROL ..... 103
INJECTION EQUIPMENT DESCRIPTION AND FUNTIONING - FUEL INJECTION ..... 103
Injection pump ..... 68
Injection pump - Assembling ..... 101
Injection pump - Disassembly ..... 43
Injection pump : "MICO" type F 002 F 10 006 - Features of the pump on the bench ..... 68
Injection pump : "MICO" type F 002 F 10 006 - Test conditions ..... 68
Injection pump control cam - Disassembly ..... 45
Injection pump control cam – Assembling ..... 97
Injector : MICO F 002 C 6 Z 396 ..... 69
Injector setting ..... 69
Injector, fireproof bulkhead - Disassembly ..... 41
Injector-injection pump connecting pipe - Assembly ..... 105
Main features of electrical starter ..... 82
Measurement to determine the thickness of the head gasket. ..... 90
Min. and max r.p.m. regulation ..... 115
Minimum oil pressure switch - Assembly ..... 106
Muffler - Assembly ..... 107
Muffler - disassembly ..... 29
Oil dipstick case - Assembly ..... 93
Oil dipstick case - Disassembly ..... 48
Oil level check ..... 93
Oil filter - Assembly ..... 107
Oil filter - Disassembly ..... 29
Oil pressure regulating valve - Disassembly ..... 50
Oil pressure switch - Disassembly ..... 48
Oil pump ..... 75
Oil pump driving gear and oil pump - Disassembly ..... 50
Oil pump gear and oil pump - reassembling ..... 86
Oldham union - Assembling ..... 97
Piston and cylinder ..... 89
Precombustion chamber – disassembly and reassembly ..... 74
Primary gearbox ring gear and clutch housing pan ..... 87
Reassembling the gearbox shaft: tightening the speed coupling spider ..... 77
Reassembling the gearbox shaft: tightening the spider clamping ring nut. ..... 78
Reassembly of valves ..... 72
Ring gear - Disassembly ..... 49
Sensor for cooling liquid temperature indicator light - Disassembly ..... 42
Sensor for cooling liquid temperature indicator light – Assembling ..... 101
Separation of the housing halves ..... 52
Shim thickness for tappet gap adjustment ..... 100
Speed gear control box ..... 89
Starting motor - Assembly ..... 106
Starting motor - Disassembly ..... 30
Tappet cover - Assembly ..... 105



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Tappet cover disassembly ..... 46
Tappets - Disassembly ..... 46
Then check injection advance tining as follows - A. ..... 112
Thermostat – Assembly ..... 101
Thermostat - Disassembly ..... 44
Timing belt cover - Assembly ..... 105
Timing belt cover, air shroud and stator support ..... 32
Timing gear and speed gear control box - Disassembly. ..... 51
Timing pulley and camshaft oil seal ring - Disassembly ..... 45
Timing system ..... 37
Toothed camshaft timing pulley - Assembly ..... 93
Toothed crankshaft timing pulley - Assembly ..... 93
Toothed timing belt - Disassembly ..... 39
Toothed timing belt - Reassembly ..... 39
Toothed timing belt tensioner - Assembly ..... 96
Valves grinding ..... 71
Water pump - Disassembly ..... 48

**XII TOOLS ..... 117-121**

**XIII MAIN TORQUE SPECIFICATIONS ..... 122-123**



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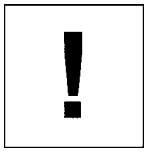
# SAFETY AND WARNING DECALS

**DANGER**



**Failure to comply with the instructions could result in damage to persons and property**

**CAUTION**



**Failure to comply with the instructions could lead to technical damage to the machine and/or system**

---



## SAFETY INSTRUCTIONS

- Lombardini Engines are built to supply their performances in a safe and long-lasting way. To obtain these results, it is essential for users to comply with the servicing instructions given in the relative manual along with the safety recommendations listed below.
- The engine has been made according to a machine manufacturer's specifications and all actions required to meet the essential safety and health safeguarding requisites have been taken, as prescribed by the current laws in merit. All uses of the engine beyond those specifically established cannot therefore be considered as conforming to the use defined by Lombardini which thus declines all liability for any accidents deriving from such operations.
- The following indications are dedicated to the user of the machine in order to reduce or eliminate risks concerning engine operation in particular, along with the relative routine maintenance work.
- The user must read these instructions carefully and become familiar with the operations described. Failure to do this could lead to serious danger for his personal safety and health and that of any persons who may be in the vicinity of the machine.
- The engine may only be used or assembled on a machine by technicians who are adequately trained about its operation and the deriving dangers. This condition is also essential when it comes to routine and, above all, extraordinary maintenance operations which, in the latter case, must only be carried out by persons specifically trained by Lombardini and who work in compliance with the existing documentation.
- Variations to the functional parameters of the engine, adjustments to the fuel flow rate and rotation speed, removal of seals, demounting and refitting of parts not described in the operation and maintenance manual by unauthorized personnel shall relieve Lombardini from all and every liability for deriving accidents or for failure to comply with the laws in merit.
- On starting, make sure that the engine is as horizontal as possible, unless the machine specifications differ. In the case of manual start-ups, make sure that the relative actions can take place without the risk of hitting walls or dangerous objects, also considering the movements made by the operator. Pull-starting with a free cord (thus excluding self-winding starting only), is not permitted even in an emergency.
- Make sure that the machine is stable to prevent the risk of overturning.
- Become familiar with how to adjust the rotation speed and stop the engine.
- Never start the engine in a closed place or where there is insufficient ventilation. Combustion creates carbon monoxide, an odourless and highly poisonous gas. Lengthy stays in places where the engine freely exhausts this gas can lead to unconsciousness and death.



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- The engine must not operate in places containing inflammable materials, in explosive atmospheres, where there is dust that can easily catch fire unles specific, adequate and clearly indicated precautions have been taken and have been certified for the machine.
- To prevent fire hazards, always keep the machine at least one meter from buildings or from other machinery.
- Children and animals must be kept at a due distance from operating machines in order to prevent hazards deriving from their operation.
- Fuel is inflammable. The tank must only be filled when the engine is off. Thoroughly dry any spilt fuel and move the fuel container away along with any rags soaked in fuel or oil. Make sure that no soundproofing panels made of porous material are soaked in fuel or oil. Make sure that the ground or floor on which the machine is standing has not soaked up any fuel or oil.
- Fully tighten the tank plug each time after refuelling. Do not fill the tank right to the top but leave an adequate space for the fuel to expand.
- Fuel vapour is highly toxic. Only refuel outdoors or in a well ventilated place.
- Do not smoke or use naked flames when refuelling.
- The engine must be started in compliance with the specific instructions in the operation manual of the engine and/or machine itself. Do not use auxiliary starting aids that were not installed on the original machine (e.g. Startpilot').
- Before starting, remove any tools that were used to service the engine and/or machine. Make sure that all guards have been refitted.
- During operation, the surface of the engine can become dangerously hot. Avoid touching the exhaust system in particular.
- Before proceeding with any operation on the engine, stop it and allow it to cool. Never carry out any operation whilst the engine is running.
- The coolant fluid circuit is under pressure. Never carry out any inspections until the engine has cooled and even in this case, only open the radiator plug or expansion chamber with the utmost caution, wearing protective garments and goggles. If there is an electric fan, do not approach the engine whilst it is still hot as the fan could also start operating when the engine is at a standstill. Only clean the coolant system when the engine is at a standstill.
- When cleaning the oil-cooled air filter, make sure that the old oil is disposed of in the correct way in order to safeguard the environment. The spongy filtering material in oil-cooled air filters must not be soaked in oil. The reservoir of the separator pre-filter must not be filled with oil.
- The oil must be drained whilst the engine is hot (oil T ~ 80°C). Particular care is required to prevent burns. Do not allow the oil to come into contact with the skin.
- Make sure that the drained oil, the oil filter and the oil it contains are disposed of in the correct way in order to safeguard the environment.
- Pay attention to the temperature of the oil filter when the filter itself is replaced.
- Only check, top up and change the coolant fluid when the engine is off and cold. Take care to prevent fluids containing nitrites from being mixed with others that do not contain these substances since "Nitrosamine", dangerous for the health, can form. The coolant fluid is polluting and must therefore be disposed of in the correct way to safeguard the environment.
- During operations that involve access to moving parts of the engine and/or removal of rotating guards, disconnect and insulate the positive wire of the battery to prevent accidental short-circuits and to stop the starter motor from being energized.
- Only check belt tension when the engine is off.
- Only use the eyebolts installed by Lombardini to move the engine. These lifting points are not suitable for the entire machine; in this case, the eyebolts installed by the manufacturer should be used.



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# I TROUBLE SHOOTING

## POSSIBLE CAUSES AND TROUBLE SHOOTING

The following table contains the possible causes of some failures which may occur during operation. Always perform these simple checks before removing or replacing any part.

| FAULT FINDING | REMEDIES |
|---|---|
| **STARTING PROBLEMS** | |
| Faulty fuel pump | Check and, if necessary, replace |
| Presence of air inside the injection system | Purge by operating the fuel pump lever |
| Faulty glow plug | Replace |
| Faulty starting motor or remote control switch | Detect the problem and, if necessary, overhaul or replace |
| Faulty or dirty injector | Check and, if necessary, replace |
| Faulty injection pump | Check and, if necessary, replace |
| Faulty engine stop solenoid valve | Check and, if necessary, replace |
| **LOW POWER** | |
| Air filter clogged | Clean and, if necessary, replace |
| Diesel fuel filter clogged | Replace |
| Delayed injection | Check and time correctly |
| Inadequate diesel fuel delivery | Verify fuel filter, check injection and fuel pumps efficiency |
| Faulty delivery or advance regulators | Check the assembly and, if necessary, overhaul it |
| **THE ENGINE STOPS** | |
| Low idling speed | Work on the appropriate register |
| Presence of impurities inside the diesel fuel tank | Empty the tank and clean it, replace the diesel fuel and the filter |
| Absence of air | Clean the air filter and, if necessary, replace it |
| Faulty engine stop solenoid valve | Check and, if necessary, replace |
| **THE ENGINE OVERHEATS** | |
| Low cooling liquid level | Restore level |
| Faulty water thermostat | Check and replace |
| Narrower water passages in cylinder or hoses | Check and clean up |
| Faulty water pump | Check and replace |
| Clogged radiator core | Check and clean up |
| One ore more blades of the cooling fan are broken | Check and replace |
| Low oil level | Restore level |



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| FAULT FINDING | REMEDIES |
|---|---|
| **WHITE EXHAUST SMOKE** | |
| Cold engine | Heat the engine for few minutes at low speed |
| Faulty injector | Check and, if necessary, replace |
| High oil level | Restore the level |
| **BLACK EXHAUST SMOKE** | |
| Air filter clogged | Replace |
| Incorrect injection pump delivery | Check and restore |
| Faulty injector | Clean and, if necessary, replace |
| **NOISY ENGINE** | |
| Wrong injection advance | Check the static and dynamic advance and restore |
| Faulty injector | Clean and, if necessary, replace |
| Tappets with excessive clearance | Adjust |
| Excessive wear of the engine internal parts | Overhaul |
| **LOW OIL PRESSURE** | |
| Insufficient oil level | Restore the level |
| Worn oil pump | Overhaul |
| Worn or damaged crankshaft or small end bearings | Overhaul |
| **CLUTCH : SLIPPING** | |
| Insufficient idle stroke | Adjust the stroke |
| Weak return spring | Replace |
| Worn or burnt driven disk gasket | Replace the disk |
| **SPEED GEAR : SPONTANEOUS GEAR DISENGAGEMENT** | |
| Worn or damaged gearbox | Check and, if necessary, replace |
| Incorrectly adjusted control rod | Adjust |
| Wrongly assembled or worn gearbox or coupling spider gears | Overhaul |
| **VIBRATIONS TRANSMITTED FROM ENGINE TO FRAME** | |
| The silent-blocks anchoring the engine to the frame are not locked correctly or are damaged | Lock or replace |



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**! Failure to carry out the operations described in the table may lead to technical damage to the machine and/or system**

## LDW 422 ENGINE - SPECIAL MAINTENANCE

| OPERATION | COMPONENT | after the first 1000 Km | after the first 5000 Km |
|---|---|---|---|
| CLEANING | Dry-type air filter | ■ | |
| | | | |
| CHECK | Checking cooling liquid level | ■ | |
| | Valve clearance | ■ | |
| | Water in the fuel filter | ■ | |
| | Clutch control and possible adjustment | ■ | |
| | Bolts and nuts correct fastening | ■ | |
| | Dinamic Injection Advance | ■ | |
| REPLACEMENT | Engine oil | ■ | ■ |
| | Oil filter | ■ | ■ |

## LDW 422 ENGINE - ORDINARY MAINTENANCE

| OPERATION | COMPONENT | INTERVAL KM | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1000 | 2500 | 5000 | 10000 | 20000 | 40000 |
| CLEANING | Dry-type air filter | | | ■ | | | |
| | Injector | | | | | | ■ |
| CHECK | Checking engine oil level | ■ | | | | | |
| | Checking cooling liquid level | | | ■ | | | |
| | Valve clearance | | | | | ■ | |
| | Water in the fuel filter | ■ | | | | | |
| | Integrity of propeller shaft boot | | | ■ | | | |
| | Low-pressure fuel lines | | | | ■ | | |
| | Clutch control and possible adjustment | | | | ■ | | |
| | Bolts and nuts correct fastening | | | | ■ | | |
| | Glow plug performance | | | | ■ | | |
| | Dinamic Injection Advance | | | | ■ | | |
| | Injector calibration | | | | | | ■ |
| REPLACEMENT | Engine oil | | | ■ | | | |
| | Oil filter | | | | ■ | | |
| | Fuel filter cartridge | | | | ■ | | |
| | Dry-type air filter cartridge | | | | | ■ | |
| | Timing belt | | | | | | ■ |
| | Cooling liquid | | | | | | ■ |



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The engine could be damaged if allowed to operate with insufficient oil. It is also dangerous to add too much oil as its combustion could sharply increase the rotation speed.
Use a suitable oil in order to protect the engine.
The lubrication oil influences the performances and life of the engine in an incredible way.
Use of an inferior quality oil or failure to regularly change the oil will increase the risk of piston seizure, may make the compression rings jam and will lead to rapid wear on the cylinder liner, the bearings and all other moving parts. Engine life will also be notably reduced.
Oil viscosity must suit the ambient temperature in which the engine operates.

Old oil can cause skin cancer if repeatedly left in contact with the skin and for long periods of time. If contact with the oil is inevitable, you are advised to thoroughly wash your hands with soap and water as soon as possible.
Appropriate protective gloves etc should be wore during this operation.
Old oil is highly polluting and must be disposed of in the correct way. Do not litter.

**Engine oil fuelling**

Set the engine on a flat surface, then pour in oil up to the max. level mark on the plug dipstick.

**RECOMMENDED OIL**

SAE 15 W 40 API CF - Viscosity SAE 15W/40 ( for Indian market )

**OIL SUPPLY (liters)**

| | |
|---|---|
| **filter included** | 3,5 |
| **filter excluded** | 3,0 |

**ACEA SEQUENCES**

A = Gasoline (petrol)
B = Light Diesel fuels
E = Heavy Diesel fuels

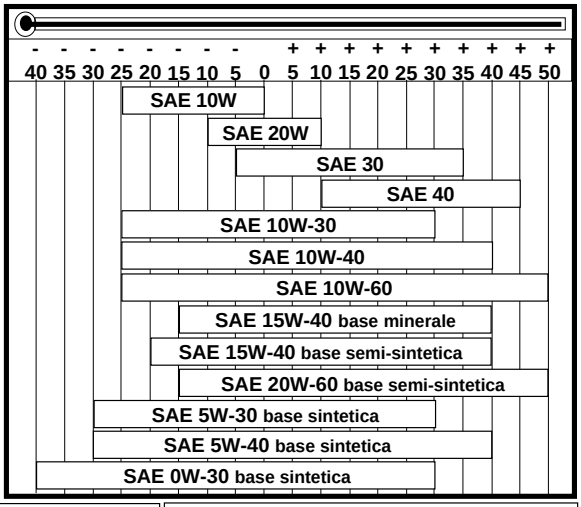
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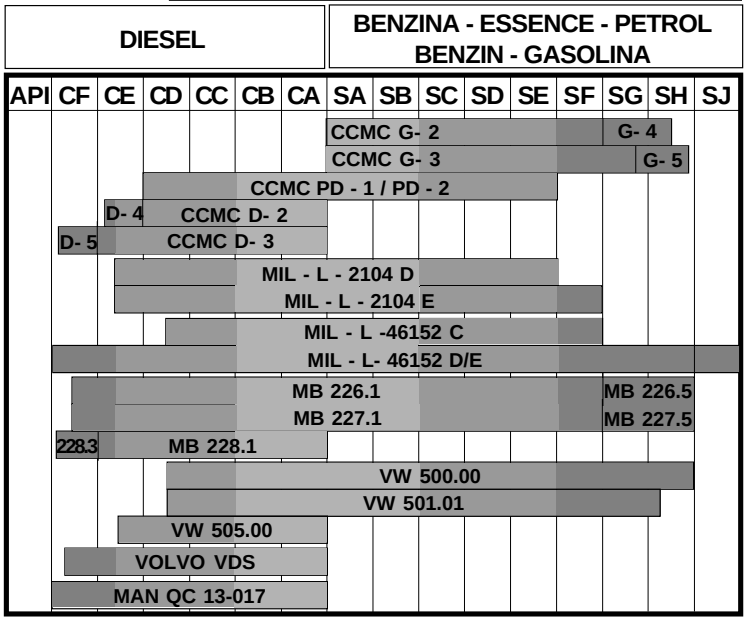
A1-96
A2-96
A3-96

B1-96
B2-96
B3-96

E1-96
E2-96
E3-96

**GRADE**



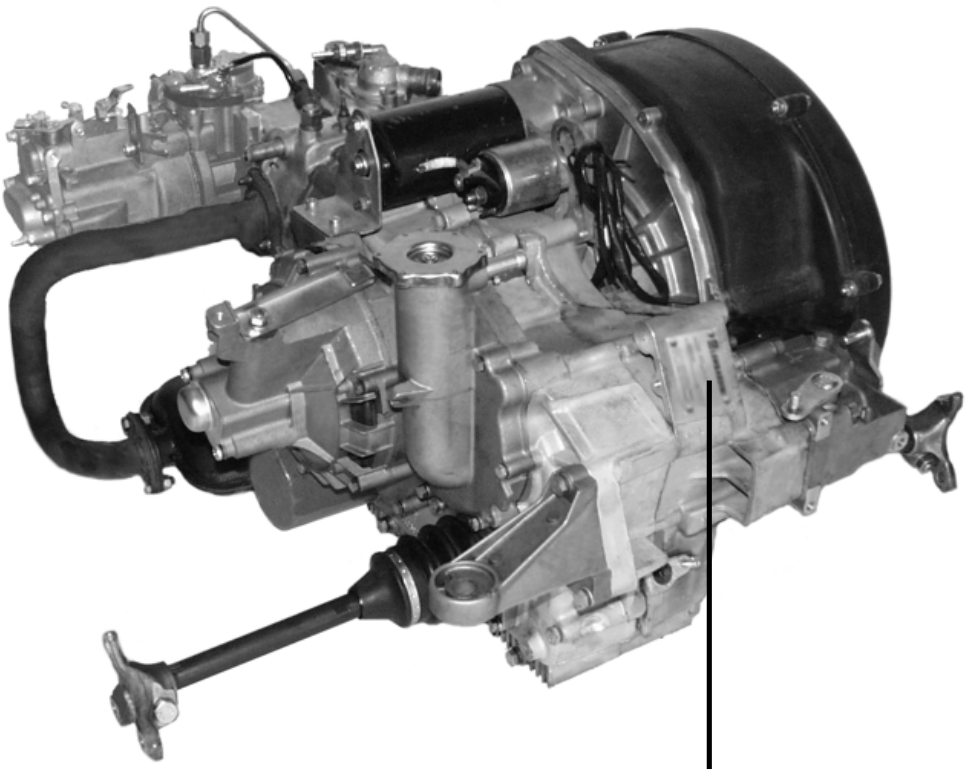



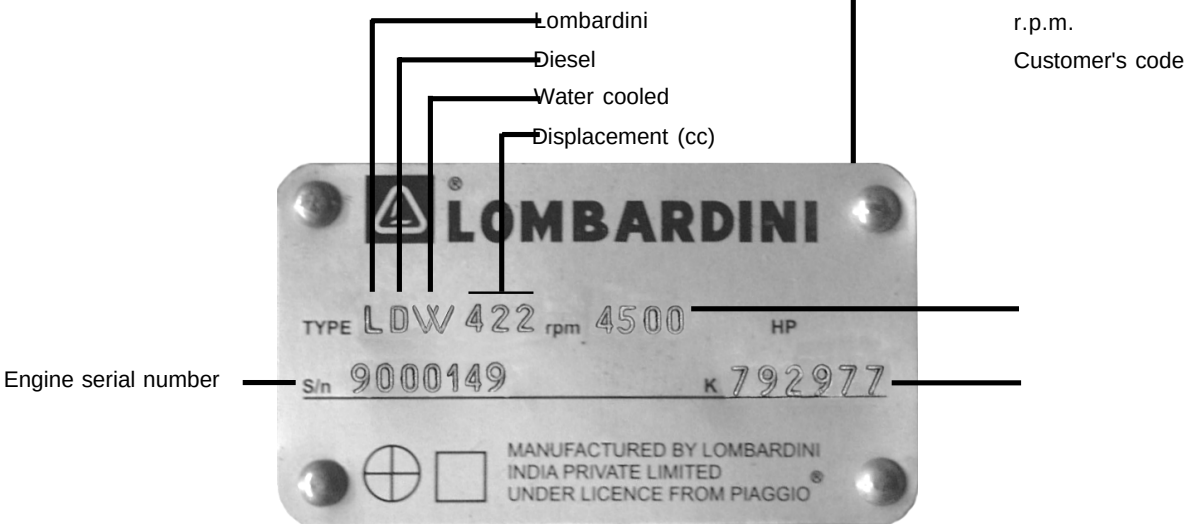



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# IV MODEL NUMBER AND IDENTIFICATION








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## LDW 422 ENGINE MAIN SPECIFICATIONS

- 4-stroke single cylinder engine
- Indirect-injection Diesel-cycle type
- Liquid cooling system with axial fan
- Differential gear and gearbox assembly on rear axle
- OHC axle driven by toothed belt
- Lubrication is made through a lobe pump controlled by driving-shaft chain
- Injection system by immersed-type pump, fed by diaphragm fuel pump
- Dry-type cartridge air filter
- Oil filter with cartridge
- Oil type SAE 15 W 40 API CF



# LDW 422

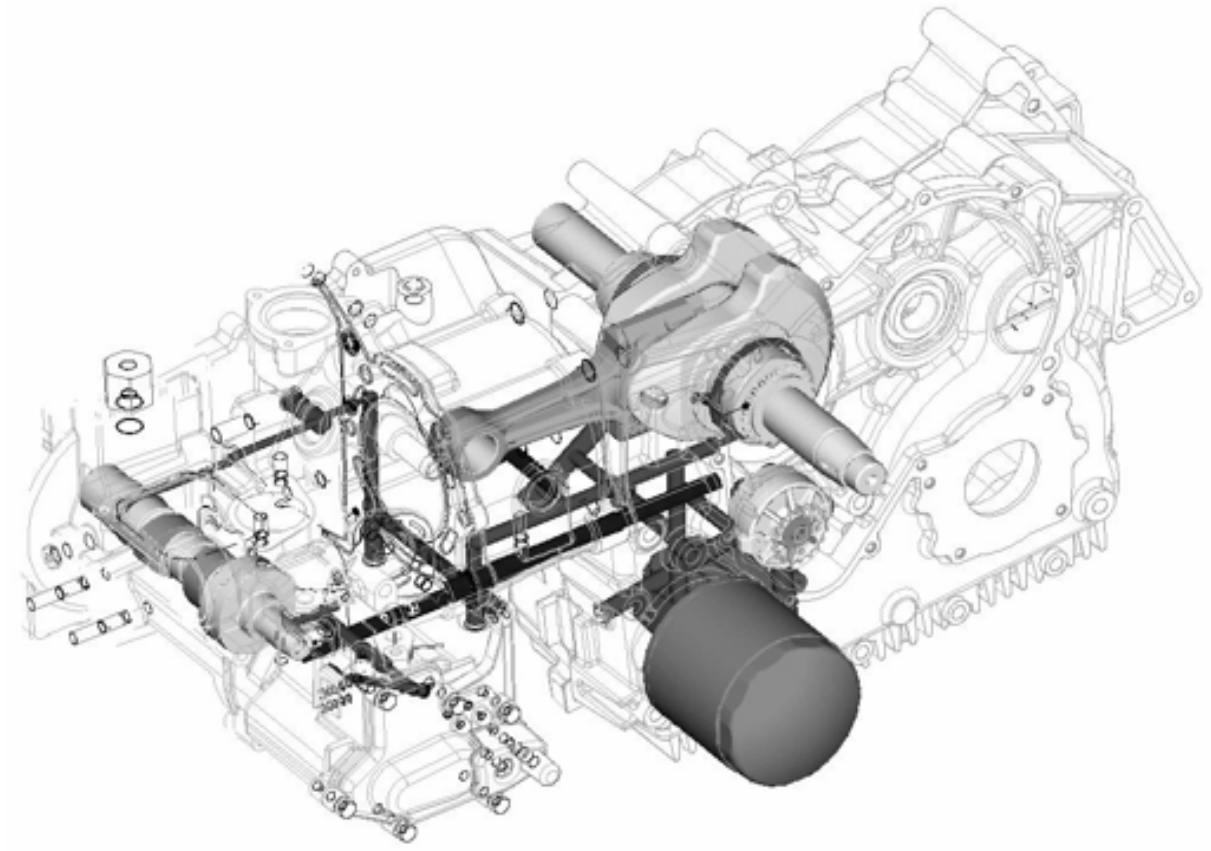
| TECHNICAL DATA | | LDW 422 |
|---|---|---|
| Number of cylinders | N° | 1 |
| Bore | mm | 83 |
| Stroke | mm | 78 |
| Displacement | Cm³ | 422 |
| Compression ratio | | 23 : 1 |
| R.P.M./1' min | | 1200 ± 100 |
| Max idle R.P.M./1' | | 5000 |
| Max load R.P.M./1' | | 4500 ± 100 |
| Power kW | kW | 8,8 |
| Max torque at 3200 R.P.M./1' | Nm | 21,6 |
| Fuel consumption | gr kW/h | 315 |
| Oil quantity without oil filter | l. | 3,0 |
| Oil quantity with oil filter | l. | 3,5 |
| Dry weight | Kg | 94 |

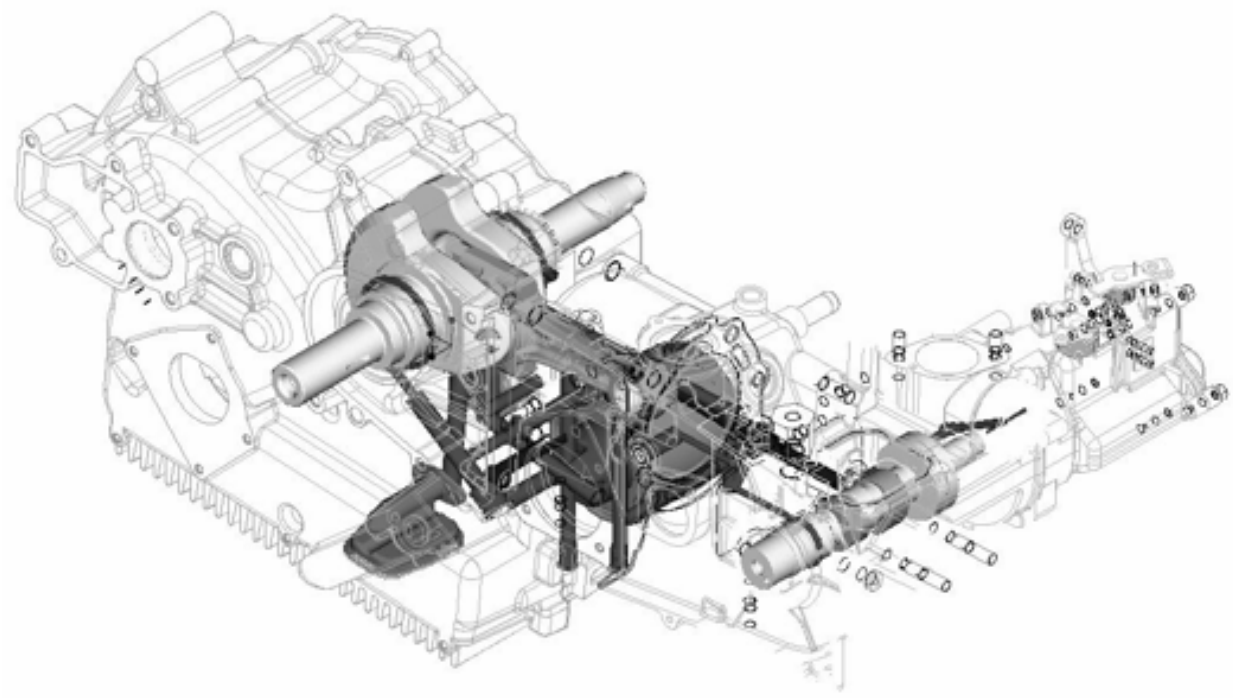


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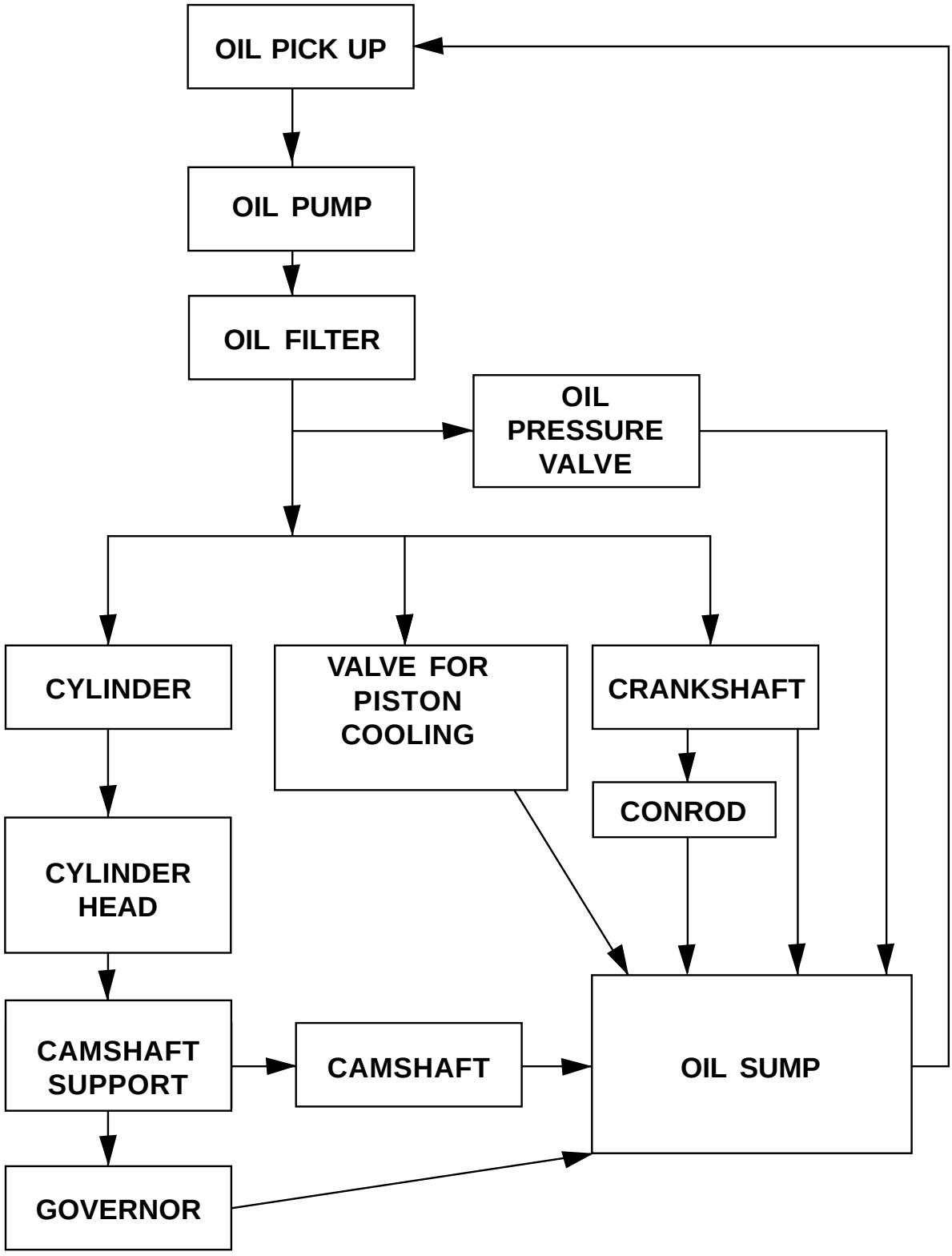


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# LDW 422 OIL CIRCUIT DIAGRAM



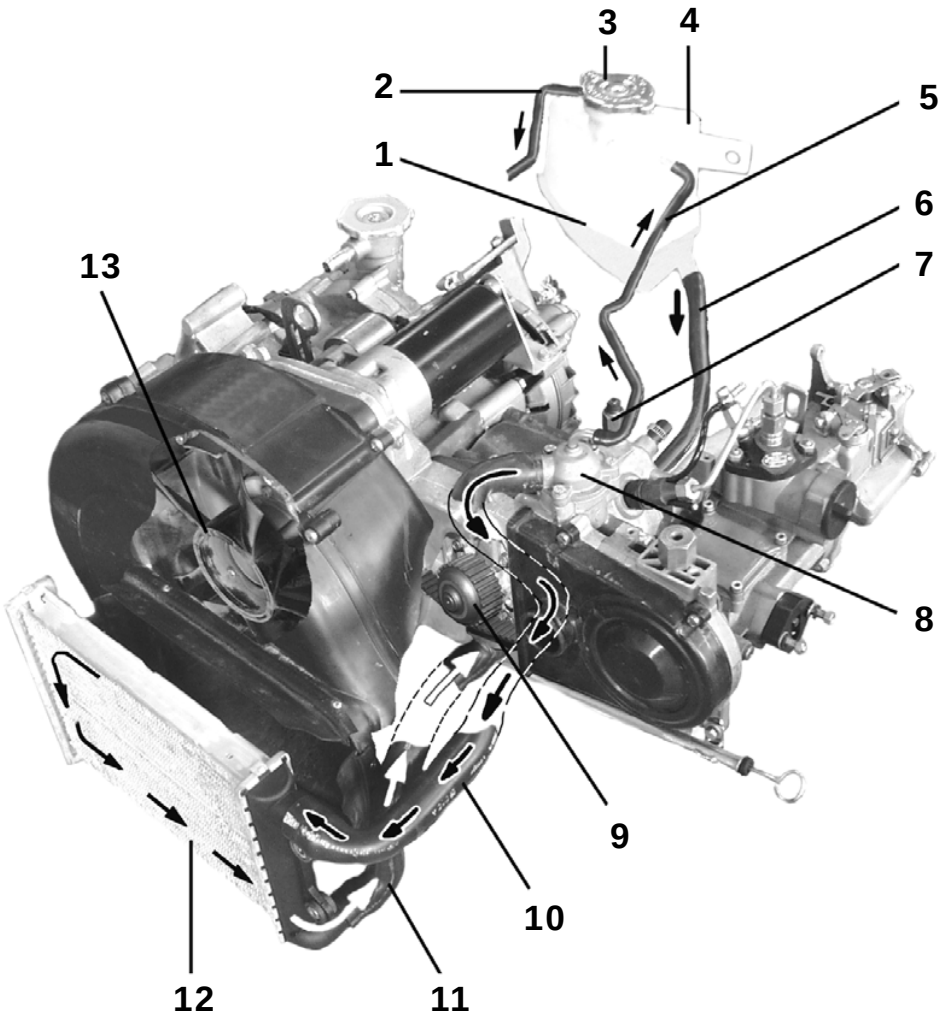



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**FORCED LIQUID COOLING SYSTEM WITH AXIAL FAN**




**Details:**

1) Cooling liquid level
2) Overflow pipe
3) Plug with calibrated pressurizing valve
4) Compensation tank
5) Breathing pipe
6) Pipe for the connection to the expansion vessel
7) Liquid temperature monitoring thermostat
8) Thermostat
9) Liquid circulating pump
10) Engine outlet-radiator inlet hose
11) Radiator outlet-engine inlet hose
12) Radiator
13) Cooling fan



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**Cooling liquid features**

It is recommended to use cooling liquids according to the recommended percentages, because besides lowering the freezing point as well as the pressure determined by the plug (radiator or expansion vessel), it determines the rise of the liquid boiling point inside the circuit.
Furthermore, it protects the whole circuit from corrosion, deposits, and cavitations can also be easily avoided.
In case radiators with aluminium cores are used, it is strictly necessary to use a solution of 50% $H_2O$ and 50% glycol solution.

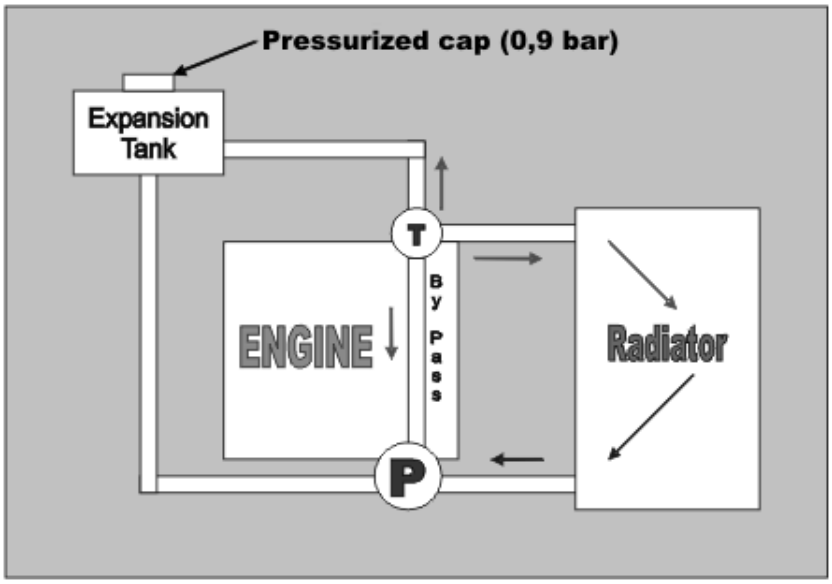
**It's mandatory the use for the cooling system of the correct percentage of mixture water and glycole.**
**The lack to the above prescription will result in warranty avoidance**

| PLUG SETTING | WATER | SOLUTION WITH 30 % ÷ 50 % GLYCOL |
|---|---|---|
| 0,50 bar | 98° C | 102° ÷ 105° C |
| 0,70 bar | 102° C | 107° ÷ 110° C |
| 0,90 bar | 105° C | 110° ÷ 112° C |
| 1,00 bar | 106° C | 112° ÷ 114° C |

**Thermostatic valve features**

- Opening starting point 80° C ± 2° C

- Max opening 95° C with 7 mm stroke




WATER COOLED SYSTEM DESCRIPTION

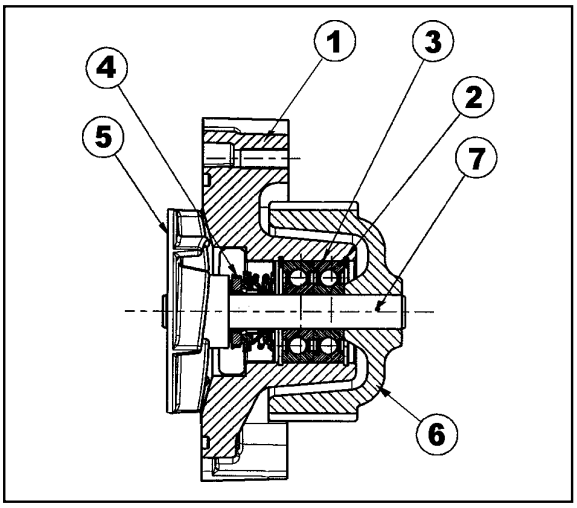
The engine cooling is carried out by means of liquid (50% of water and 50% of glicole) by the centrifugal pump, driven by the timing belt.
Until the temperature of the liquid is 84-87 °C, the water is recirculated through a by-pass circuit. After, the thermostat valve provided on the cylinder head allows the recirculation and the cooling through the radiator.



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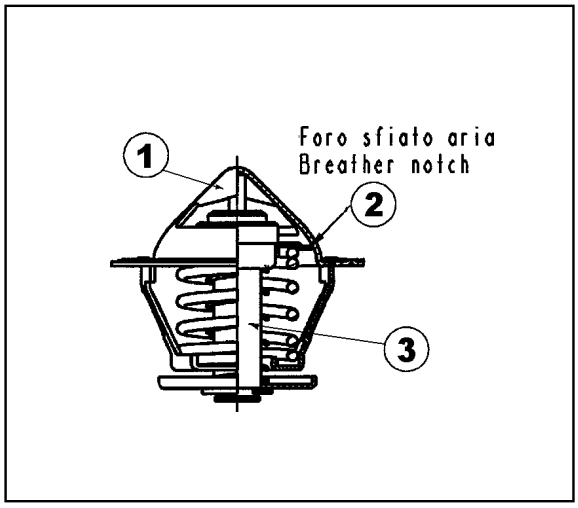

**Cooling liquid circulating pump**

Components:

1 Water pump case
2 Snap ring
3 Water pump bearing
4 Water pump sealing
5 Water pump impeller
6 Pulley
7 Shaft

**Checks on water pump**

Water pump is provided with two drain channels located in the upper part to the purpose of unveiling possible liquid leakages thus indicating an incipient failure of the pump seal.
Particularly during the engine run-in period small leakages of fluid are to considered normal.
Make sure the pump shaft does not show any axial clearance and can turn freely without undue localised friction.
Check that the impeller is free from dents, cracks or – worse – some blade is broken or missing at all.
If anyone of these checks is negative, just replace the water pump.
When re-assembling, replace the O-ring seals, tighten the fixing screws with a torque wrench at the indicated torque of 12÷15 Nm and check for a free turning of the pump after the tightening.
Replace the gasket of the inlet fitting of the pump.
Replace the timing belt.




**Thermostatic valve**

1 Case
2 Air vent
3 Valve head with wax sensor

Features:

Opening temperature: ..... 80° ± 2° C
Max stroke at 95° C: ..... 7 mm
Liquid return ..... 30/80 lt/h

! The following operation must be performed with the utmost attention. The water temperature reaches very high values – near boiling (about 100°C). Serious burns can result from contact.
Pay attention to splashes and overflows. Be careful not to knock over the container

**Checks on thermostat valve**

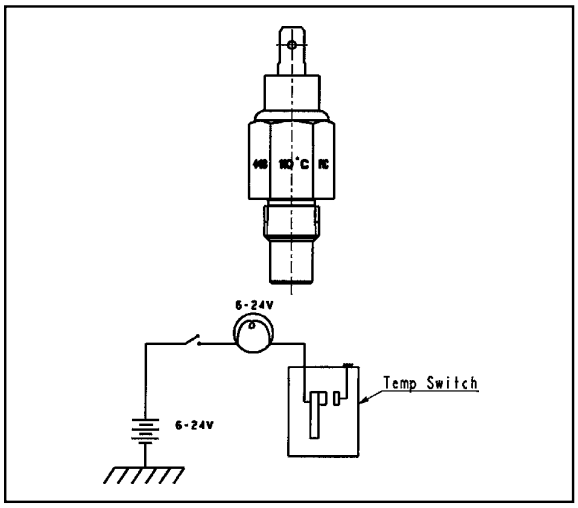
Dip the thermostat valve into a metal container ( a pan ) filled with water.
Procure a thermometer with max reading of 150 °C and dip in also in the same container to monitor the water temperature.
Heat up water and check – by means of the thermometer – that the thermostat valve starts opening at the required temperature of 80° ±2° C.
If the valve opening temperature is different replace the thermostat.
With the previously described setting, keep heating the water up to 95 °C : at this temperature the valve must be completely open, meaning that the lift is 7 mm.
Make sure that in cold water the valve is definitely closed.
In cased the thermostat valve would not open, the result is a substantial increase of the coolant temperature with abundant overflow of the coolant itself out of the expansion tank.



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**Sensor for cooling liquid temperature indicator light**

Features:

Circuit: .....Unipolar
Supply voltage: .....6/24 V
Voltage: .....6/24 V
Absorbed power: .....3 W
Operating temperature: 110 ± 3° C

! The following operation must be performed with the utmost attention. The oil temperature reaches very high values – near boiling (about 110°C). Serious burns can result from contact. Pay attention to splashes and overflows. Be careful not to knock over the container

**Check of the coolant temperature switch.**

Dip the threaded part of the sensor in a metal container filled with engine lube oil; monitor the oil temperature using a precision thermometer with max reading of 150 °C.
Heat up the oil until it reaches the required temperature of 110° ±3° C.
Since the switch is the ON-OFF type the check is made through an Ohm-meter ( tester ).
When the oil temperature is below the rated value the electric circuit of the sensor is open and the tester must not read continuity.
When the oil in the container reaches the rated temperature of 110 ± 3° C the tester must indicate continuity, showing a closed electric circuit.



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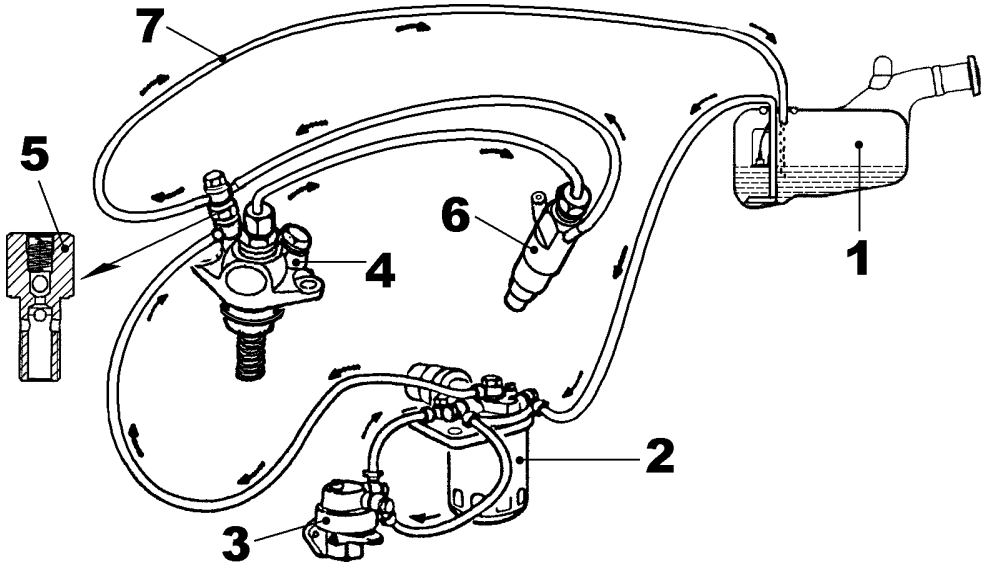
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**FUEL SUPPLY CIRCUIT WITH QUICK STOP DEVICE ( QSD )**

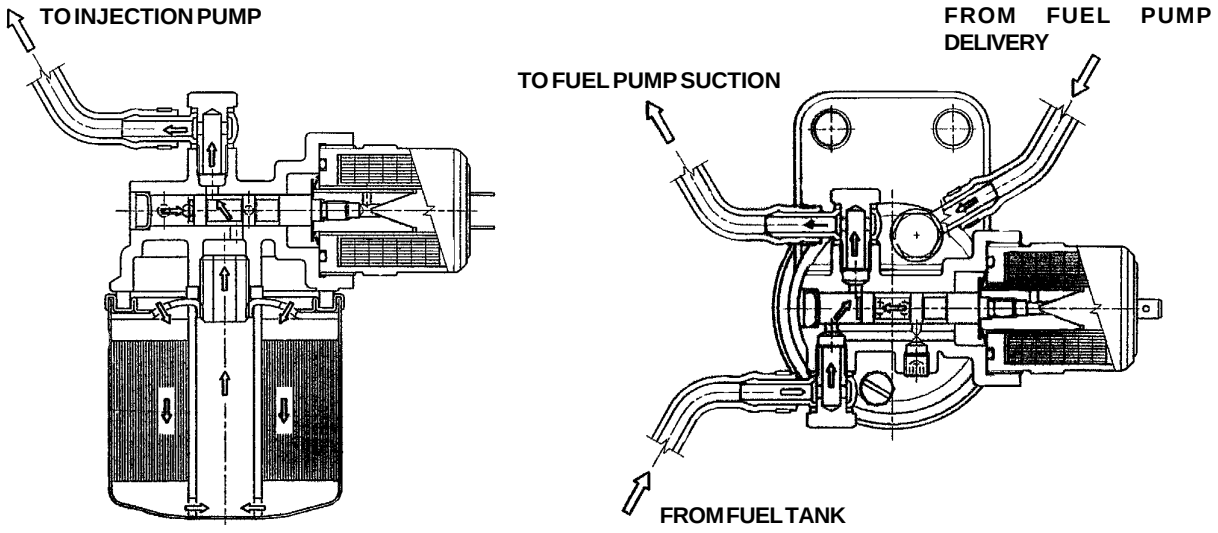
This device stops electrically the diesel engines, equipped with immersed-type injection pumps of type Q and K.
The device operation is based mainly on a special electronically-controlled slide valve integrated in the fuel filter.
During the stop phase of the engine, fuel is sucked from the injection pump thanks to the suction vacuum of the fuel pump. This ensures reliable and rapid engine stops and subsequent start-ups.

**Running engine (excited electromagnet)**




**CAPTION:**
**1** – Fuel tank
**2** – Fuel filter with QSD
**3** – Fuel supply pump
**4** – Injection pump
**5** – Special union for QSD ( valve open )
**6 -** Injector
**7** – Fuel return pipe to tank

**QSD behaviour with excited electromagnet**



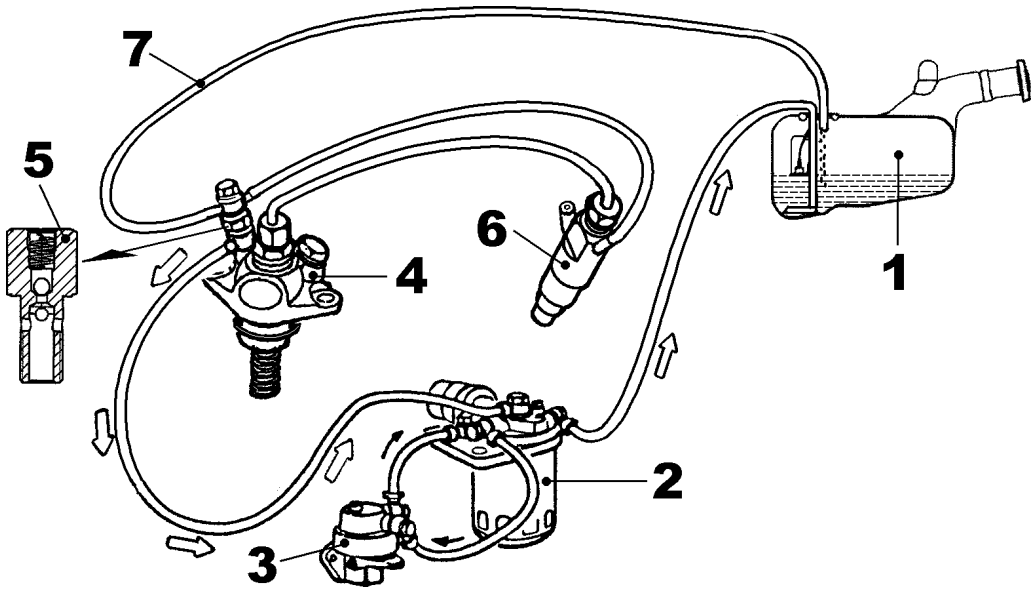



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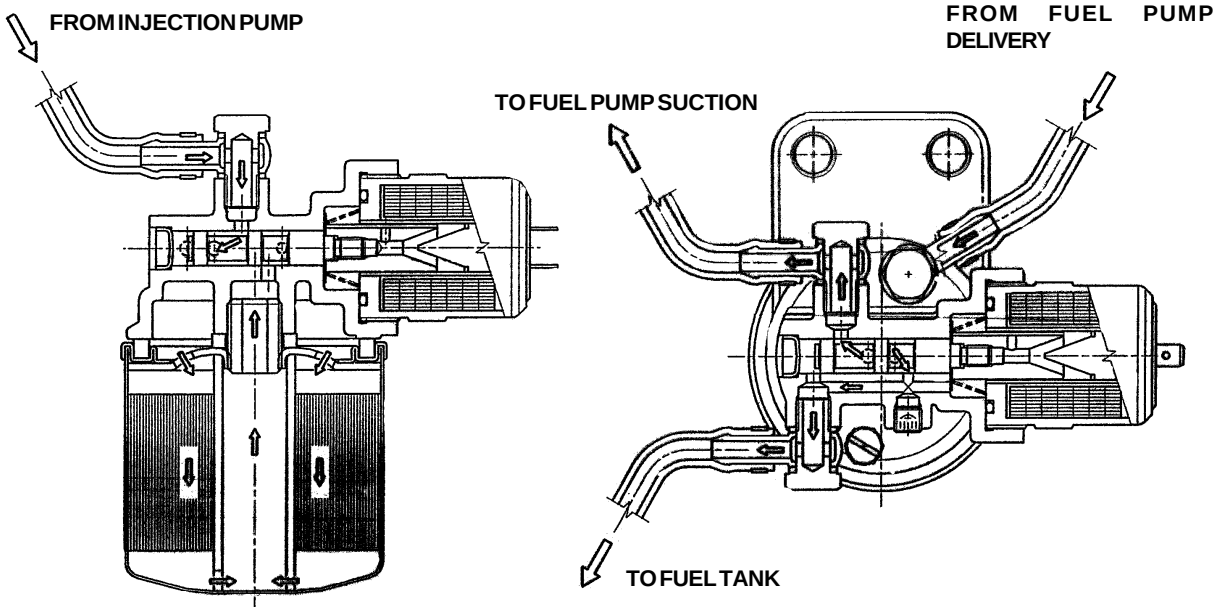
**Running engine (excited electromagnet)**




**CAPTION:**

**1** – Fuel tank
**2** – Fuel filter with QSD
**3** – Fuel supply pump
**4** – Injection pump
**5** – Special union for QSD ( valve closed )
**6 -** Injector
**7** – Fuel return pipe to tank

**QSD behaviour with de-excited electromagnet**



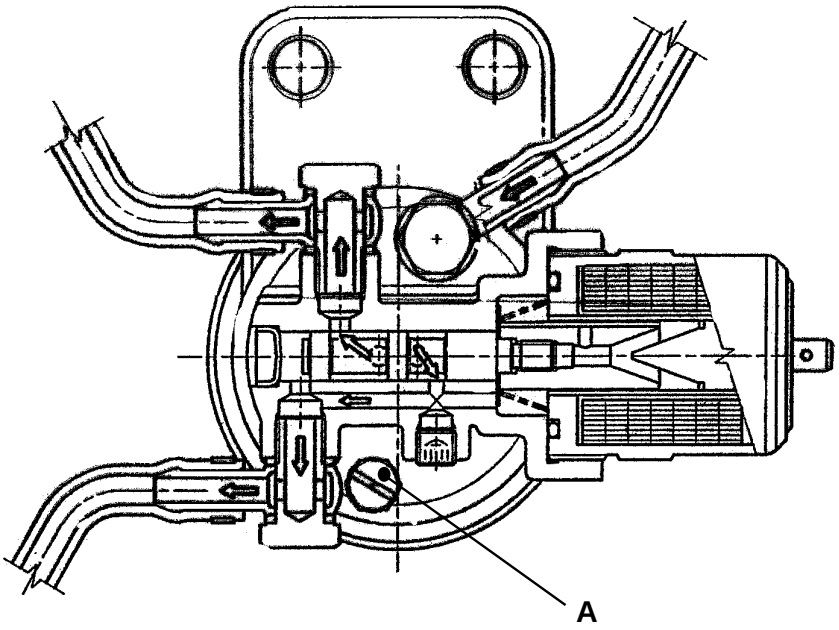



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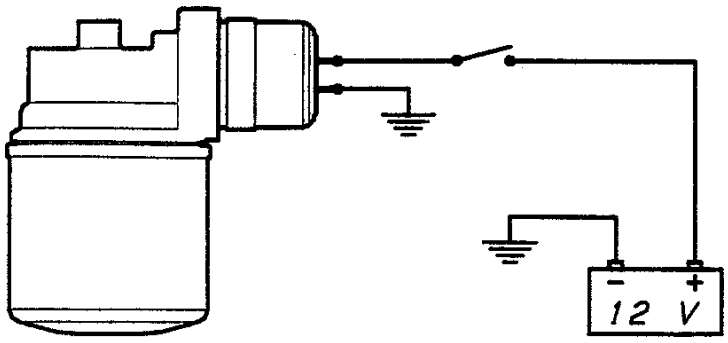


**Fuel circuit air bleeding**




! Should you empty the fuel circuit completely, bleed it carefully by using the indicated screw **A**.
This operation is to be carried out once the fuel refilling is over and with the engine running at idle speed.

**QSD WIRING DIAGRAM**

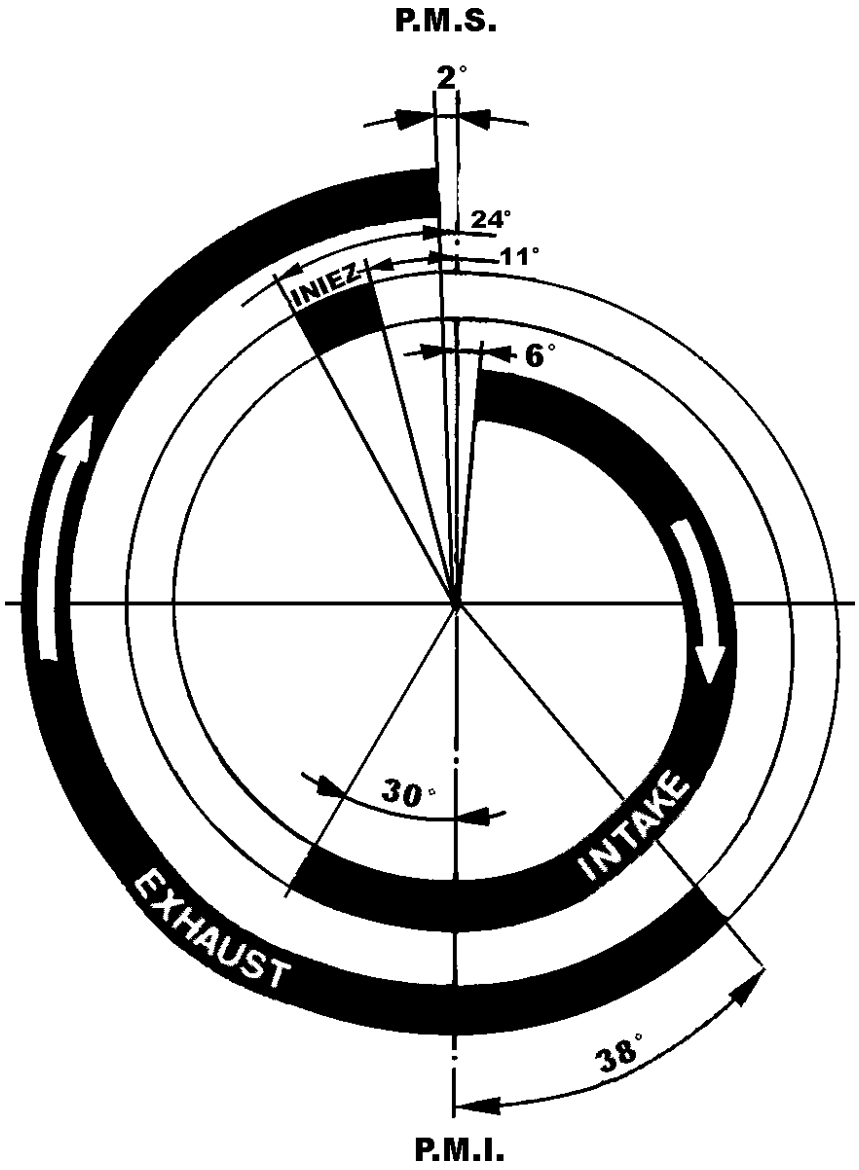





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**Timing diagram**

Data concern 1 mm. cold play between tappets and valves

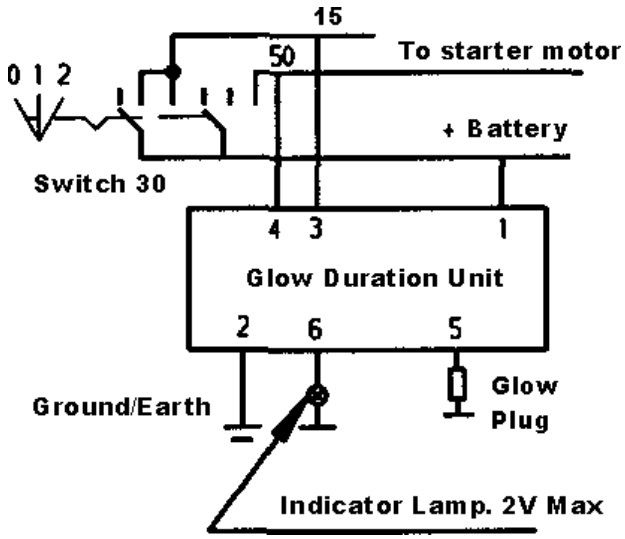


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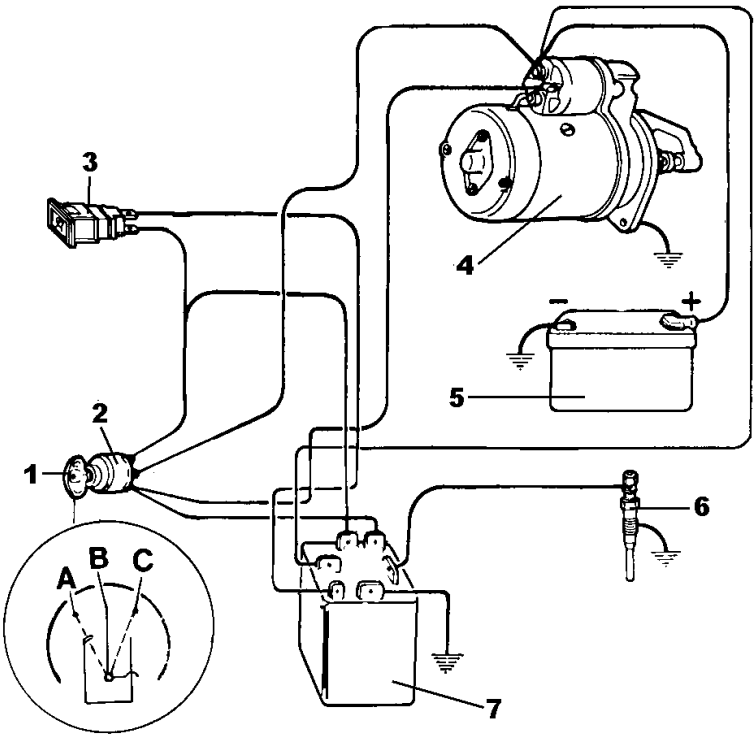
# X PREHEATING SYSTEM

**Preheating system**

The preheating system is made up of: a key switch, a gear case with built-in temperature sensor, a glow plug, a preheating indicator light.




By turning key **1** to the ON position on switch **2** the preheating indicator lamp **3** turns on indicating the waiting time, which depends on the ambient temperature detected by the sensor located inside the gear case **7**.
Once the preheating indicator light turns off, the glow plug maintains the temperature for about 4 seconds (distraction time) even if no start command has been given
Once the engine is running, the gear case receives a signal and maintains the glow plug temperature for further 5 seconds (preheating time).
Whereas the preheating phase is necessary to start the engine and varies according to the ambient temperature, the post heating phase is necessary to avoid white exhaust smoke after the start. Fixed activation time = 4 seconds.
By high ambient temperatures (tropical climate), the preheating indicator light turns on for a few seconds even when the glow plug is not heated




CAPTION:

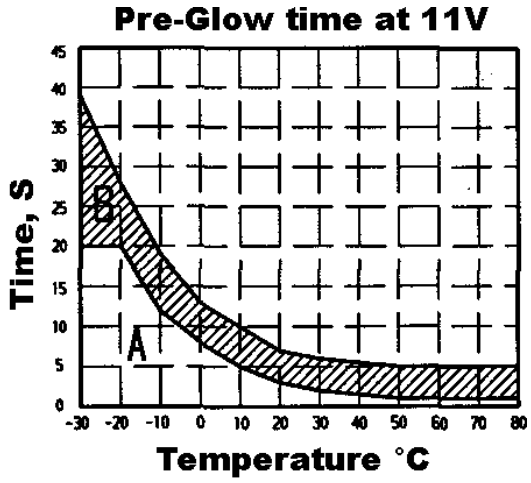
1 - Key
2 - Swi§34tch
3 - Preheating indicator light
4 - Starting motor
5 - Battery
6 - Glow plug
7 - Gear case



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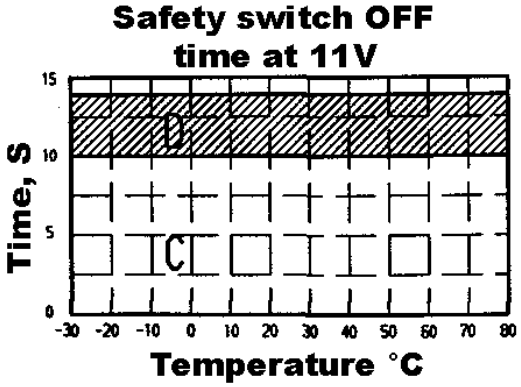





**Preheating time diagram according to ambient temperature ( 11V )**

**A)** Preheating indicator lamp on and glow plug heated

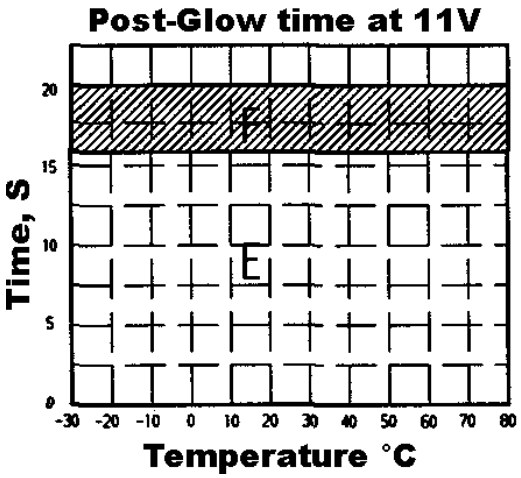
**B)** (Tolerance) Indicator lamp off and glow plug heated (for the time needed to start the engine)




**Distraction time diagram**

**C)** Switch-key turned from ON to OFF position before the set preheating-time is over – Preheating time beyond zone B – the preheating indicator lamp is off – the glow plug is on but only for a few seconds

**D)** (Tolerance) the preheating indicator lamp and the glow plug are off




**Post heating time diagram**

**E)** Post heating time – the indicator lamp is off – the glow plug is heated – the engine is running

**F)** (Tolerance) The preheating indicator lamp and the glow plug are off - the engine is running



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## NOTE



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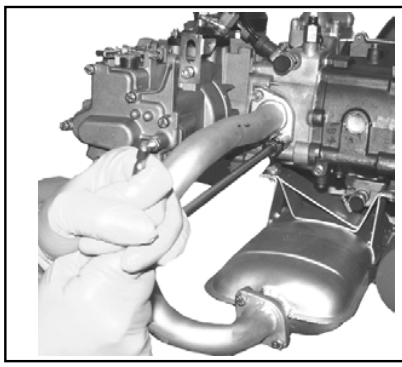
Apart from disassembly and reassembly operations, this handbook also includes checks, setting up, dimensions, repairs and running instructions.
It is necessary to use LOMBARDINI original spare parts for a correct repair.

**During repair operations, when using compressed air, wear eye protection.**

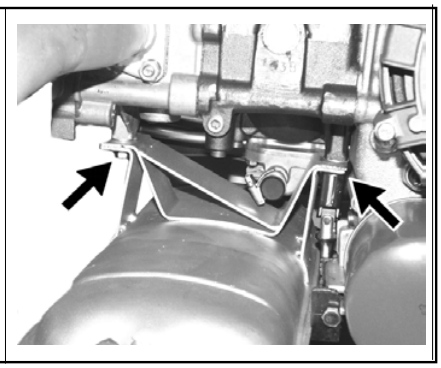
Before removing the engine from the vehicle, be sure the battery negative cable (-), the electrical cables of the alternator flywheel and of the starting motor, the fuel pipes, the controls of accelerator, braking lights, speed gear and clutch have all been disconnected.
Remove the engine only after draining the oil from the engine cover.
Old oil is highly polluting and must be disposed of in the correct way. Do not litter.

**Muffler - disassembly**

To disassemble the muffler it is necessary to remove both hex nuts fixing the exhaust manifold to the head first, then the two nuts on the bracket anchoring the muffler to the engine (see pictures 1-2).



1



2

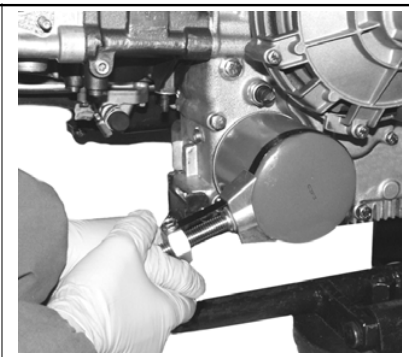
**Oil filter - disassembly**

Install the gear engine unit on the support 986171.193 (see picture 3).
Disassemble the oil filter by means of a band type filter wrench (see picture 4).



**support 986171.193**

3



4



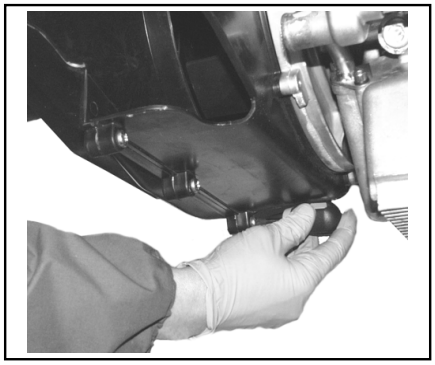
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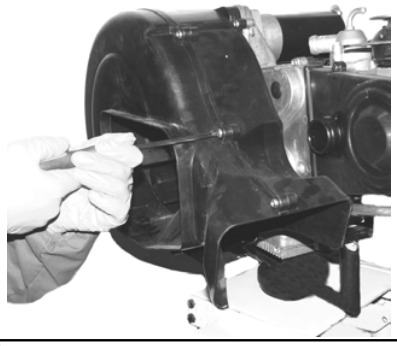


**Air shroud, Cooling fan - Disassembly**

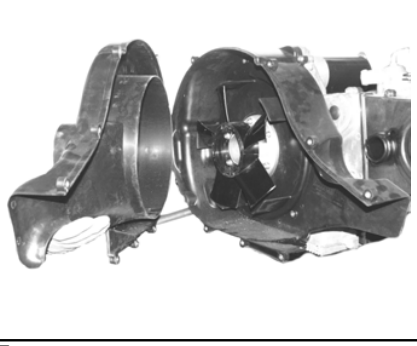
Loosen the 9 fastening screws to disassemble the air shroud on the radiator side (see picture 6). Use a short cross-head screwdriver to loosen the 3 lower screws (see picture 5).
Loosen the 4 M6x20 fastening socket head screws to disassemble the cooling fan (see picture 8).
Be sure the fan blades are intact; should one be damaged, the fan must be replaced.



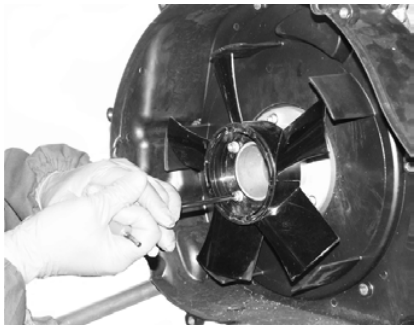
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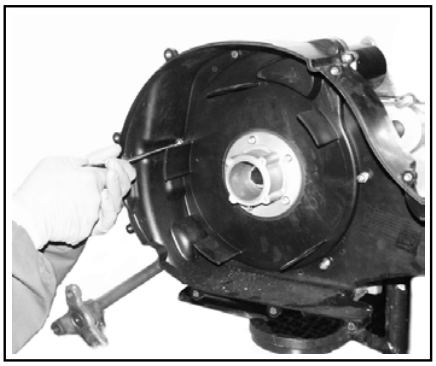
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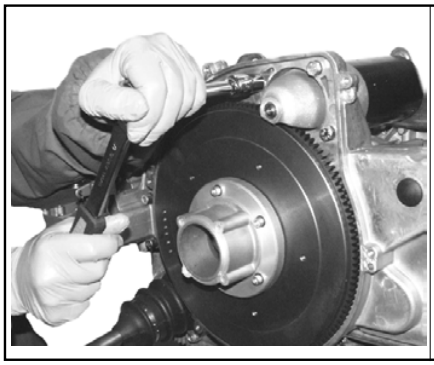
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**Flywheel-side air shroud - Disassembly**

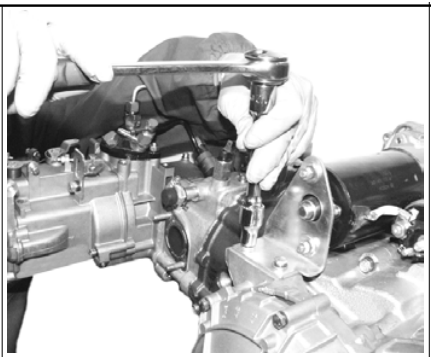
To remove the flywheel-side air shroud loosen the 5 M 6x20 ( fig. 9) socket head screws

**Starting motor - Disassembly**

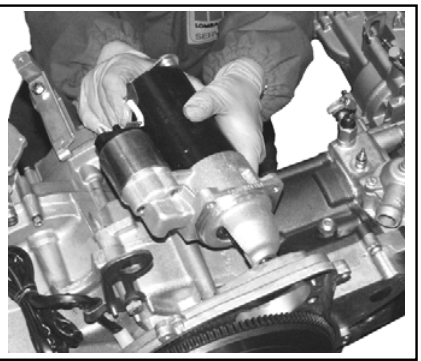
Unscrew the 3 M 8x40 fastening hex bolts on the engine support (see picture 10) and the 2 M 6x22 bolts on the anchoring bracket (see picture 11) to remove the starting motor.



10



11



12



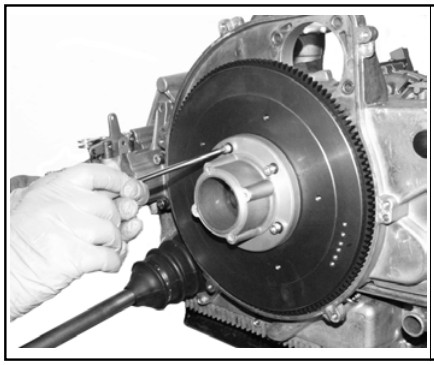
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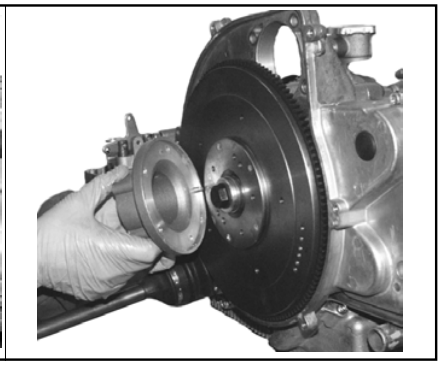


**Cooling fan support - Disassembly**

Loosen the 5 M 6x20 socket head screws (see picture 13) to disassemble the liquid cooling fan support of the radiator from the flywheel.



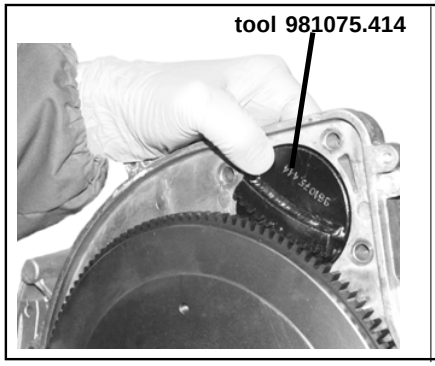
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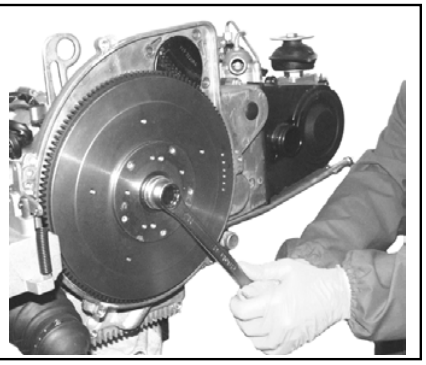
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**Flywheel - disassembly**

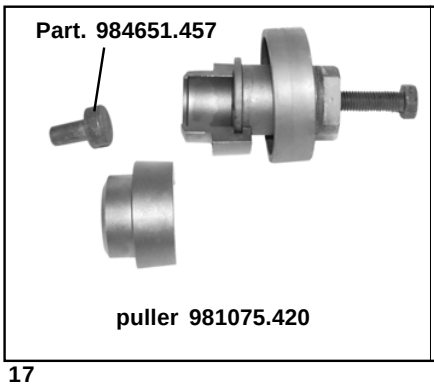
Place tool 981075.414 onto the starting motor housing (see picture 15) to lock the flywheel, remove the flywheel retaining screw using the 22 mm socket wrench ( see picture 16) and extract the cone (see pictures 18-19) using puller 981075.420 - equipped with component 984651.457 - and remove the flywheel (see pictures 21-22) using puller 981075.418 (see picture 20).



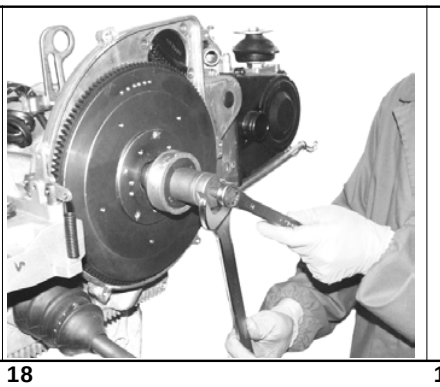

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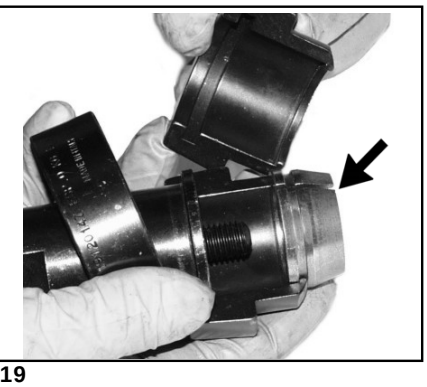
16



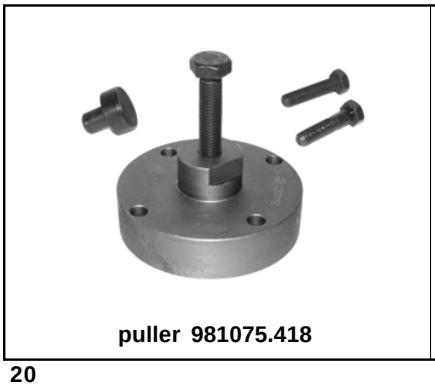

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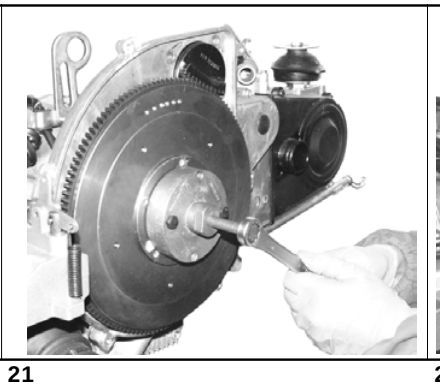
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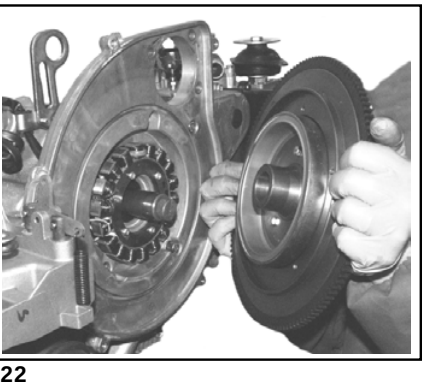
19




20



21



22



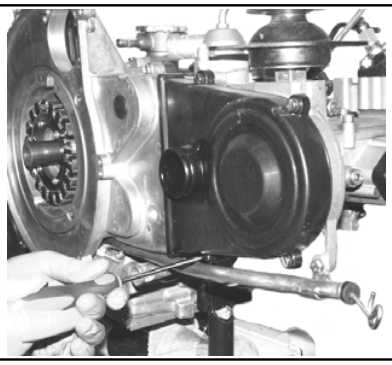
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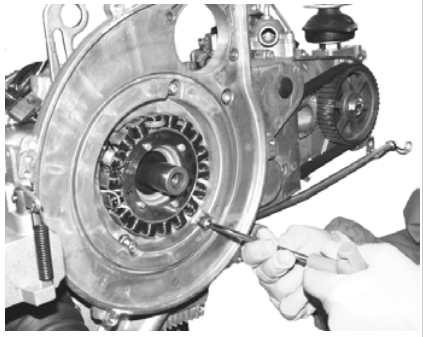


**Timing belt cover, air shroud and stator support**

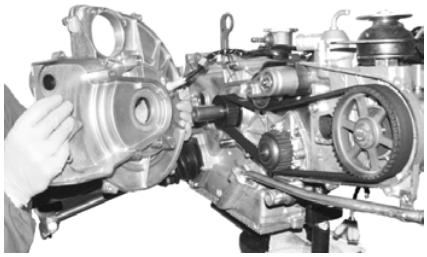
After removing the timing belt cover (see picture 23), loosen the 6 screws and remove the air shroud and stator support (Fig. 24), and remember to remove the clamp from the alternator cable (Fig. 25).



23



24



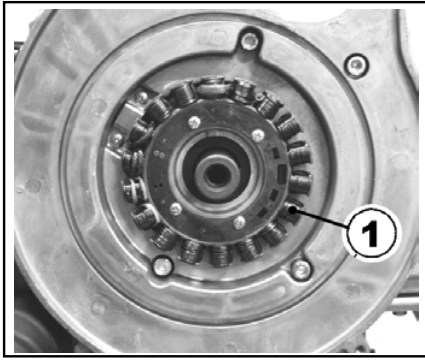
25

**Internal alternator**

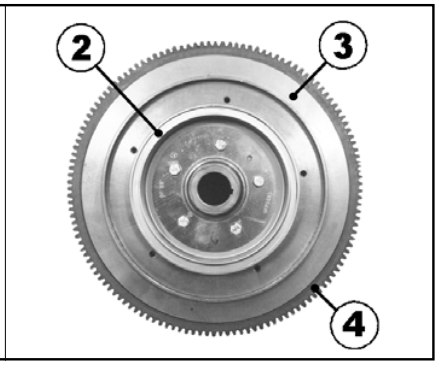
Components:

**1** Stator
**2** Rotor
**3** Flywheel
**4** Toothed crown

In this installation, the rotor section is composed of permanent magnets generating a rotating magnetic field.
The number of rotor pole pairs is equal to the number of rotor windings and is evenly distributed on its 360° circle.
Current is taken to stator windings and adjustment is carried out by disconnecting current to the rotor.
Therefore, current supply is not continuous and the battery must dampen voltage picks.




26



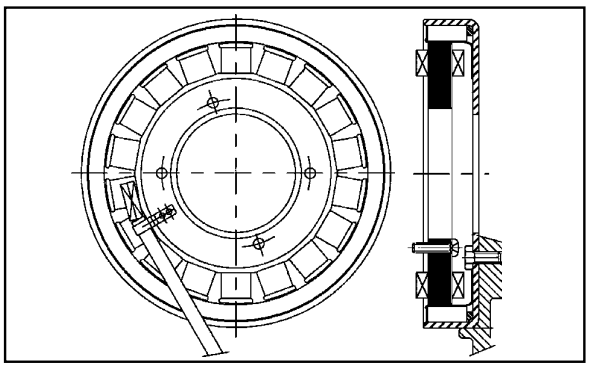

27



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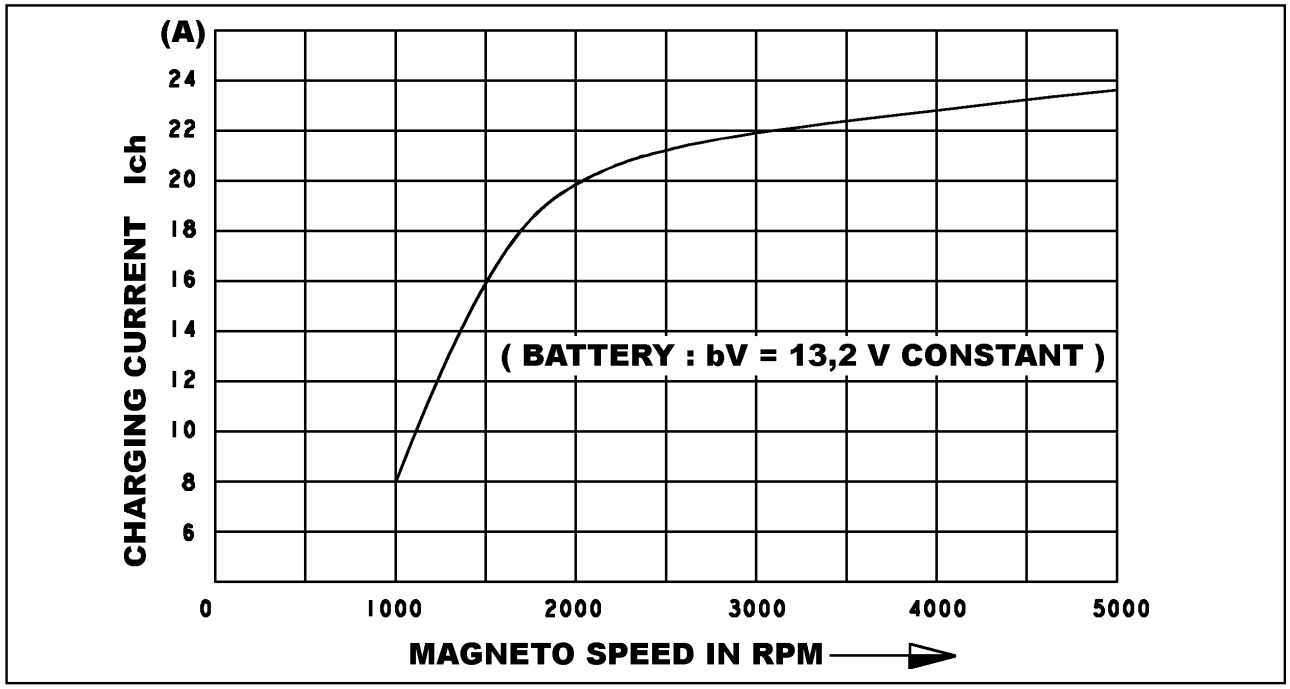


28

**Internal alternator - features**

3-phase magnet flywheel
Max rpm ..... 5000 rpm
Rotor poles ..... 12
Stator poles ..... 18
Operating temperature ..... -10° C ÷ + 110° C

**Battery recharge curve**




29

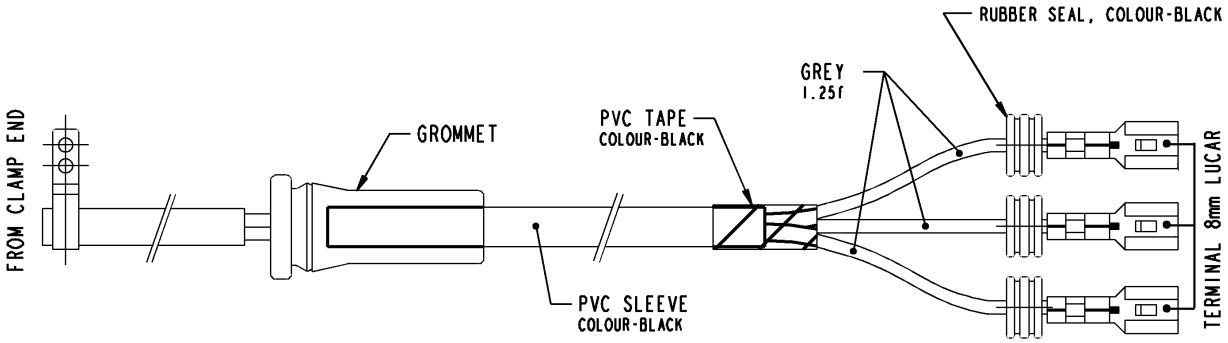


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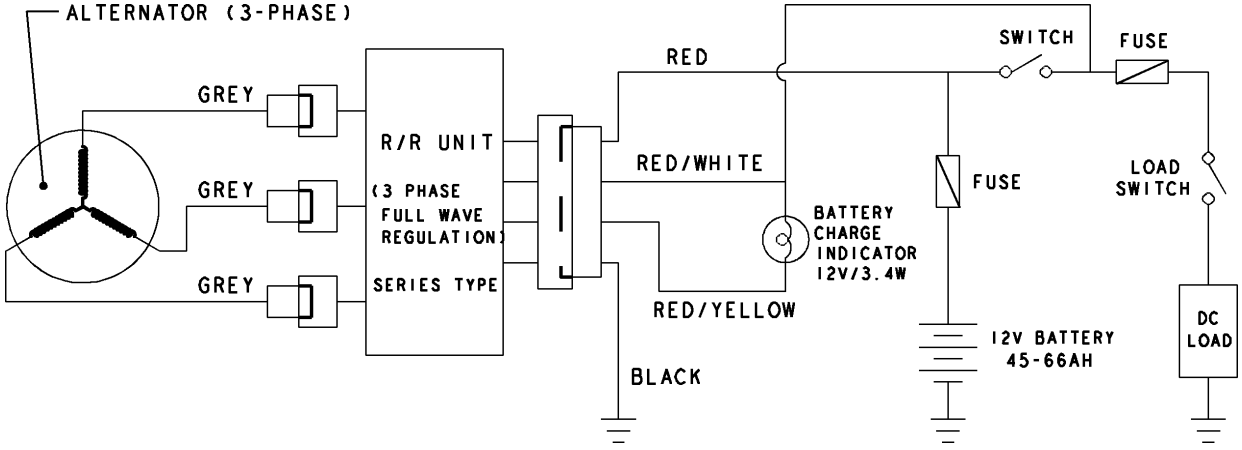
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**Alternator-voltage regulator connecting cable**




**Tree-phase alternator and voltage regulator wiring diagram**






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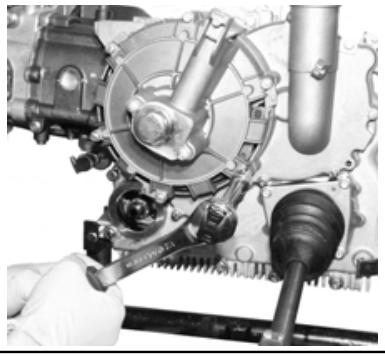
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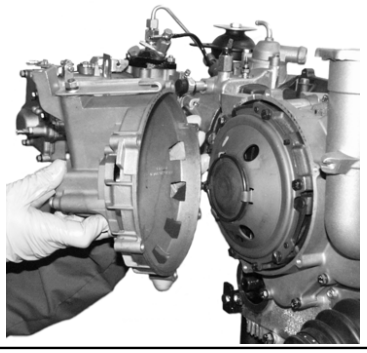


**Clutch cover, clutch pack - Disassembly**

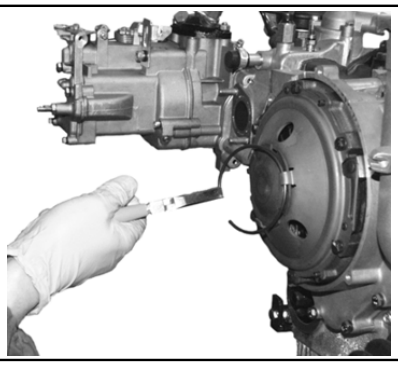
Loosen the 6 M 6x45 hex bolts to disassemble the entire clutch cover ( fig. 30-31 ).
Extract the snap ring using pliers then remove the thrust plate ( fig. 32-33 ).
Place the stop device 985110.039 (see picture 34) and unscrew the fastening nut (see picture 35).
Place the puller 981075.419 and loosen the middle screw to remove the clutch pack (see picture 37-38).



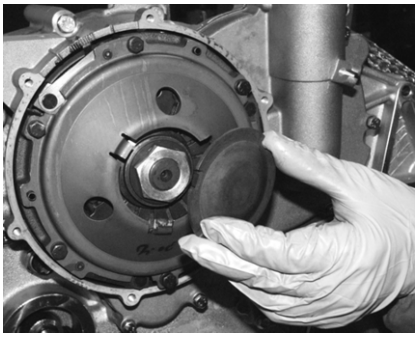
30



31



32

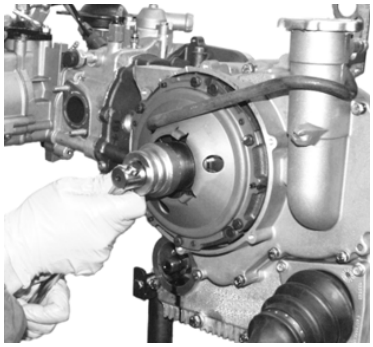


33



stop key 985110.039

34

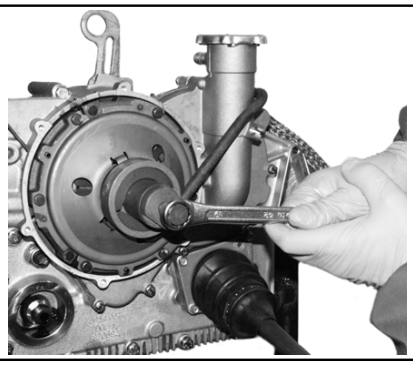


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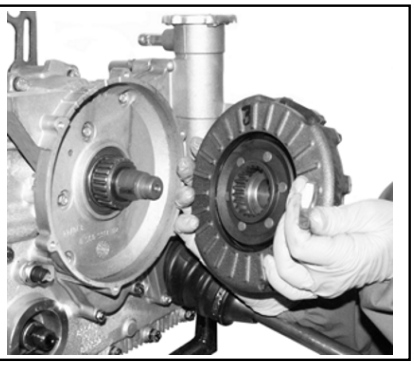


puller 981075.419

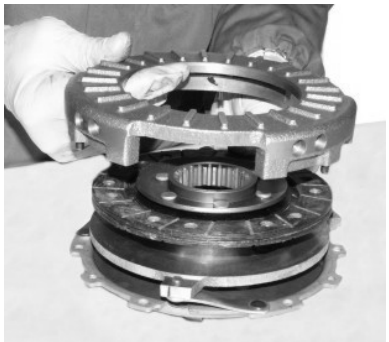
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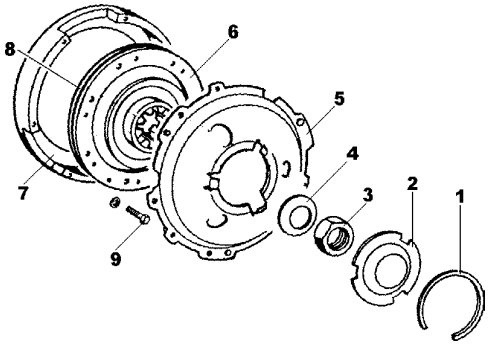
37



38



39




**Caption:**

**1-** Collar retaining ring
**2-** Thrust cap
**3-** Nut
**4-** Cup spring
**5-** Clutch pressure pad
**6-** Clutch disk
**7-** Flange
**8-** Centering pin
**9-** Fastening bolt

40



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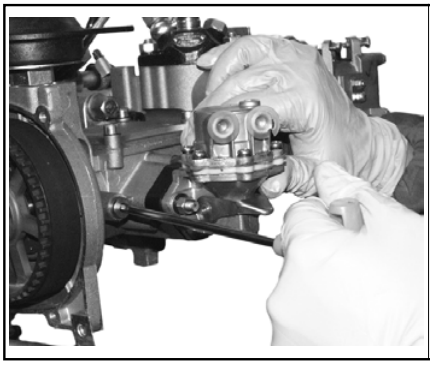


**Timing system**

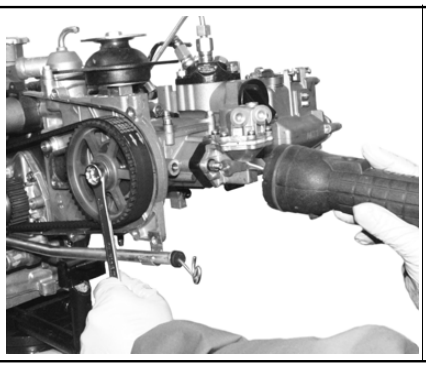
Before starting to disassemble the timing belt, camshaft and crankshaft timing is necessary.

**Camshaft timing**

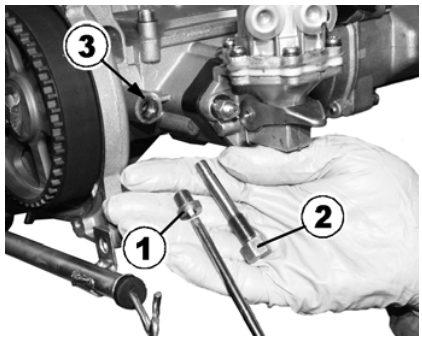
Remove the screw plug from the camshaft support (see picture 41).
Turn the timing gear until hole **3** on the camshaft is aligned with the hole on the support from which screw plug **1** has been removed (see picture 43).
Then fit timing gear **2** (see picture 43), serial number 8430.123 (see picture 44) and screw it down till it is tight on the camshaft boss surface.
Thanks to this operation, the camshaft is now locked at the correct timing point.



41



42

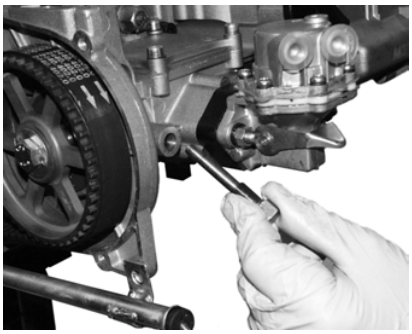



43



pin 8430.123

44



45



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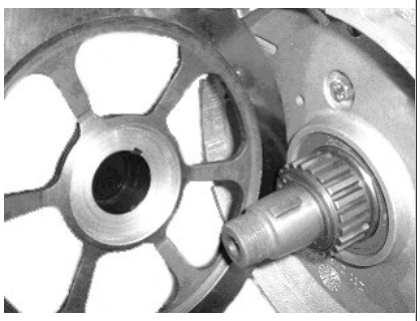
**Crankshaft timing**

Place tool 5900.217 (see picture 46 ) on the crankshaft replacing the previously disassembled clutch pack, by using the key. By means of the same fastening nut used for the clutch, tighten the tool to 120÷140 Nm.
Then fit timing pin 8430.124 (see picture 46) and screw it on the clamping hub so that it corresponds to the hole on the clutch housing pan (see picture 48). The crankshaft is now locked in timing phase.

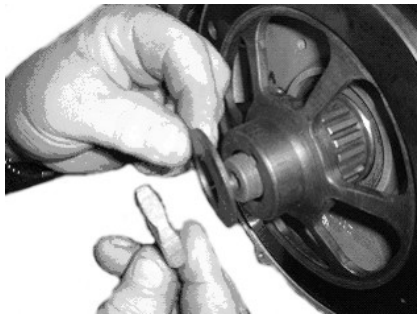



special tools 5900.217

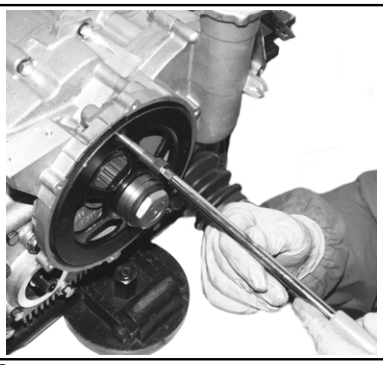
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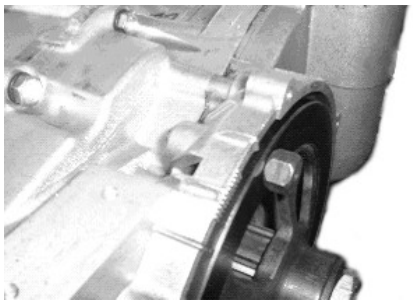
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48



49



50



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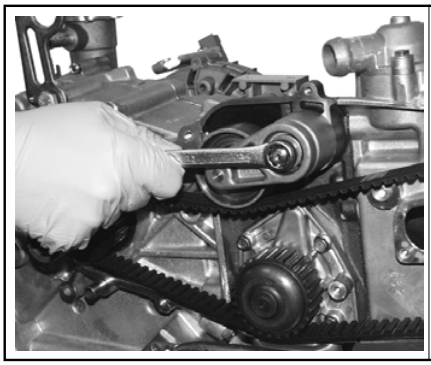


**Toothed timing belt - Disassembly**

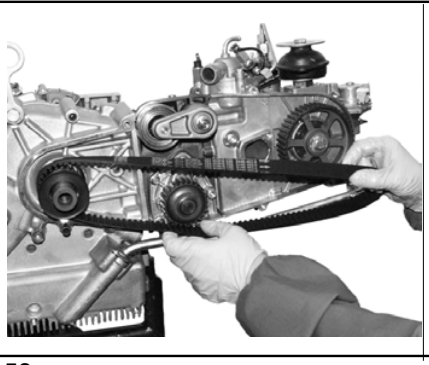
Once the relevant parts – i.e. crankshaft and camshaft – have been set in timing phase following to the procedures explained before, the toothed timing belt can be disassembled.
First loosen the belt tightener fastening nut (fig. 51), then push the tightener upwards until it lays against the cover and lock it in this position by retightening the nut.
This operation allows to release the tension on the toothed timing belt, thus enabling its removal (fig. 52).

**! When removing the timing belt, this should be replaced even if its scheduled motion period is not over.**

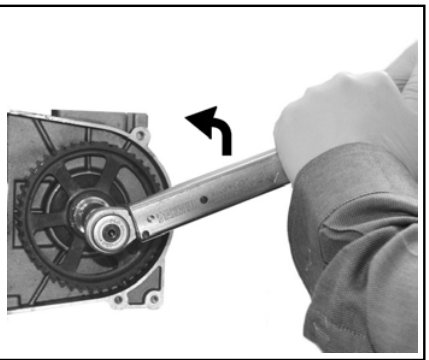
**! The toothed timing belt should not be tensioned during the scheduled motion period**



51



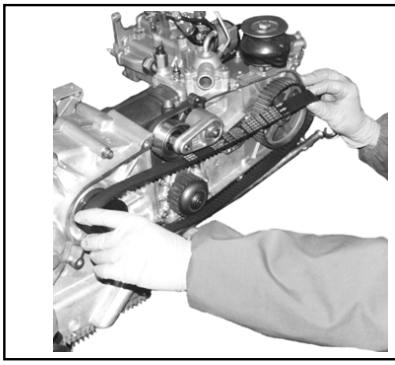
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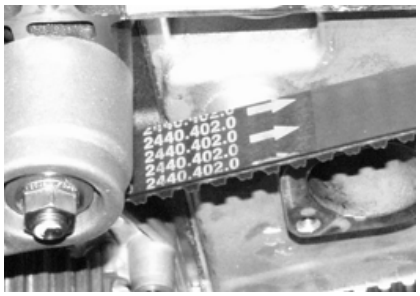
53

**Toothed timing belt - Reassembly**

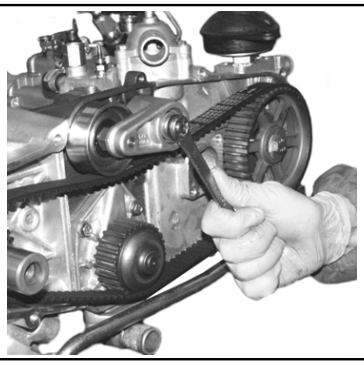
Loosen the fastening nut of the toothed timing pulley, controlling the camshaft, so that it can rotate freely on the shaft (fig. 53).
Insert the new toothed belt on the crankshaft pulley first, then on the camshaft one (fig. 54).
When assembling, pay special attention to the timing belt rotation direction. The direction is specified by the arrows on the belt (fig. 55), which should point the engine rotation direction, i.e. clockwise.
Unscrew the belt tightener fastening nut to allow the spring to extend and press onto the tightener itself, thus tensioning the toothed timing belt (fig. 56).



54




55



56

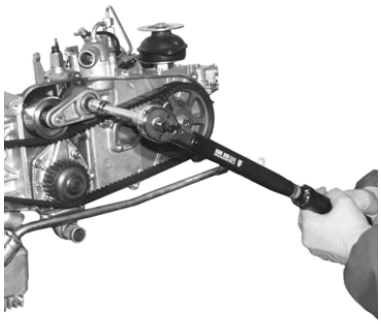


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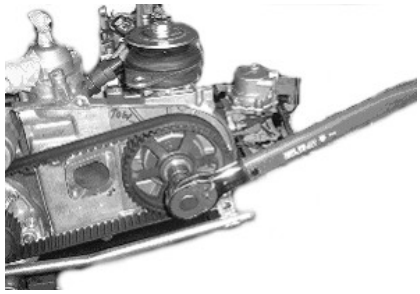
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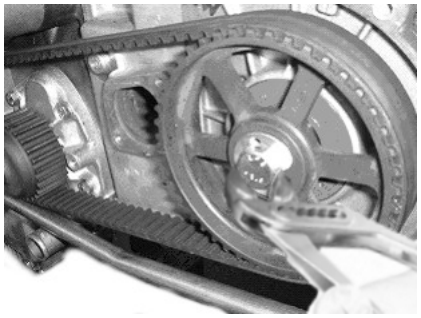
Then tighten again the belt tightener fastening nut to a 40÷44 Nm torque (fig. 57).
Tighten the fastening nut of the camshaft toothed pulley to 70 Nm (fig. 58).
Close the safety lock onto the camshaft fastening nut (fig. 59).



57

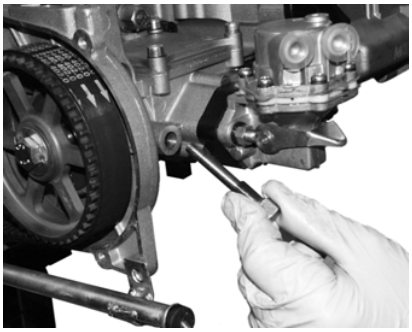


58

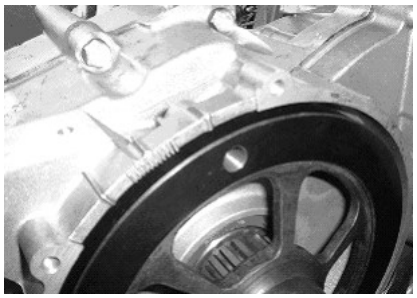


59

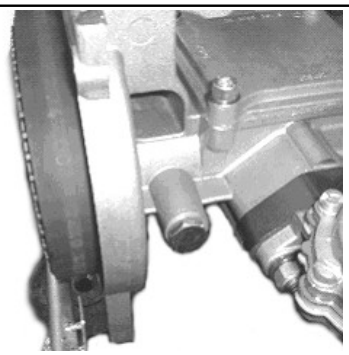
Now remove both timing pins to allow the camshaft and the crankshaft to rotate (fig. 60-61).
Plug the hole on the camshaft support by using a copper seal and the special plug (fig. 62).
Use the flywheel to make the crankshaft rotate two or three times in order to settle the timing belt.



60



61

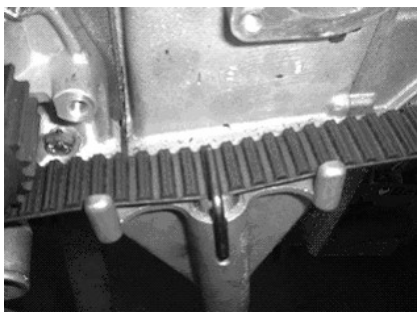


62

By using a special tool, check that the toothed timing belt tensioning is correct (fig. 63). In our example, the tool used is supplied by DENSO.
To read the correct tensioning value, place the tool sensor onto the belt tooth (fig. 64).
The correct tensioning value should be within 25 and 28 Kg (fig. 65). Should this not be case, loosen the belt tightener and increase or decrease tension according to the value read.
Retighten the belt tightener fastening nut to the set torque, make the driving shaft rotate two or three times, then check again the belt tension by using the tool.




63



64




65

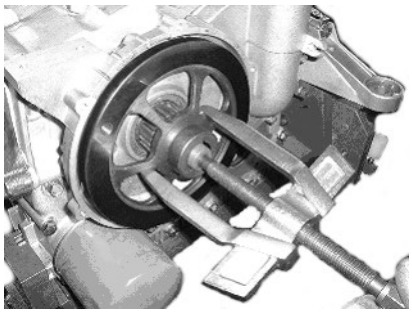


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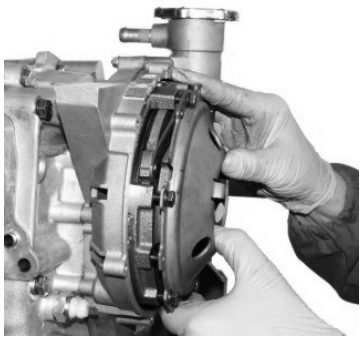
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Once the correct tension of the toothed timing belt has been set, remove the timing tool from the crankshaft by using a multi-purpose puller as shown in fig. 66, then reassemble the clutch (fig. 67).



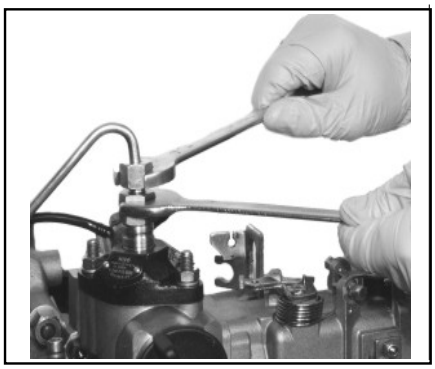
66



67

**Injector, fireproof bulkhead - Disassembly**

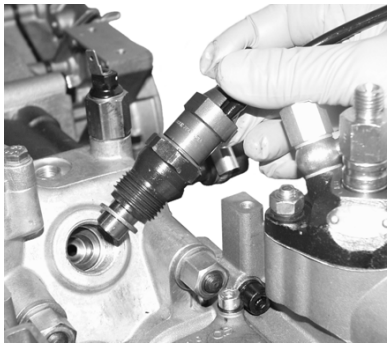
Disassemble the hose connecting the injection pump to the injector (fig. 68).
Loosen and remove the injector from the head by using a ring spanner.
Check that the copper seal is present (fig. 70).
To remove the fireproof bulkhead from the head, the special tool serial number 981075.413 is to be used (fig. 71).
Screw this tool in the head in the injector place, then operate the registers on top of the tool itself to let the mandrel expand so as to hook the fireproof bulkhead in the special circular groove.
Lock the mandrel rotation by using a wrench as you screw in the ring nut - hex nut – onto the thread (fig. 72) until the fireproof bulkhead is removed from the head (fig. 73).



68



69

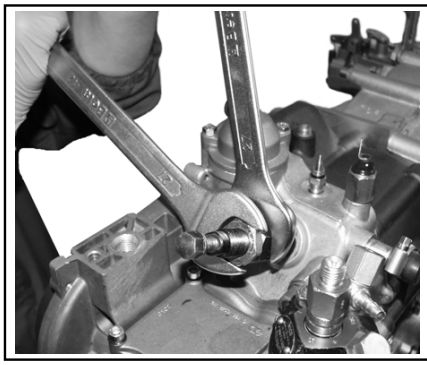


70

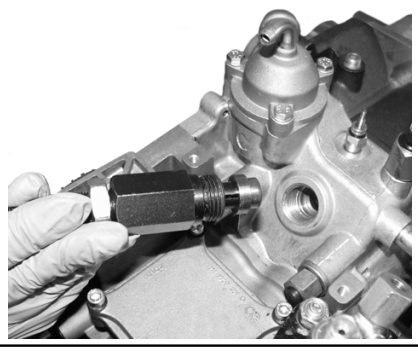


puller 981075.413

71



72



73



! Replace the fireproof bulkhead and the copper seal every time the injector is disassembled.

74



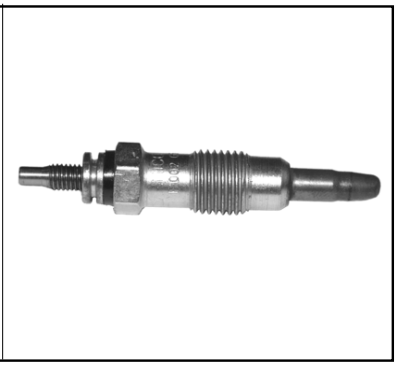
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75



76

**Glow plug - Disassembly**

Thermoelectric specifications

Connection: ..... 1 pole

Nominal voltage: ..... 11 Volt

Operating voltage: ..... 9 ± 1 Amp

Temperature: ..... 850° C = </= 6.5 sec.

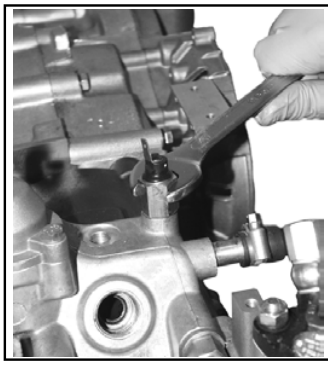
Maximum temperature: </= 1150° C

**Glow plug - Check**

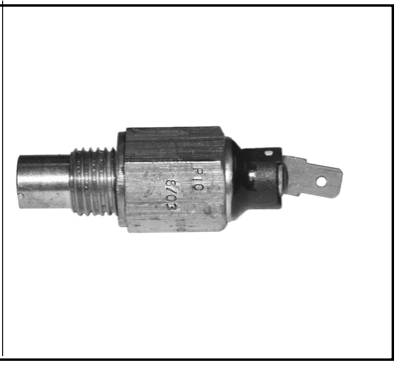
Remove the glow plug from the cylinder head and connect it through two cables to the poles of a 12 V battery. The positive [ +] pole of the battery must be connected to the appropriate contact of the glow plug whereas the negative [–] pole will be connected to the threaded part of the plug ( ground ).
In these conditions the glow plug shall first turn red and then glows, starting from the tip and growing towards the thread.
If you see the glow plug getting red and then glowing not from the tip but from the middle of the glow tube, just replace it.
The whole procedure must be carried out in few seconds not to damage the glow plug.

**WARNING: this check shall be considered dangerous , because the glow plug in a few seconds reaches a very high temperature, over 1,000 °C, and any physical contact with a human body can cause severe burns**.

After removing the glow plug from the cylinder head, should you find it corroded or without the tip that protrudes into the prechamber, check the Injection system parameters and replace the glow plug.
When the glow plug does not work the engine does not start, specially in cold temperature.
If it starts after repeated and long cranking attempts ( depending from ambient temperature, wear conditions and fuel setting ) you would notice heavy exhaust smoke, from white to pale grey, very annoying for eyes and nose.
After fitting the glow plug into the cylinder head, check with a tester for electrical continuity.



77



78

**Sensor for cooling liquid temperature indicator light - Disassembly**

Features:

Circuit: ..... Unipolar

Supply voltage: ..... 6/24 V

Voltage: ..... 6/24 V

Absorbed power: ..... 3 W

Operating temperature: 110 ± 3° C



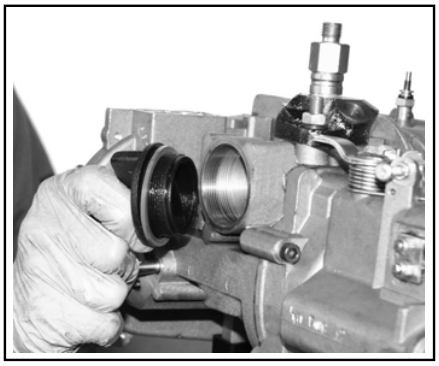
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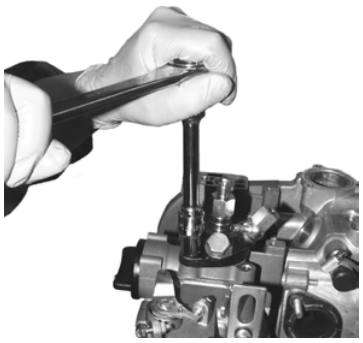


**Injection pump - Disassembly**

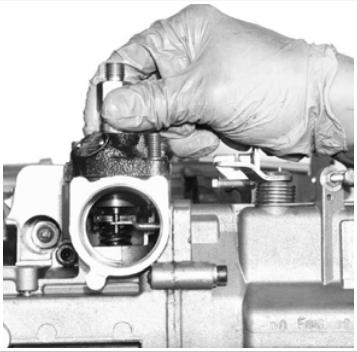
Remove inspection plug (fig. 79).
To disassemble the injection pump from the camshaft support, unscrew the two M8 nuts and remove them together with the relevant spring washers (fig. 80).
Disengage the injection pump control rod (fig. 81).
Extract the injection pump by paying particular attention to the seals inserted between the pump and the cover surfaces. These seals allow modifying the engine static advance. By increasing their thickness, the pump moves away from the injection cam - delay. By decreasing the thickness, the injection pump moves closer to the cam - advance (fig. 82).
Remove the injection tappet with the relevant collar housed inside it (fig. 83-84).
The bolt of the fuel supply union coming from the injection pump fuel filter houses the valve that helps stop the engine. The valve consists of a spring and a metal ball, whereas the ball retaining seat is realized inside the union bolt (fig. 85).



79



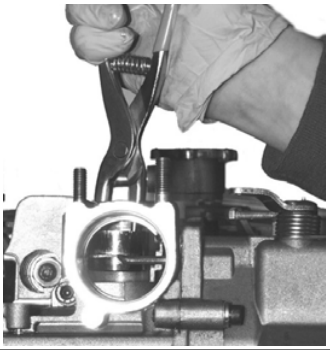
80



81



82



83



84



85



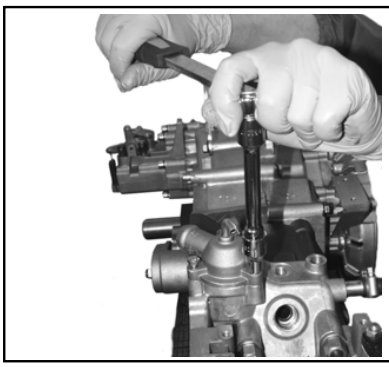
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**Thermostat - Disassembly**

After removing the three M6X25 bolts, disassemble the cover (fig. 86) to reach the thermostatic valve (fig. 87).
To avoid air intake, check the seal ring and replace it if necessary.
The thermostatic valve is to be assembled properly: the bleeding hole should face upwards (fig. 88).



86



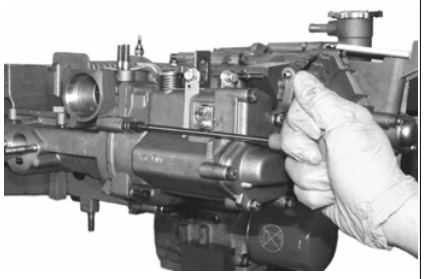
87



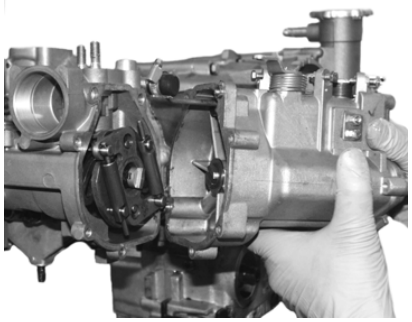
88

**Complete governor assembly - Disassembly**

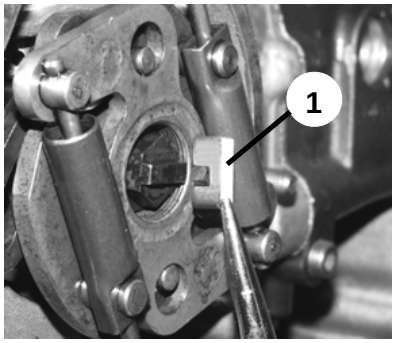
Unscrew the 5 bolts and remove the complete governor assembly (fig. 89-90).
Pay attention to the Oldham union when disassembling and reassembling.
Indeed, when separating the governor and the camshaft supports, it could fall and get lost.
For this reason, when disassembling, we advice you to cover the Oldham union with grease, so that it can act as an adhesive (fig. 91).



89



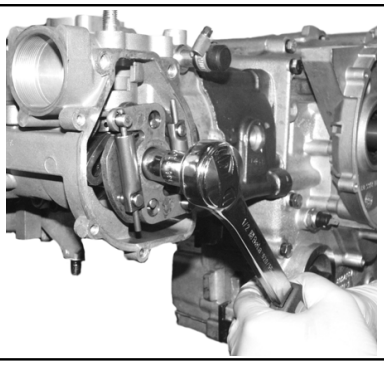
90



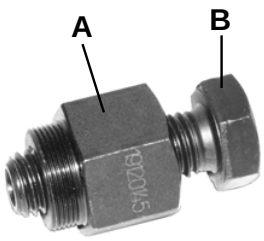

91

**Injection advance variator - Disassembly**

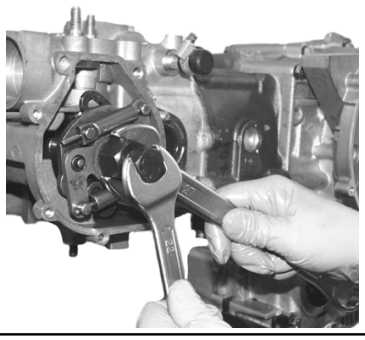
Unscrew the fastening bolt of the injection advance variator by using a 14 mm wrench (fig. 92), use puller 981075.421 and rotate screw **B** to remove weights (fig. 93-94). While doing this, keep the hexagonal support **A** locked.



92




puller 981075.421



94



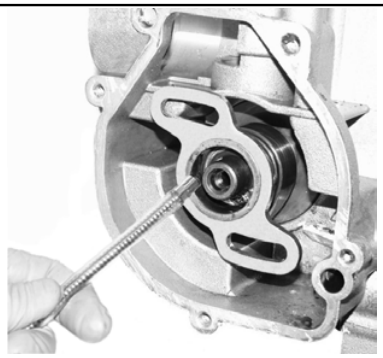
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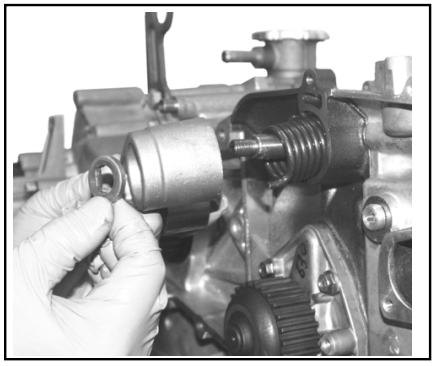
95



96

**Injection pump control cam - Disassembly**

Remove the snap ring by using pliers for internal snap rings (Fig. 95), extract the shoulder washer (Fig. 96) and extract the injection cam .



97

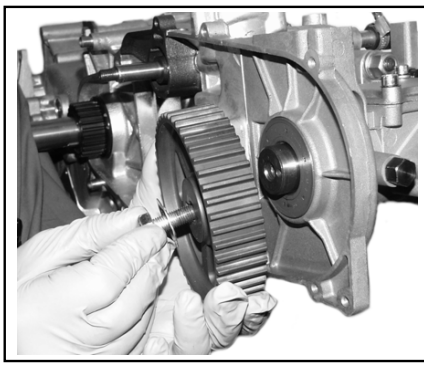
**Belt tightener - Disassembly**

After unscrewing the flanged fastening nut, remove the safety washer, the belt tightener and the tensioner spring (Fig. 97).
As for the belt tightener pin, if it is not worn-out or broken, there is no need to disassemble it.

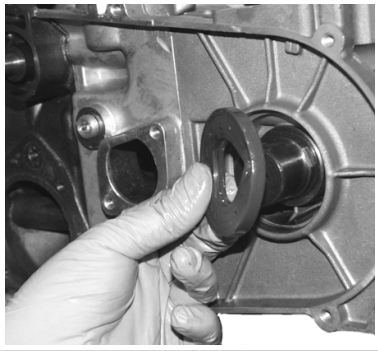
**Timing pulley and camshaft oil seal ring - Disassembly**

Open the safety lock, unscrew the bolt and remove the timing pulley (Fig. 98).
Remove the oil seal ring by using a screwdriver (Fig. 99), then the snap ring by using pliers for internal snap rings and the clearance shim (Fig. 100).

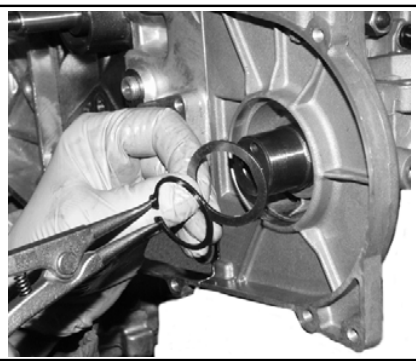
! When reassembling, replace the oil seal ring with a new one



98



99



100



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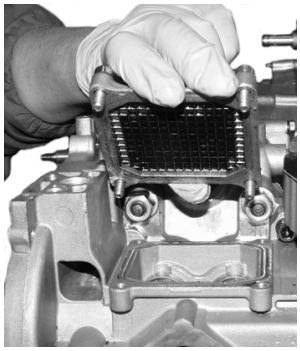


**Tappet cover disassembly**

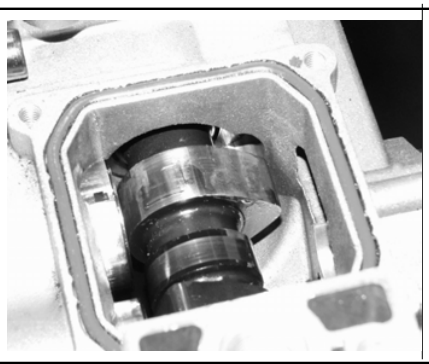
Unscrew the four M6x20 hex screws to disassemble the tappet cover, check the seal ring and replace it - if necessary - before reassembly (fig. 101).

**Camshaft extraction**

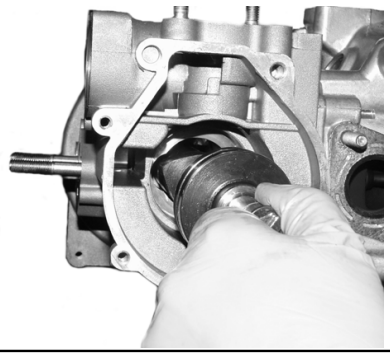
Turn the shaft and bring the cam lobe to coincide with the opening provided for (Fig. 102).
Repeat the procedure on the second cam to extract the shaft completely (Fig. 103).



101



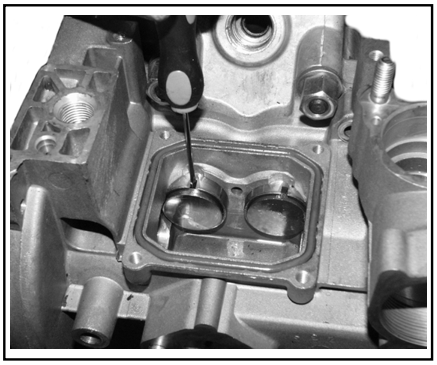
102



103

**Tappets - Disassembly**

To remove the tappet shims, rotate the tappets until it is possible to insert a screwdriver into one of the special cuts to detach the shim from the tappet itself. The surface of the adjusting collar on which the shim identification number is marked should be facing the tappet socket.
If you are using the same tappets, because they are not worn-out, mark both tappets and shims before disassembly, in order to be able to reassemble them in the same position – i.e. the exhaust tappet into the exhaust and the intake tappet into the intake.



104




105



106



107



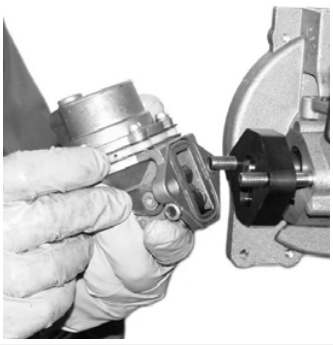
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**Fuel pump - Disassembly**

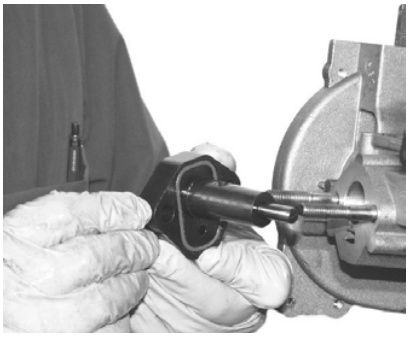
To disassemble the fuel pump, unscrew both fastening nuts (fig., 108), then remove the spacer with the cam driven rod controlling the pump (fig. 110).
Always check and replace the two seal rings if necessary (fig. 109).



108



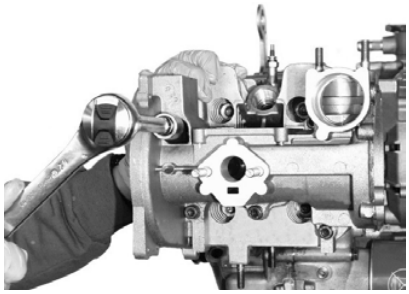
109



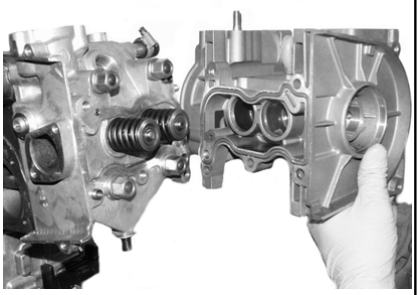
110

**Camshaft support - Disassembly**

Use a proper wrench to unscrew the four M6x20 cheese screws for the anchoring to the head (fig. 111) and then remove the camshaft support (fig. 112).



111

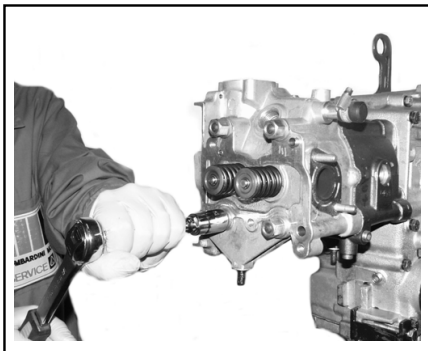


112

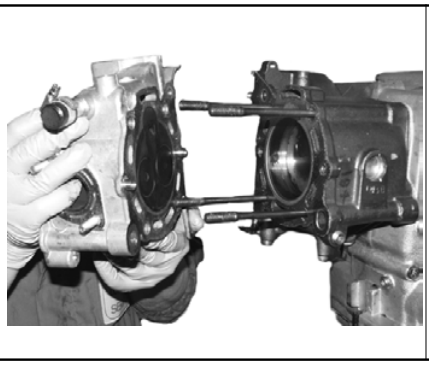
**Cylinder head - Disassembly**

Unscrew the 4 fastening nuts (Fig. 113), extract the cylinder head assembly (Fig. 114) and remove gasket (Fig. 115).

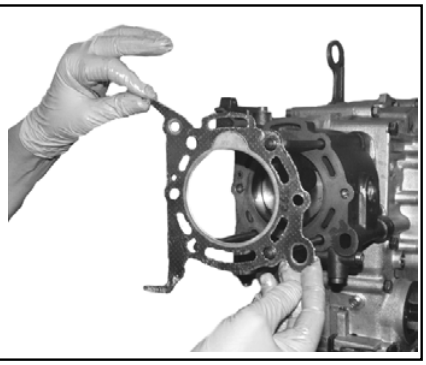
! When reassembling always replace the cylinder head gasket with a new suitable one



113



114



115



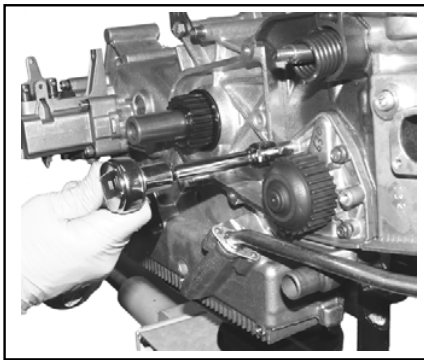
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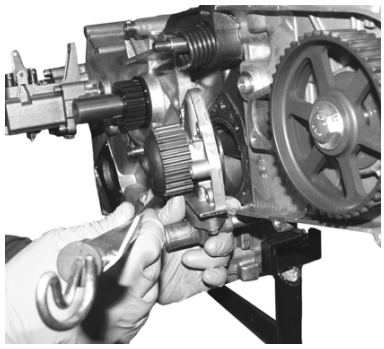


**Water pump - Disassembly**

Unscrew the 4 fastening bolts of the water pump and disassemble it (fig. 116-117).
Every time the water pump is to be disassembled, we advise you to replace the two seal rings (fig. 118).
Should the water pump not work properly, it cannot be repaired but only replaced.



116



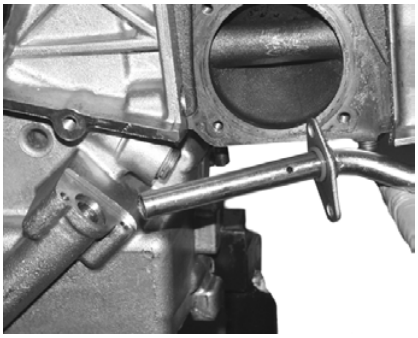
117



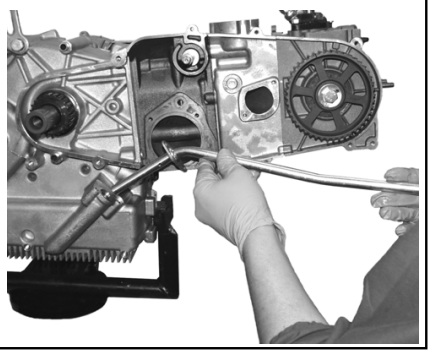
118

**Oil dipstick case - Disassembly**

Unscrew the two HH M6x20 hex screws and disassemble the oil dipstick case.
Check and replace – if necessary – the seal ring to be found between the case clamping flange and the cover (fig. 119-120).

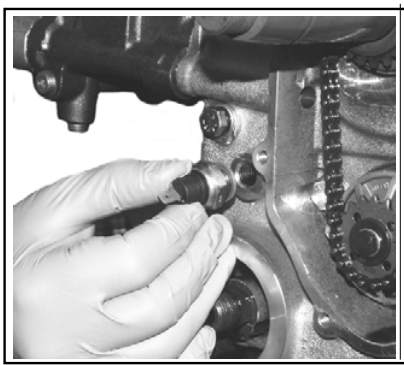


119



120

**Oil pressure switch - Disassembly**



121



122

**Technical specifications**

Type: ..... normally closed

Operating pressure: ..... 0.30÷0.60 Kg/cm2

Operating temperature: .... -25°÷+130° C

Maximum pressure: ..... 6 Kg/cm2

Tightening torque: 22 Nm



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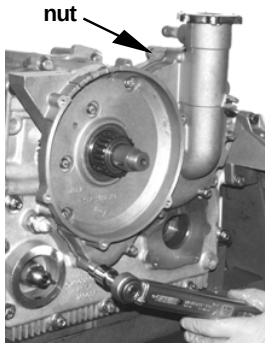


**Ring gear - Disassembly**

Disassemble the clutch housing pan by removing the single nut and the 10 screws (Fig. 123), then use the provided tool 981075.412 (Fig. 124) to lock the ring gear and unscrew the fastening bolt (Fig. 125).

As you disassemble the clutch housing pan (fig. 123), make sure not to damage the oil seal ring by scraping it against the crankshaft gear.

N.B. When reassembling, the bolt shall be tightened using the same tool
.




123



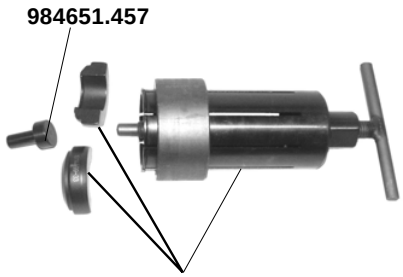
tool 981075.412

124

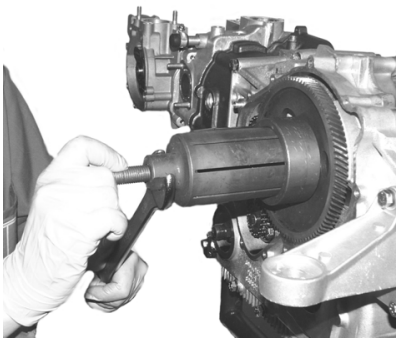


125

Using tool 981075.425 together with component 984651.457 (fig. 126) extract the cone (fig. 127) and remove the ring gear (fig. 128)




126



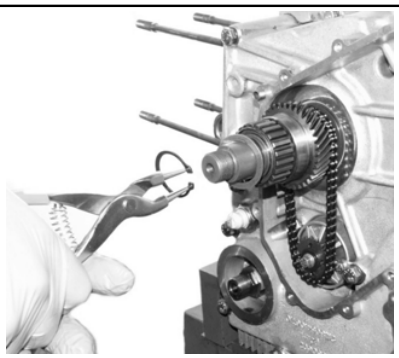
127



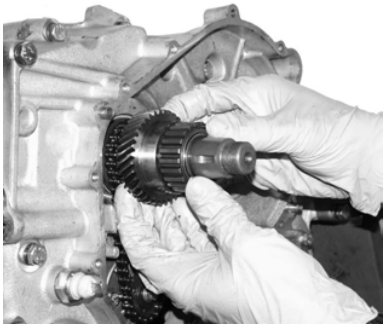
128

**Driving shaft gear**

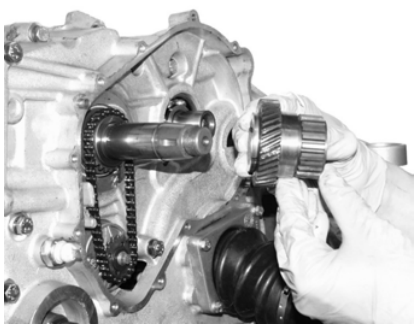
After removing the retaining snap ring by means of proper pliers, remove the clearance shim (Fig. 129), which is available as spare part with thicknesses ranging from 1.20 mm to 1.75 mm, and the driving shaft gear (Fig. 130÷131).



129



130



131



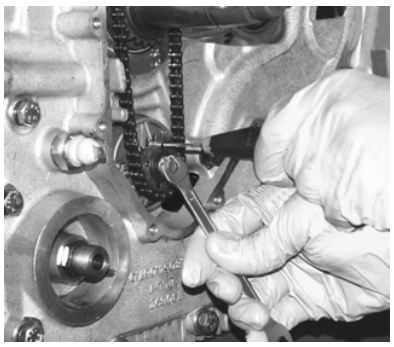
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**Oil pump driving gear and oil pump - Disassembly**

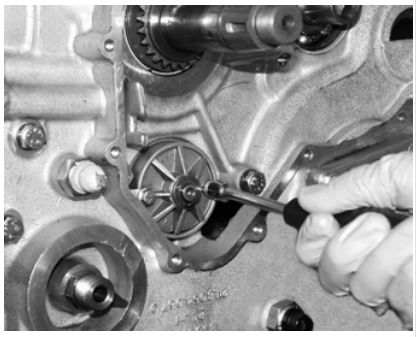
Lock the oil pump control gear using a screwdriver in order to unscrew the retaining bolt (Fig. 132), and then remove the chain (Fig. 133).
Unscrew the two bolts securing the oil pump (Fig. 134) and extract it minding the correct sequence for reassembly (see fig. 135).
Replace the gasket whenever you disassemble the oil pump (Fig. 136).



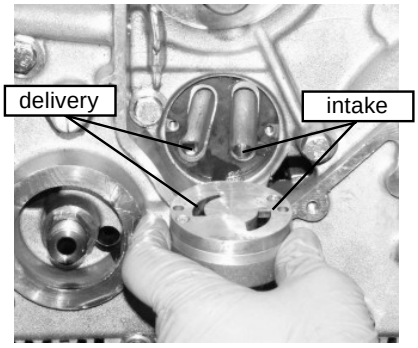
132



133



134



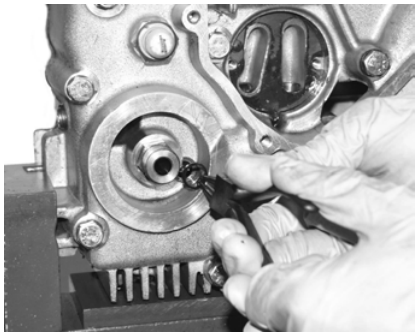

135



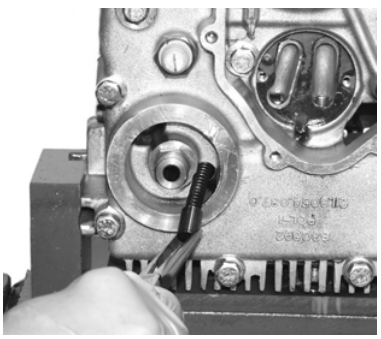
136

**Oil pressure regulating valve - Disassembly**

Remove the snap ring, extract the spring and the by-pass valve.Check for possible dirt build up in the ducts and for good spring condition (fig. 137-138).



137



138



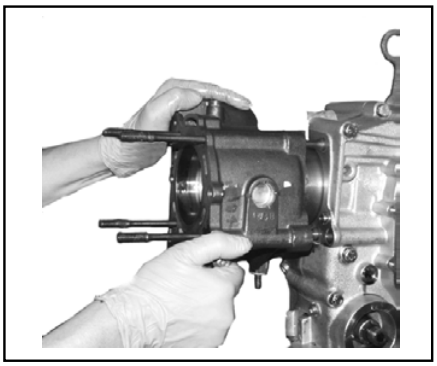
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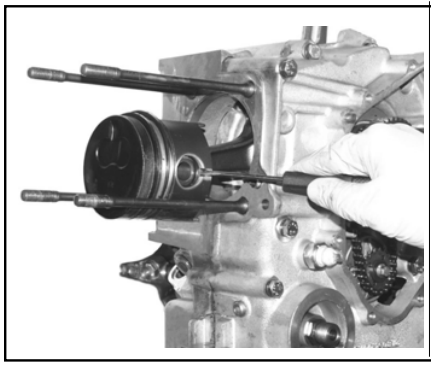


**Cylinder – Piston – Wrist pin - Disassembly**

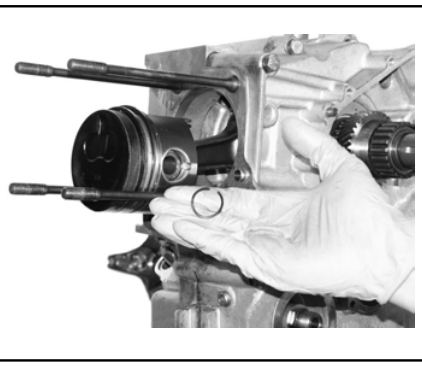
After extracting the cylinder (Fig. 139), remove the retaining snap rings from their seat by using a screwdriver (Fig. 140÷141) then extract the wrist pin (Fig. 142) and disassemble the piston.



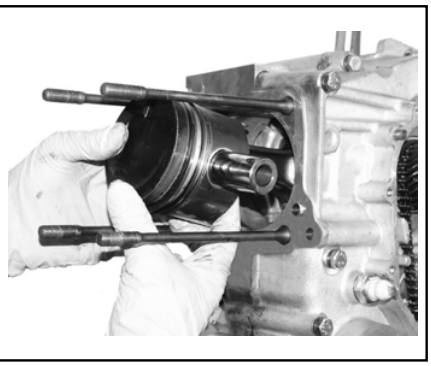
139



140



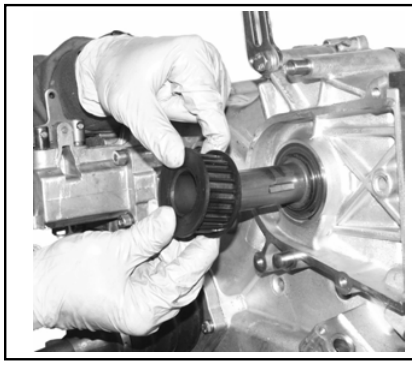
141



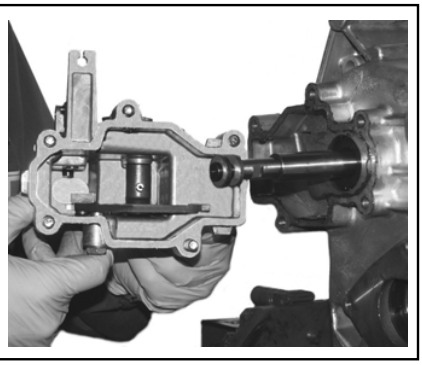
142

**Timing gear and speed gear control box - Disassembly.**

Remove the timing gear (Fig. 143).
Unscrew the 5 fastening bolts and remove the speed gear control box (Fig. 144).



143



144



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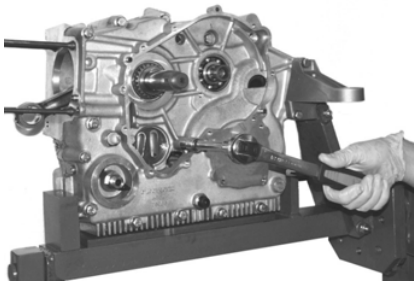
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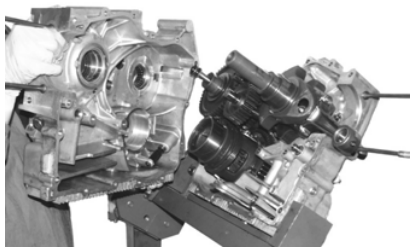
**Separation of the housing halves**

Unscrew the 15 union screws (Fig. 100), position the engine horizontally as shown in the figure (Fig. 146) and separate the two housing halves by hitting with a mallet.

! When reassembling, the shoulder washers which are located between drive shaft and flywheel-side housing should be placed with the 4 lubrication marks turned towards the drive shaft.



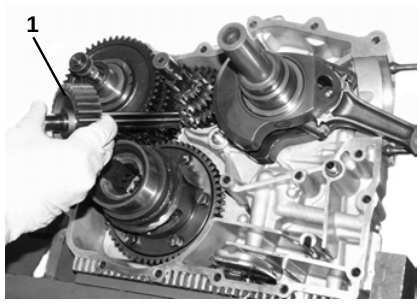
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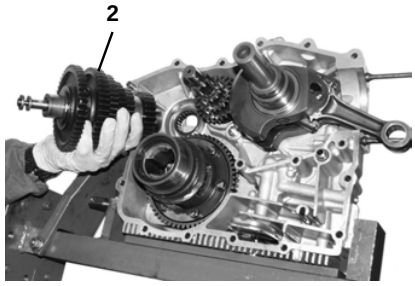
146

**Crankshaft – Reverse shaft – Gearbox shaft – Multiple gear – Differential gear assembly**

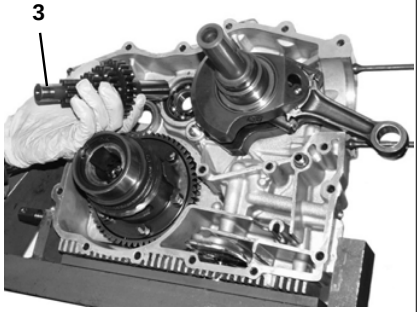
Remove reverse gear "**1**" (Fig. 147), gearbox shaft "**2**" (Fig. 148), multiple gear "**3**" (Fig. 149), crankshaft "**4**" (Fig. 150) and remove differential gear assembly "**5**" using extractor 981075.411 (Fig. 151) which is provided (Figg. 152÷153).



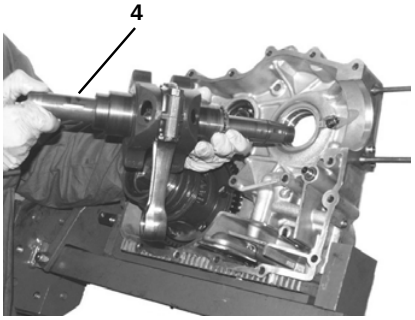

147



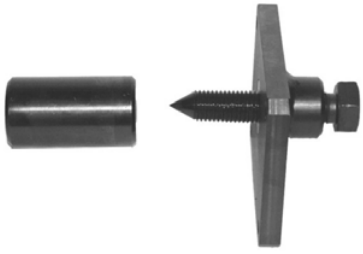

148




149

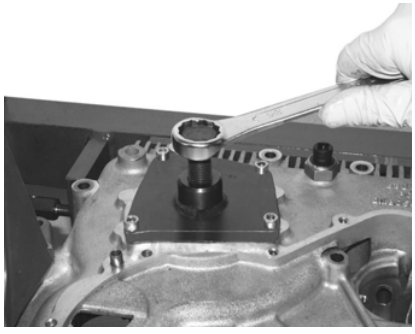



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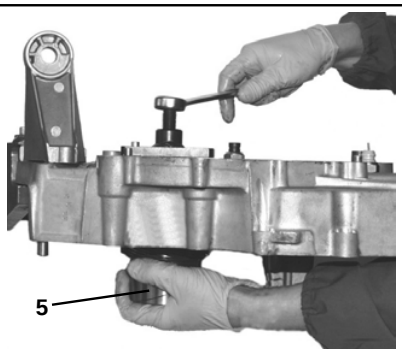


puller 981075.411

151



152




153



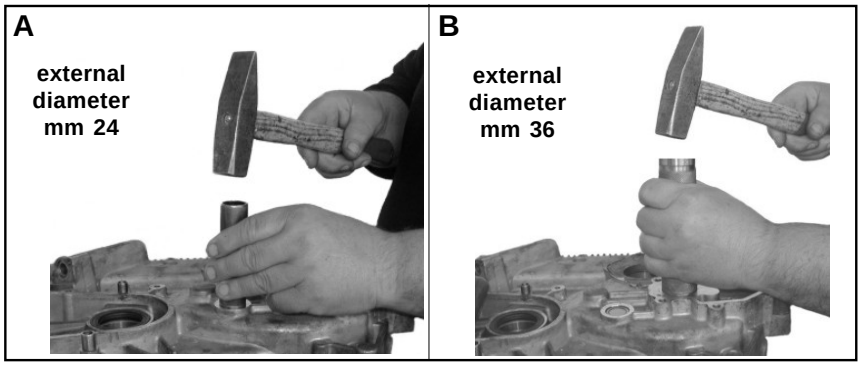
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**Flywheel-side housing half – Roller case, multiple gear and roller case, gear - Disassembly**

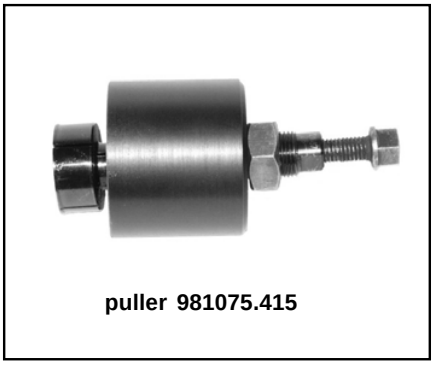
Remove the two gearbox shaft roller cases by using a crop end as a punch, with an external Ø of 24 mm (Fig. 154) for the roller case of the multiple gear "**A**" and with an external Ø of 36 mm for roller case of the gear shaft "**B**" (Fig. 155).




**154** **155**

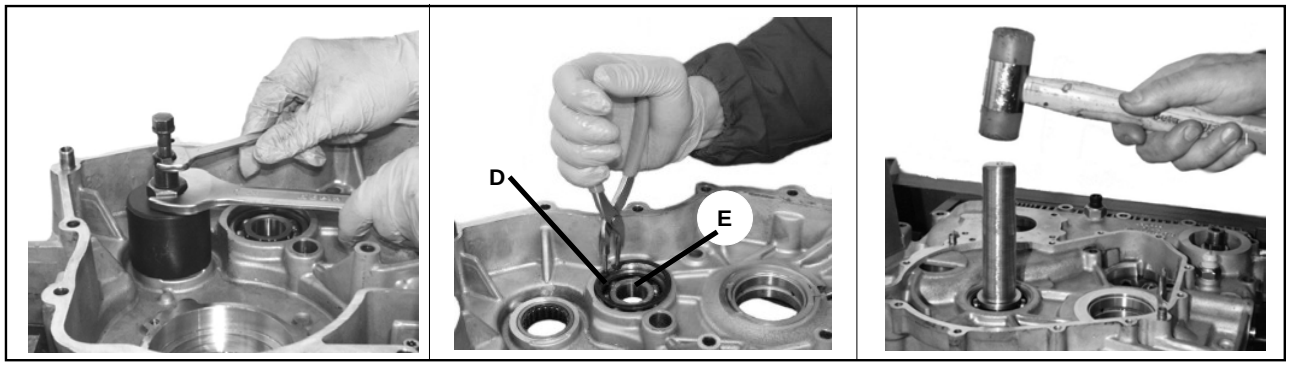
**Clutch-side housing half – Gearbox shaft roller case and multiple gear ball bearing - Disassembling.**

Assemble puller 981075.415 (Fig. 156) onto the gearbox shaft roller case and work on the central nut until the extraction is completed (Fig. 157).
Remove the snap ring "**D**" (Fig. 158), work on the opposite side to the one shown in the figure and expel "**E**" (Fig. 159) ball bearing using a 30 mm external Ø punch**.**



**puller 981075.415**

**156**




**157** **158** **159**



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## NOTE



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## NOTE



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**FUEL FLOW GOVERNOR DESCRIPTION**

From figures **1** and **2** one can see the essential components and the functioning of the governor.

The mass holder (**1**) is driven in rotation by its own shaft driven in turn by the camshaft.
In to the mass holder (**1**) there are 4 centrifugal counterweights (**2**) that act on the push rod (**3**) . The push rod activate's the lever (**4**) hinged on the pivot (**5**) which is fixed to the governor housing, the other end of the lever links to the injection pump regulation rod (**7**) .
Between the lever (**6**) and the lever (**4**) acts a spring (**8**) for the starting maximum fuel flow. On the control lever (**6**) acts : the spring (**9**) for the idle-speed control ; the spring (**20**) for the adjust of the fuel flow to the engine rpm ; and through the cup (**10**) and the shaft (**11**) , the maximum engine rpm control spring (**12**). The last spring , assembled with pre-load in the frame (**17**) , is futter compressed by the lever (**13**) which is connected with the speed control lever (**14**).
The lever (**15**) , which is connected to the engine stop control (**16**) , acts on the lever (**4**) and then on the injection pump control rod (**7**). On the governor box a magnet (**18**) is fixed , its function is to keep the lever (**4**) in the position of supplementary flow at the engine start position. The lever (**6**) pushcs on the regulation screw (**19**) that puts in a correct position the rod (**7**).

**Magneto positioning on the governor**

Insert the injection pump on the cylinder head and lock it after positioning in may del position.
Loosen the magneto fixing screws and move the magneto itself in order to meet the push rod lever; fix the magneto in this position and check that the release load of the push rod lever is 700 ÷ 800 gr.

**Engine stop lever adjustment**

Running position: adjust the catch screw (**20**) of the engine stop lever (**16**), in such a way that it's internal part does not interfere with the rod control lever (**4**).
Stop position: adjust the stop screw (**21**) of the engine stop lever (**16**), in such a way that the stop does not take place through the rod control lever (**4**) and the connection rod (**7**), on the injection pump

**Mass play axial play and adjusting spacers**

Play : 0,1÷0,16 mm

Spacers : mm 1,2 - 1,3 - 1,4 Tolerance : ± 0,05



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**The governor main functions are the following:**

- Engine low idling speed adjustment
- Engine maximum RPM limitation
- Delivery increase during start up

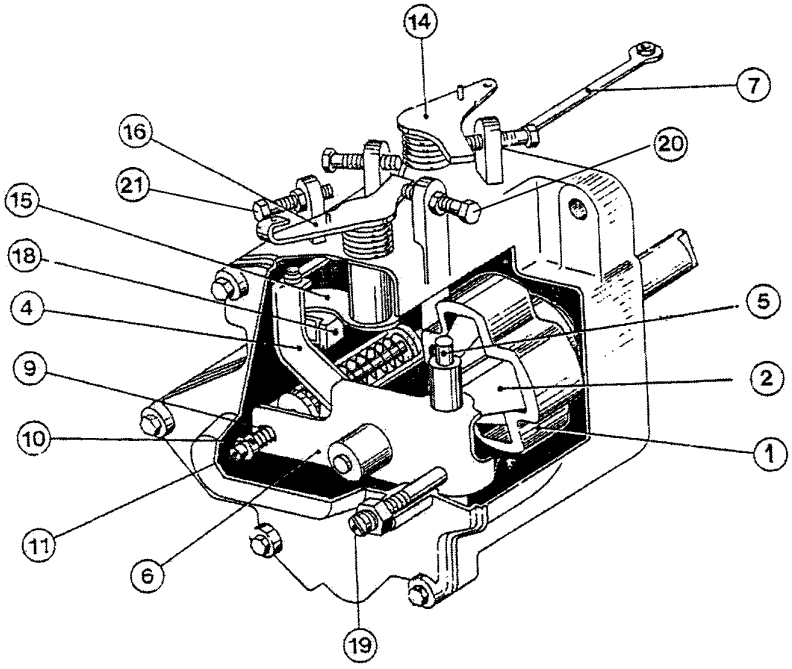



**FIG. 1**

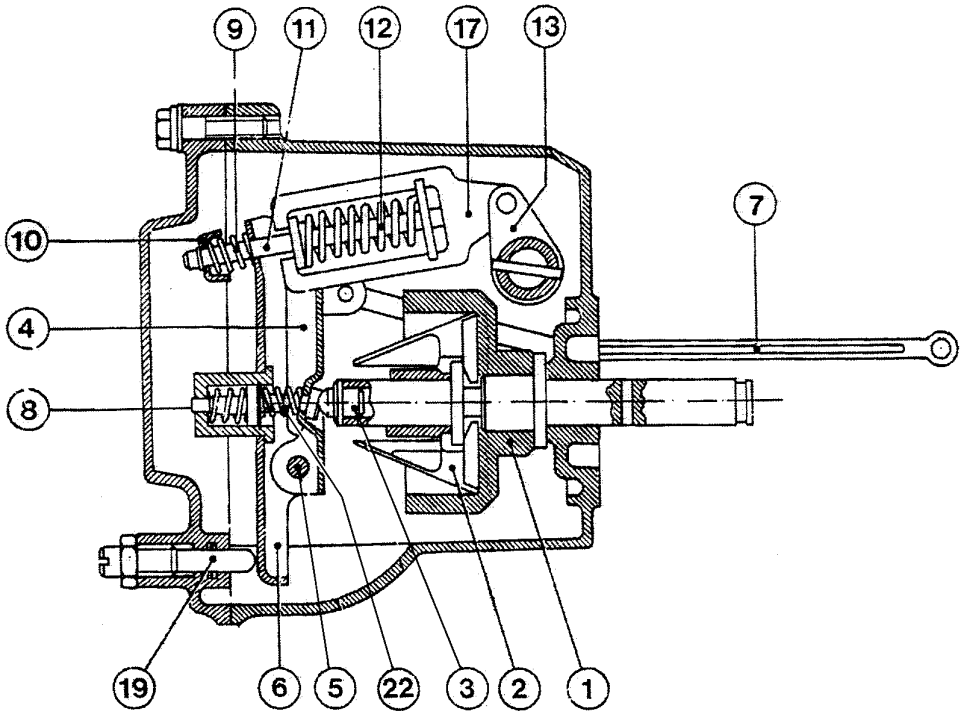



**FIG. 2**



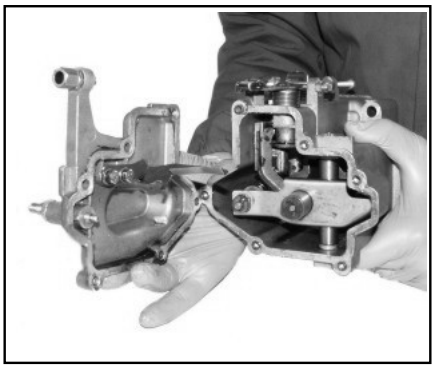
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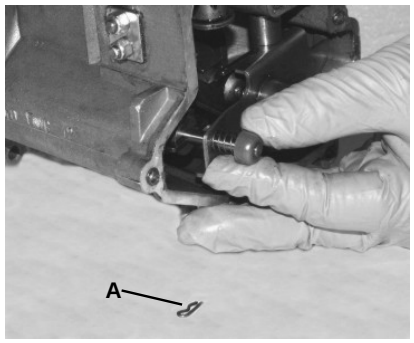


**Delivery regulator** - Disassembly

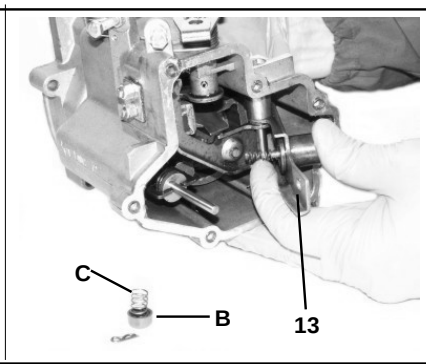
Remove the cover by way of the 6 retaining screws (Fig. 160).Remove retainer **A** (Fig. 161), cap **B** and idling spring **C** (Fig. 162).Set adjustment lever **13** (Fig. 162) towards the outside, extract supplementary spring **D**, extract retainer **E** and remove pump control rod **6** (Fig. 163).



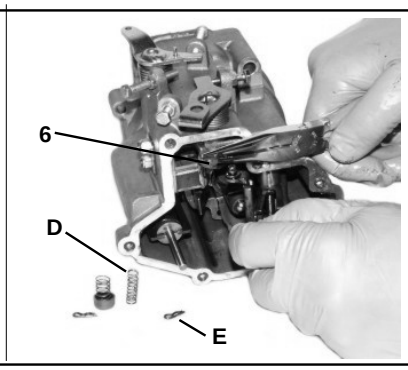
160




161

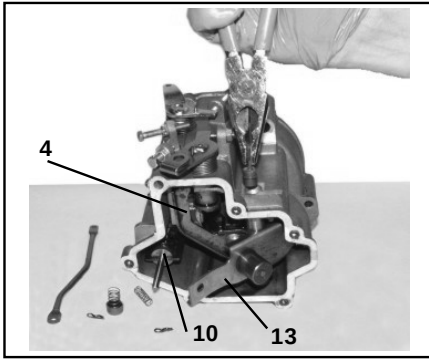



162

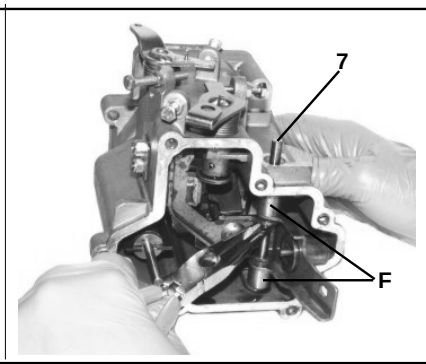



163

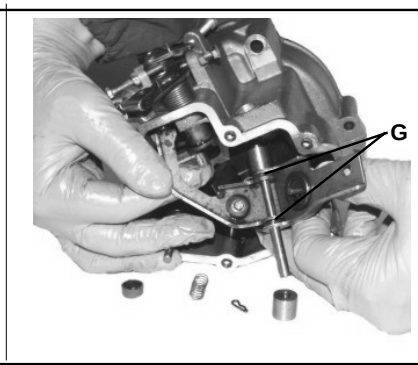
Remove the snap ring (fig. 164), extract pin **7** (fig. 165), disassemble the adjustment lever **13** and rod control lever **4** (Fig. 164), spacers **F** (Fig. 165) and shim washers **G** (Fig. 166) which are located between the two levers **13**; when assembling follow the correct sequence.



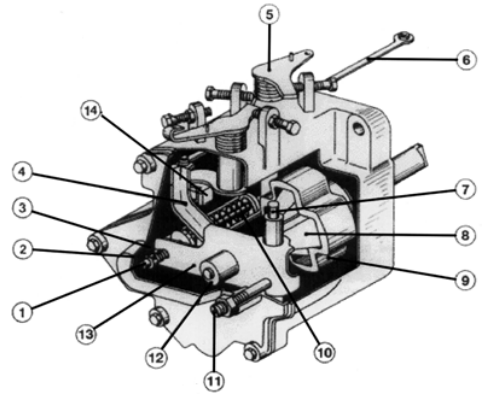

164




165




166




**1)** Shaft
**2)** Cup
**3)** Idling speed governor spring
**4)** Rod control lever
**5)** Throttle control
**6)** Pump connection rod
**7)** Pin
**8)** Centrifugal weights
**9)** Weight container
**10)** Maximum RPM governor spring
**11)** Delivery control screw
**12)** Adjustment spring container
**13)** Adjustment lever
**14)** Magnet

167



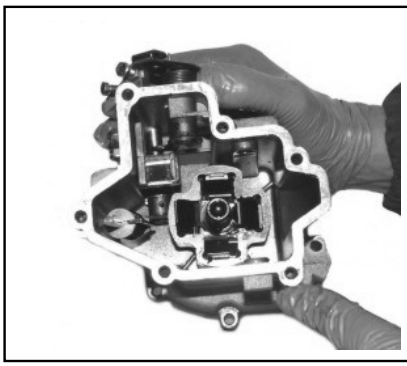
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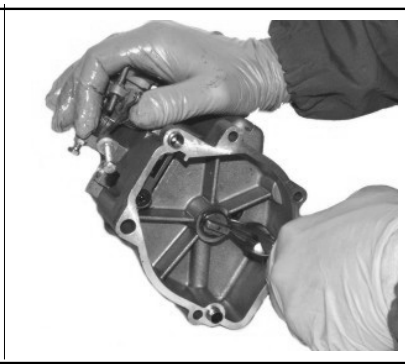


Remove the snap ring from its slot using the pliers which are provided (Fig. 169) then extract the shaft and the weights holder shaft (Fig. 170).
Now unscrew the two retaining nuts **A** (see Figg. fig. 171÷172), then remove the metal plate and disassemble the magnet holding the lever in extra fuel position (Figg. 164÷167).
If the spring holder shaft for maximum RPM governing has to be replaced, use a pin-driver punch as shown in Fig. 173.

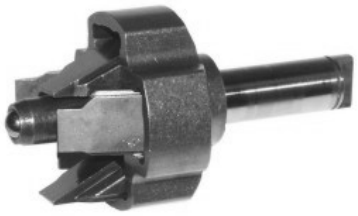
When reassembling follow a reverse sequence than the above-described one.



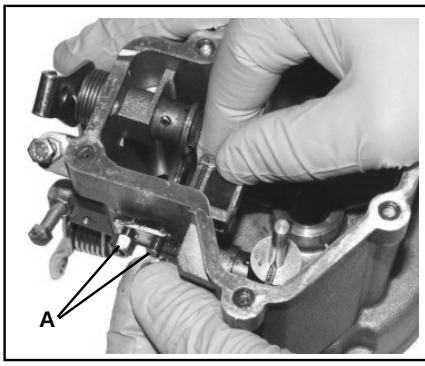
168



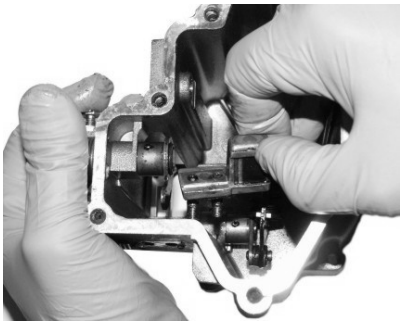
169



170




171



172



173

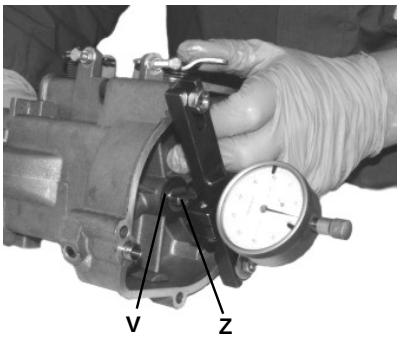
**Delivery regulator – reassembly**

When reassembling is completed, check the axial endfloat of "**Z**" shaft using the special no-studbolts tool code 981075.417 (Fig. 174) which comprises a bore gauge; axial endfloat should be between 0.10 and 0.16 mm (Fig. 175).
If you find that the axial endfloat is different from schedule, replace clearance shim "**V**".
To this end 3 washers having different thickness values from mm 1,2 - 1,3 - 1,4 are provided.



tool 981075.417

174




175



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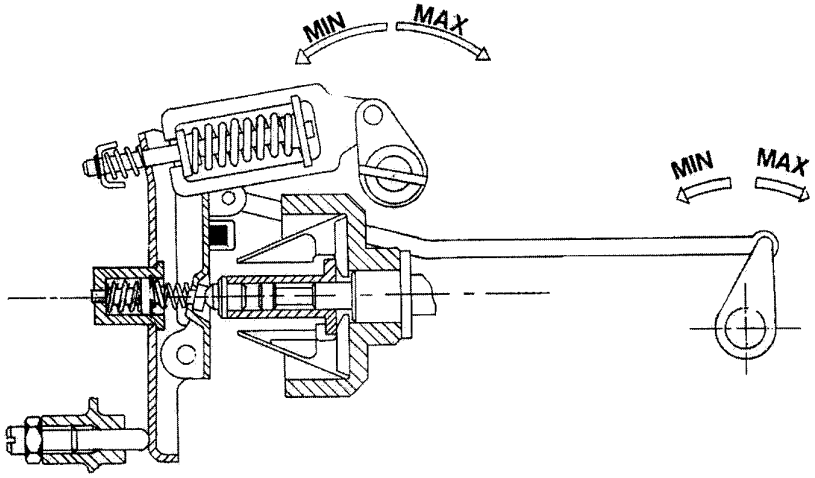
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**GOVERNOR'S WORKING DESCRIPTION**

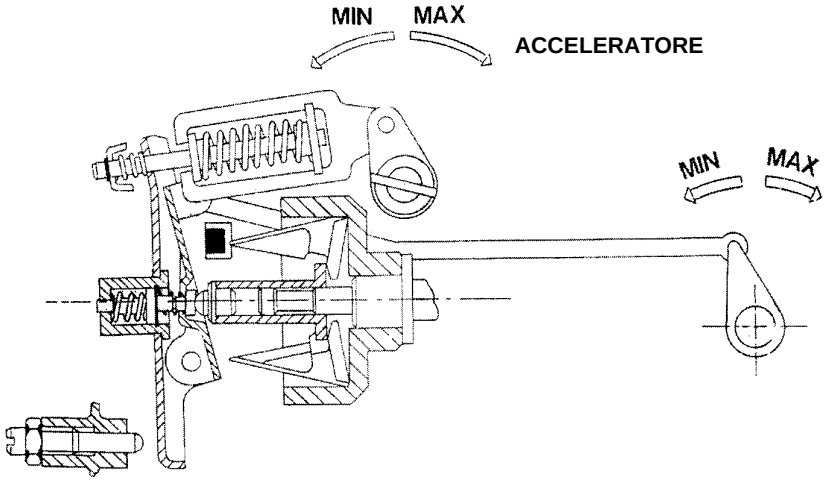
**ENGINE STANDING OR AT STARTING**

In these conditions the governor flyweight are completely closed, due to the slider thrust on which acts the minimum and the extra-fuel springs (see fig. 3) . The control lever, pushed at one end by the minimum spring, reacts on the regulation screw. The control rod lever, pushed by the relative extra-fuel spring, puts the pump control rod in the maximum fuel flow position and therefore in the engine start position. Notice that acting on the accelerator lever there will not be any effect on the pump control rod because the control lever is already in contact with the regulation screw ; so this mean that you can start the engine with the accelerator at the minimum position.
The magnet, with the help of the supplementary spring, keep in the maximum fuel flow position the control rod until the engine has not reached about 2000 rpm.
When the engine exceed 2000 rpm the flyweight centrifugal force exceed the spring and magnet force, so open the flyweight that shift by means of the slider i the control rod lever and then the pump connecting rod i to lower fuel flow positions.




**ENGINE AT IDLE SPEED**

After the starting of the engine, if someone does not act on the accelerator lever, the governor flyweight are in equilibrium with the minimum spring at about 1200 rpm. The engine speed increasingly open the flyweight moving the slider , the regulation lever until the system do not reach a new equilibrium position; at the same time the pump connecting rod is moved to lower fuel flow positions, for this reason the engine comes back to the initial speed. The opposite happens if the engine reduce the speed. With the engine at idle speed the governor will fluctuate continuously around the equilibrium position in order to maintain the speed as constant as possible.





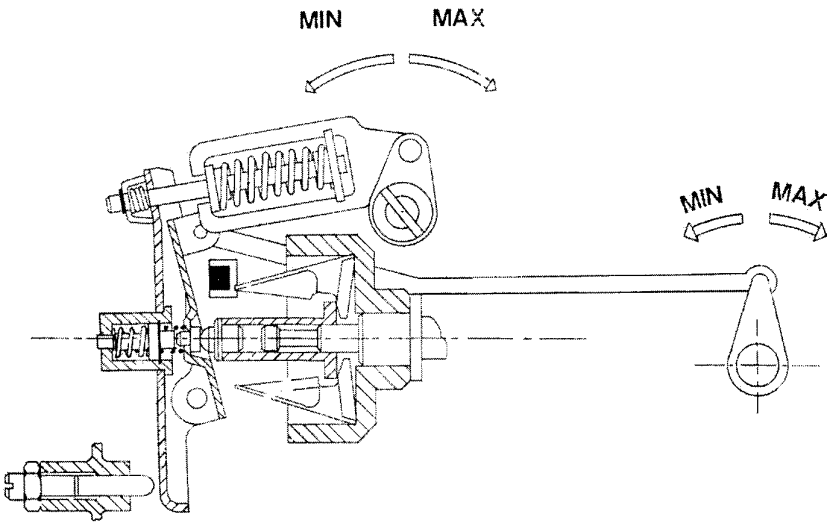

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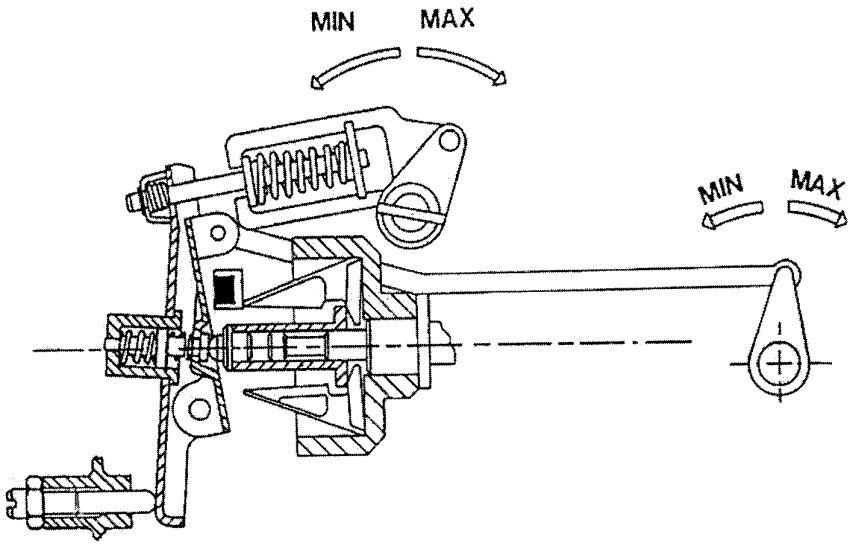
**ENGINE AT PARTIAL LOAD**

From the minimum position, by acting on the accelerator lever, the minimum spring is completely pre-loaded; after that, the cup. Is push directly on the regulation lever carrying the pump connection rod toward greater fuel flow positions partially closing the governor flyweight. In this situation the injection pump flow regulation rod acts as if it is directly connected to the accelerator lever, that means that the movements of the accelerator lever produce proportional mouvements of the pump connection rod. At intermediate engine speed, the governor generate a load that compress partially the flow adjusting spring moving the rod control lever, producing consequently change of the pump flow against change of rpm.




**ENGINE AT FULL LOAD**

Moving completely the accelerator lever until the position of full load, the lever will touch the regulation screw, after that the maximum rpm regulation spring will be compressed. Starting from low speed, when the speed increases, the governor flyweights centrifugal load compress the flow adjust spring, proportionally reducing the pump fuel flow.
This is the wasking position of the pump connecting rod for maximum fuel flow .





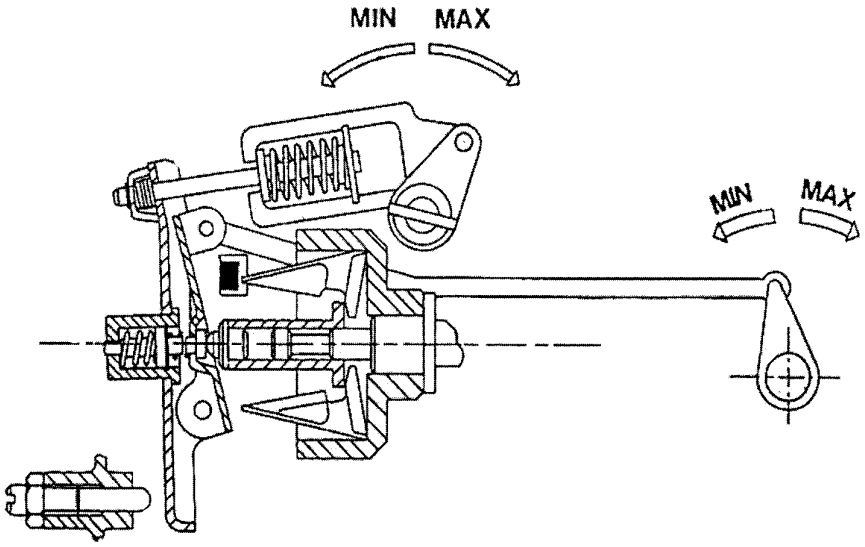

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**ENGINE AT MAX SPEED**

When the engine reaches the maximum working speed the governor flyweights centrifugal force exceede the reaction of the maximum speed regulating spring; the expanding flyweights move the regulating lever and the pump connecting rod towards a position of lower fuel flow.
If the engine continues to accelerate the flyweights continue to move until the pump connecting rod reaches the position of zero flow. The governor begins to operate at about 3800 rpm and the zero fuel flow occures at about 4200 rpm.






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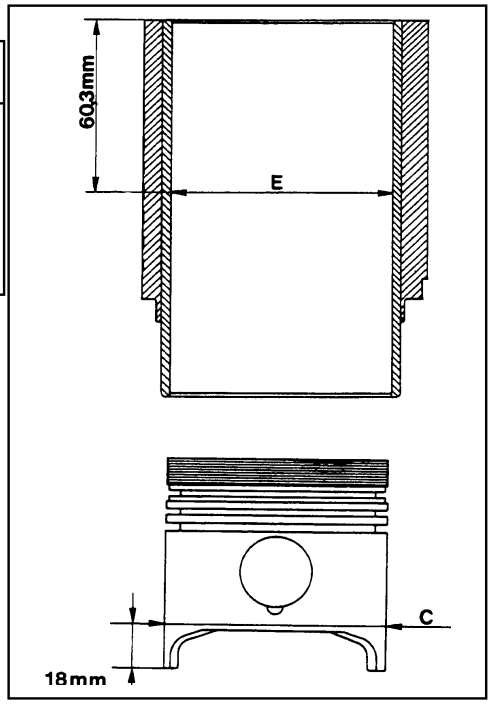


**Assembly play**

Pistons and cylinders supplied by the Factory as spares are marked with letters of the alphabet. In cases where a cylinder or a piston is to be substituted, it should be replaced with the same letter as the mating component.
In case of a rebored cylinder, the dimension "**E**" should exceed the dimension "**C**" on the piston to be fitted (marked on the piston itself), by the value indicated for each part, "clearance on assy".

**Cylinder-Piston**

| Piece name nominal dimension | Class symbol | Matching class | | Assembling gap "A" |
|---|---|---|---|---|
| | | Cylinder | Piston | |
| Cylinder normal E = 83 -0 +0,05 | A | 83,000÷83,010 | 82,935÷82,945 | 0,055÷0,075 |
| | B | 83,010÷83,020 | 82,945÷82,955 | |
| Piston normal C = 82,96 ± 0,025 | C | 83,020÷83,030 | 82,955÷82,965 | |
| | D | 83,030÷83,040 | 82,965÷82,975 | |
| | E | 83,040÷83,050 | 82,976÷82,985 | |

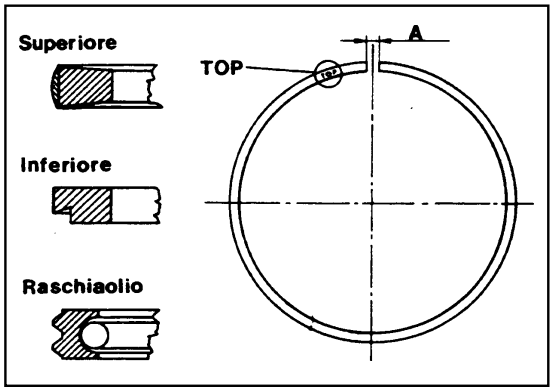


176

**Piston rings**

| Part name | Diameter (mm) |
|---|---|
| Piston ring, upper<br>Piston ring, lower<br>Scraper ring assy | 83 |

**Superiore** =Upper
**Inferiore** =Lower
**Raschiaolio** = Scraper



177

N.B. - Piston rings must be fitted with inscription "**Top**" facing piston crown and the inside spring of scraper ring must be positioned with the joint at 180° from scraper ring joint.

**Clearance "A" on assy (mm)**

| | |
|---|---|
| Piston ring, upper | 0,25÷0,50 |
| Piston ring, lower | 0,25÷0.50 |
| Scraper ring assy | 0,10÷0,30 |



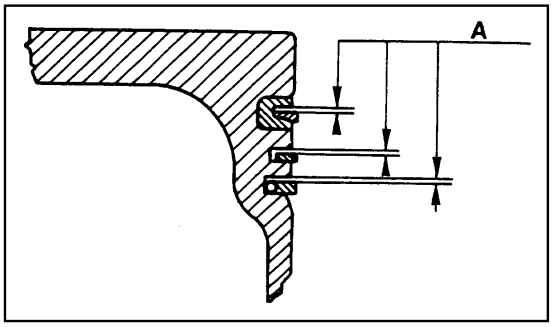
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**Piston slots - piston rings**

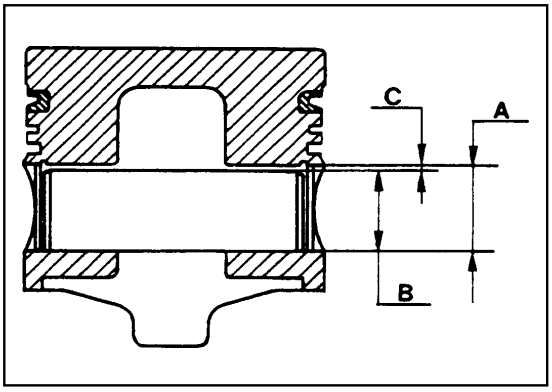
| Part name | | Part name | Clearance -A- (mm) |
|---|---|---|---|
| 1st piston slot | 2,160÷2,190 (Ø80) | Piston ring, upper 2,095÷2,075 (Ø80) | 0,065÷0,115 |
| 2nd piston slot | 2,040÷2,060 | Piston ring, lower 1,990÷1,970 | 0,050÷0,090 |
| 3rd piston slot | 3,020÷3,040 | Scraper ring 2,990÷2,975 | 0,030÷0,065 |




178

**Piston - Piston pin**

| | |
|---|---|
| **Piston "A"** | Ø 25 - 0,001 - 0,006 |
| **Piston pin "B"** | Ø 24,991 ± 0,002 |
| **Assembling gap "C"** | Ø 0,001÷0,010 |



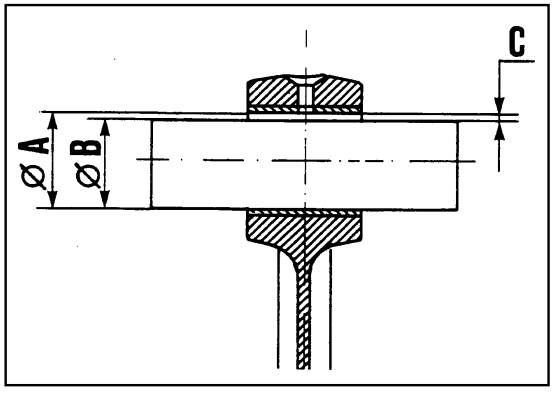

179

**Small end bush - wrist pin**

| | |
|---|---|
| Small end "**A**": | Ø 25,006÷25,009 |
| Wrist pin "**B**": | Ø 24,991±0,002 |
| Clearance "**C**" on assy: | 0,013÷0,020 |

**Connecting rod small end bush**

| | |
|---|---|
| Con rod S.E. Bush "**A**": | Ø 28 +0,80 + 0,118 |
| Con rod SM. end "**B**": | Ø 28 -0 -0,021 |
| Interference | 0,059÷0,118 |




180

- Parallelism tolerance allowed between big end and small end axis (measured at 125 mm from the stem of the connecting rod) must be = 0,08 mm



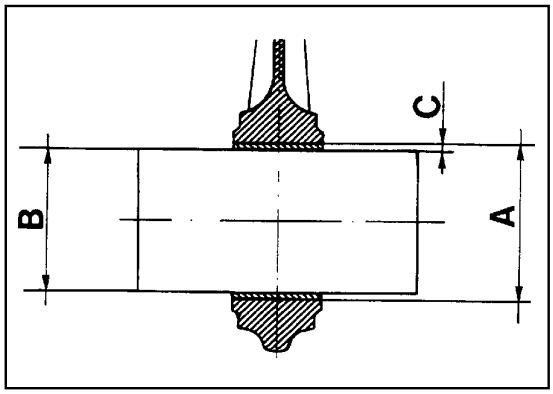
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**Crankshaft - big end**

| Part name | Dimension (mm) |
|---|---|
| Big end "**A**" | 51,333 - 0 + 0,013 |
| Con-rod bearing, half "**C**" | 1,535÷1,526 |
| Crankshaft "**B**" | 48,288 - 0,02 +0 |



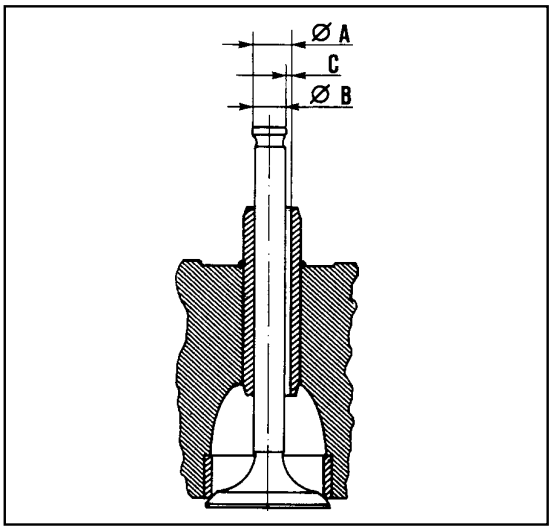

181

**Valve guide - valve stim**

| Part name | Dimension (mm) |
|---|---|
| Valve guide "A" | 8,015÷8,033 |
| Valve stim exh. and ind. "B" | 7,974÷7,992 |

**Clearance "C" on assy 0,023÷0,059**

**N.B.** Dimension of valve guide inside dia. is understood to be after assembly and after machining.




182

**Valve seat**

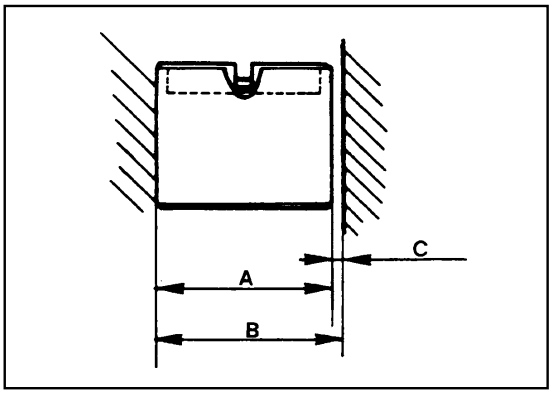
| Denomination | Inlet | Outlet |
|---|---|---|
| Valve seat chanfer angle | 45 ° ± 5' | 45 ° ± 5' |
| Valve head chanfer angle | 45° 30' ± 7' | 45° 30' ± 7' |
| Valve head diameter | 38,300÷38,600 | 33,300÷33,600 |
| Valve seat housing diameter | 39,988÷40,012 | 34,988÷35,012 |
| Valve seat outside diameter | 40,094÷40,119 | 35,094÷35,119 |
| Valve seat-cylinder head mounting interference | 0,082÷0,131 | 0,082÷0,131 |



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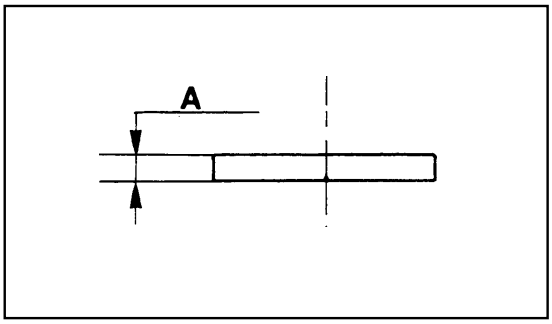





183

**Tappet**

| | |
|---|---|
| Tappet dia. “**A**” | 35,000÷35,025 |
| Tappet seat dia. “**B**” | 34,975÷34,995 |
| Clearance on assy “**C**” | 0,005÷0,050 |



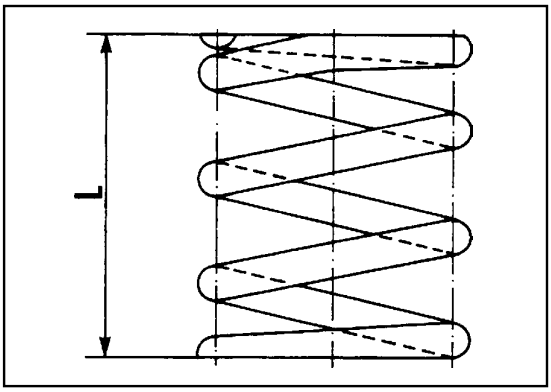

184

**Valves caps**

**Thickness** “**A**”:

3,25 - 3,30 - 3,35 - 3,40 - 3,45 - 3,50 - 3,55 - 3,60 - 3,65 - 3,70 - 3,75 - 3,80 - 3,85 - 3,90 - 3,-95 - 4,00 - 4,05 - 4,10 - 4,15 - 4,20 - 4,25 - 4,30 - 4,35 - 4,40 - 4,45 - 4,50 - 4,55 - 4,60

Tolerance ± 0,015




185

**Valves - spring**

Free length “**L**” mm 53,9

Load at 36 mm heightkg 38,9±1,5

Load at 26.5 mm height kg 59,5±2,5



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## CRANCKCASE - BEARINGS

### CLUTCH SIDE MULTIPLE GEAR BALL BEARING

| | |
|---|---|
| Bearing external diameter | Ø 62,000÷61,987 |
| Seat diameter | Ø 61,979÷61,949 |
| Assemble interference | gap 0,008 mm<br>interf. 0,051 mm |

### NEEDLE BEARING HOUSING

| | |
|---|---|
| Seat diameter for multiple gear needle bearing flyweel side | Ø 25,979÷26,000 |
| Seat diameter for gear needle bearing clutch side | Ø 46,983÷46,958 |

### REVERSE GEAR

| | | |
|---|---|---|
| Shaft seat | Ø 18,016÷18,034 | Gap<br>0,016÷0,052 |
| Reverse gear shaft | Ø 18,000÷17,982 | |
| Reverse gear | Ø 17,944÷17,962 | Interference<br>0,056÷0,020 |

### DIFFERENTIAL HOUSING

| Denomination | Dimensions | Matching |
|---|---|---|
| Differential box | Ø 75,970÷75,924 | gap |
| Differential seat | Ø 76,000÷76,046 | 0,122÷0,030 |

### CRANKSHAFT - CRANKCASE - BEARING HOUSING

| Denomination | Dimensions | Matching |
|---|---|---|
| Timing side half crankcase<br>Clutch side half crankcase | Ø 60 0 - 0,030 | Interference<br>0,133÷0,195 |
| Free bearing | Ø 60 +0,133 +0,165 | |
| Machined bearing assembled on the crankcase | Ø 55 +0,010 +0,029 | gap |
| Crankshaft | Ø 55 -0,030 -0,043 | Ø 0,040 ÷0,072 |



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**Injection pump : "MICO" type F 002 F 10 006**

**Test conditions**

| | |
|---|---|
| Pumping element dia.: | 6 mm |
| L.H. helix pitch: | 12 mm |
| Test Oil: | SHELL S 93 65 |
| Test Oil temperature: | 40°C±2° |
| Pump inlet pressure: | 0,2 Kg/cm$^2$ |
| Pumping element prelift: | 2÷3 mm |

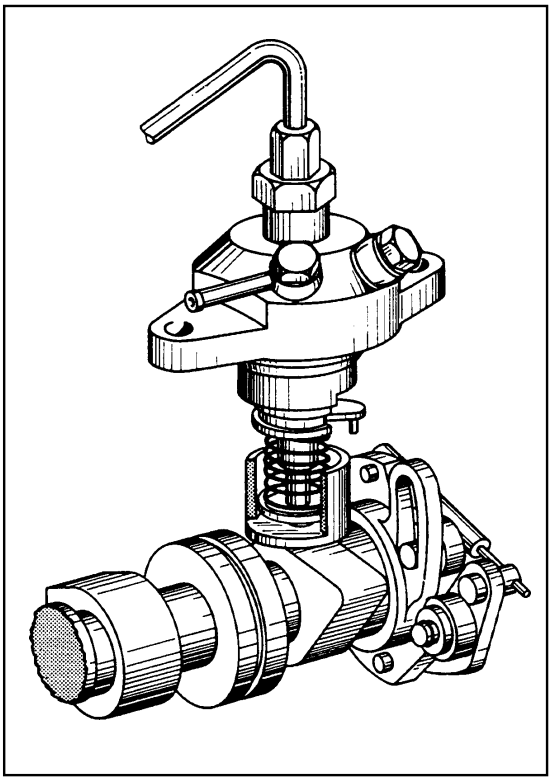
**Features of the pump on the bench**

Adjusting lever in reference to central position:

| r.p.m. | Delivery mm$^3$/cycle | Rack rod stroke form max delivery position |
|---|---|---|
| 1500 | 23,3 ± 0,5 | 9 |
| 1900 | 20,8 ± 1 | 8,3 |
| 2250 | 29 ± 1 | 9,5 |

**Adjusting lever in max. delivery position:**

| r.p.m. | Delivery mm$^3$/cycle |
|---|---|
| 150 | 45 ± 3,5 |

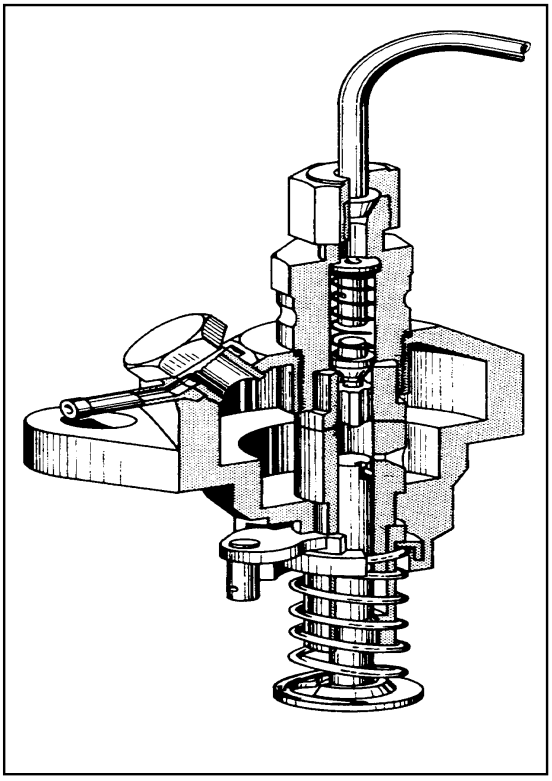


**186**

**Injection pump**

Caption:

1- High pressure injector pump delivery pipe
2- Nut for connection to the delivery pipe
3- Spring
4- Filler
5- Valve
5- Plunger barrel
6- Plunger blade
7- Plunger barrel
8- Plunger piston
9- Spring collar
10- Spring
11- Spring retainer collar
12- Delivery control lever
13- Pump housing
14- Fuel inlet coupling



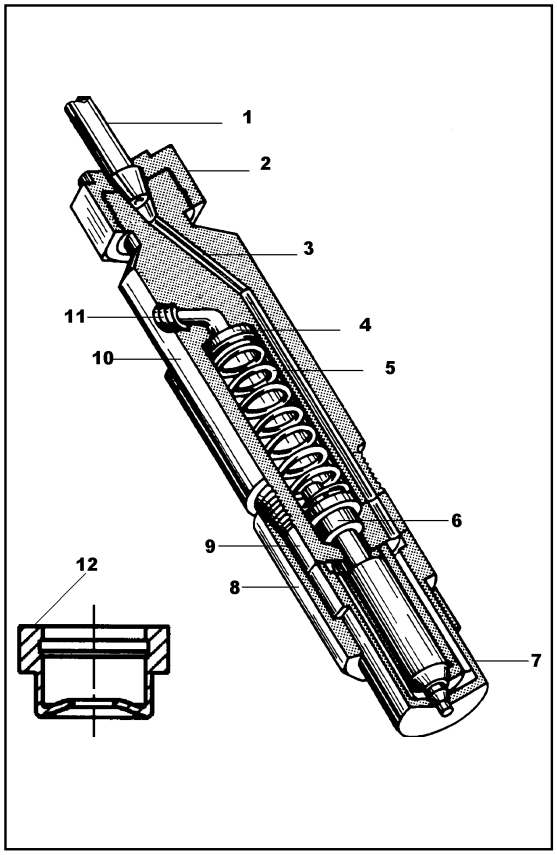
**187**



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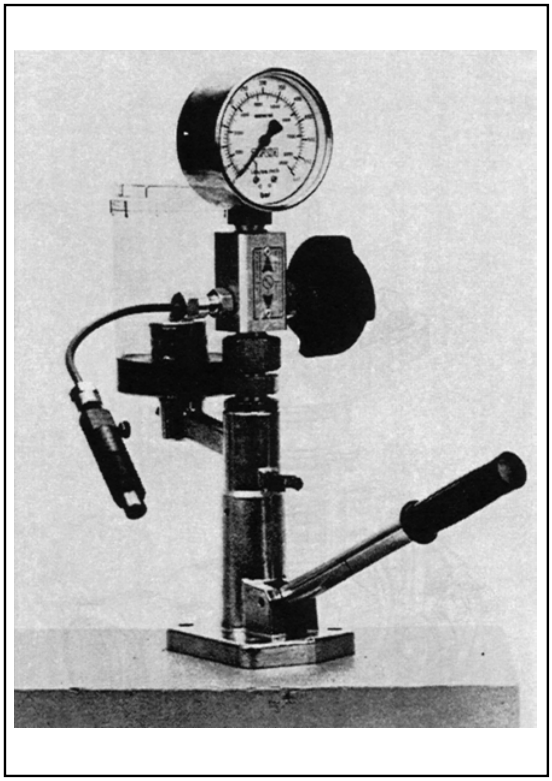



188

**Injector : MICO F 002 C 6 Z 396**

Caption:

1- High pressure delivery pipe ( Ø 6 - Ø 1,75x168 )
2- Nut for connection to the delivery pipe
3- Pressure duct
4- Pressure setting shim
5- Pressure spring
6- Pressure pin
7- Nozzle MICO DNO SD 287
8- Nozzle clamping ring nut
9- Intermediate washer
10- Nozzle case
11- Connection for leakage recovery
12- Fire ring



189

**Injector setting**

Connect injector to a hand pump and check that setting pressure is 150 +10 - 0 bar; Make the required adjustments, if any, by changing the shim over the spring. Eleven different shims are available as spares with size from 1 to 2 mm.
When replacing the spring, setting should be performed at a 10 bar greater pressure(160 bar) to allow for bedding during operation.
Check needle valve sealing by slowly moving the hand pump until approximately 120 bar for 10 seconds.

**Injector sealing**

**Seal**: Keep inside injector a oil pressure 10÷20 kg/cm$^2$ lower than the opening pressure.No drop should form on the end of the injector in less than 10 seconds.However a light sweating is allowed.

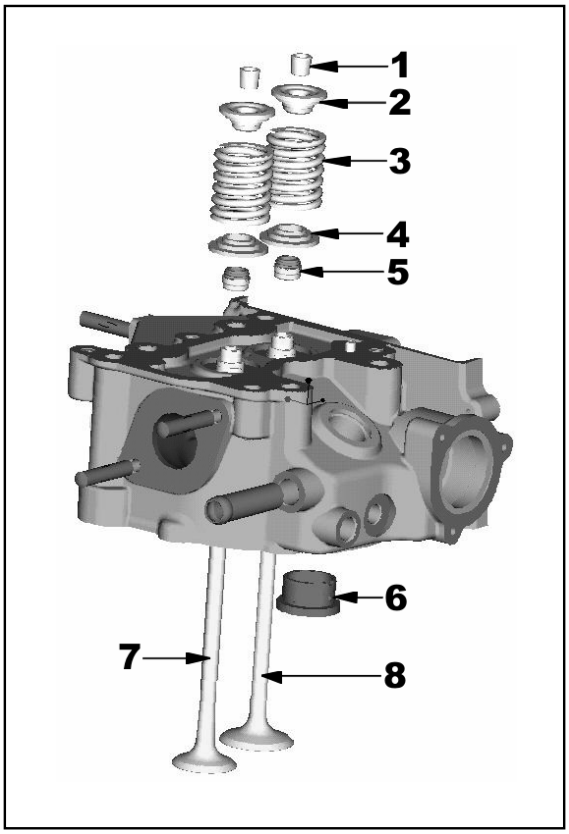
**Caution** - The injector jet, because of high output pressure car cause wounds whose consequences can be very serious. Take care that during the tests the jet itself doesn't hit any part of the body.



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190

**Cylinder head**

Caption:

**1-** Cotters
**2-** Valve spring upper collars
**3-** Valve spring
**4-** Valve guide sealing rings
**5-** Valve spring lower collars
**6-** Precombustion chamber
**7-** Exhaust valve
**8-** Intake valve

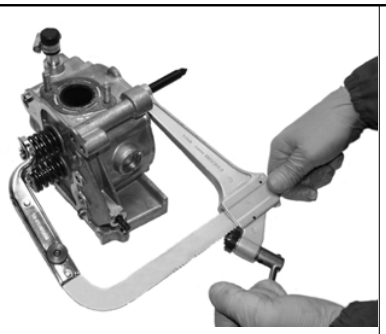
**Dismantling values**

Compress valves springs (fig. 192) by using a valve lifting clamp as shown in fig. 191 ( the tool was not included in the special tool set as it is commercially available), take away cotters (fig. 193), halves and release the fixture until spring and valves are removed



**all purpose valve lifter clamp**

191



192



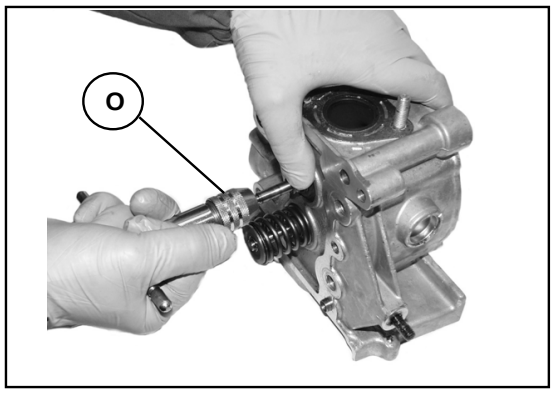
193



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194

**Valves grinding**

Carefully remove carbon deposit without notching the metal and wash with cleaning liquid.
Inspect valves seats: they shouldn't present indentations or scorings, but they must have a uniform surface so as to assure a perfect valve seal. Otherwise carry out valves seat grinding. This operation must be performed as follows with the best attention: smear valves with fine emery, introduce the valve in its guide and fix wrench "**O**" to the stem end. Alternately maneuver the wrench by changing, from time to time, position.

**Absolutely** avoid that emery is introduced into valves guides. When the operation has been carried out carefully wash and blow cylinder head and valves. For the checking of the perfect seal of valves pour some gasoline (petrol) into admission and exhaust ducts, then check that gasoline (petrol) doesn't flow through valves themselves.

**N.B.** - If valves seats are worn or with deep indentations it is necessary, before carrying out the grinding, to perform on the valves seats with proper milling cutters.



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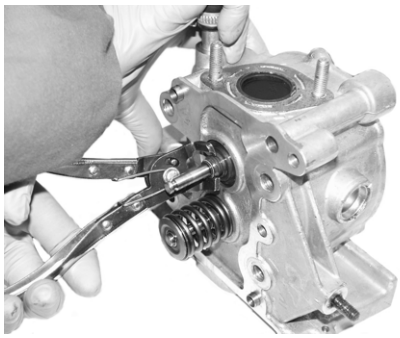
**Reassembly of valves**

Prior to valve reassembling, which is done in reverse sequence as to disassembling, always replace the two sealing rings (fig. 195) on the valve guides using punch 986290.109 (fig. 197-198).

**Important** - Before reassembling valves lubricate guides and stems.



195

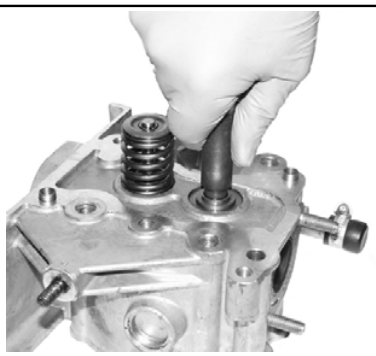


196

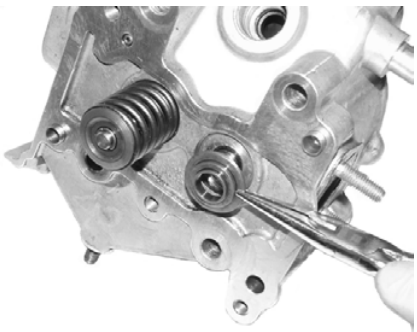


punch 986290.109

197



198



199



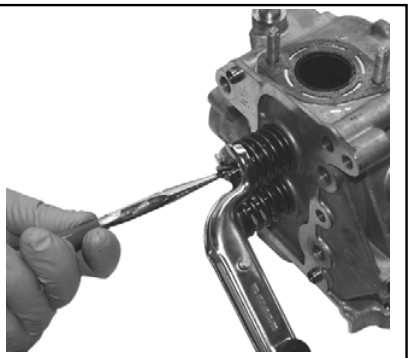
200



201



202



203



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## NOTE



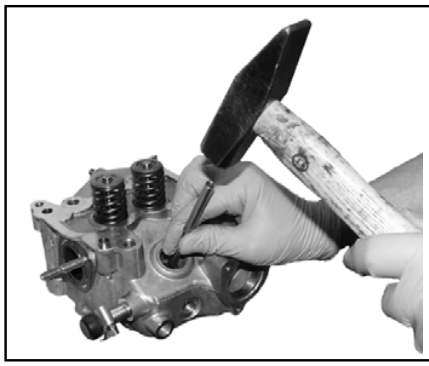
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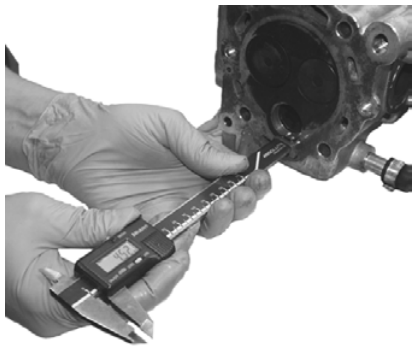


**Precombustion chamber – disassembly and reassembly**

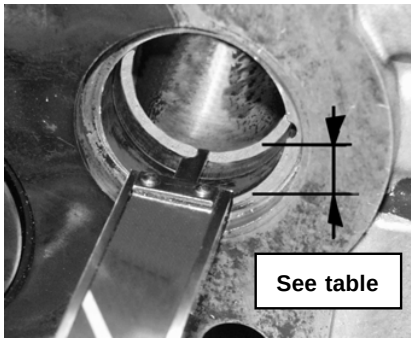
To extract the precombustion chamber, top the injector seat with a purch (Fig. 204) from the injector seat.This expulsion method causes damages to the precombustion chamber, therefore it must be replaced every time it is extracted.Before assembling the new precombustion chamber, the depth of the seat inside the head shall be measured (Fig. 205÷206); the resulting measurement will determine the most appropriate precombustion chamber of the four of different height that are available.In order to identify them, each precombustion chamber is marked with a paint brush-stroke in different colors according to its height (as indicated in the table).The precombustion chamber shall be inserted into the seat so that the dowel **1** coincides with the appropriate seat **2** (fig 207).
The interference between the precombustion chamber external diameter and the seat internal diameter shall be 0.01÷0.05.The precombustion chamber housing shall conform to the specifications shown in the related table with respect to the head surface (fig. 209).



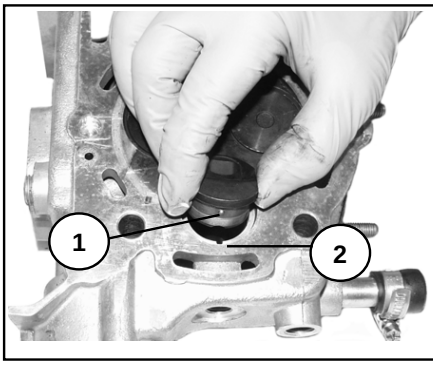
204



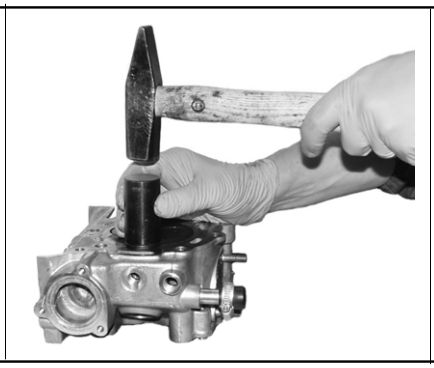
205



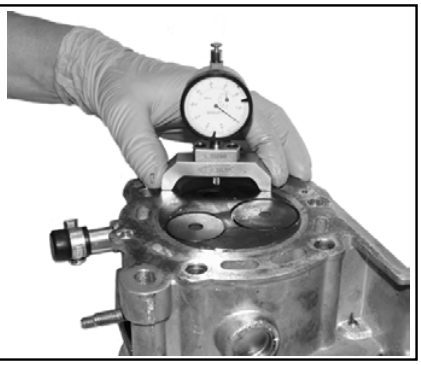

206




207



208



209

| Class symbol | Color | Prechamber cap thikness | Prechamber seat depth | Recess in cylinder head |
|---|---|---|---|---|
| **A** | Yellow | 4,080÷4,090 | 4,100÷4,109 | 0,010÷0,029 |
| **B** | Red | 4,091÷4,100 | 4,110÷4,119 | 0,010÷0,028 |
| **C** | Blue | 4,101÷4,110 | 4,120÷4,129 | 0,010÷0,028 |
| **D** | White | 4,111÷4,120 | 4,130÷4,140 | 0,010÷0,02 |

| Piece name | Nominal dimension | Interference |
|---|---|---|
| Combustion prechamber housing inter. diam | Ø 27,50÷27,52 | 0,01÷0,05 |
| Combustion prechamber exter. diameter | Ø 27,53÷27,55 | |



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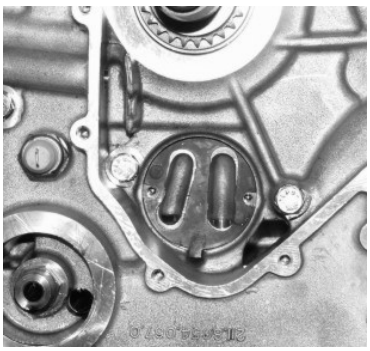
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**Oil pump**

Clean all parts and check : - that the union surfaces are flat.
- Replace the faulty parts in case of deformation
- The side play of the rotors and the radial play between the two rotors

If the desired values are not found, replace the faulty parts



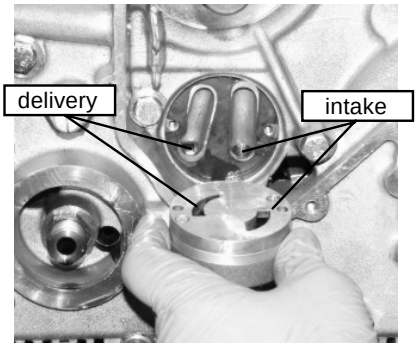
**210**



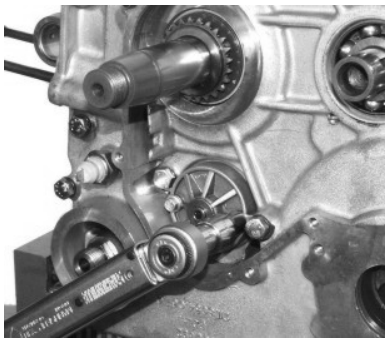
**211**



**212**



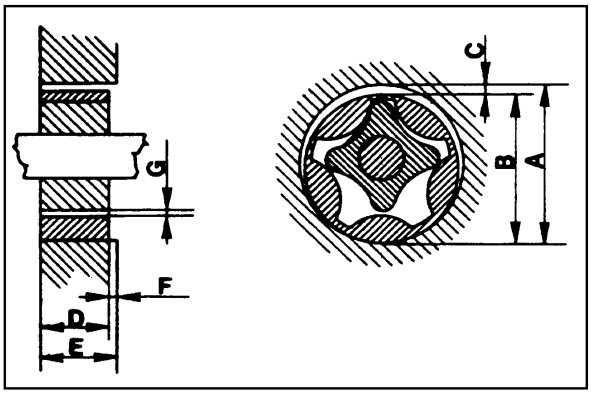

**213**



**214**

**Oil pump**

**Pump:** ..... lobe type.
**Pump control:** ..... through a chain gear dragged by the drive shaft
**Pressure adjusting valves:** ..... on pump body.
**Rotor seat dia. "A":** ..... 40,576÷40,588
**Rotor outside dia. "B":** ..... 40,513÷40,551
**Clear, bet. seat and rotor "C":** ..... 0,025÷0,075
**Rotor height "D":** ..... 5,985÷6,00
**Rotor seat depth "E":** ..... 11,025÷11,050
**Side clear, between rotors and pump body "F":** ..... 0,025÷0,065
**Radial clearance between rotors "G":** ..... 0,15 max
**Lubrication pressure with oil at 100°C:** ..... at slow running 1÷2 kg/cm²
at max. r.p.m 3,5÷4,5 kg/cm².

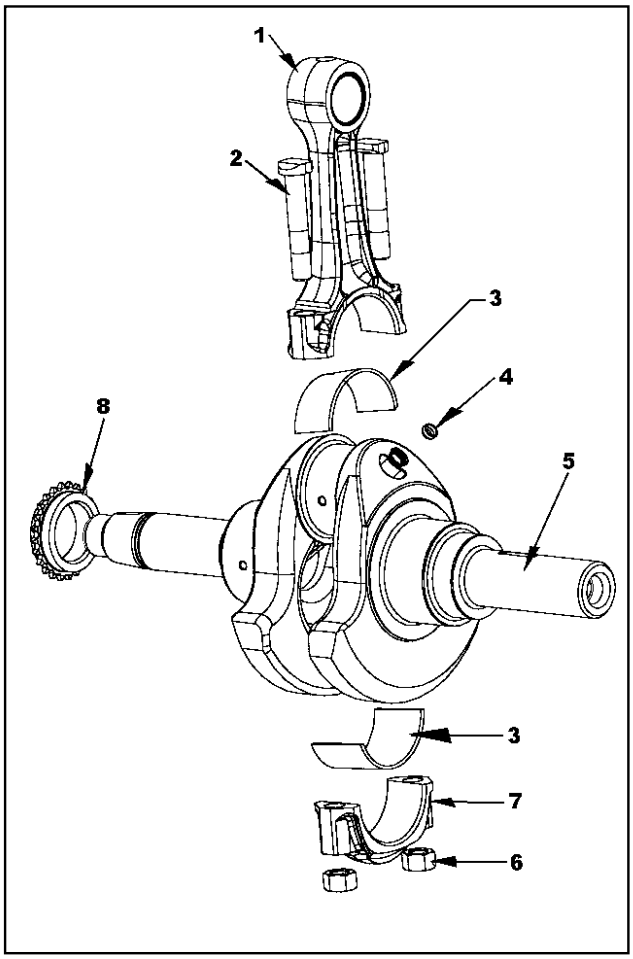





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215

**Drive shaft and connecting rod**

**1-** Connecting rod shaft
**2-** Connecting rod cap fastening screw
**3-** Connecting rod half bearings
**4-** Breech plug
**5-** Crankshaft
**6-** Connecting rod cap fastening nuts
**7-** Connecting rod cap
**8-** Oil pump gear

**Connecting rod**

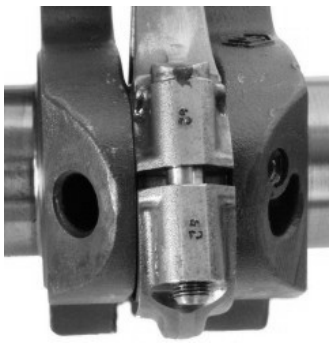
Remove the two retaining nuts and the connecting rod. When reassembling place the connecting rod onto the crankshaft keeping the cap and connecting rod marks oriented in the same way as before the disassembling, see Fig 218.
Then tighten the two bolts gradually to a 70 Nm torque.



216



217



218

**N.B.** - Replacement of con-rod bearings, halves is possible if crankshaft is without scratches, scorings or ovalization.

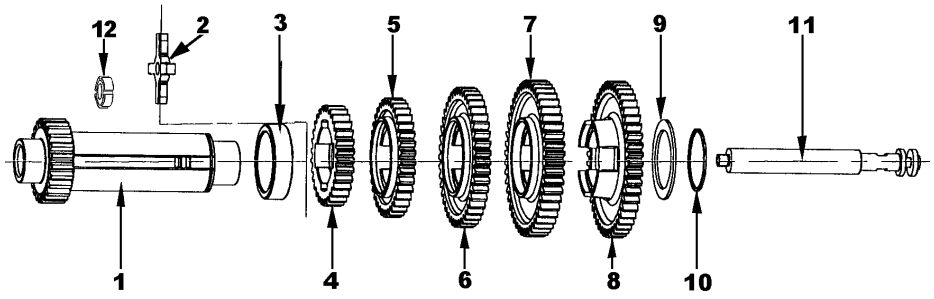


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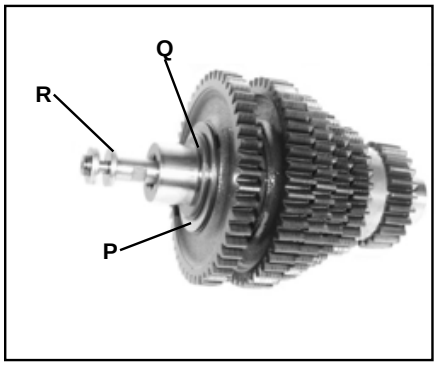
**Gearbox shaft 4th speed gear:**




**219**

**Caption Gearbox shaft 4th speed gear:**

1- Gearbox shaft with differential gear control coil
2- Speed coupling spider
3- Spacer
4- 4th speed gear
5- 3rd speed gear
6- 2nd speed gear
7- 1st speed gear
8- Reverse gear
9- Clearance ring
10- Stop ring
11- Speed control stem
12- Spider clamping ring nut



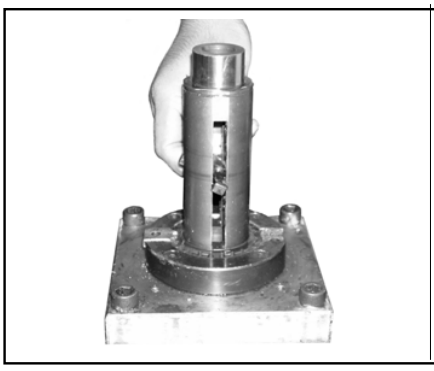

**220**

**Gearbox shaft**

Remove the snap ring "**Q**", the shoulder washer "**P**" and the gears. Unscrew the stem "**R**", set the coupling spiders, one at a time, to coincide with the slot for the sliding groove and extract them from the shaft.

**Reassembling the gearbox shaft: tightening the speed coupling spider**

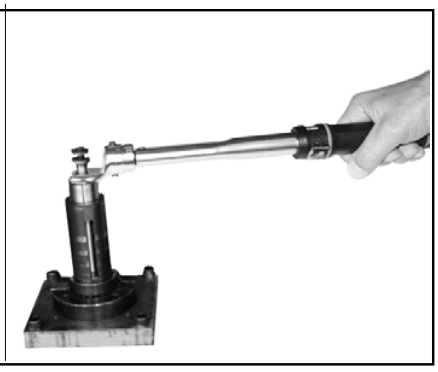
Insert the coupling spider into the sliding groove slot (fig. 220a).
Screw the speed control stem on the spider coupling ( fig. 220b ) and tighten to 50 Nm ( fig. 220c ) by means of a torque wrench.



**220a**



**220b**



**220c**



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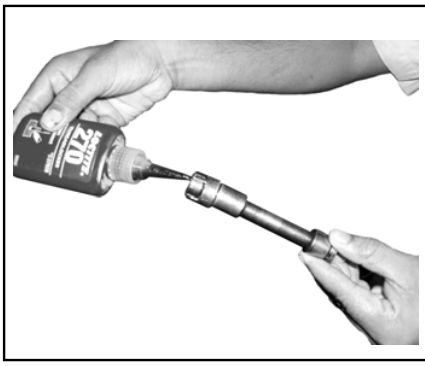


tools 1460.206

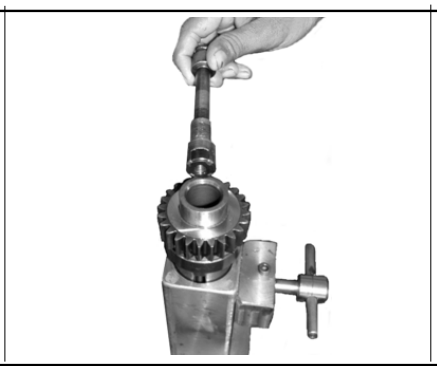
221

**Reassembling the gearbox shaft: tightening the spider clamping ring nut.**

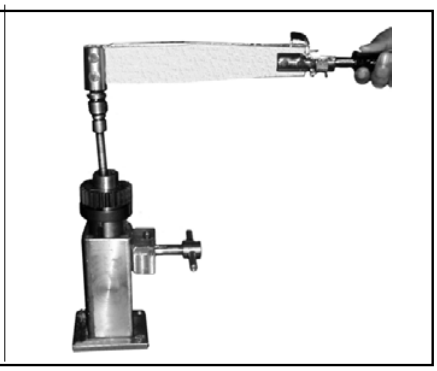
Apply Loctite 270 (fig. 221a) on the thread of the spider clamping ring nut.
Insert ring nut into the gearbox shaft (fig. 221b) on the differential gear control coil side.
By means of tool with serial number 1460.206 ( fig. 221 ) screw the ring nut and tighten to 25 Nm ( fig. 221c ) by means of the torque wrench.



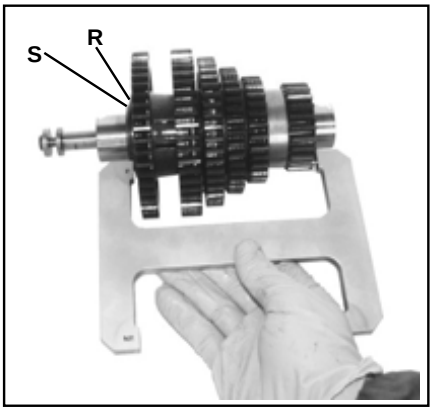
221a



221b



221c




222

**Gear assembly measure check**

After reassembling the gears, the spacer "**R**" (with the groove facing the shoulder washer), the shoulder washer "**S**", with the snap gauge (go and not go) 984980.324, check the gear assembly measure (mm 132 –0.12 -0.17).
If the gauge does not fit or the play is excessive, replace the shoulder washer with one of higher or lower size as needed.
Once the check is completed reassemble the snap ring.

**IMPORTANT:** the shoulder washer "**S**" is provided, as spare part, in eight different sizes of thickness. ( 1,750 - 1,830 - 1,910 - 1,990 - 2,070 - 2,150 - 2,230 - 2,310 )



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## NOTE



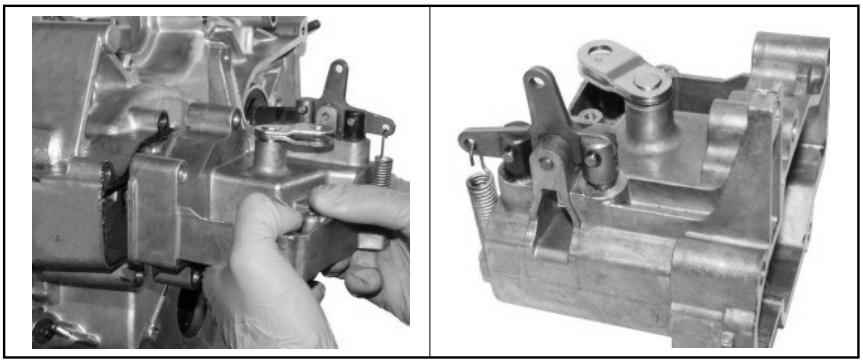
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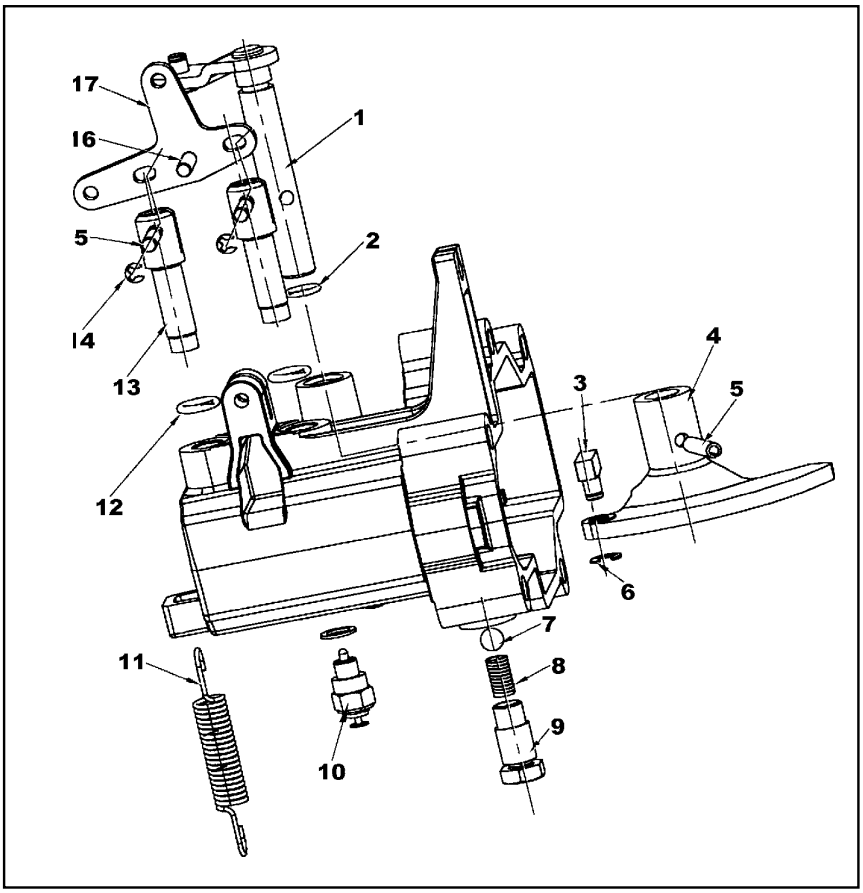


**Gearbox**

After unscrewing the gearbox coupling screws, disengage the gear speed control stem from the selector switch sliding block and disassemble the gearbox.



223




Caption:

**1-** Lever pin with P.I.
**2-** O-ring
**3-** Sliding block
**4-** Selector switch
**5-** Elastic pin
**6-** Lock ring
**7-** Ball
**8-** Spring
**9-** Spring housing
**10-** Reverse sensor
**11-** Return spring
**12-** O-ring
**13-** Safety pin
**14-** Lock ring
**15-** Pin
**16-** Pin
**17-** Lever

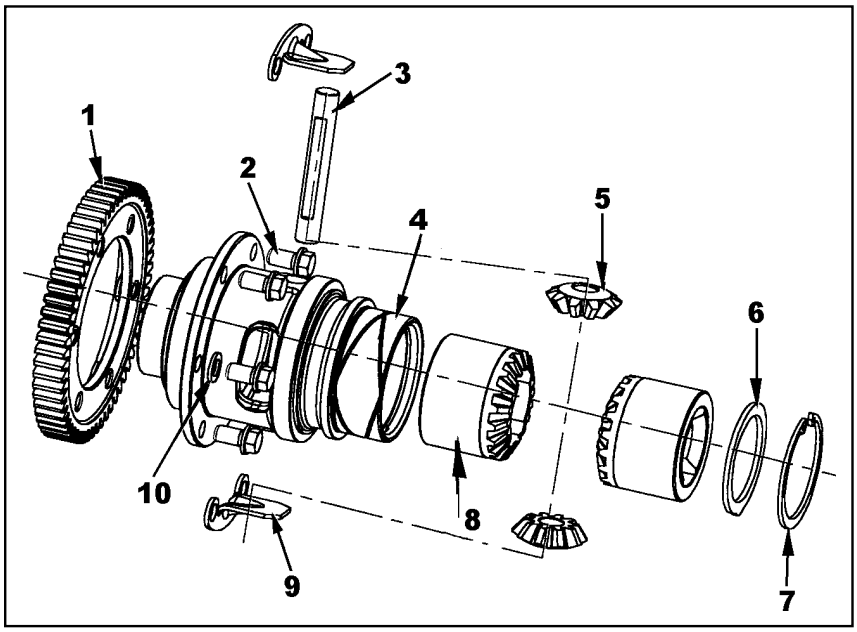
224



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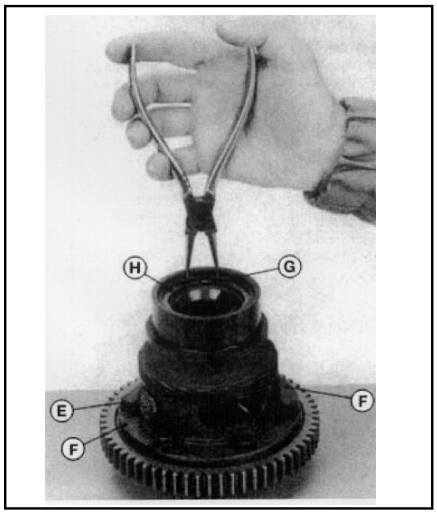



225

**Differential gear box**

Caption:

**1-** Differential gear ring
**2-** Screws
**3-** Differential gear pin
**4-** Differential gear box
**5-** Differential gear side pinions
**6-** Clearance ring
**7-** Snap ring
**8-** Differential gear crown wheel
**9-** Differential gear pin check squares
**10-** Washers




226

**Differential case**

Take away the 6 bolts "**E**", side pinions pin retaining brackets "**F**" and drive gear. With the specific pliers remove circlips "**G**", shoulder washer "**H**" and crown wheel.

Extract pin and remove side pinions and the other crown wheel.Replace the damaged parts and reassemble by following the reverse procedure of removal. Torque the 6 bolts "**E**" according to values of locking torque 55÷60 Nm.



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**Starting motor**

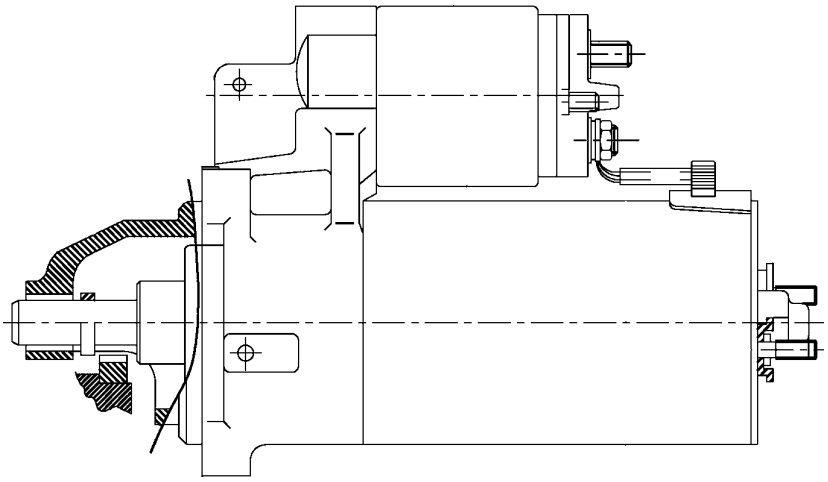
4-pole permanent-magnet-type starting motor.
It is controlled by a remote control allowing pinion clutch and power supply enabling.
The starting motor is battery powered and controlled by a key switch.
It is connected to the engine by means of the pinion and of the ring gear on the flywheel.

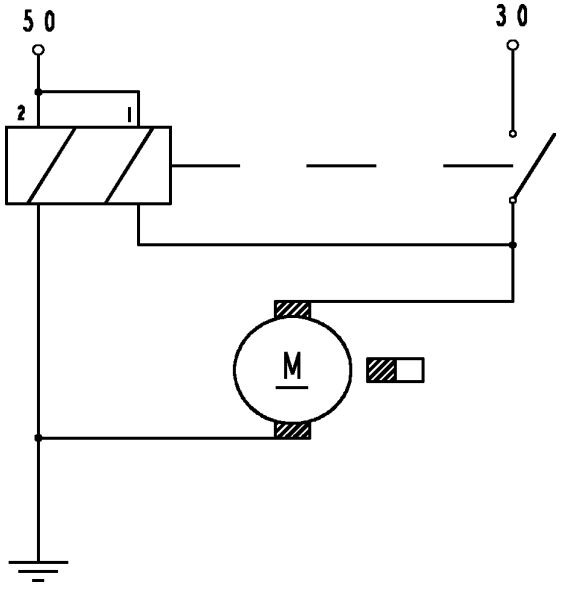
**Main features of electrical starter .**

| | |
|---|---|
| Type | BOSCH |
| Rated voltage | 12V |
| Rated output | 1,6 kW |
| Direction of rotation | Sinistra |

| STARTER MOTOR PERFORMANCE | | | |
|---|---|---|---|
| | NO LOAD | LOAD | LOCK |
| VOLTAGE | 12V | 9V | 6V |
| CURRENT | max 75A | 390A | max 780A |
| TORQUE | ---- | MIN 1 Kgm | MIN 2,2 Kgm |
| REVOLUTION | MIN 8.000 g/1' | MIN 1.500 g/1' | ---- |

Connection with engine.






**ELECTRICAL DIAGRAM**

**Solenoid starter characteristics**

Contact closing voltage at ..... 20° C ≤ 7,8 V
Contact closing voltage at ..... 100° C ≤ 10,3 V
Contact release max voltage ..... ≤ 5 V

1. Starting winding
2. Running winding

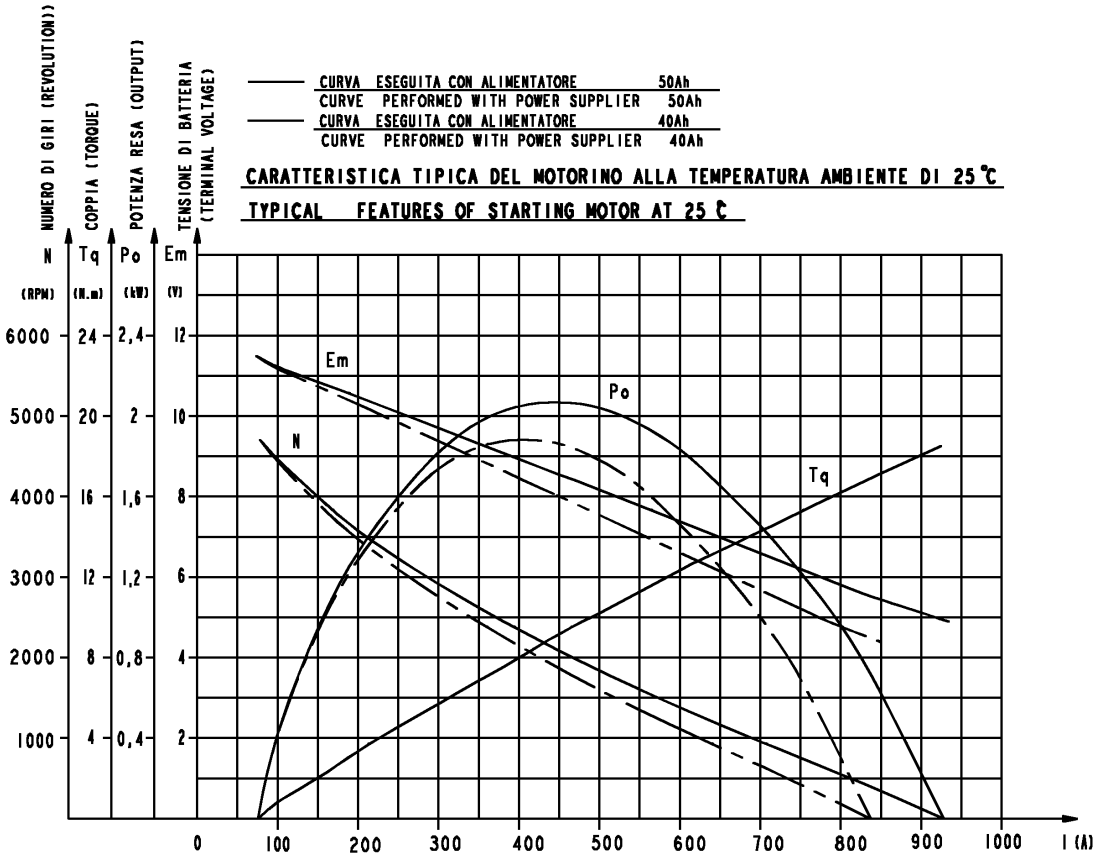


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**Characteristic curve of the 12 V 1.6 kW starting motor**






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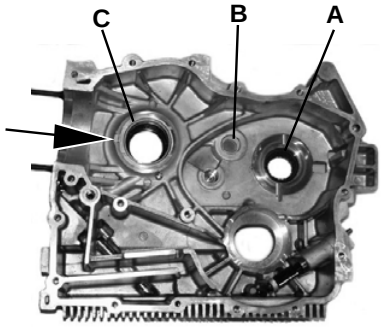
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**Crankcase, half, flywheel side**

**Drive shaft and gear cluster d.c. roller bearings**:

place crankcase half on a base plate and fit, by using the specific punches 986290.106 d.c. roller bearing "**A**" of drive shaft and 986290.104 d.c. roller bearing "**B**" of gear cluster. Position on crankcase, half, duly greased on housing face, to avoid fall during assembling operations, shoulder bearing "**C**" with 4 tracks for the lubrication facing crankshaft and the appendix placed in its housing as pointed out by arrow in fig. 182.



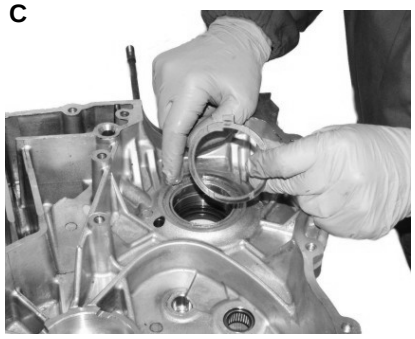

232




233




234




235

**Clutch-side housing half**

Place the housing half on a base plate and warm it to 80° C in the ball bearing seat by using a thermal gun.
By using the appropriate punch 986290.108 fit the bearing into its seat.



**punch 986290.108**

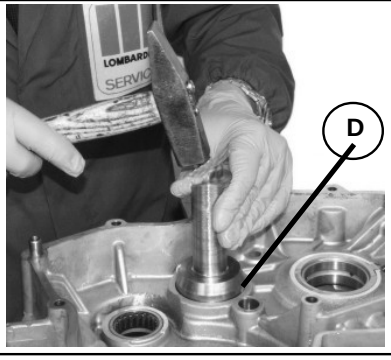
236



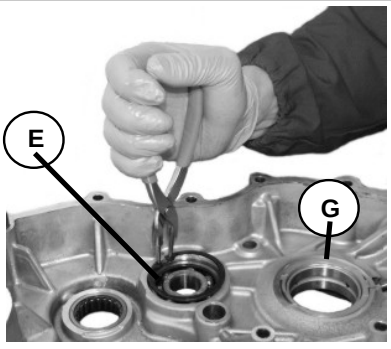
237

**Gear cluster ball bearing and drive shaft d.c. roller bearing**

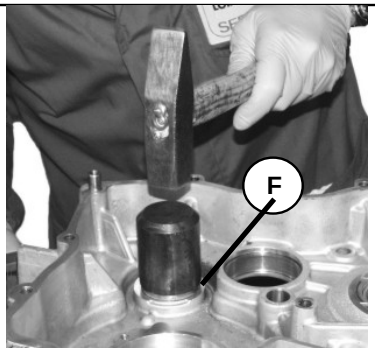
Fit by using, if necessary an outside dia. 50 mm (1.96") punch, ball bearing "**D**" and with pliers introduce circlip "**E**". Let crankcase cool and by using the specific punch 986290.105 position d.c. roller bearing "**F**" of drive shaft. Then in the same way as carried out on crankcase, half, flywheel side, position shoulder bearing "**G**".




238




239




240



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**Drive shaft, reverse gear shaft, multiple gear, gearbox shaft and differential gear**

Insert the differential gear (Fig. 241) assembly, the multiple gear (Fig. 242), the gearbox shaft (Fig. 243), the reverse gear (Fig. 244), the drive shaft (Fig. 245), the oil filter "**G**" , the pipe "**N**" and the sealing ring "**I**" (Fig. 246÷247), as indicated in the figure.
Clean the union surfaces of housing halves (Fig. 248÷249), smear with sealant (Loctite 518) (Fig. 250) and couple the housing halves by setting the screws to the specified torque (Fig. 251÷252).



241



242



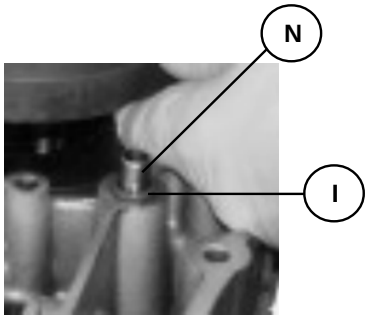
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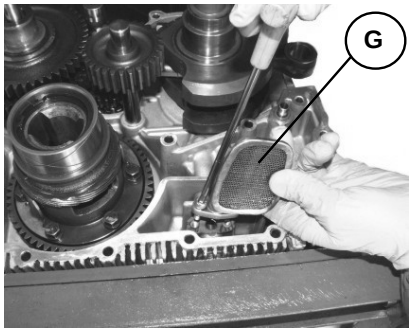
244



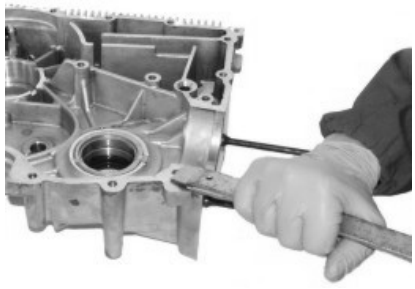
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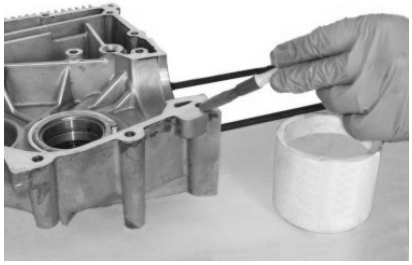

246




247



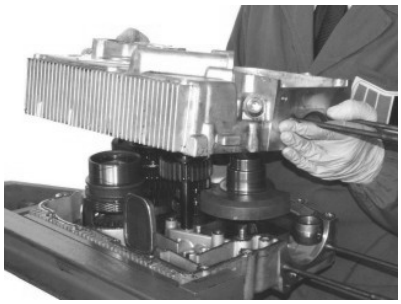
248



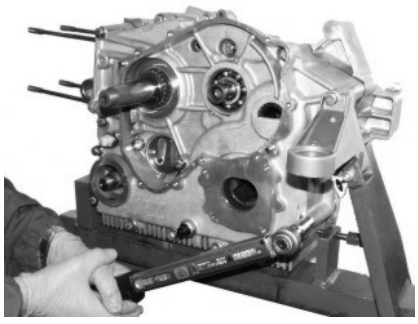
249




250



251



252

| COMPILER TECNIATI | REG. CODE | MODEL N° | DATE OF ISSUE | REVISION 00 | DATE | ENDORSED | |
|---|---|---|---|---|---|---|---|
| | 1-5302-662 | 51092 | 18-10-2004 | | 18-10-2004 | | 85 |

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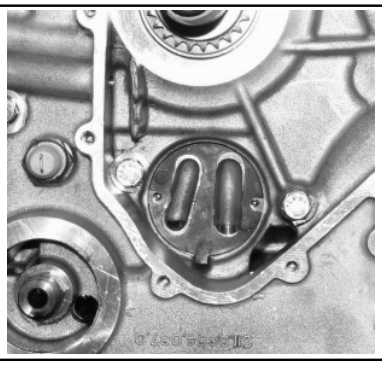
**Oil pump gear and oil pump - reassembling**

When reassembling the oil pump, always replace the seal with a new one.
Reassemble the oil pump paying attention to the correct assembly direction (suction and delivery). We advise you to fill the pump case with oil before the assembly.
Before and after final tightening the two fastening bolts "**A**" of the pump case to the housing half, check that the pump turns freely by rotating the shaft manually 4 or 5 times. The two bolts "**A**" are tightened to an 8 Nm torque.
Reassemble the chain after attaching it by using the oil pump control gear. The bolt fastening the gear to the oil pump shaft shall be tightened to a 10÷12 Nm torque.

Oil pump pressure check

The oil pressure check shall be performed with the oil at a temperature of 100° C.
Connect the pressure gauge in the place of the pressure or switch placed on the main duct.
Run the engine and measure the following pressure values:

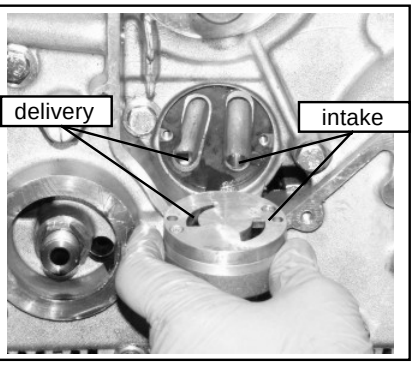
- at minimum rpm ≥ 1 Kg/cm$^2$
- at 3000 RPM 3.5 to 4.5 Kg/cm$^2$



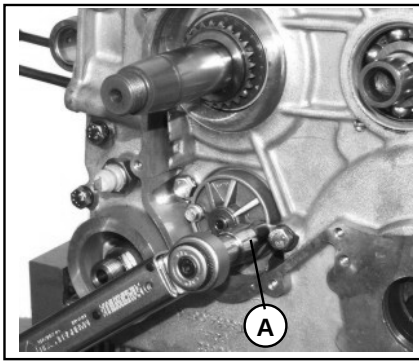
253



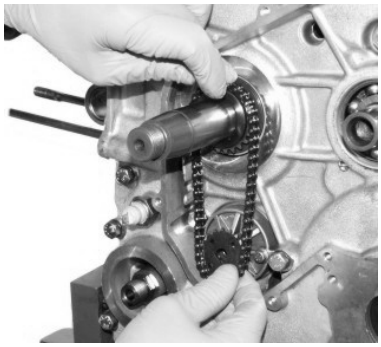
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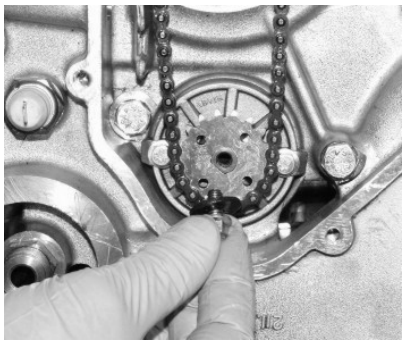

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256



257



258



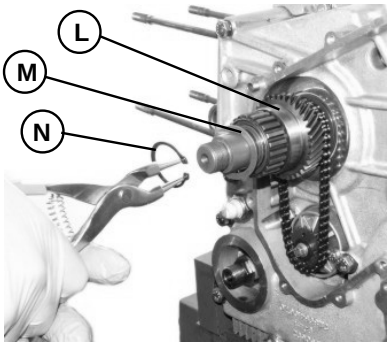
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**Engine gear**

Assemble the gear "**L**", the clearance shim "**M**" and the snap ring "**N**" by using the pliers for internal snap rings.
Use the tool 986782.034 provided with a dial indicator on the housing pan and verify that the gear axial endfloat is mm 0.04÷0.1. If this endfloat is not obtained, replace the clearance shim "**M**" with a washer of appropriate size; 13 washers having different thickness are provided.

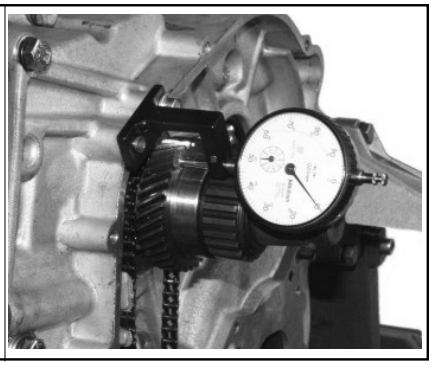



259



Tool 986782.034

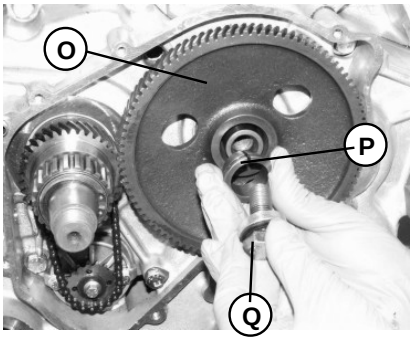
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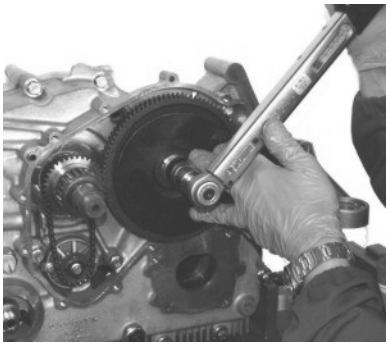
261

**Primary gearbox ring gear and clutch housing pan**

Place the ring gear "**O**" the cone "**P**" and lock with the bolt "**Q**" to a 120÷140 Nm torque by using a wrench.
Assemble the oil seal on the clutch housing pan by using the appropriate tool 986290.110.
Smear the coupling surface with sealant (Loctite 510), assemble the clutch housing pan by the 10 bolts and the single nut by tightening them to a 8 Nm torque




262

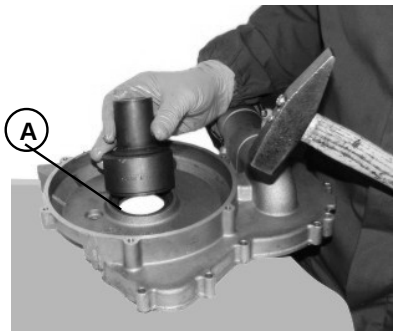


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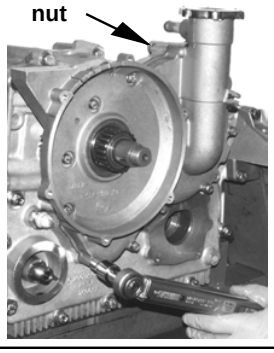


Tool 986290.110

264




265




266



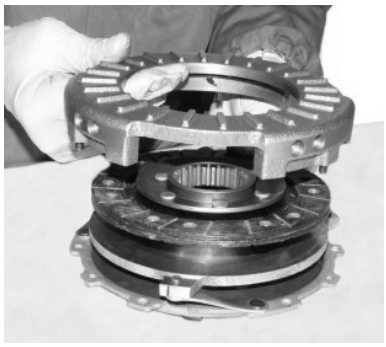
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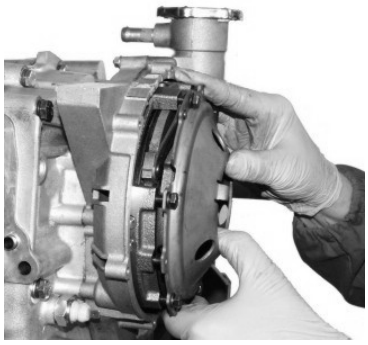


**Clutch assembly**

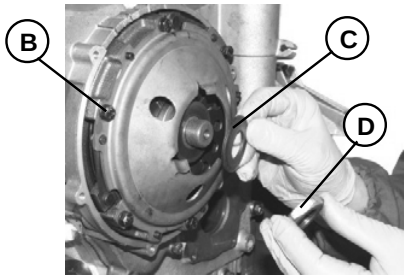
To replace the duct disk no particular tools are required, simply remove the 6 bolts **"B"** and remove the duct disk. When reassembling, before locking bolts **"B"** , assemble the clutch assembly on the drive shaft to help centering the duct disk, then place washer **"C"**, secure nut **"D"** 120÷140 Nm and the 6 bolts **"B"** 10 Nm by fastening the clutch assembly using the appropriate stop key 985110.039. Complete the operations by assembling the clutch pressure cap of the cover retaining ring.



267



268

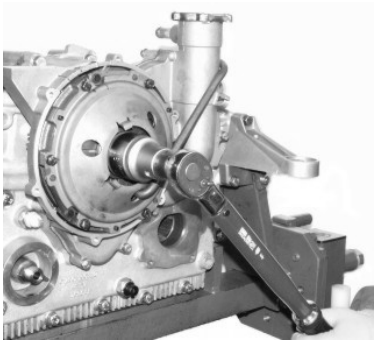



269

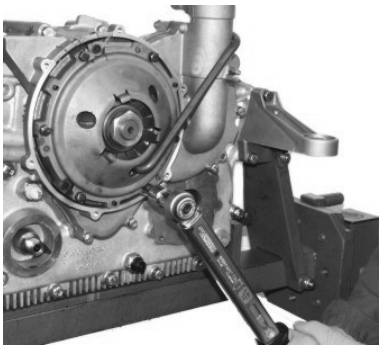


stop key 985110.039

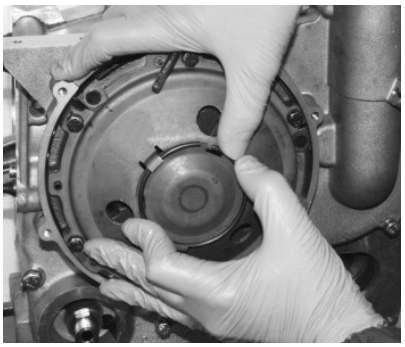
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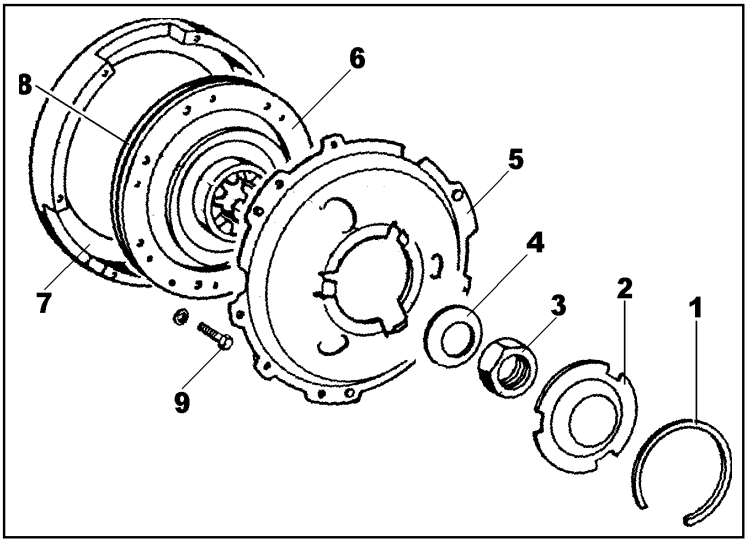
271



272



273




274

**Caption:**

**1-** Collar retaining ring
**2-** Thrust cap
**3-** Nut
**4-** Cup spring
**5-** Clutch pressure pad
**6-** Clutch disk
**7-** Flange
**8-** Centering pin
**9-** Fastening bolt



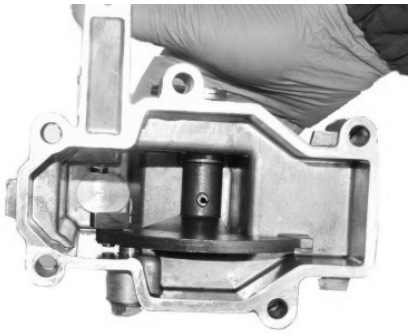
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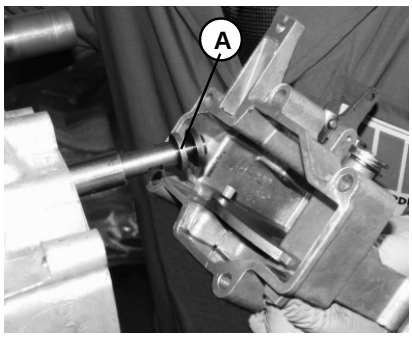


**Speed gear control box**

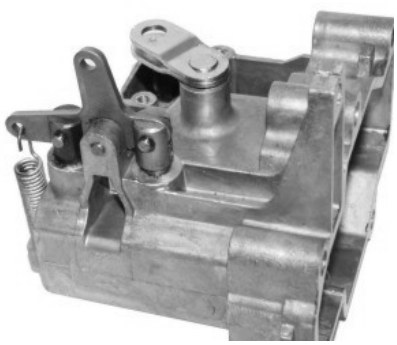
Rotate the drive shaft and bring the gears in a position such to allow stem **"A"** the maximum protusion, position upper lever in 2nd gear; spread with seal paste (Loctite 510) speed-gear control box union surface, engage sliding bloc of 3rd and 4th gears lever, then the one of reverse, bottom and 2nd gears. Lock the box by means of the 5 securing bolts and check the regular speed gear operation.



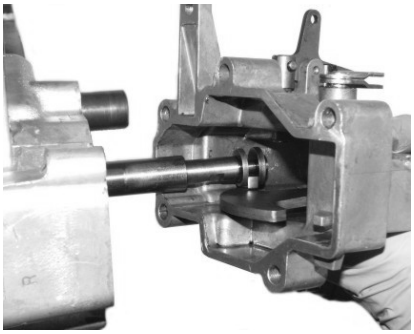
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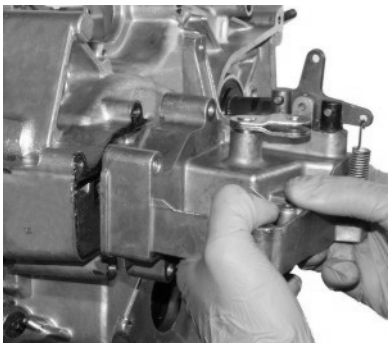

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277



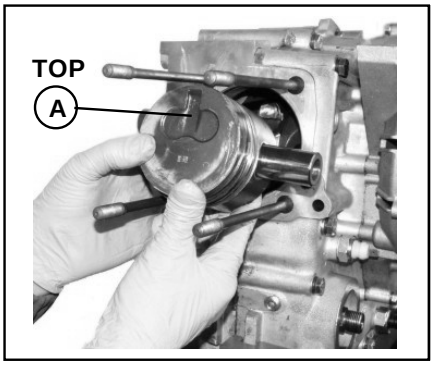
278



279

**Piston and cylinder**

Assemble piston with the combustion chamber **A** facing upwards (fig.280), lubricate and rotate the sealing rings so that the cuts have a displacement of about 120° between them. After lubricating the liner, insert the cylinder using the tool 985820.212 (fig. 281÷282).
Push the cylinder till it is fit (fig.283).




280

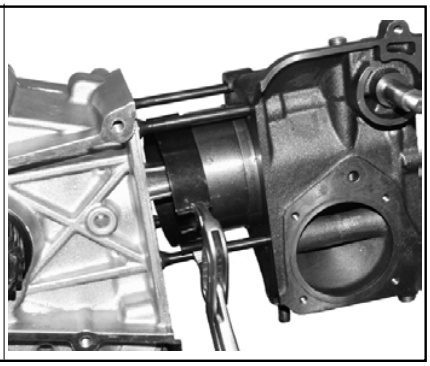


tool 985820.212

281



282



283



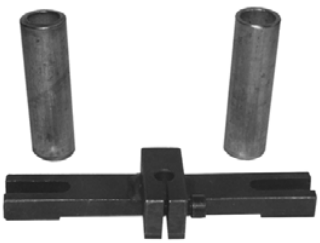
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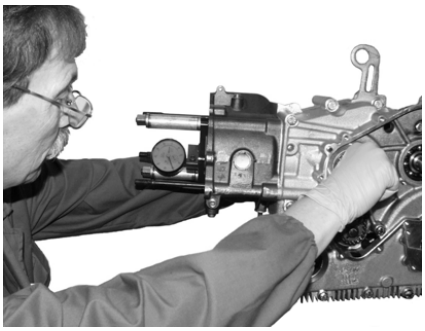
**Measurement to determine the thickness of the head gasket.**

Use the dial indicator on the tool 981075.417 (fig.284) and set it to zero on a surface plate. Assemble the tool on the cylinder by using the 2 head and cylinder clamping stud bolts, set the piston to the top dead centre and measure on the dial indicator the piston protrusion beyond the zero (fig.285).
In order to keep the compression rate within the tolerance value, select the head gasket thickness according to the indications of the following specification table.

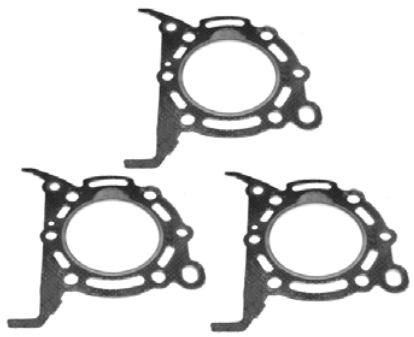


Tool 981075.417

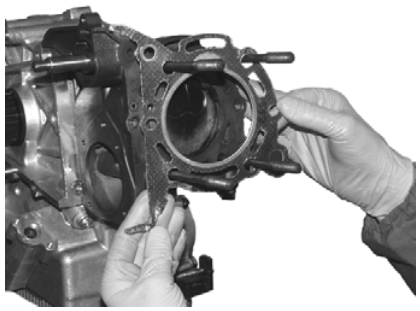
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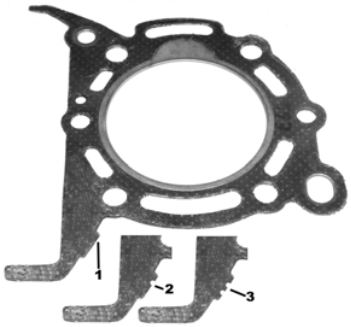
285



286



287




288

| Piston projection (over zero) mm | Gasket thickness | External identification | Compression ratio |
|---|---|---|---|
| 0,45÷0,60 | 1,50 | 1 notch | 22,5÷23,5 |
| 0,60÷0,75 | 1,65 | 2 notches | |
| 0,75÷0,90 | 1,80 | 3 notches | |

Warning :

The above measurements given for the determination of the suitable gasket are necessary only in case of replacement of one of the following parts: cylinder, piston, con-rod, crankshaft or crank-case, half: if one of the mentioned conditions is absent, the new gasket must be equal (external identification) (fig. 288) to the previously fitted one.



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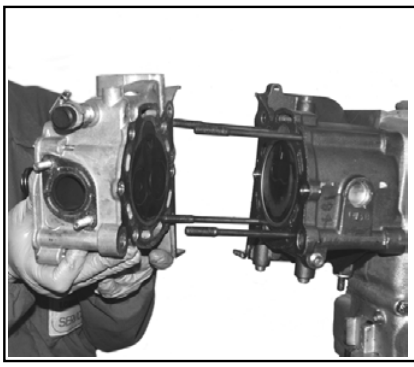
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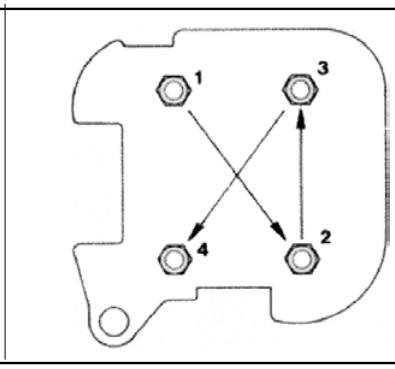
**Cylinder head installation - Reassembly**

Fit the cylinder head and after lubricating washers, studs and the 4 nuts, in order to carry out a perfect locking act as follows, by bearing in mind that for each tightening stage the sequence pointed out below must be performed according to the diagram in fig. 290.

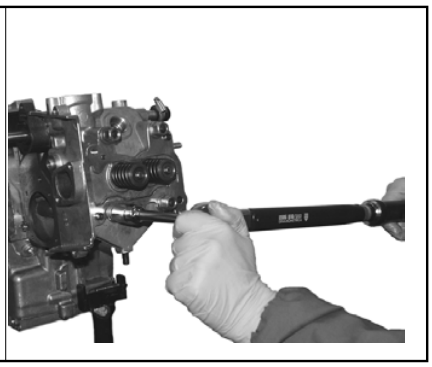
**1)** Torque the four nuts with a locking torque of 5 N.m.
**2)** Torque to 40 N.m..
**3)** Carry out a 90° rotation (1/4 turn).
**4)** Complete the torquing with a second rotation of 90° (1/4 turn).



289




290



291

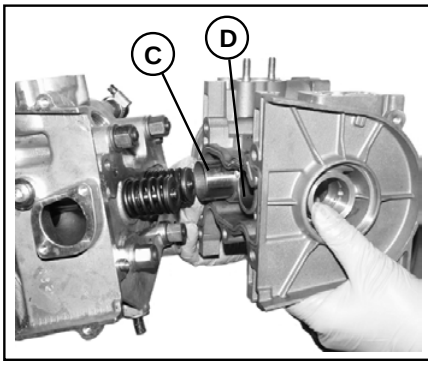
**Cylinder-cylinder head securing studs**

to avoid progressive permanent elongation from repeated torquing operations it is necessary to replace the studs every three dismantling and reassembly operations of the cylinder head. If in doubt, replace them every time.

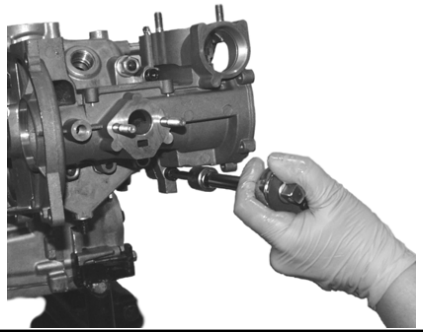
**Camshaft and tappet support**

Assemble the camshaft support on the head (fig. 292) by tightening the bolts to a 20÷22 Nm (fig. 293) torque, lubricate the camshaft supports as well as the intake and exhaust tappet seats **"C"** and **"D"** supports (fig. 292).
Fit the tappets fitted with adjustment shims in their seats **"C"** and **"D"**" (fig. 294).
Place the gasket **"E"** (fig. 294)**.**

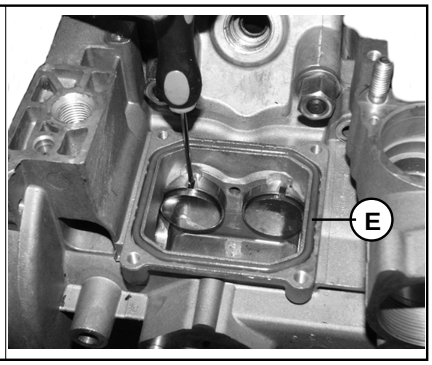
| | |
|---|---|
| - Tappet seat diameter | 35,000÷35,025 |
| - Normal tappet external diameter | 34,975÷34,995 |
| - Seat-tappet : assembly gap | 0,005÷0,050 |




292



293




294



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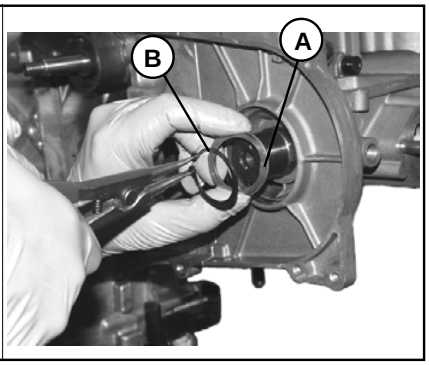


**Camshaft - Reassembly**

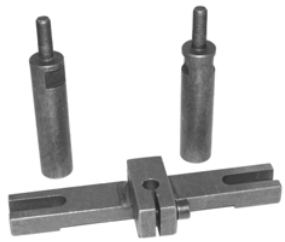
Insert the camshaft into the support (fig. 295), assemble ther shoulder washer **"A"** and the retaining snap ring **"B"** (fig. 296).
Use the dial indicator on the tool 981075.417 (fig. 297), assemble it on the support and check that the camshaft axial endfloat is mm 0.15÷0.20 (fig. 298).
If the right axial endfloat is not obtained, replace the shoulder washer **"A"** with one of a higher or lower size as required until the specified endfloat is obtained (to this end 6 washers having different thickness are provided) (fig. 299).



**295**




**296**



**Tool 981075.417**

**297**



**298**

| Shoulder washers | Thickness (mm) |
|---|---|
| 1 | 1,80 +0/-0,05 |
| 2 | 1,85 +0/-0,05 |
| 3 | 1,90 +0/-0,05 |
| 4 | 1,95 +0/-0,05 |
| 5 | 2,00 +0/-0,05 |
| 6 | 2,05 +0/-0,05 |

**299**

**Camshaft: control of size**

| | | |
|---|---|---|
| Camshaft pivots diameter | belt side: | 31,959÷31,980 |
| | regulator side: | 55,961÷55,980 |
| Seat diameters of camshaft pivots into the camcarrier | belt side: | 32,000÷32,025 |
| | regulator side: | 56,000÷56,030 |
| Mounting gap between seat and Camshaft pivots | belt side: | 0,020÷0,066 |
| | regulator side: | 0,020÷0,069 |
| Cam lift | | 8,29 |

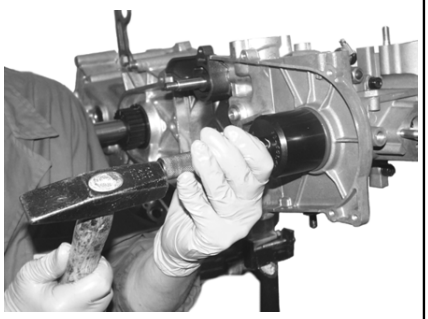
**Camshaft oil seal and timing pulley**

Insert by using the proper punch 986290.110 (fig. 300) oil seal (fig. 301).



**Tool 986290.110**

**300**



**301**



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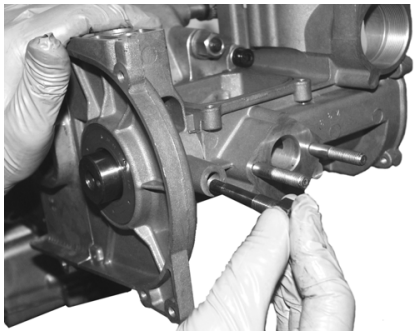


**Toothed camshaft timing pulley - Assembly**

Fit the camshaft clamping pin (fig.302), assemble the toothed timing pulley (fig.303), then tighten the bolt to a 70÷75 Nm torque as specified (fig.304), fit again the brake washer (fig.305).

**Toothed crankshaft timing pulley - Assembly**

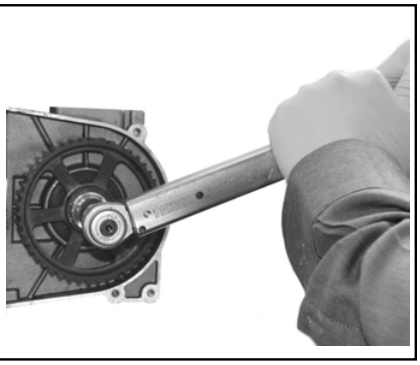
Taking care that the key remains in its housing, reassemble the toothed pulley on the crankshaft (fig.306).



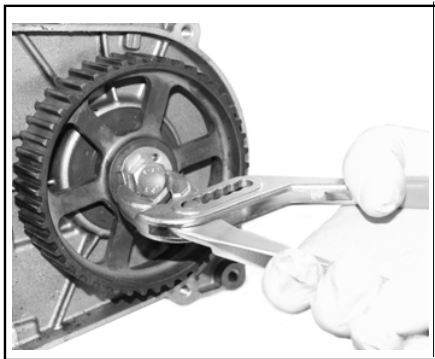
302



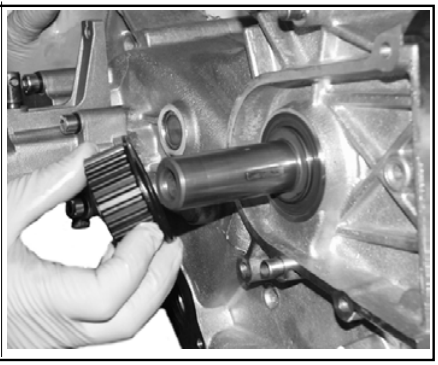
303



304



305



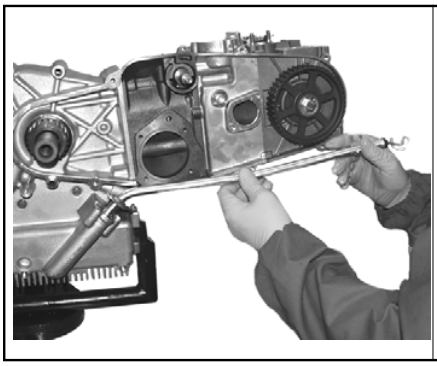
306

**Oil dipstick case - Assembly**

After inserting the sealing ring in the special housing, reassemble the oil dipstick case and fix it by tightening the bolts at 8 Nm (fig.307).

**Oil level check**

The oil level must be between the MIN and MAX marks.
If the oil level is low check for leaks. Top up to the MAX mark



307




307a



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## NOTE



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# NOTE



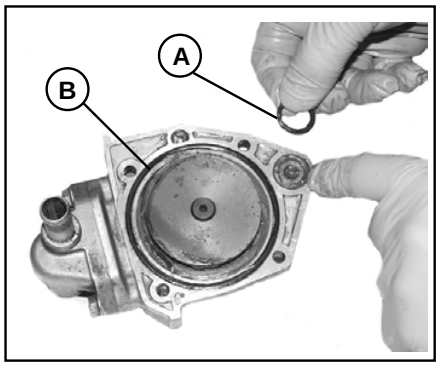
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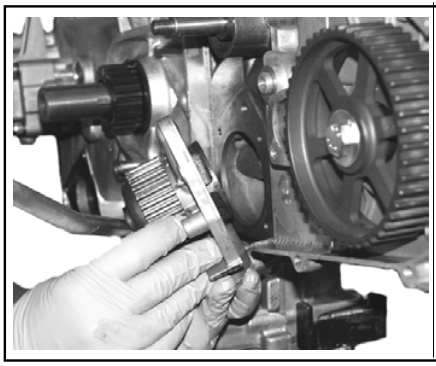


**Cooling liquid circulating pump - Assembly**

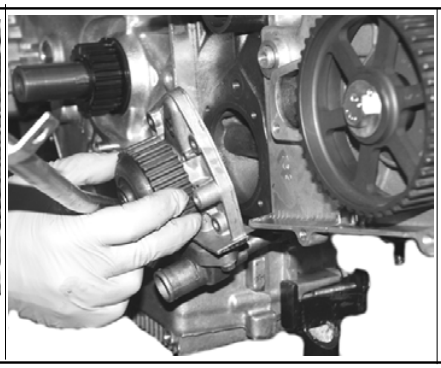
At every disassembly replace the sealing rings A and B (fig.308).
Insert the cooling liquid circulating pump in its housing in the cylinder (fig.309-310) and fix it by tightening the screws at 15 Nm (fig. 311).



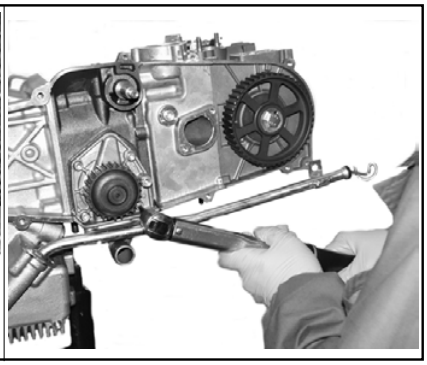

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309



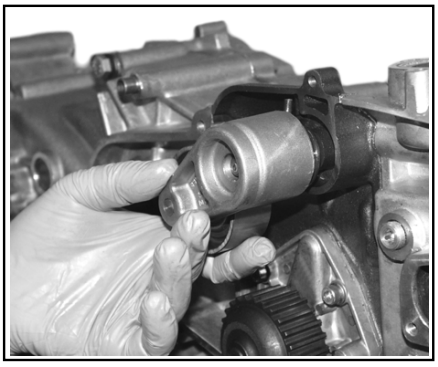
310



311

**Toothed timing belt tensioner - Assembly**

Insert the calibrated spring for the toothed timing belt tensioning inside the tensioner (the spring can be assembled only in one direction).
Attach the spring and the tensioner to the pin and fix it by assembling the safety washer before the nut.



312

## WARNING

## Assembly of toothed belt and timing

The assembly, timing and tension adjustment of the timing drive toothed belt have already been described from page 29 to page 33.



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**Injection pump control cam – Assembling**

Insert the injection pump control cam on the timing shaft (fig. 313), then insert the shoulder washer and assemble the snap ring by means of pliers for internal snap rings (fig.314).

**Centrifugal weights assembly - Assembling**

Insert the centrifugal weights assembly taking care to insert the pins of the weights "**L**" inside the slots "**M**" (FIG.315).
Working on the side opposed to the one shown in the figure, keep the timing gear locked and clamp the weight-holder hub along with the related bolt by tightening it to a 25÷28 Nm torque (fig. 316).

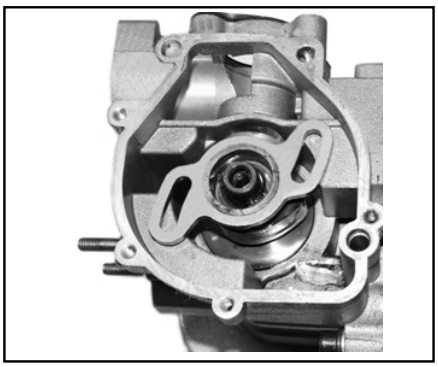
**IMPORTANT**: After the assembly, verify that all the weights perform properly without getting stuck.

**Oldham union - Assembling**

Cover the Oldham union with grease with adhesive function, and fit it onto the groove located on the head of the centrifugal-weight fastening bolt of the injection advance variator (fig.317).

**Delivery governor assembly**

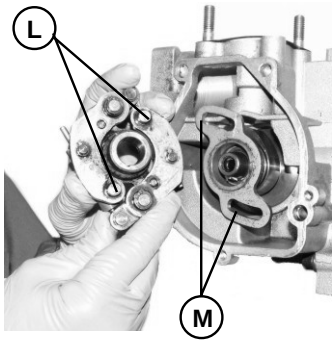
Smear the coupling surface with Loctite 510 and couple the delivery governor assembly to the camshaft support, taking care to insert the governor control shaft by turning the camshaft (fig. 318).
Complete the fastening of the delivery governor assembly by means of the 5 bolts, tightening with a torque wrench the 4 M6 bolts at 12 Nm and the M8 bolt at 25 Nm (fig. 319).



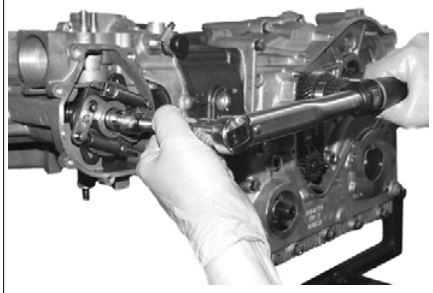
313



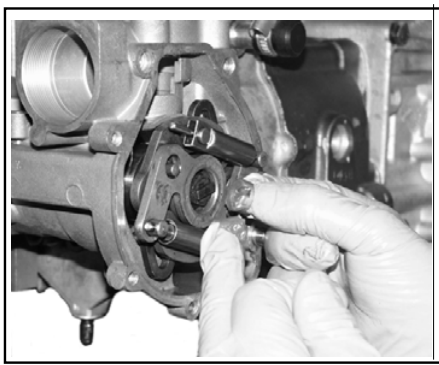
314



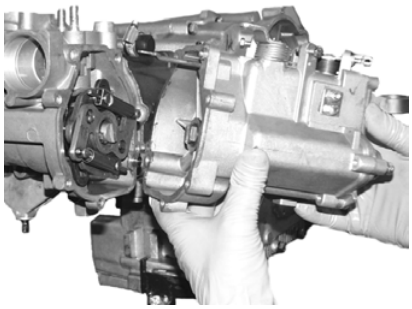

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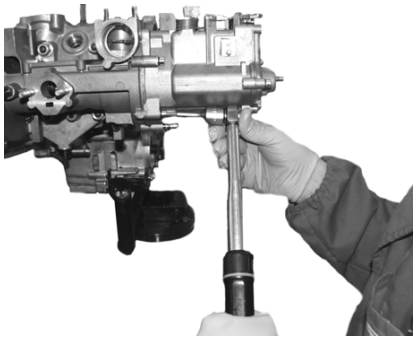
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317



318



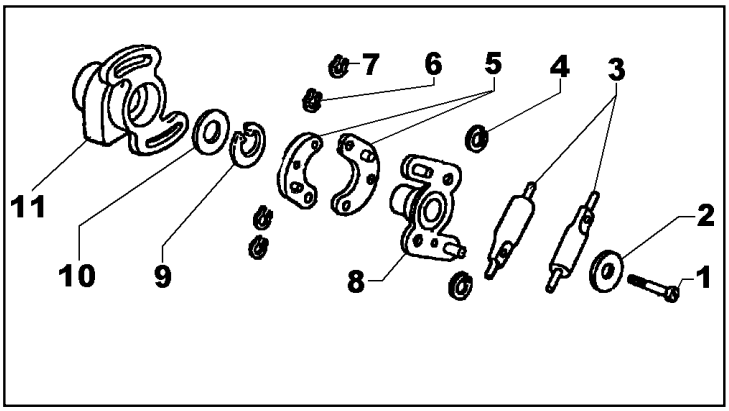
319



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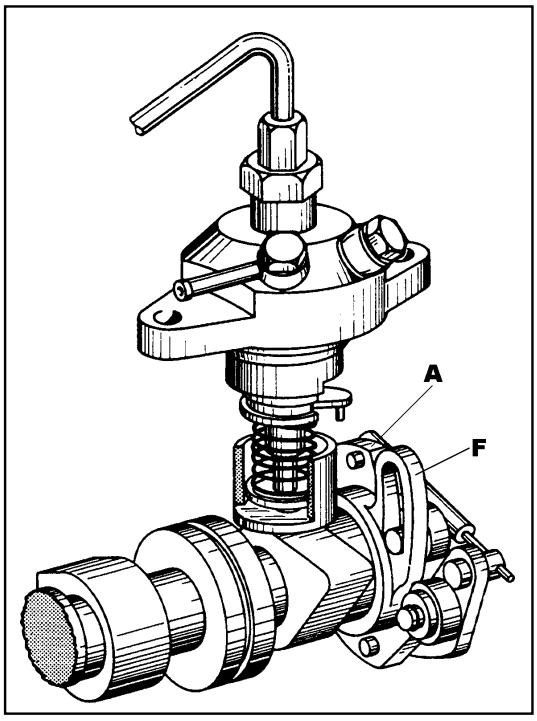



320

**Injection advance variator**

**Caption:**

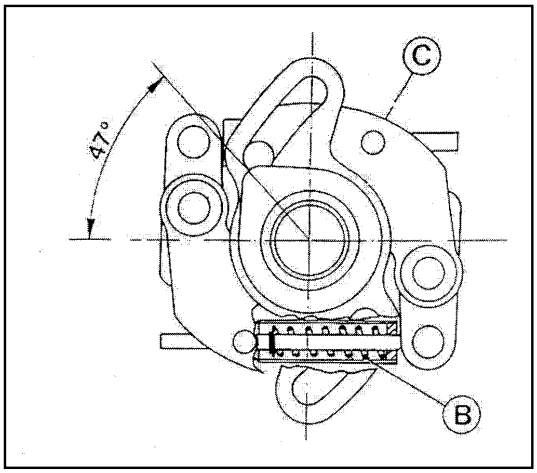
**1-** Injection advance variator fastening screw
**2-** Washer
**3-** Calibrated spring cases
**4-** Lock rings
**5-** Centrifugal weights
**6-** Lock rings
**7-** Lock rings
**8-** Counterflange
**9-** Snap ring for shafts
**10-** Washer
**11-** Cam for injection pump with P.I.




321

**Description of the injection advance regulator**

When starting, and at a low idling speed the correct value of injection advance is 11° before P.M.S..
This value increases in accordance with the engine RPM, attains 24° at 3500 R.P.M., then renains constant.
The advance variation is obtained through the injection advance regulator, see fig. 321.
It consists of the flange **A** (fig. 321) splined to the camshaft and the carrier, both with the fulcrum on two pins, of the centrifugal weights **C** (fig. 322); of a counterflange **F** (fig. 321), integral with the injection cam and free to rotate on the camshaft, on which two slots are made where the pins **D** (fig. 323) connected to the centrifugal weights slide.
Appropriate springs **B** (fig. 322) are applied between the centrifugal weights **C** (fig. 322) and the flange **A** (fig. 321).




322

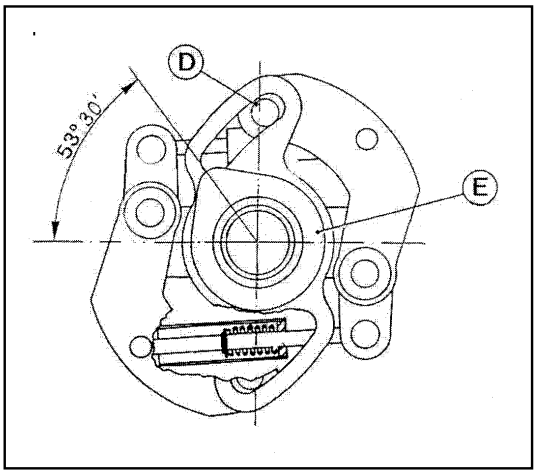
With the engine stopped and at low idling speed the spring load is higher than the weights centrifugal force, therefore they remain closed, see fig. 322.



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323

When the RPM increases, the centrifugal weights force becomes higher than the spring load, the weights move and through the pins **D** (fig. 323) engaged into the slots rotating the injection cam.
At 3500 R.P.M. the weights are completely open, see fig. 323 and the injection advance is 24° before P.M.S.



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**Clearance Check**

Rotate the crankshaft and bring the piston to the TDC at explosion level. Using a thickness gauge, check that clearance is 0.30 mm for the intake valve and 0.40 mm for the exhaust valve, when the engine is cold (fig. 324÷325).
If clearance does not match these measurements, proceed as follows:

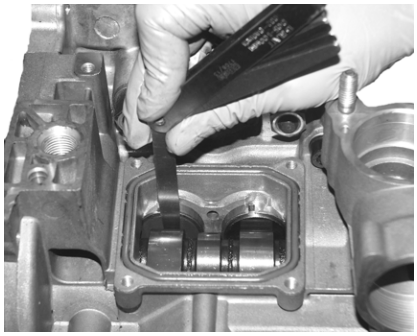
Turn the crankshaft backwards of about 40° (to avoid that the valves get stuck on the piston during the manual lowering phase). Turn the tappets until the cuts "**A**" (fig. 329) reach the top, making removal of the collars easier.
**2)** Insert the tool 981075.424 (fig. 326) between the intake tappet collar and the camshaft (fig.327) and push to compress totally the tappet. Insert the component **985620.320** (fig. 328) to keep the tappet lowered, and extract the component **981075.424** (fig. 328).
**3}** Disconnect the collar using a steel tip, extract it and replace it with one of a suitable size (fig. 329÷330). 28 collars from 3.25 mm to 4.60 mm are available as spare parts, as indicated in the following table.

**IMPORTANT:** the collar value is indicated on one of the surfaces of the collar itself, which during assembly should be facing the tappet. Using a micrometer, check that the real thickness of the collar corresponds to the indicated value.

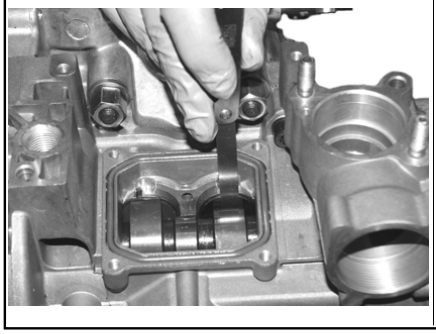
**Shim thickness for tappet gap adjustment**

Thickness 3,25 - 3,30 - 3,35 - 3,40 - 3,45 - 3,50 - 3,55 - 3,60 - 3,65 - 3,70 - 3,75 - 3,80 - 3,85 - 3,90 - 3,-95 - 4,00 - 4,05 - 4,10 - 4,15 - 4,20 - 4,25 - 4,30 - 4,35 - 4,40 - 4,45 - 4,50 - 4,55 - 4,60

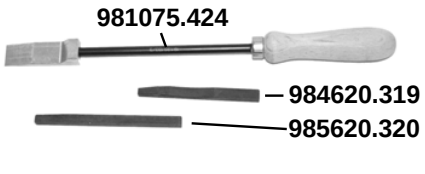
Tolerance ± 0,015



**324**



**325**

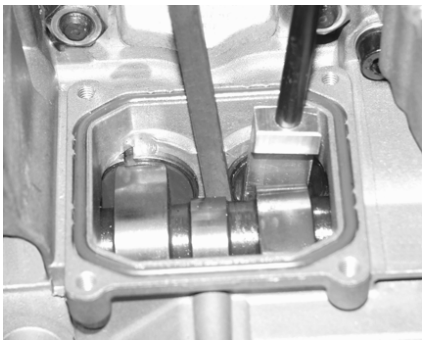



**tool 981075.424**

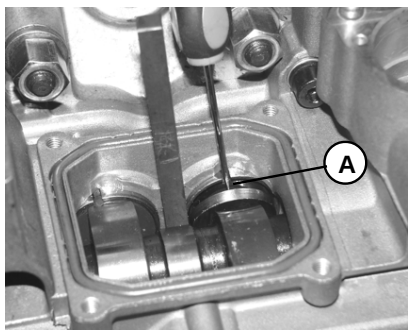
**326**



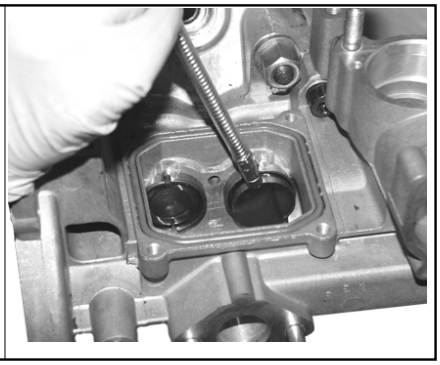
**327**



**328**




**329**



**330**



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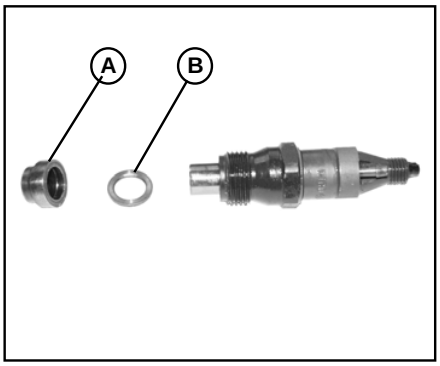
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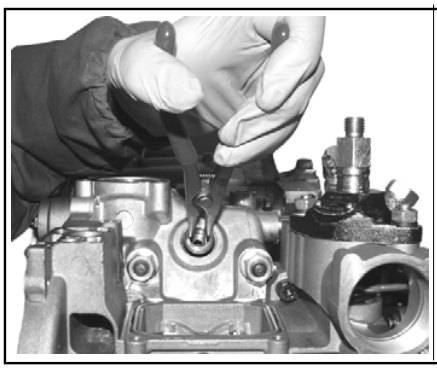
**Fireproof bulkhead and injector - Assembly**

Insert the fireproof bulkhead **A** into the seat on the head (fig. 332), place the copper seal **B** (fig. 333) on the injector, screw the injector into its seat and tighten it to a 70 Nm torque (fig. 334), as specified.

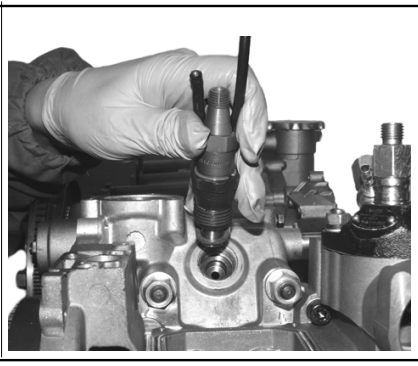
**Note:** The copper seal and the fireproof bulkhead must be replaced every time the injector is disassembled ( **A-B** fig. 331).



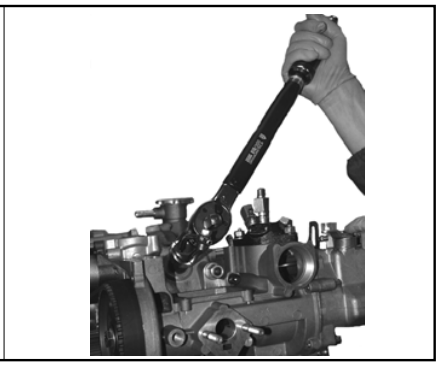

331



332



333



334

**FLAME BREAKER BUSH**

| PIECE NAME | NOMINAL DIMENSION | ASSEMBLING GAP |
|---|---|---|
| SPARK ARRESTOR OUTSIDE DIAMETER | 15,973 ÷16,00 | 0,00 ÷ 0,036 |
| SPARK ARRESTOR HOUSING | 16,00 ÷ 16,018 | |

**INJECTOR**

| PIECE NAME | NOMINAL DIMENSION | ASSEMBLING GAP |
|---|---|---|
| Nozzle holder | Ø 19,85 ÷19,97 | 1,03 ÷ 1,25 |
| Nozzle holder seat | Ø 21,00 ÷ 21,10 | |

**Thermostat – Assembly**

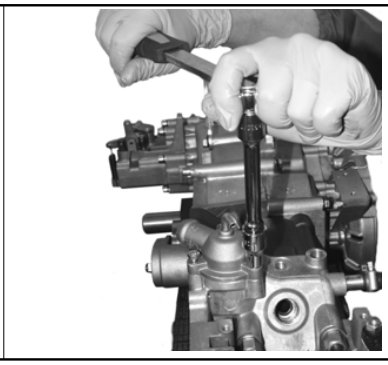
Place the thermostat in its housing in the thermostat head, making sure that the bleeding hole is assembled facing upwards (fig. 335). Check and replace the seal if necessary.
Tighten the fastening bolts at a 10÷12 Nm torque (fig. 335 A)

**Sensor for cooling liquid temperature indicator light – Assembling**

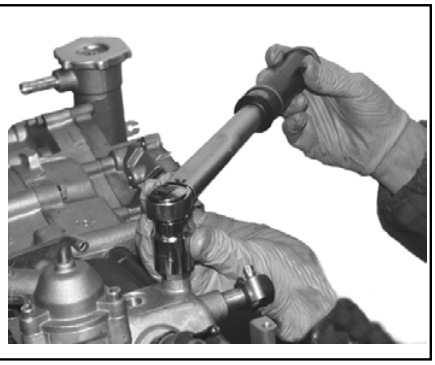
Screw the cooling liquid temperature sensor in its housing on the head.
Tighten it with a torque wrench to a 25 Nm torque ( fig. 335 B).



335



335 A



335 B



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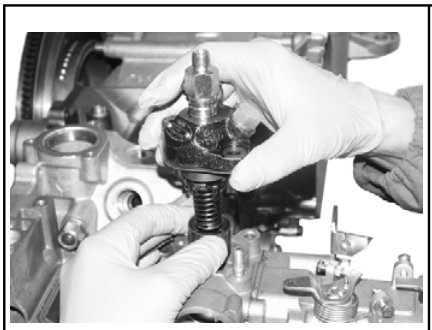
336

**Glow plug - Assembling**

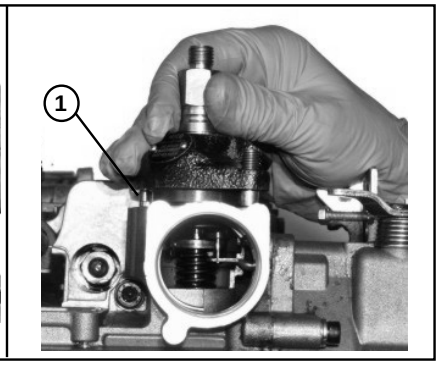
The glow plug must be tightened with the torque wrench to the indicated torque, because inside the head there is no limit stop and the glow plug threading is conical. An incorrect tightening would irreparably damage the cylinder head 15 Nm (fig. 336).

**Injection pump - Assembling**

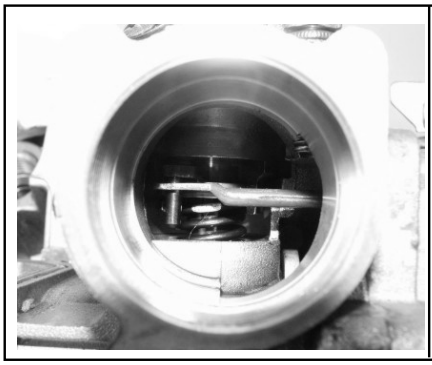
Insert the injection tappet with the relevant collar inside its housing on the camshaft support (fig. 337).
Insert the injection pump placing the gaskets which - thanks to their thickness - determine the static advance (fig.337).
The injection pump can be inserted on the support only in one direction, which is determined by the dowel **1** (fig. 338).
Looking through the special inspection hole, check the correct insertion of the pin which determinates the delivery of the injection pump into the hole of the rod controlled by the speed governor (fig. 339).
Screw the plug with the sealing ring on the inspection hole (fig. 340).
Tighten the fastening nuts of the injection pump to the support with a torque wrench at 30 Nm. (fig. 341).



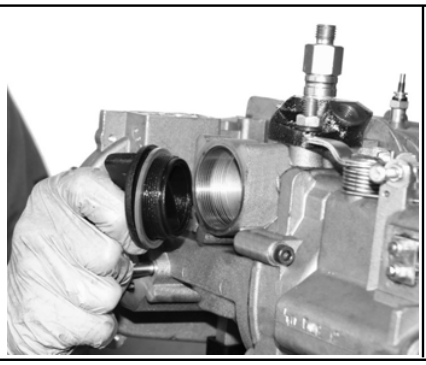
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338



339



340



341



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**INJECTION EQUIPMENT DESCRIPTION AND FUNTIONING**

**FUEL INJECTION**

In the Diesel engine the fuel is injected towards the end of the compression process into the precombustion chamber via the injection pump and relative injector.

The quantity of fuel injected for each cycle is regulated by a function of the power/capacity required through the rotation of the pumping element of the injection pump that is carried out by the regulation rod.

**FUEL FLOW CONTROL**

The regulation rod is set into action by the governor. The governor is connected to the upper part of the engine and is driven by a shaft connected with the camshaft.

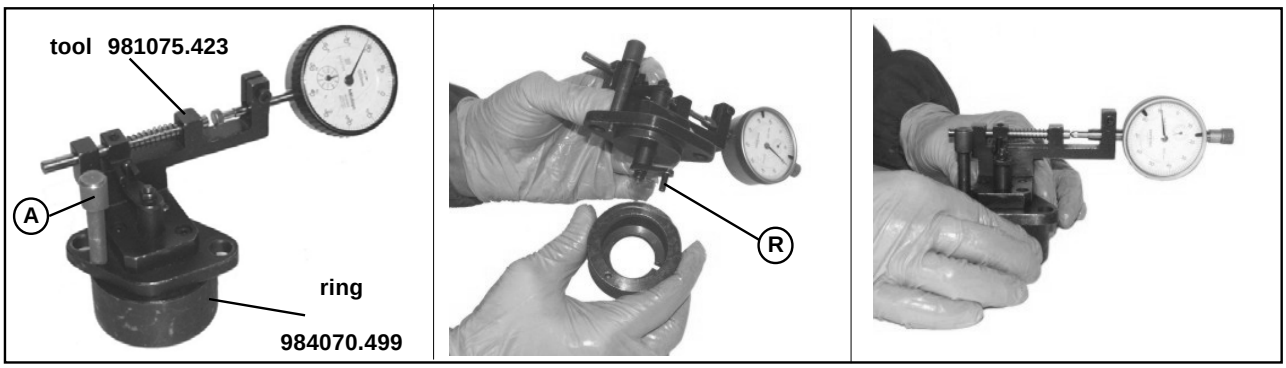
The principal functions of the governor are :

- engine idle speed control
- to limit engine maximum rpm
- to increase fuel flow at the engine starting.

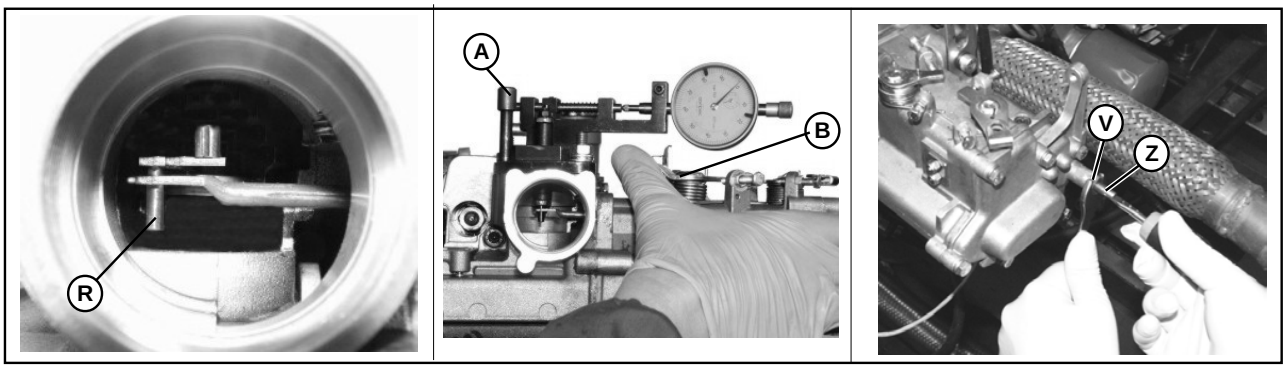
**Adjustment of pump control rod**

In case of engine overhauling or interventions on delivery control it is necessary to check the position of injection pump control rod and if necessary carry out the adjustment as follows: fit dial gauge on tool 981075.423, insert ring 984070.499 on tool making sure that pin **"R"**seats in its concerning slot; let tool reference 984070.499 hole match with the one of the ring; insert punch "**A**" and set to zero dial gauge.
Take away the ring **"A"** and fit the tool on the place of the injection pump making sure that pin "**R**" of tool is inserted into the hole of pump control rod, then fit reference punch "**A**" and lock the tool with both nuts.
Place lever "**B**" of accelerator to max. position and check that dial gauge is on the previously carried out zero setting position. If these conditions do not occur act on adjusting screw "**Z**" until such zero setting is realized.Lock, by holding the screw "**Z**" steady, lock-nut "**V**" and check by placing more times lever "**B**" to max position, that the dial gauge result is set to zero.

**Warning - The mentioned checking operations must be carried out without injection pump control tappet.**




342 343 344



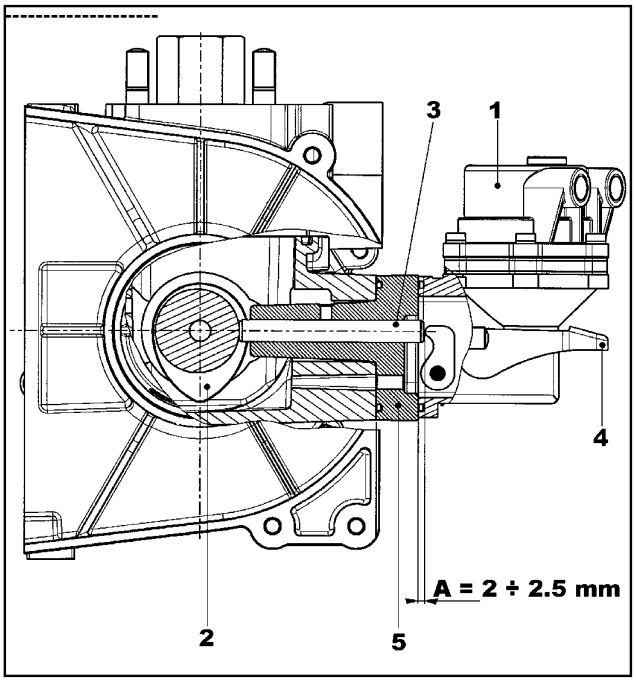

345 346 347



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**Fuel pump – Characteristics and components**

The diaphragm type fuel pump **1** is operated by a camshaft eccentric **2** through a rod **3**.
It is equipped with an external lever for the manual priming **4**.
A spacer **5** is inserted between the surface of the head and the surface of the fuel pump.

**Rod protrusion check**

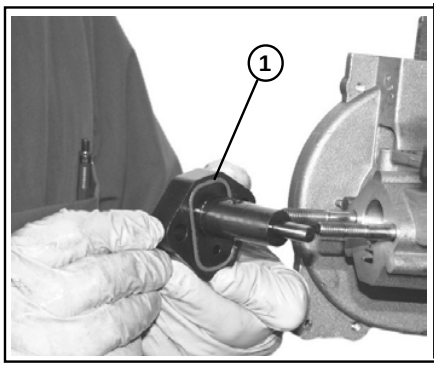
Rod protrusion from the spacer surface (measurement A) must be from 2 to 2.5 mm.
To make the protrusion fall into the specification (**A**) 2 rods are available with different leghth

**1** = mm 65.700 ± 0.050
**2** = mm 66.100 ± 0.050

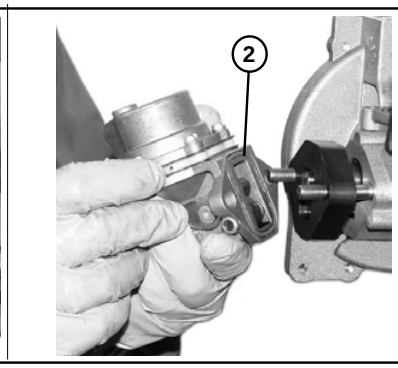
After checking with a dial indicator the protrusion of both rods, install the one which is in the specified tolerance (measurement **A**).
Check the rod protrusion from the spacer surface when the camshaft eccentric is at rest (on the cam bottom).

**Fuel pump - Reassembling**

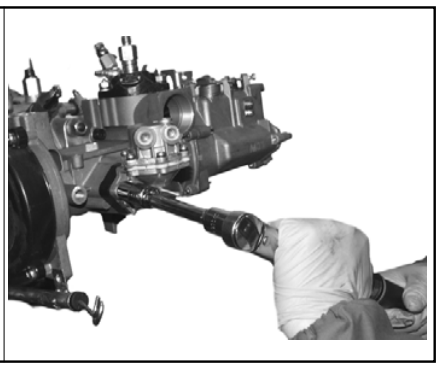
After checking the rod protrusion, we assemble the fuel pump.
Insert the spacer with the inserted rod in its housing on the camshaft support (fig. 348).
Check that the sealing ring **1** is properly fitted in its insert.
Assemble the fuel pump after checking the sealing ring **2** (fig. 349).
Tighten the two fastening nuts to a 20÷22 Nm torque (fig.350).




348




349



350

**Feeding pump**

| | |
|---|---|
| Minimum flow at 2000 r.p.m. of camshaft | : ≥ 100 l/h |
| Control lever stroke | : 2,0 mm |
| Feeding pressure at 2000 rpm of the camshaft | : 0,2 bar |



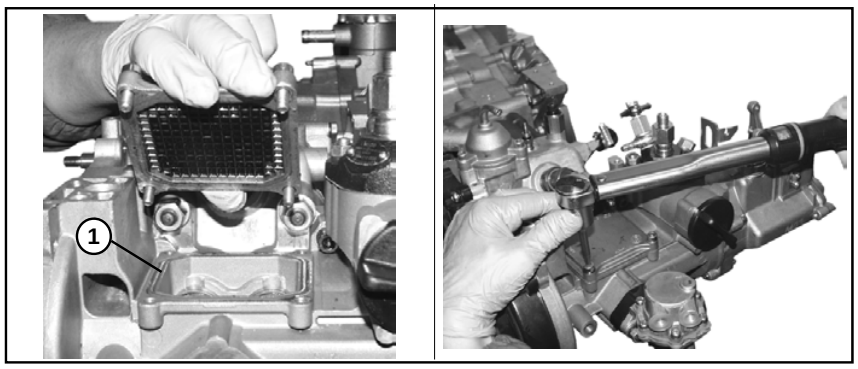
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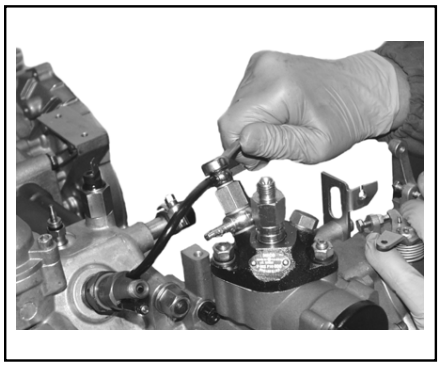


**Tappet cover - Assembly**

After replacing the rubber sealing ring **1** (fig. 351), reassemble the tappet cover and tighten the four M 6x20 fixing screws at 8 a torque of Nm (fig. 351-352)



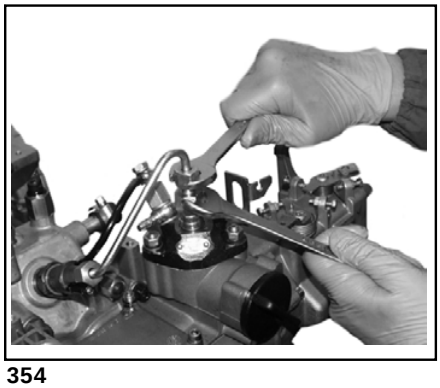

**351** **352**



**353**

**Fuel exhaust pipe - Assembly**

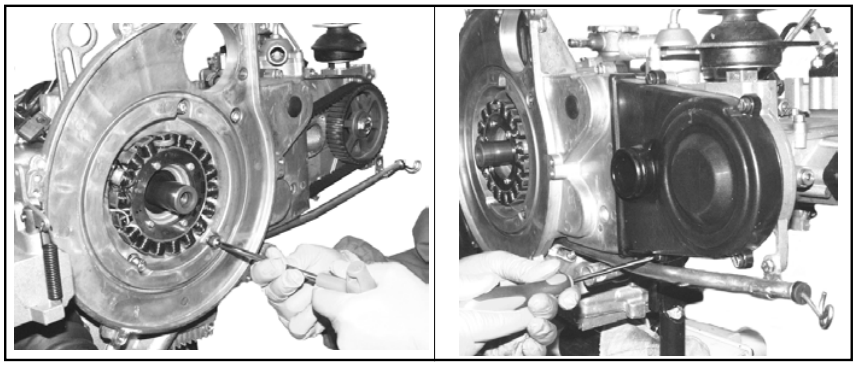
Use the special pliers to connect the pipe (RILSAN) to the injector and, on the opposite end, to the two-way banjo.
Fasten the banjo to the union on the injection pump by using a M 8 union bolt tightened at 20÷25 Nm (fig. 353).



**354**

**Injector-injection pump connecting pipe - Assembly**

Assemble the injector-injection pump pipe and tighten it at a 18÷20 Nm torque (fig. 354)



**355** **355a**

**Air shroud and stator support – Timing belt cover - Assembly**

Reassemble the air shroud and stator support and fasten it by means of the six screws: 4 to 20÷22 Nm and two with the cross-head screwdriver (fig. 355).

After fitting the timing belt cover using both a slot-head and a cross-head screwdriver, screw the six fixing screws (fig. 355a).



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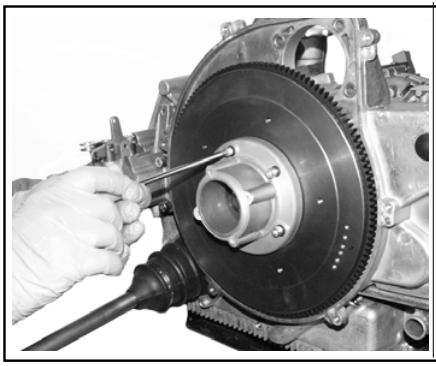


**Flywheel and cooling fan support - Assembly**

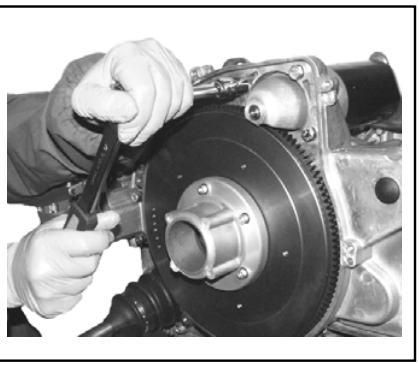
Reassemble the flywheel onto the crankshaft and then fasten it with the cone and the fastening bolt.
Use tool 981075.414 to lock the flywheel, thus allowing the fastening bolt to be tightened at 180÷200 Nm.
Assemble the cooling fan support onto the flywheel and fasten it by tightening the five screws at 12÷15 Nm (fig. 356).

**Starting motor - Assembly**

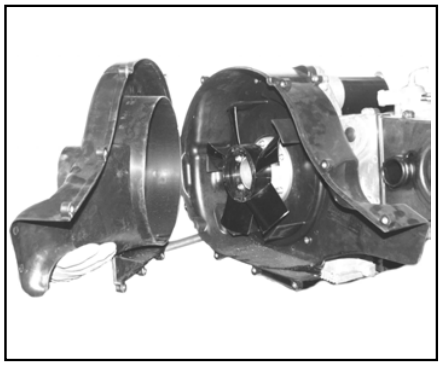
Assemble the starting motor by tightening the three M 8x40 screws at 29 Nm and the two M 6x22 anchoring bracket ones at 12÷15 Nm (fig. 357)



**356**



**357**



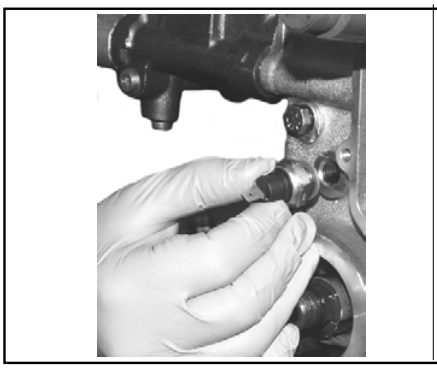
**358**

**Air shroud, cooling fan – Radiator shroud - Assembly**

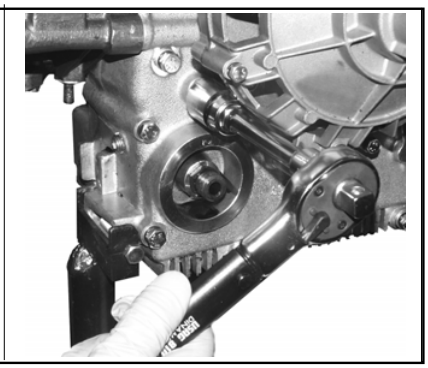
Fasten the cooling fan shroud to the cover by using the five M 6x20 screws.
Assemble the cooling fan onto its support, paying attention to the correct rotation direction, and the snap ring with the edge folded towards the outside.
Fasten the fan to the support by using the four screws at a 12÷15 Nm torque.
In the end, assemble the radiator shroud, fasten it by using the six M 6x20 and the three M 6x25 screws and then tighten them at a 0.8÷10 Nm torque (fig. 358).

**Minimum oil pressure switch - Assembly**

Reassemble the oil pressure switch placing a new seal, then tighten it at a torque of 22 Nm (fig. 359÷360)



**359**



**360**



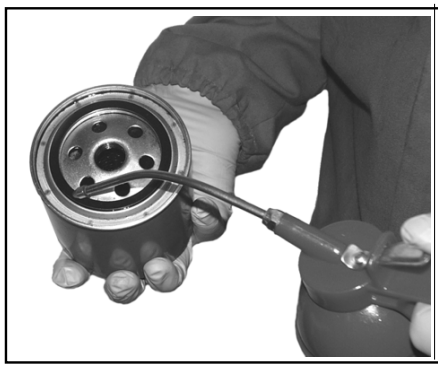
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**Oil filter - Assembly**

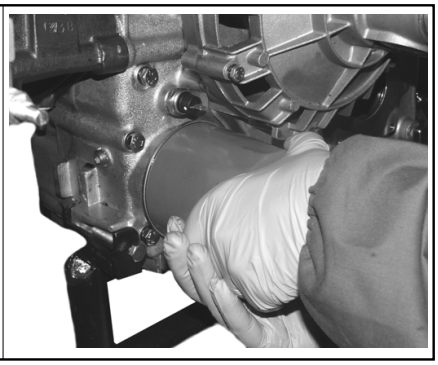
Lubricate and oil the seal between the oil filter and the support surface on the half casing using engine oil (fig. 361÷362). Then screw and tighten the cartridge manually (fig. 363).



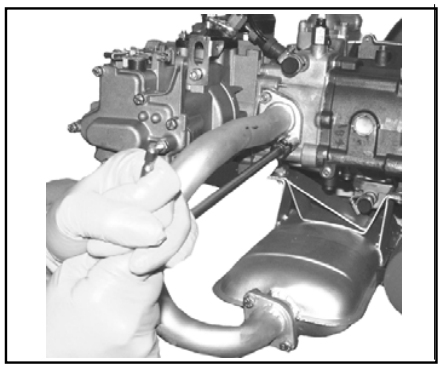
361



362



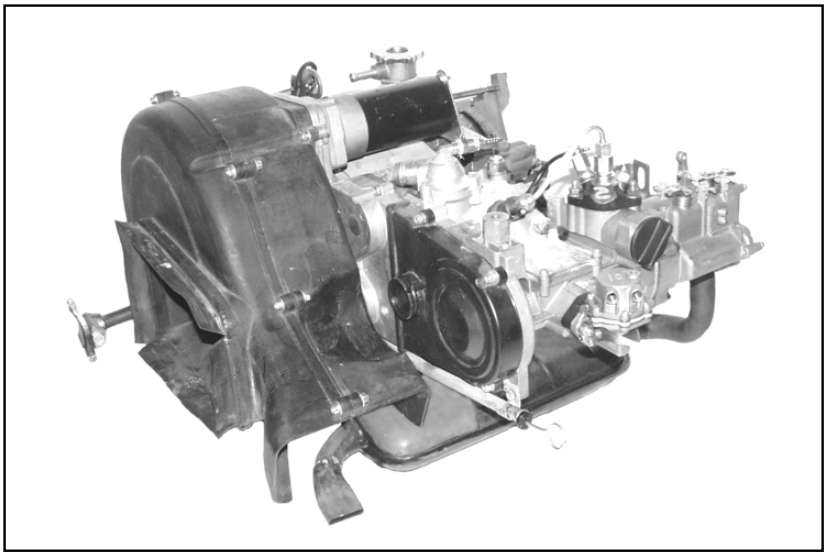
363



364

**Muffler - Assembly**

Insert the exhaust manifold by placing the seal between head and manifold.
Tighten the fastening nuts at 19÷21 Nm.
Tighten the muffler anchoring bracket nuts at 30 Nm.



365



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**Injection static advance timing**

Set the camshaft in timing phase and fix it with appropriate pin, serial number 8430.123 (fig. 367÷368).
Disassemble the whole speed governor support and remove the Oldham union (fig. 369).
Unscrew the injection advance variator fixing screw (fig. 371) and remove the injection advance variator weights with the proper puller (fig. 372).

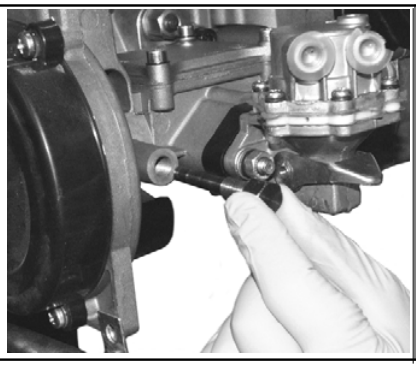


366

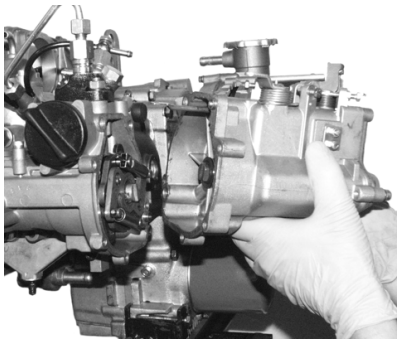


pin 8430.123

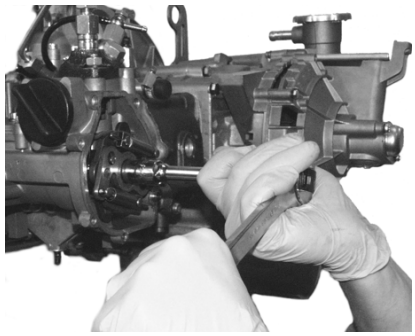
367



368



369

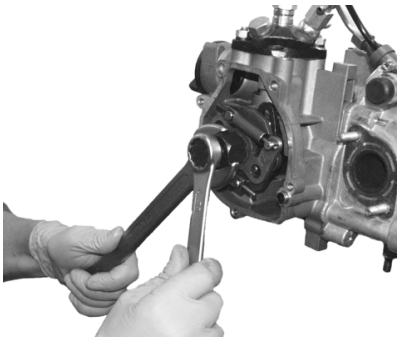


370



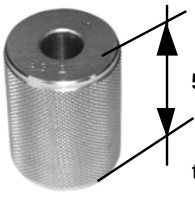
puller 981075.421

371



372

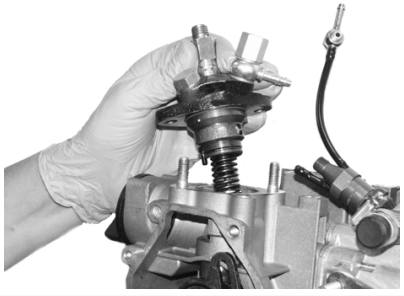
Disassemble the injection pump (fig. 374) and replace it with dial indicator (together with dial indicator holder) previously reset (fig. 375) by means of proper template 4200.051 to 53.2 mm (fig. 373).
Manually turn the injection cam (fig. 376) until it reaches its base and measure the difference – positive or negative – with value 53.2 mm.



53.2 mm

template 4200.051

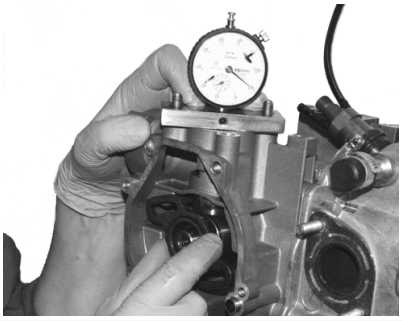
373



374



375



376



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Disassemble the dial indicator holder and replace it with tool 1460.192 (timing gauge) (fig. 377). If the previously measured difference with dial indicator was null (i.e. equal to given value 53.2 mm), insert four 0.1-mm shims (fig. 378-379) between the tool base plane and the guard base plane.
Otherwise, remove or add 0.1-mm shims according to the measured error.

For example: if the distance between guard base plane and injection cam base is less than 0.2 mm, add two 0.1-mm shims. If the distance is higher than 0.2 mm, remove two 0.1-mm shims.
Calculate and position the right number of shims between guard and tool base planes and fix the tool by means of proper knobs (fig. 380).

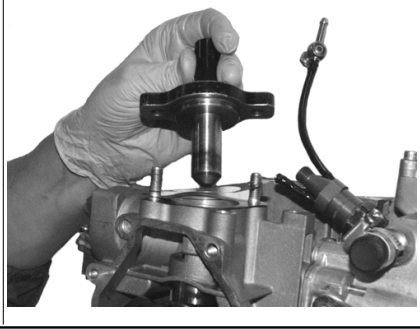


tool 1460.192

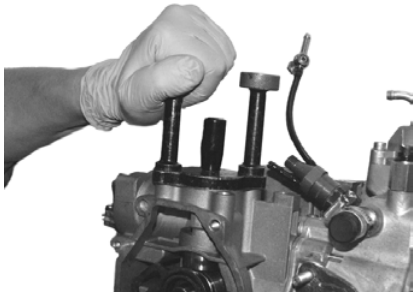
377



378

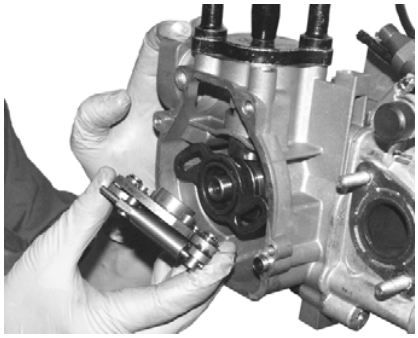


379

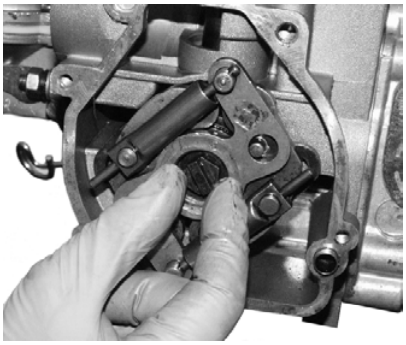


380

Reassemble the injection advance weights on the injection cam (fig. 381). Screw the fixing nut manually without tightening (fig. 382).
Insert tool, serial number 1460.193 (fig. 383) to correctly time the injection advance variator weights and injection cam.
Pay the utmost attention to correctly insert the tool pins into the advance variator slots (fig. 384).



381

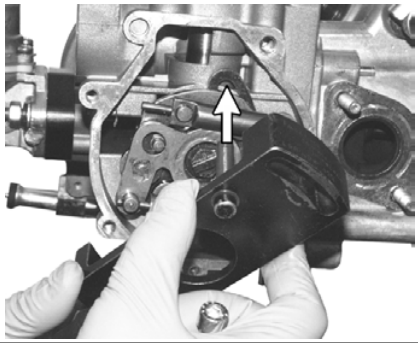


382



tool 1460.193

383



384

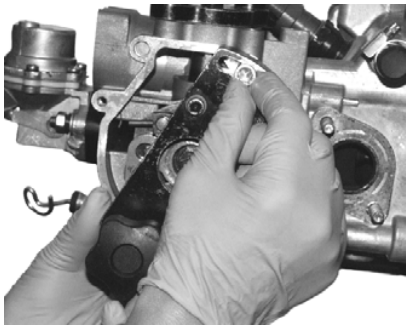


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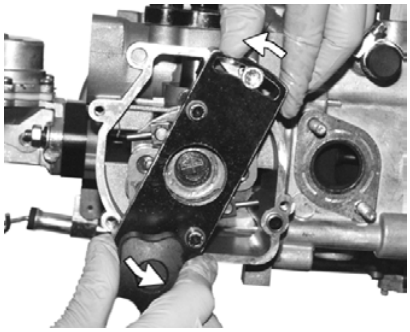
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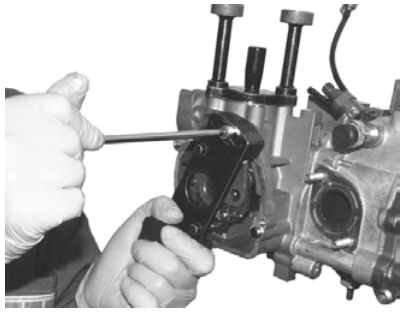
Screw the tool fixing upper screw manually without tightening (fig. 385)
Turn the tool anti-clockwise (fig. 386). It will time the advance variator in the correct position with the injection cam, in perfect contact with injection tappet.
Once the timing is completed, two operations are required: turn the proper knob anti-clockwise and simultaneously tighten the screw that fixes the tool and all parts connected and timed (injection advance variator, injection cam, camshaft and injection tappet) (fig. 387).
Now tighten the advance variator fixing screw to 25÷28 Nm by means of the torque wrench (fig. 388).



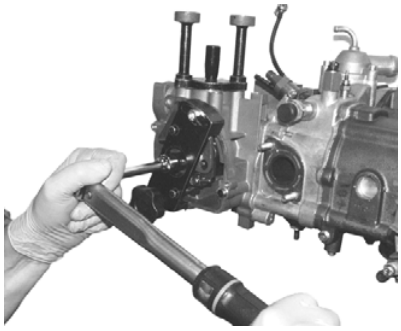
385



386



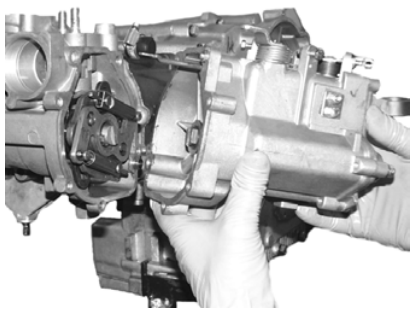
387



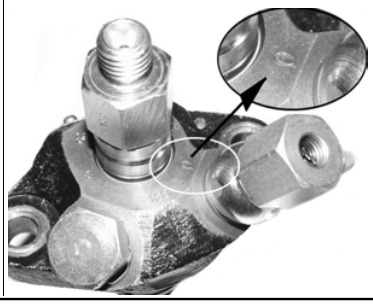
388

Disassemble the equipment, reassemble the Oldham union and coat all contact surfaces with loctite 510. Then, reassemble the speed governor support to the camshaft support.
Position the injection pump by inserting the measured shims between the two surfaces (injection pump÷guard), to which the shims required for the pump reset will be added or removed.
This value is given by the injection pump manufacturer and is marked on the pump case.

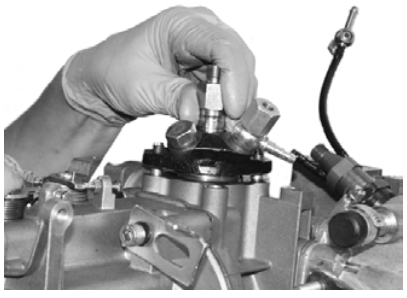
Example: - if the value marked on the pump case is 0, leave the shims as they are.
- if the value is -1, remove one 0.1-mm shim.
- if the value is +1, add one 0.1-mm shim.



389



390



391



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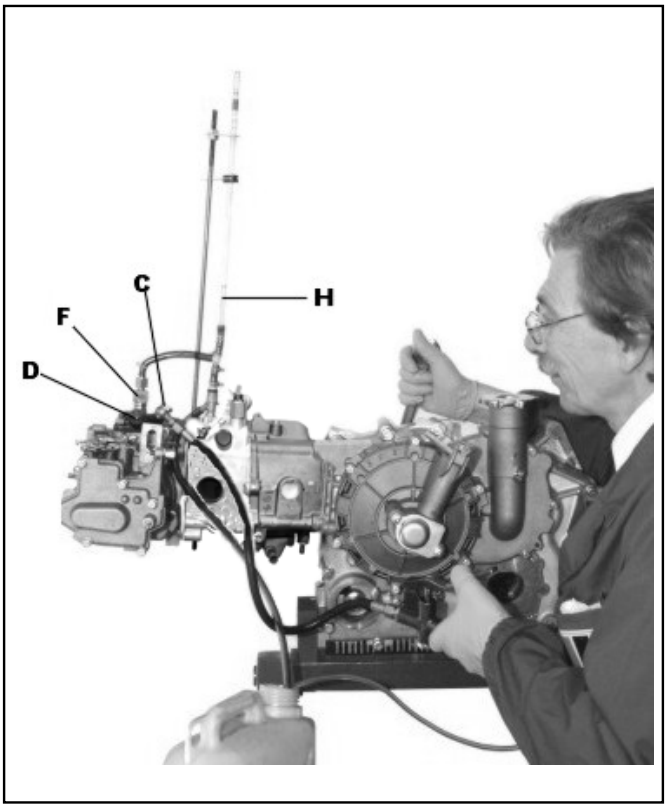
# NOTE



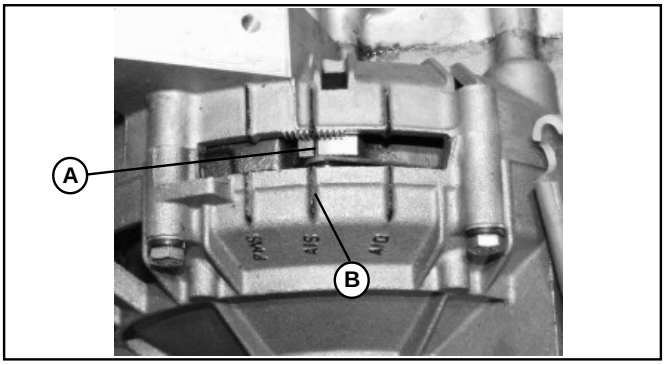
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392




393

**Then check injection advance tining as follows - A.**

**1)** Connect delivery pipe "**C**" of the proper hand pump (for inst. BOSCH Type) to the feed union of injection pump and insert suction pipe into a container filtered and full of gas oil and plug the hole of gas oil recovery "**D**" by means of a threaded plug.

**2)** Rotate the engine so as A.I.D. (dynamic injection advance) reference mark coincide on clutch cover (compression stroke).

**3)** Operate hand pump and bleed the circuit by means of plug on hole "**D**", previously fitted. Then exert pressure on the gas oil so as it comes out from injection union "**F**".

**4)** Fit a transparent pipe "**H**" on union "**F**". Operate again the pump and at the some time rotate the engine towards T.D.C. up the point where the climbing of gas oil in the transparent hose doesn't cease. Timing is correct if in such a point reference mark the clutch is aligned to A.I.S mark (static injection advance 11° before T.D.C.).

If the engine results are advanced or retarded replace the shins below the injection pump (as spares to this aim two packings of 0.2 mm and 0.3 mm are supplied) or fit more packings according to need. Bear in mind that by increasing 0.1 mm. the packing we obtain a retard of 1° and by reducing 0.1 mm the packing we have 1° in advance.

**N.B.** - In order to be certain of the correct timing of injection advance repeat more times the test carried out on the point 4.



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394

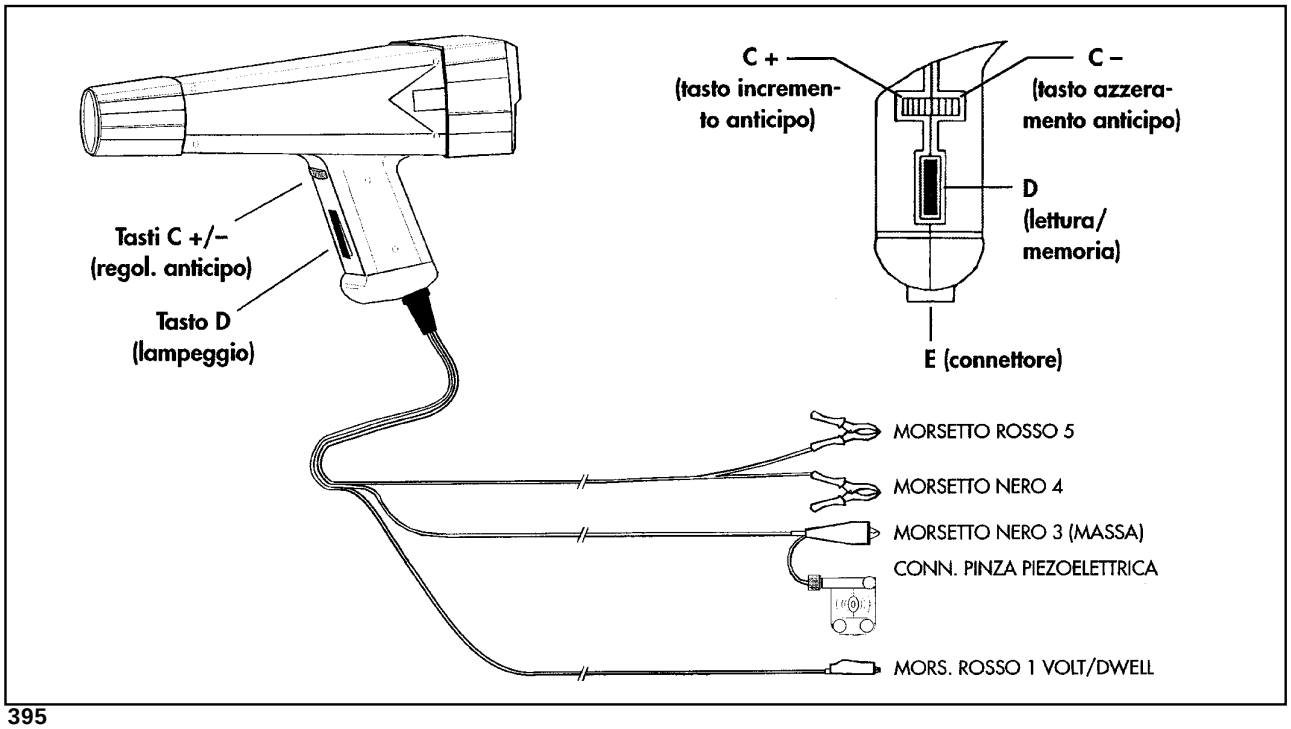
**Injection advance dynamic control - B**

The dynamic control of the injection advance is made through a suitable equipment - stroboscopic gun - according to the following:

**1**) Clean carefully the injection pipe and check that the sensor coupling zone "**V**" is free from scoring signs

**2)** Install the sensor "**V**" of tester, paying attention not to turn it after fastening. Connect the tester supply cable as shown in fig. 369

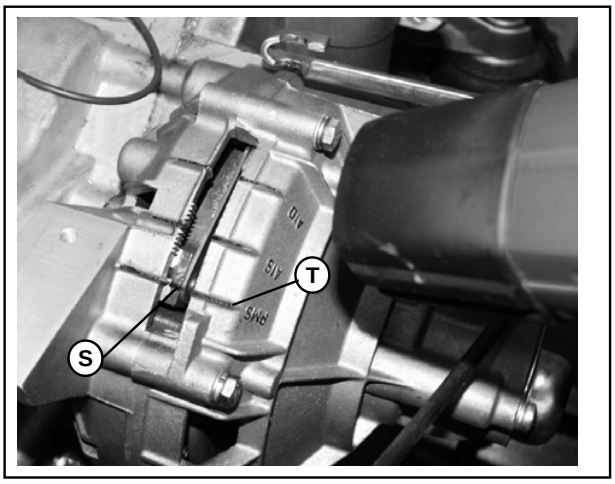
**3**) Start and heat the engine. With the engine idling at 1200 rpm, use the button on the stroboscopic gun to make path "**S**" on the clutch flywheel coincide with path "**T**" of TDC on the clutch cover. Check that the advance read on the tester display is 13°. Increase rpm rating gradually and check that at 3200 - 3500 rpm the advance gradually increased reaches 26° If the range is lower than the one provided, it is necessary to overhaul the advance variator.



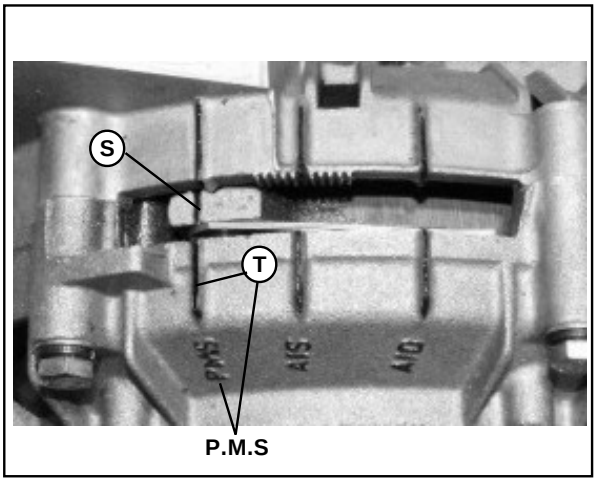

395



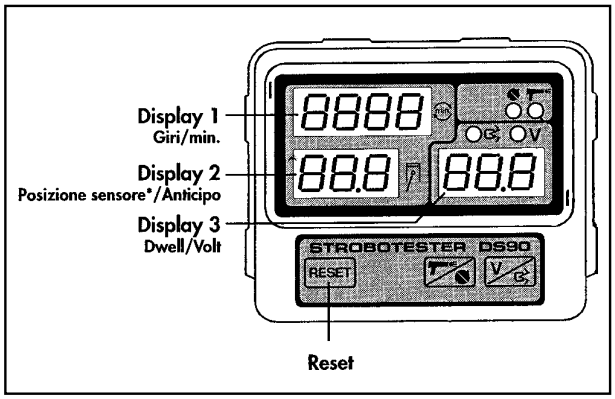
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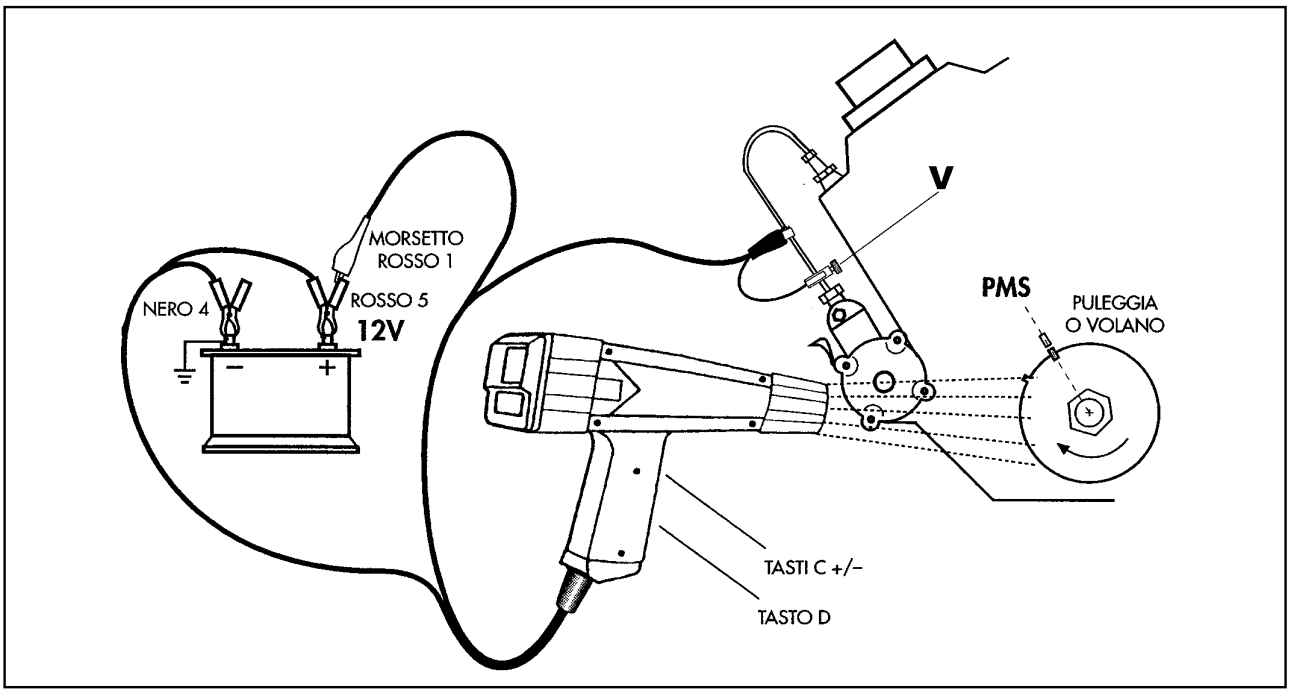

396




397




398




399

**4**) If the conditions described at point 3 are not satisfied, and the injection timing is advanced or delayed, replace or increase the gaskets under the injection pump, following the instructions given in Injection pump and checking the static injection advance relevant to the engine static timing.



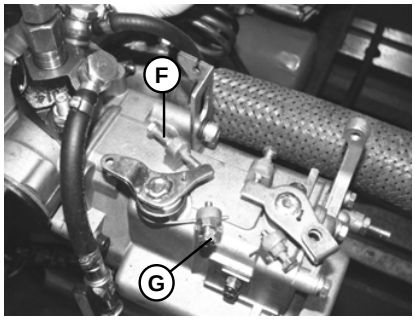
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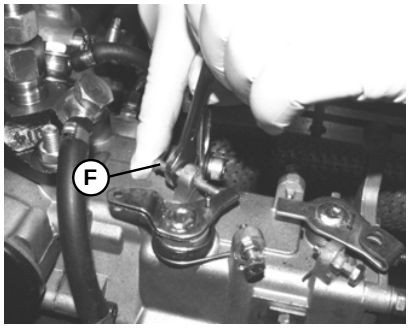


**Min. and max r.p.m. regulation**

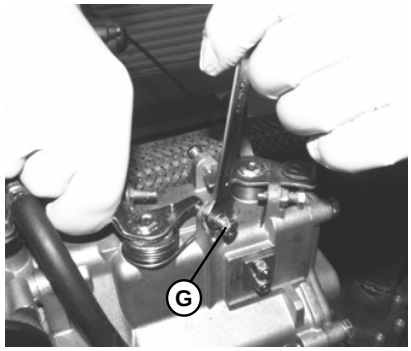
The operations of min. and max r-p.m. must be carried out with a warm engine, as follows: act after unlocking the lock nut, on screw "**F**" of accelerator lever position so as min. r.p.m. result 1200 and lock again lock nut. loosen the lock nut of screw "**G**", gradually accelerate the engine until 4150 r.p.m. are reached and by means of a screw limit accelerator lever stroke in this position and lock the lock nut.




400




401




402



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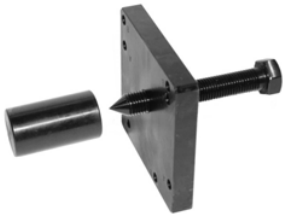
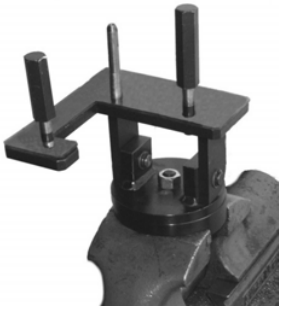
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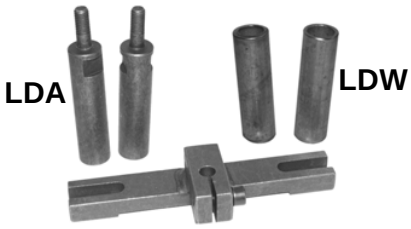
| DRAWING | DESCRIPTION | LOMBARDINI DRAWING CODE | LOMBARDINI PART CODE |
|---|---|---|---|
| 8430.124  | Timing reference tool A.G and Pin for camshaft timing | 5900.217 + part. 8430.124 | 5900.217 + part. 8430.124 |
|  | Pin for camshaft timing | 8430.123 | 8430 123 |
|  | Differential box extraction tool | 981075.411 | 1460.170 |
|  | Primary gear blocking tool | 981075.412 | 1460.169 |
|  | Flame protection cover extraction tool | 981075.413 | 1460.168 |
|  | Flywheel blocking tool | 981075.414 | 1460.172 |
|  | Bearing extractot diam. 35 mm | 981075.415 | 1460.166 |
|  | Head blocking tool | 981075.416 | 1460.165 |



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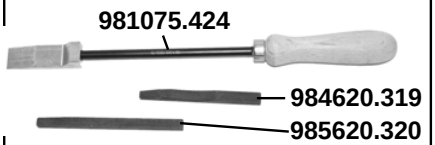
| DRAWING | DESCRIPTION | LOMBARDINI DRAWING CODE | LOMBARDINI PART CODE |
|---|---|---|---|
|   | Head seal identification tool | 981075.417 | 1460.163 |
|  | Flywheel extraction tool | 981075.418 | 1460.162 |
|  | Clutch extraction tool | 981075.419 | 1460.181 |
|   | Flywheel cone extraction tool | 981075.420 + 984651.457 | 1460.180 + 1460.179 |
|  | Anticipation extraction tool | 981075.421 | 1460.156 |
|  | Engine support tool 422 | 981075.422 | 1460.177 |
|  | Maximum load control tool | 981075.423 + 984070.499 | 1460.184 |



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| DRAWING | DESCRIPTION | LOMBARDINI DRAWING CODE | LOMBARDINI PART CODE |
|---|---|---|---|
|  | Valve plates replacement tools | 981075.424<br>+ 984620.319<br>+ 985620.320 | 1460.161 + 1460.182 + 1460.183 |
|  | Bearing extractor | 981075.425<br>+<br>984651.457 | 1460.178<br>+<br>1460.179 |
|  | Bearing extractor | 981075.426 | 1460.167 |
|  | Double fork to check the P-NP differential shaft | 984980.324 | 1460.158 |
|  | Clutch stop hook | 985110.039 | 1460.173 |
|  | Buffer handle | 985430.007 | 1460.176 |
|  | Piston insertion spring | 985820.212 | 1460.159 |
|  | Punch to install roller box on the primary shaft of the cover (flywheel side) | 986290.104 | 1460.187 |
|  | Punch for roller box for elbow shaft on clutch side | 986290.105 | 1460.174 |



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# XII TOOLS

| DRAWING | DESCRIPTION | LOMBARDINI DRAWING CODE | LOMBARDINI PART CODE |
|---|---|---|---|
|  | Punch for roller box for elbow shaft on flywheel side | 986290.106 | 1460.189 |
|  | Punch for roller box diam35 | 986290.107 | 1460.188 |
|  | Differential bearing punch | 986290.108 | 1460.175 |
|  | Punch to install sealing ring on the valve trach | 986290.109 | 1460.160 |
|  | Punch to install sealing rings | 986290.110 | 1460.157 |
|  | Comparator support to check the play of the engine gear | 986782.034 | 1460.164 |
|   | Punch to calk the crosspiece | 986800.254 + 986800.255 | 1460.186 e 1460.171 |
|  | Gear box ring nut tightening tool | 1460.206 | 1460.206 |
|  | Dial indicator calibration template for injection advance check | 4200.051 | 4200.051 |



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| DRAWING | DESCRIPTION | LOMBARDINI DRAWING CODE | LOMBARDINI PART CODE |
|---|---|---|---|
|  | Calibrated tool for injection cam positioning | 1460.192 | 1460.192 |
|  | Positioning tool for injection cam advance variator | 1460.193 | 1460.193 |
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# XIII MAIN TORQUE SPECIFICATIONS

## MAIN TORQUE SPECIFICATIONS

| POSITION | Diam. and pitch ( mm ) | Torque ( Nm ) |
|---|---|---|
| Connecting rod cap fixing nut | M 10x1 | 70 |
| Flywheel fixing screws | M 14x1,5 | 180÷200 |
| Clutch – fixing screws | M 22x1,5 | 120÷140 |
| Alternator rotor fixing screws | M 6 | 12÷15 |
| Clutch disk pusher fixing screw | M 6 | 10 |
| Primary ring gear of gear box fixing screw | M 14x1,5 | 120÷140 |
| Differential ring gear fixing screws | M 10x1,25 | 65÷70 |
| Half crankcases assembly screws | M 8 | 20÷22 |
| Clutch housing fixing screws | M 6 | 8 |
| Clutch cover fixing screws | M 6 | 8 |
| Axle shaft hood flange fixing screws | M 6 | 8 |
| Shift-select lever case fixing screws | M 6 | 8 |
| Shift-select lever case fixing screws | M 8 | 20÷22 |
| Belt tensioner fixing nut | M 10 | 40÷44 |
| Oil pressure switch | M 12x1,5 | 22 |
| Starter motor fixing screws | M 6 | 20÷22 |
| Muffler fastening nuts | M 8 | 30 |
| Speed governor protection fastening screws | M 6 | 8 |
| Air shroud fixing screws | M 6 | 8 |
| Cylinder head fixing nuts | M 10x1.25 | 40 Nm + 180° |
| Timing belt cover fixing screws | M 6 | 8 |
| Cylinder head fixing stud bolt | M 14x1,5 | 15 |
| Cam shaft carrier fixing screws | M 6x20 | 20÷22 |
| Timing toothed pulley fastening screw | M 10x1,25 | 70÷75 |
| Injection advance variator fastening screw | M 8 | 25÷28 |
| Injector | M 24 | 70 |
| Injection pump fixing screws | M 8 | 30 |
| Spark plug | M 12x1,25 | 15 |
| Feed pump fixing nuts | M 8 | 20÷22 |
| Tappet cover fixing screws | M 6 | 8 |
| Cylinder head exhaust manifold fixing nuts | M 8 | 19÷21 |
| Dipstick tube fixing screw | M 6 | 8 |
| Clamp for starter motor fixing screws | M 6 | 8 |
| Starter motor to clamp fixing nuts | M 6 | 8 |
| Oil duct plugs | M 26x1,5 | 6 |
| Injector – injection pump connecting pipe | M 12x1,5 | 20 |
| Stator fixing screws | M 5 | 4 |
| Piston cooling valve | M 7 | 12 |
| Water pump fixing screws | M 6x20 | 8 |
| Cooling liquid temperature indicator light sensor | M 14x1,5 | 25 |
| Engine side shroud fixing screws | M 6 | 10÷12 |
| Radiator side shroud fixing screws | M 6 | 8÷10 |
| Fan support screws | M 6 | 12÷15 |
| Fan fixing screws | M 6 | 12÷15 |
| Thermostatic valve cover fixing screws | M 6 | 10÷12 |
| Oil pump fastening screws | M 5x35 | 8 |
| Oil pump coil fastening screw | M 6x14 | 10÷12 |
| Spider clamping ring nut | | 25 |
| Spider control stem | | 50 |
| Water pump intake fitting | M 6x25 | 12 |
| Air shroud – stator support fastening screws | | 20÷22 |



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## STANDARD BOLT TORQUE SPECIFICATIONS

| DESCRIPTION |  | |  | |  | |
|---|---|---|---|---|---|---|
| Diameter x pitch (mm) | R ≥ 800 N/mm2 | | R ≥ 1000 N/mm2 | | R ≥ 1200 N/mm2 | |
| | Nm | Kgm | Nm | Kgm | Nm | Kgm |
| 4x0,70 | 3,6 | 0,37 | 5,1 | 0,52 | 6 | 0,62 |
| 5x0,80 | 7 | 0,72 | 9,9 | 1,01 | 11,9 | 1,22 |
| 6x1,00 | 12 | 1,23 | 17 | 1,73 | 20,4 | 2,08 |
| 7x1,00 | 19,8 | 2,02 | 27,8 | 2,84 | 33 | 3,40 |
| 8x1,25 | 29,6 | 3,02 | 41,6 | 4,25 | 50 | 5,10 |
| 9x1,25 | 38 | 3,88 | 53,4 | 5,45 | 64,2 | 6,55 |
| 10x1,50 | 52,5 | 5,36 | 73,8 | 7,54 | 88,7 | 9,05 |
| 12x1,75 | 89 | 9,09 | 125 | 12,80 | 150 | 15,30 |
| 14x2,00 | 135 | 13,80 | 190 | 19,40 | 228 | 23,30 |
| 16x2,00 | 205 | 21,00 | 289 | 29,50 | 347 | 35,40 |
| 18x2,50 | 257 | 26,30 | 362 | 37,00 | 435 | 44,40 |
| 20x2,50 | 358 | 36,60 | 504 | 51,50 | 605 | 61,80 |
| 22x2,50 | 435 | 44,40 | 611 | 62,40 | 734 | 74,90 |
| 24x3,00 | 557 | 56,90 | 784 | 80,00 | 940 | 96,00 |



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