

# WORK SHOP MANUAL


11LD522-3 series engines, p.no. 1-5302-616

## 11 LD 522/3

1<sup>st</sup> Edition



**SERVICE**

|   |                         |                   |                        |                    |                    |                          |   |          |
|---|-------------------------|-------------------|------------------------|--------------------|--------------------|--------------------------|---|----------|
| COMPILER TECNICI<br><i>M. M. M. M. M.</i> | REG. CODE<br>1-5302-616 | MODEL N°<br>50898 | DATE OF ISSUE<br>07-03 | REVISION <b>00</b> | DATE<br>14.07.2003 | ENDORSED<br><i>F. M.</i> |  | <b>1</b> |
|---|-------------------------|-------------------|------------------------|--------------------|--------------------|--------------------------|---|----------|



## 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).



|   |   |                         |                   |                        |             |                    |                                |
|---|---|-------------------------|-------------------|------------------------|-------------|--------------------|--------------------------------|
| 2 |  COMPILER TECNICI<br><i>M. Cimella</i> | REG. CODE<br>1-5302-616 | MODEL N°<br>50898 | DATE OF ISSUE<br>07-03 | REVISION 00 | DATE<br>14.07.2003 | ENDORSED<br><i>[Signature]</i> |
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## WARRANTY CERTIFICATE

The products manufactured by Lombardini Srl are warranted to be free from conformity defects for a period of 24 months from the date of delivery to the first end user.

For engines fitted to stationary equipment, working at constant load and at constant and/or slightly variable speed within the setting limits, the warranty covers a period up to a limit of 2000 working hours, if the above mentioned period (24 months) is not expired.

If no hour-meter is fitted, 12 working hours per calendar day will be considered.

For what concerns the parts subject to wear and deterioration (injection/feeding system, electrical system, cooling system, sealing parts, non-metallic pipes, belts) warranty covers a maximum limit of 2000 working hours, if the above mentioned period (24 months) is not expired.

For correct maintenance and replacement of these parts, it is necessary to follow the instructions reported in the documentation supplied with each engine.

To ensure the engine warranty is valid, the engine installation, considering the product technical features, must be carried out by qualified personnel only.

The list of the Lombardini authorized dealers is reported in the "Service" booklet, supplied with each engine.

Special applications involving considerable modifications to the cooling/lubricating system (for ex.: dry oil sump), filtering system, turbo-charged models, will require special written warranty agreements.

Within the above stated periods Lombardini Srl directly or through its authorized network will repair and/or replace free of charge any own part or component that, upon examination by Lombardini or by an authorized Lombardini agent, is found to be defective in conformity, workmanship or materials.

Any other responsibility/obligation for different expenses, damages and direct/indirect losses deriving from the engine use or from both the total or partial impossibility of use, is excluded.


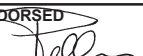

The repair or replacement of any component will not extend or renew the warranty period.

Lombardini warranty obligations here above described will be cancelled if:

- Lombardini engines are not correctly installed and as a consequence the correct functional parameters are not respected and altered.
- Lombardini engines are not used according to the instructions reported in the "Use and Maintenance" booklet supplied with each engine.
- Any seal affixed to the engine by Lombardini has been tampered with or removed.
- Spare parts used are not original Lombardini.
- Feeding and injection systems are damaged by unauthorized or poor quality fuel types.
- Electrical system failure is due to components, connected to this system, which are not supplied or installed by Lombardini.
- Engines have been disassembled, repaired or altered by any part other than an authorized Lombardini agent.

Following expiration of the above stated warranty periods and working hours, Lombardini will have no further responsibility for warranty and will consider its here above mentioned obligations for warranty complete.

Any warranty request related to a non-conformity of the product must be addressed to the Lombardini Srl service agents.

|   |                         |                   |                        |                    |                    |   |          |
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**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.

| POSSIBLE CAUSE               |  | TROUBLE               |                         |                 |                   |             |             |                      |                    |                           |                                    |
|------------------------------|--|-----------------------|-------------------------|-----------------|-------------------|-------------|-------------|----------------------|--------------------|---------------------------|------------------------------------|
|                              |  | Engine does not start | Engine starts but stops | No acceleration | Non-uniform speed | Black smoke | White smoke | Too low oil pressure | Increase oil level | Excessive oil consumption | Oil and fuel dripping from exhaust |
| FUEL CIRCUIT                 | Clogged pipes                          | •                     |                         | •               |                   |             |             |                      |                    |                           |                                    |
|                              | Clogged fuel filter                    | •                     | •                       | •               |                   |             | •           |                      |                    |                           |                                    |
|                              | Air inside fuel circuit                | •                     | •                       | •               | •                 |             | •           |                      |                    |                           |                                    |
|                              | Clogged tank breather hole             | •                     | •                       | •               |                   |             |             |                      |                    |                           |                                    |
|                              | Faulty fuel pump                       | •                     | •                       |                 |                   |             |             |                      |                    |                           |                                    |
|                              | Injector jammed                        | •                     |                         |                 |                   |             |             |                      |                    |                           |                                    |
|                              | Jammed injection pump delivery valve   | •                     |                         |                 |                   |             |             |                      |                    |                           |                                    |
|                              | Wrong injector setting                 |                       |                         |                 |                   | •           |             |                      |                    | •                         |                                    |
|                              | Excessive plunger blow-by              | •                     |                         |                 |                   | •           |             | •                    |                    |                           |                                    |
|                              | Jammed injection pump delivery control | •                     |                         | •               | •                 |             |             |                      |                    |                           |                                    |
| Wrong injection pump setting |  | •                     | •                       | •               | •                 |             |             |                      |                    |                           |                                    |
| LUBRICATION                  | Oil level too high                     |                       |                         |                 | •                 |             | •           |                      | •                  |                           |                                    |
|                              | Jammed pressure relief valve           |                       |                         |                 |                   |             |             | •                    |                    |                           |                                    |
|                              | Worn oil pump                          |                       |                         |                 |                   |             |             | •                    |                    |                           |                                    |
|                              | Air inside oil suction pipe            |                       |                         |                 |                   |             |             | •                    |                    |                           |                                    |
|                              | Faulty pressure gauge or switch        |                       |                         |                 |                   |             |             | •                    |                    |                           |                                    |
| Clogged oil suction pipe     |  |                       |                         |                 |                   |             | •           |                      |                    |                           |                                    |
| ELECTRIC SYSTEM              | Battery discharged                     | •                     |                         |                 |                   |             |             |                      |                    |                           |                                    |
|                              | Wrong or inefficient cable connection  | •                     |                         |                 |                   |             |             |                      |                    |                           |                                    |
|                              | Defective ignition switch              | •                     |                         |                 |                   |             |             |                      |                    |                           |                                    |
|                              | Defective starter motor                | •                     |                         |                 |                   |             |             |                      |                    |                           |                                    |
| MAINTENANCE                  | Clogged air filter                     | •                     |                         | •               |                   | •           |             |                      | •                  |                           |                                    |
|                              | Excessive idle operation               |                       |                         |                 |                   |             | •           |                      | •                  | •                         |                                    |
|                              | Incomplete running-in                  |                       |                         |                 |                   |             | •           |                      | •                  | •                         |                                    |
|                              | Engine overloaded                      | •                     | •                       | •               |                   | •           |             |                      |                    |                           |                                    |
| SETTINGS/REPAIRS             | Advanced injection                     | •                     |                         |                 |                   |             |             |                      |                    |                           |                                    |
|                              | Delayed injection                      | •                     |                         |                 |                   | •           | •           |                      |                    |                           |                                    |
|                              | Incorrect governor linkage adjustment  | •                     |                         |                 | •                 |             |             |                      |                    |                           |                                    |
|                              | Broken or loose governor spring        |                       | •                       | •               |                   |             |             |                      |                    |                           |                                    |
|                              | Idle speed too low                     |                       | •                       |                 | •                 |             |             |                      |                    |                           |                                    |
|                              | Worn or jammed piston rings            |                       |                         |                 |                   |             | •           |                      | •                  | •                         |                                    |
|                              | Worn or scored cylinders               |                       |                         |                 |                   |             | •           |                      | •                  | •                         |                                    |
|                              | Worn valve guides                      |                       |                         |                 |                   |             | •           |                      | •                  | •                         |                                    |
|                              | Jammed valves                          | •                     |                         |                 |                   |             |             |                      |                    |                           |                                    |
|                              | Worn bearings                          |                       |                         |                 |                   |             |             | •                    |                    |                           |                                    |
|                              | Governor linkage not free to slide     | •                     | •                       |                 | •                 |             |             |                      |                    |                           |                                    |
|                              | Drive shaft not free to slide          |                       |                         |                 |                   | •           |             |                      |                    |                           |                                    |
| Damaged cylinder head gasket | •                                      |                       |                         |                 |                   |             |             |                      |                    |                           |                                    |

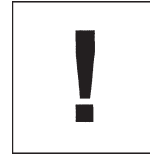
## SAFETY AND WARNING DECALS

### 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**




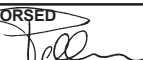

## SAFETY INSTRUCTIONS

- 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 unless 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.

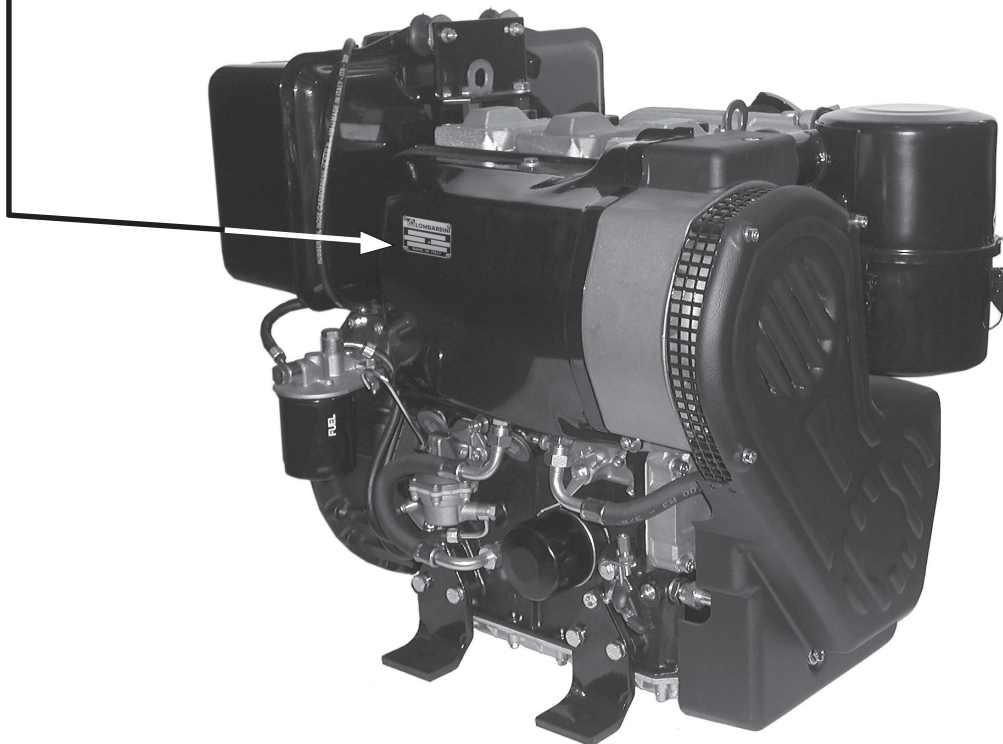
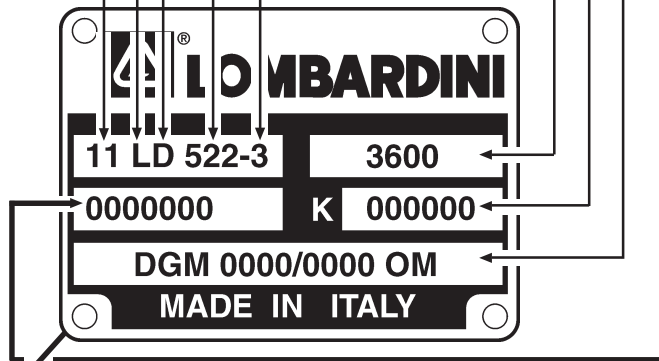
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**MODEL NUMBER**

Nr. Cylinders \_\_\_\_\_  
 Displacement (cc) \_\_\_\_\_  
 Diesel \_\_\_\_\_  
 LOMBARDINI \_\_\_\_\_  
 Engine group number \_\_\_\_\_

**ENGINE IDENTIFICATION**

R.P.M. \_\_\_\_\_  
 Customer's code \_\_\_\_\_  
 Approval code \_\_\_\_\_  
 Engine Serial Number \_\_\_\_\_



**CHARACTERISTICS**

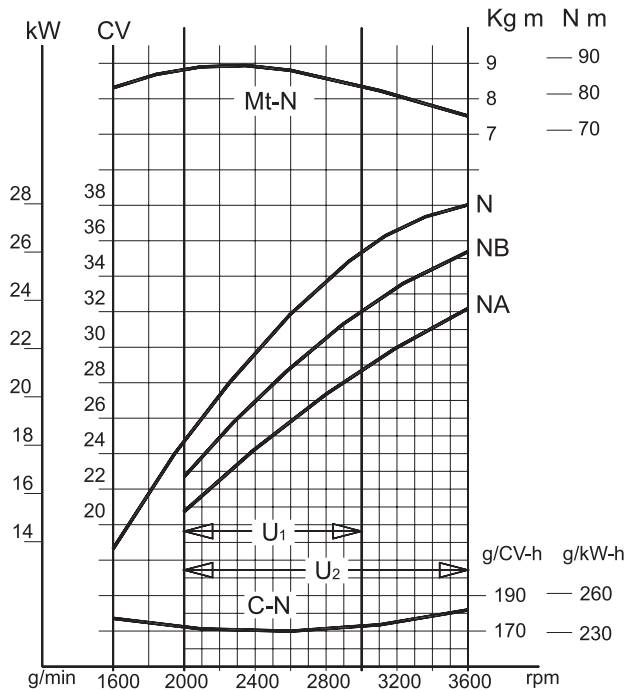
| <b>ENGINE TYPE</b>  |   | <b>11 LD522/3</b> |            |
|---|---|-------------------|------------|
| Number of cylinders   | N.  |                   | 3          |
| Bore  | m m                                       |                   | 85         |
| Stroke  | m m                                       |                   | 92         |
| Swept volume  | cm <sup>3</sup>                           |                   | 1566       |
| Compression ratio   |   |                   | 18:1       |
| Power kW (HP)   | N 80/1269/CEE-ISO 1585                    | @ 3000 RPM        | 26(35,4)   |
|   |   | @ 3600 RPM        | 28(38)     |
|   | NB ISO 3046 - 1 IFN                       | @ 3000 RPM        | 23,5(32)   |
|   |   | @ 3600 RPM        | 26(35,4)   |
|   | NA ISO 3046 - 1 ICXN                      | @ 3000 RPM        | 21(28,6)   |
|   |   | @ 3600 RPM        | 23,6(32,1) |
| Max. torque *   | Nm  |                   | 88@2200    |
| Fuel consumption **   | g/kW.h                                    |                   | 230        |
| Oil consumption   | g/kW.h                                    |                   | 0,8        |
| Capacity of standard oil sump                                   | lt  |                   | 4,3        |
| Recommended battery 12V   | Ah -A                                     |                   | 90-450     |
| Dry weight  | kg  |                   | 147        |
| Combustion air volume   | m <sup>3</sup> /h                         |                   | 170        |
| Cooling air volume  | m <sup>3</sup> /h                         |                   | 1523       |
| Max.permissible driving shaft axial: continuous (instantaneous) | kg.                                       |                   | 650(300)   |
| Max. inclination  | Fan site: continuous (instantaneous)      |                   | 25°(45°)   |
|   | Flywheel site: continuous (instantaneous) |                   | 25°(35°)   |
|   | Lateral: continuous (instantaneous)       |                   | 25°(40°)   |

\* Referred to N power

\*\* Consumption at max torque

CHARACTERISTICS POWER, TORQUE AND SPECIFIC FUEL CONSUMPTION CURVES

11 LD 522/3




- N (80/1269/EEC - ISO 1585)** **AUTOMOTIVE RATING** : Intermittent operation with variable speed and variable load.
- NB (ISO 3046 - 1 IFN)** **RATING WITH NO OVERLOAD CAPABILITY**: continuous light duty operation with constant speed and variable load.
- NA (ISO 3046 - 1 ICXN)** **CONTINUOUS RATING WITH OVERLOAD CAPABILITY**: continuous heavy duty with constant speed and constant load.
- Mt-N Torque at N power.**
- C** Specific fuel consumption at N power.
- U1:** Standard utilization range of engines rated at 3000 rpm
- U2:** Standard utilization range of engines rated at 3600 rpm

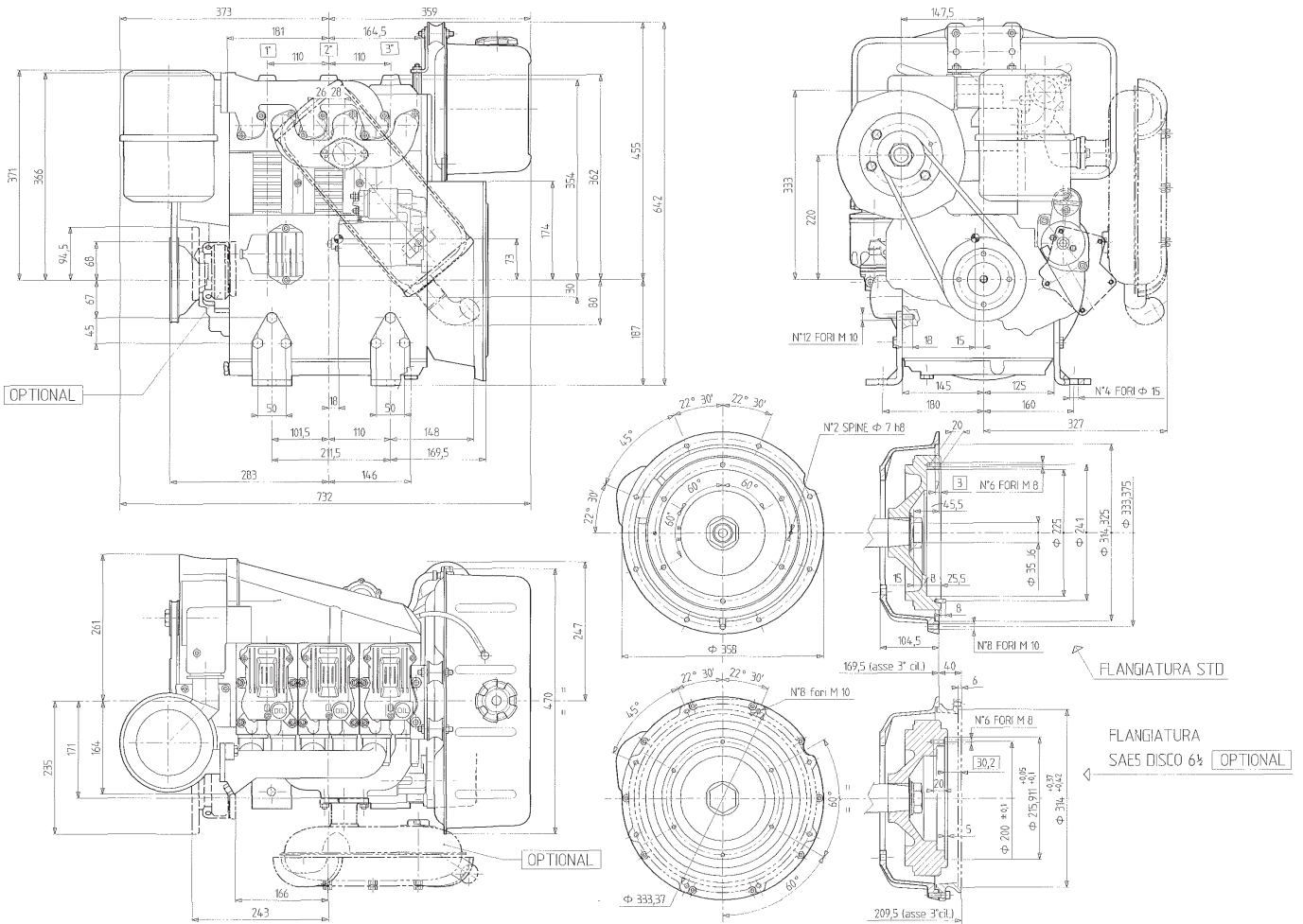
The above power values refer to an engine fitted with air cleaner and standard muffler, after testing and at the environmental conditions of 20°C and 1 bar.

Max. power tolerance is 5%.

Power decreases by approximately 1% every 100 m di altitude and by 2% every 5°C above 25°C.

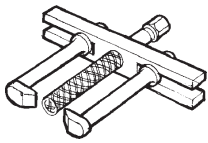
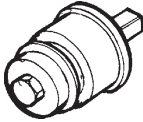
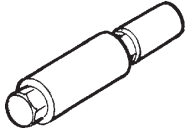

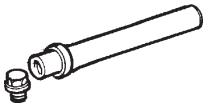

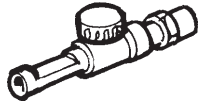
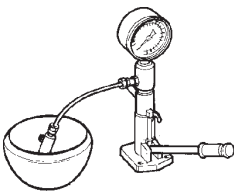
**Note:** Consult LOMBARDINI for power, torque curves and specific consumptions at rates differing from those given above.

|    |  |            |          |               |             |            |                    |
|----|--|------------|----------|---------------|-------------|------------|--------------------|
| 12 |  COMPILER TECNICI<br><i>M. Primella</i> | REG. CODE  | MODEL N° | DATE OF ISSUE | REVISION 00 | DATE       | ENDORSED           |
|    |  | 1-5302-616 | 50898    | 07-03         |             | 14.07.2003 | <i>[Signature]</i> |



Note: Dimensions in mm

|  |                         |                   |                        |                    |                    |                          |  |           |
|--|-------------------------|-------------------|------------------------|--------------------|--------------------|--------------------------|--|-----------|
| COMPILER TECNICI<br><i>M. M. M. M.</i> | REG. CODE<br>1-5302-616 | MODEL N°<br>50898 | DATE OF ISSUE<br>07-03 | REVISION <b>00</b> | DATE<br>14.07.2003 | ENDORSED<br><i>F. M.</i> |  | <b>13</b> |
|--|-------------------------|-------------------|------------------------|--------------------|--------------------|--------------------------|--|-----------|

| TOOL  | CODE       | DESCRIPTION                     |
|---|------------|---------------------------------|
|    | 00365R0010 | Universal puller                |
|    | 00366R0060 | Main bearing extractor          |
|    | 00365R0880 | By-pass valve extractor         |
|    | 00365R0910 | Central bearing assembly tool   |
|   | 00365R0930 | Valve guide rubber fitting tool |
|  | 00365R0770 | Cylinder collar Ø 80/85 mm      |
|  | 00365R0940 | Injection advance control tool  |
|  | 00365R0430 | Injector test bench             |
|   |            |                                 |
|   |            |                                 |
|   |            |                                 |



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

**MANUTENANCE**

| OPERATION          | COMPONENT                     |                 | INTERVAL (HOURS) |    |     |     |     |      |      |   |
|--------------------|-------------------------------|-----------------|------------------|----|-----|-----|-----|------|------|---|
|                    |                               |                 | 8                | 50 | 200 | 300 | 500 | 2500 | 5000 |   |
| CLEANING           | OIL-BATH AIR CLEANER          |                 | (*)              | ●  |     |     |     |      |      |   |
|                    | HEAD AND CYLINDER FINS        |                 | (*)              | ●  |     |     |     |      |      |   |
|                    | FUEL TANK                     |                 |                  |    |     |     | ●   |      |      |   |
|                    | INJECTOR                      |                 |                  |    |     |     | ●   |      |      |   |
| CHECK              | LEVEL                         | AIR CLEANER OIL |                  | ●  |     |     |     |      |      |   |
|                    |                               | OIL SUMP        |                  | ●  |     |     |     |      |      |   |
|                    |                               | BATTERY FLUID   |                  |    | ●   |     |     |      |      |   |
|                    | VALVE/ROCKER ARM CLEARANCE    |                 |                  |    |     |     | ●   |      |      |   |
|                    | BELT TENSION                  |                 |                  |    |     | ●   |     |      |      |   |
|                    | INJECTOR SETTING              |                 |                  |    |     |     | ●   |      |      |   |
| REPLACEMENT        | OIL                           | AIR CLEANER     | (**)             | ●  |     |     |     |      |      |   |
|                    |                               | SUMP            | (**)(***)        |    | □   | ●   |     |      |      |   |
|                    | EXTERNAL OIL FILTER CARTRIDGE |                 |                  |    |     | ●   |     |      |      |   |
|                    | FUEL FILTER CARTRIDGE         |                 |                  |    |     | ●   |     |      |      |   |
|                    | DRY AIR CLEANER CARTRIDGE     |                 |                  |    |     | ●   |     |      |      |   |
|                    | BELT                          |                 |                  |    |     |     |     | ●    |      |   |
| OVERALL INSPECTION | PARTIAL                       |                 | (x)              |    |     |     |     |      | ●    |   |
|                    | COMPLETE                      |                 | (xx)             |    |     |     |     |      |      | ● |

- First replacement
- (\*) Under severe working conditions, clean daily.
- (\*\*) Under extremely dusty conditions, change every 4-5 hours.
- (\*\*\*) See recommended oil type.
- (x) The partial overhaul includes the following operations: valve and seat lapping, injector and injection pump overhaul, injector projection check, fuel injection spark advance check, check of the harmful area between head and piston, camshaft and crankshaft end float check, tightening of bolts.
- (xx) The general overhaul includes - in addition to all partial overhaul - the following procedures: cylinder and piston replacement, seat, guide and valve refacing, crankshaft replacement or grinding, bench bearing and connecting rod replacement.

The maintenance operations listed above refer to an engine operating in normal conditions (temperature, degree of humidity, dust in the working environment). They may vary significantly according to the type of use.



To avoid explosions or fire outbreaks, do not smoke or use naked flames during the operations. Fuel vapours are highly toxic. Only carry out the operations outdoors or in a well ventilated place. Keep your face well away from the plug to prevent harmful vapours from being inhaled. Dispose of fuel in the correct way and do not litter as it is highly polluting.

**FUEL**

When refuelling, it is advisable to use a funnel to prevent fuel from spilling out. The fuel should also be filtered to prevent dust or dirt from entering the tank.

Use the same type of diesel fuel as used in cars. Use of other types of fuel could damage the engine. The cetane rating of the fuel must be higher than 45 to prevent difficult starting. Do not use dirty diesel fuel or mixtures of diesel fuel and water since this would cause serious engine faults.

The capacity of the standard tank is: lt. 16.

# VIII

# MAINTENANCE - RECOMMENDED OIL TYPE - REFILLING



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.

The risk of piston seizure, jammed piston rings and rapid wear of the cylinder liner, the bearings and all moving parts increases if oil whose characteristics differ from the recommended type is used, or if the oil is not regularly changed. All this notably reduces engine life.

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.

## RECOMMENDED OIL

AGIP SINT 2000 5W40 specification API SJ/CF ACEA A3-96 B3-96 MIL-L-46152 D/E.

ESSO ULTRA 10W40 specification API SJ/CF ACEA A3-96 MIL-L-46152 D/E.

In countries where AGIP and ESSO products are not available, use API SJ/CF oil for gasoline-fuelled engines or oil that complies with military specification MIL-L-46152 D/E.

## OIL SUPPLY ( liters )

Standard oil sump

filter included      lt.      4.3

## ACEA SEQUENCES

A = Gasoline (Petrol)

B = Light Diesel fuels

E = Heavy Diesel fuels

Required levels :

A1-96

A2-96

A3-96

B1-96

B2-96

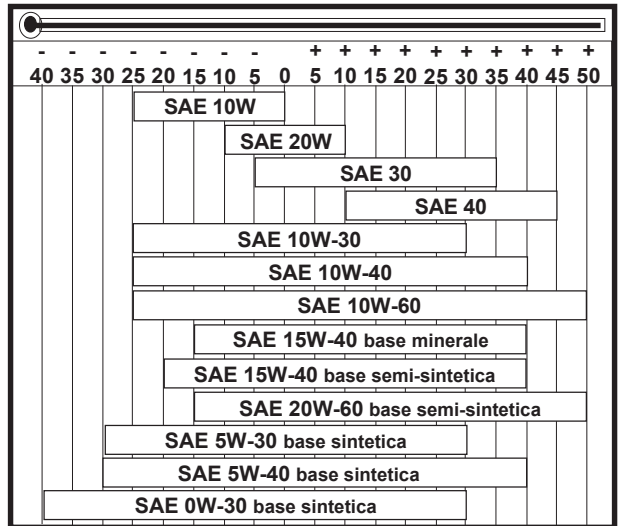
B3-96

E1-96

E2-96

E3-96

## GRADE



| DIESEL |    |       |           |                     |    |    | BENZINA - ESSENCE - PETROL<br>BENZIN - GASOLINA |    |    |    |    |      |          |    |    |
|--------|----|-------|-----------|---------------------|----|----|---|----|----|----|----|------|----------|----|----|
| API    | CF | CE    | CD        | CC                  | CB | CA | SA  | SB | SC | SD | SE | SF   | SG       | SH | SJ |
|        |    |       |           |                     |    |    | CCMC G- 2                                       |    |    |    |    | G- 4 |          |    |    |
|        |    |       |           |                     |    |    | CCMC G- 3                                       |    |    |    |    | G- 5 |          |    |    |
|        |    |       |           |                     |    |    | CCMC PD - 1 / PD - 2                            |    |    |    |    |      |          |    |    |
|        |    |       | D- 4      | CCMC D- 2           |    |    |   |    |    |    |    |      |          |    |    |
|        |    | D- 5  | CCMC D- 3 |                     |    |    |   |    |    |    |    |      |          |    |    |
|        |    |       |           | MIL - L - 2104 D    |    |    |   |    |    |    |    |      |          |    |    |
|        |    |       |           | MIL - L - 2104 E    |    |    |   |    |    |    |    |      |          |    |    |
|        |    |       |           | MIL - L - 46152 C   |    |    |   |    |    |    |    |      |          |    |    |
|        |    |       |           | MIL - L - 46152 D/E |    |    |   |    |    |    |    |      |          |    |    |
|        |    |       |           | MB 226.1            |    |    |   |    |    |    |    |      | MB 226.5 |    |    |
|        |    |       |           | MB 227.1            |    |    |   |    |    |    |    |      | MB 227.5 |    |    |
|        |    | 228.3 | MB 228.1  |                     |    |    |   |    |    |    |    |      |          |    |    |
|        |    |       |           | VW 500.00           |    |    |   |    |    |    |    |      |          |    |    |
|        |    |       |           | VW 501.01           |    |    |   |    |    |    |    |      |          |    |    |
|        |    |       |           | VW 505.00           |    |    |   |    |    |    |    |      |          |    |    |
|        |    |       |           | VOLVO VDS           |    |    |   |    |    |    |    |      |          |    |    |
|        |    |       |           | MAN QC 13-017       |    |    |   |    |    |    |    |      |          |    |    |



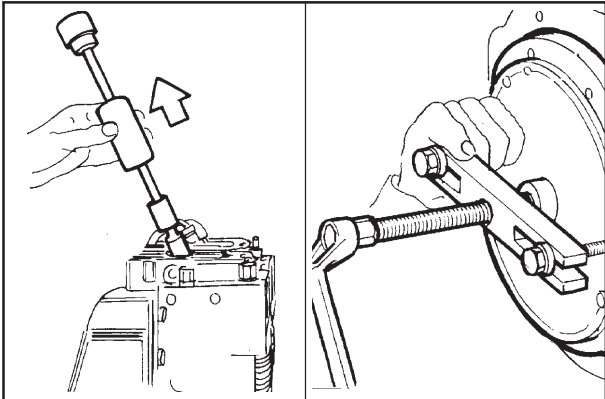




During repair operations, when using compressed air, wear eye protection.

## DISASSEMBLY AND REASSEMBLY

Besides disassembly and reassembly operations this chapter also includes checking and setting specifications, dimensions, repair and operating instructions. Always use original LOMBARDINI spare parts for repair operations.



1

2

### Extracting fuel injectors

Unscrew the fuel feeding pipes.

Remove the injectors using a commercial extractor tool as shown in fig. 1.

### Removing the flywheel

Use the extractor code 00365R0010 as shown in figure 2.

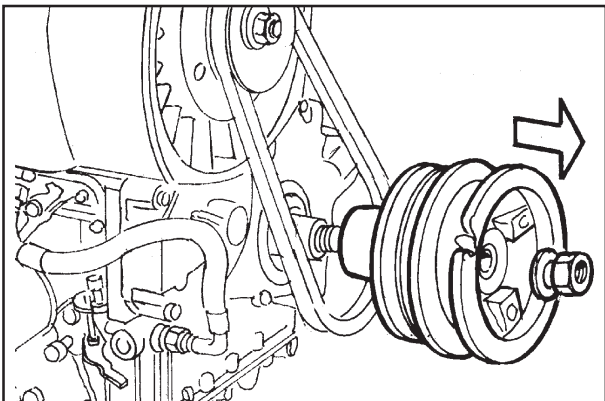


During the demounting phases, pay particular attention to prevent the flywheel from dropping as this could seriously injure the operator.

Wear protective goggles when removing the flywheel ring.



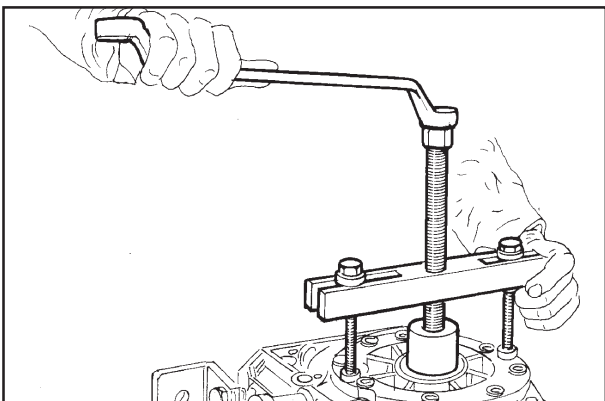
**IMPORTANT:** Do not tap the end of the extractor when removing the flywheel.



3

### Removing the pulley

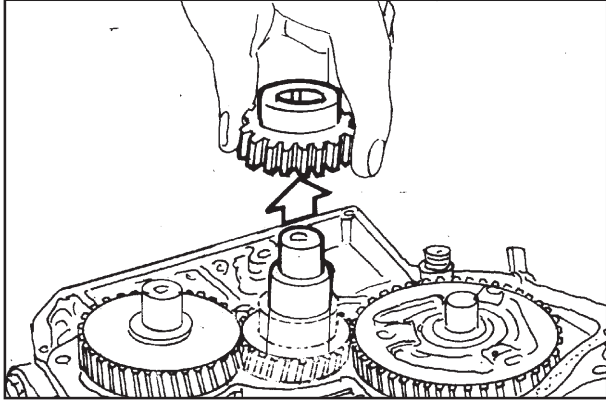
The pulley can be removed manually as shown in figure 3.



4

### Extraction of flywheel side main bearing

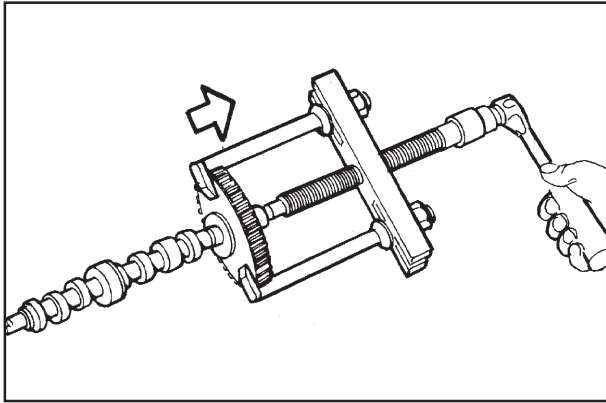
Withdraw the bearing using two M8 screws taking care to tighten them evenly; alternatively use a commercial extractor, as shown in figure 4.



5

**Extraction of crankshaft gear**

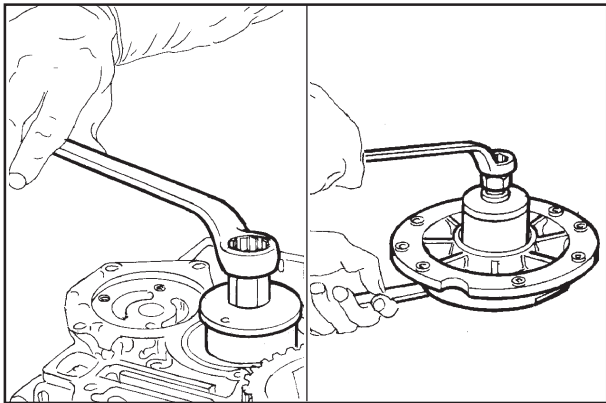
The gear can be removed manually as shown in figure 5.



6

**Extraction of the camshaft gear**

Use the extractor code 00365R0010 (fig.6)



7

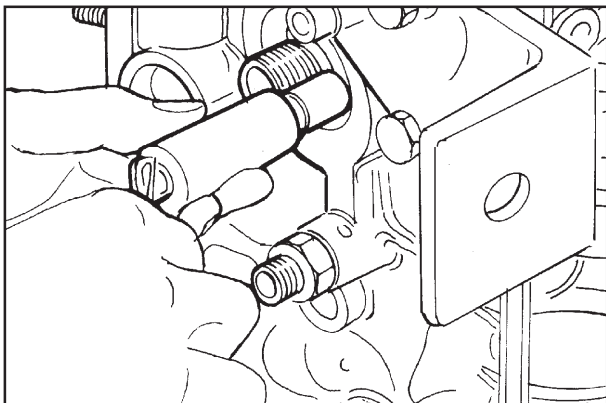
8

**Extracting crankcase bushes**

From crankcase (fig. 7)

From main bearing (fig. 8)

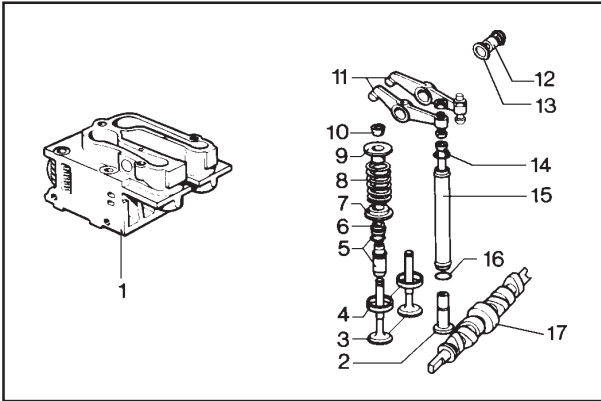
Use extractor code 00366R0060



9

**Extracting the oil pressure indicator plug**

Remove the oil filter and extract the by-pass valve using the extractor 00365R0880 (fig.9).



10

**Cylinders heads**

Parts shown in figure 10.

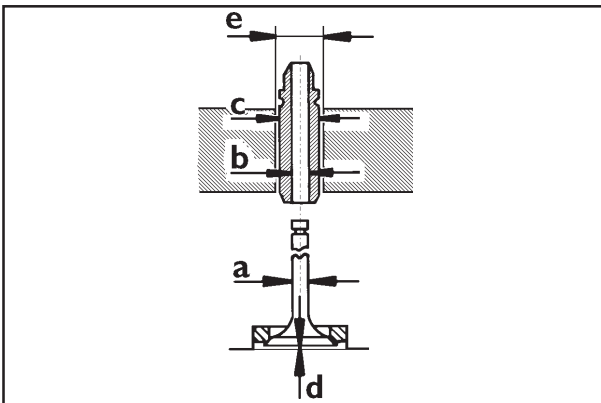
1. Head - 2. Tappets - 3. Valves - 4. Seats - 5. Guides - 6. Seals - 7. Lower washers - 8. Springs - 9. Top washers - 10. Valve locking split cones - 11. Rocker arms - 12. Rocker pins - 13. Gaskets - 14. Push rods - 15. Pipe covers 16. O-ring - 17. Camshaft.

The heads are in aluminium with valve guides and seats in cast iron.



Do not disassemble the head when the engine is hot to avoid deformation.

Clean heads of carbon deposits and check the cylinder mating surfaces; if they are deformed they must be ground to a maximum of 0.3mm. Check that there are no cracks or other imperfections in the heads. If defects are encountered the heads must be renewed. In this case consult the spare parts catalogue.

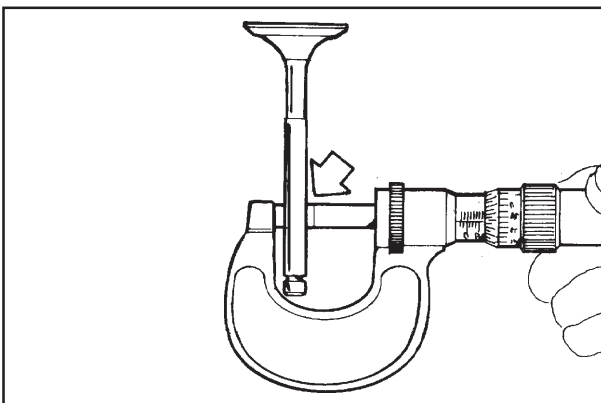


11

**Valves - Guides - Seats**

Clean the valves with a wire brush and renew them if the valve heads are deformed, cracked or worn.

| Guide   | a mm        | b mm                  | c mm          | d mm    | e mm     |
|---------|-------------|-----------------------|---------------|---------|----------|
| Inlet   | 6,960÷6,970 | 7,00÷7,01<br>assembly | 13,025÷13,037 | 0,8÷1,0 | 13÷13,01 |
| Exhaust | 6,945÷6,955 |                       |               |         |          |



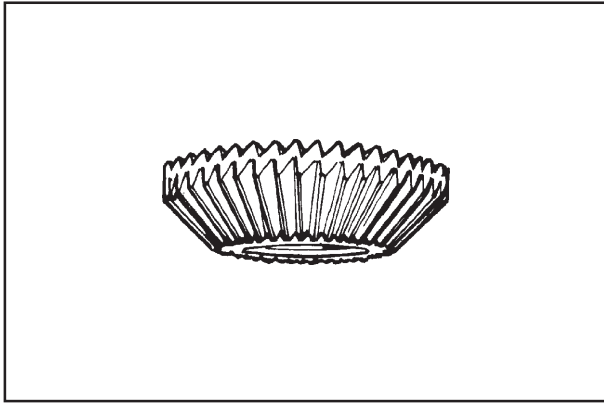
12

Check the dimensional conformity of the valve stems (fig. 12) and the clearance between valve and guide, bore out the guides to the dimensions indicated in the table (fig. 11).

Renew both guide and valve if the clearance is greater than 0.1mm.

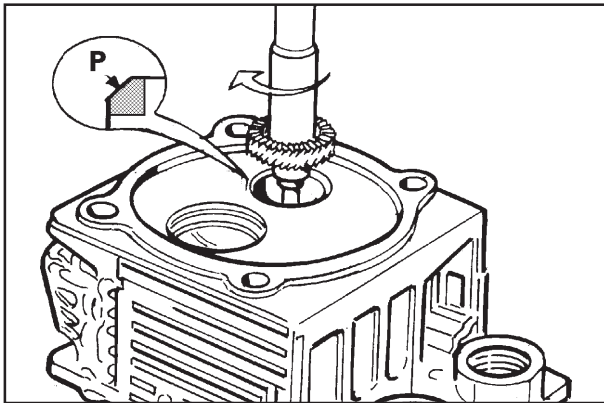
It is always necessary to grind the valve seats when new guides are fitted.

Oversize valve guides with external diameter increased by 0.10 are available.



13

After prolonged running of the engine the hammering of the valves on their seats at high temperature tends to harden the faces of the seats and makes manual grinding difficult. It is thus necessary to remove the hardened surface with a 45° cutter (fig. 13).



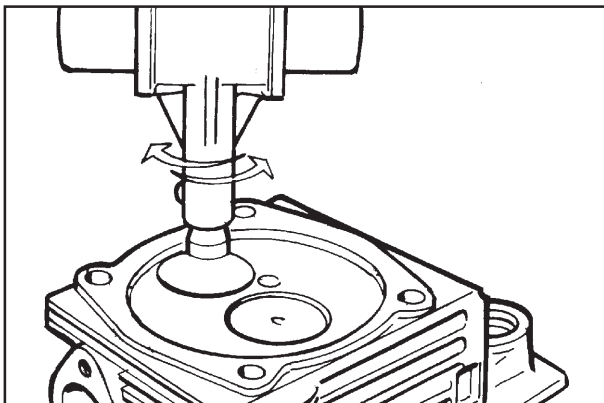
14

Grinding of valve seats causes a widening of the valve seat face P (fig. 14).

Final lapping of the valve on the seat must be carried out by coating the seat with a fine grinding paste and rotating the valve in a clockwise and counterclockwise direction with slight pressure until a perfect surface finish is obtained (fig. 15).

Observe the valve seating clearances indicated in the following table (d, fig. 11).

| Fitting mm         | Max. wear mm |
|--------------------|--------------|
| $d = 0,8 \div 1,0$ | $d = 1,3$    |



15

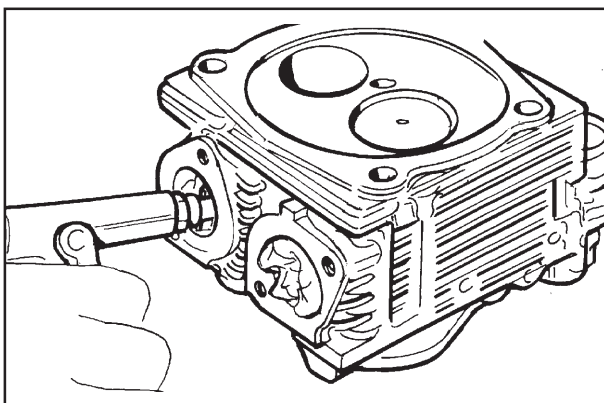
**!** In the case of lower values the valve may strike the piston. In the case of values in excess of 1.3mm the valve seat rings must be replaced.

Fitting of new seats or valves always requires preparatory grinding. Valves are available with the external diameter increased by 0.5mm.

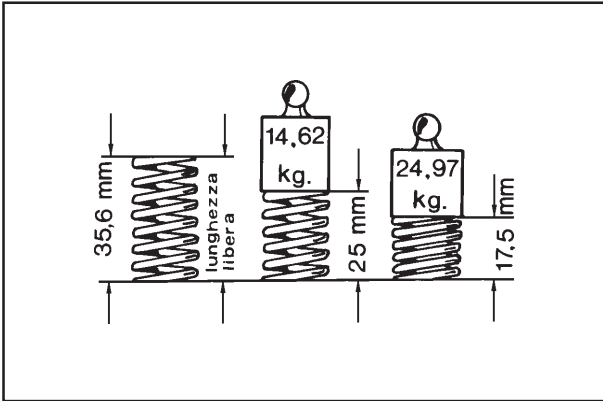
After grinding wash the valve and seat carefully with petrol or paraffin in order to remove residual grinding paste and chips. Once you have finished grinding check the efficiency of the seal between the valve and seat as outlined below:

1. Fit the valve on the head with spring, washers and split cones (fig 10).
2. Invert the head and pour in a few drops of diesel fuel or oil around the edges of the valve head.
3. Blow compressed air into the inlet of the cylinder head taking care to seal the edges so that the air does not escape (fig. 16).

Should air bubbles form between the seat and the valve remove the valve and regrind the seat.



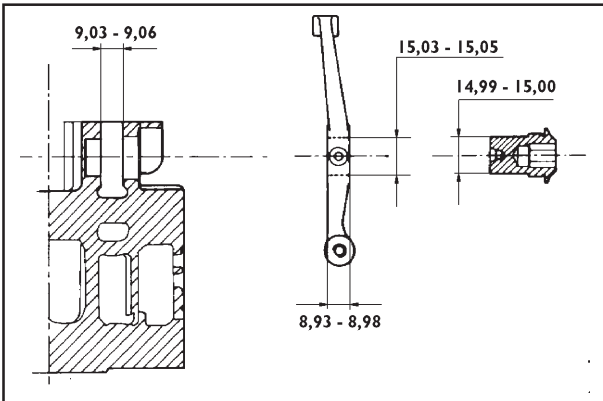
16



17

**Valves and springs**

In order to check the springs for possible failure measure the lengths under load as shown in figure 17. The permissible tolerance for loads and lengths is  $\pm 10\%$ . If the figures measured do not fall within these values, the springs must be renewed.



18

**Rocker arms**

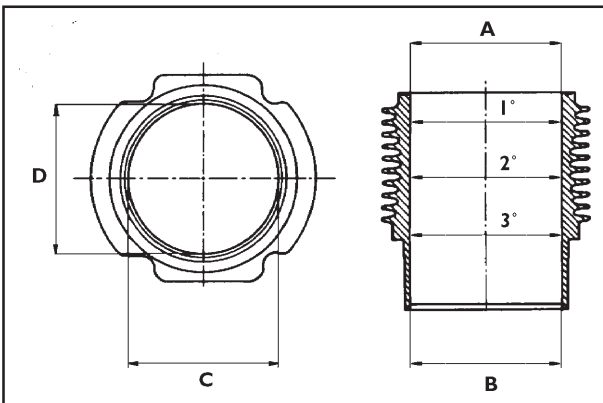
Make sure that the facing surfaces between rocker and pin are not scored and show no signs of seizure. If such marks are encountered, renew rocker and pin. Rocker / pin clearance (fig. 18).

| Fitting mm  | Max. wear mm |
|-------------|--------------|
| 0,03 ÷ 0,06 | 0,15         |

Rocker axial play (fig.18):

| Fitting mm   | Max. wear mm |
|--------------|--------------|
| 0,05 ÷ 0,130 | 0,5          |

Make sure that the rocker arm adjusting screw is not worn and that the lubrication hole is free of dirt.



19

**Cylinders**

Air cooled with cylinder barrels in special cast iron with integral liners. Use a dial gauge to check internal diameters (C-D) at three different heights (fig. 19). Maximum permitted taper (A-B) and ovality (C-D) is 0.06mm.

Diameter of the cylinder (fig. 19):

$\text{Ø } 85 \div 85,015$

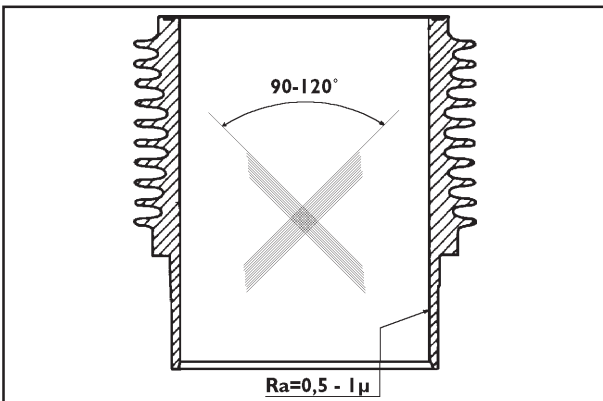
If the diameter of the cylinder does not exceed said values or if there are slight surface scores on the cylinder, it will be sufficient to change the piston rings.



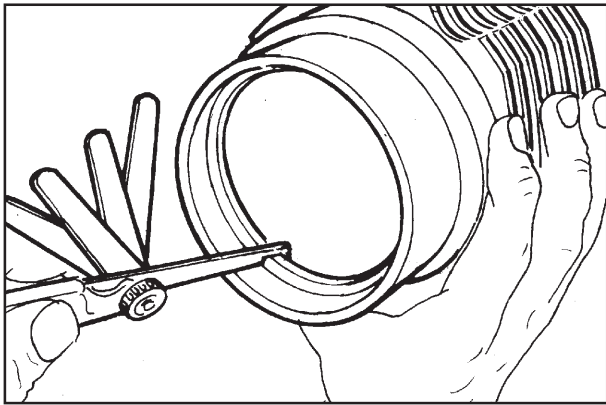
Do not manually hone the cylinder bore surfaces with emery cloth or other means.

The cross-hatch pattern should be at an angle of  $90^\circ \div 120^\circ$ ; lines should be uniform and clear in both directions. Average roughness must range between 0.5 mm  $1 \mu\text{m}$ . The cylinder surface which comes into contact with piston rings should be machined with the plateau method.

If the taper and ovality of the cylinder exceed the values indicated, then the cylinder and piston must be renewed.



20



**Piston rings - Pistons - Piston pins**

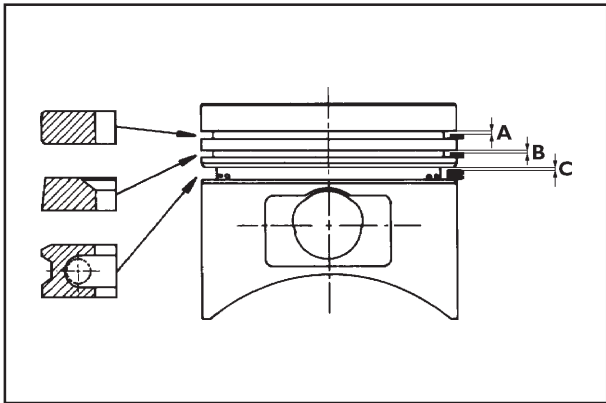
Check the wear of piston rings by fitting them into the cylinder through the lower end and measuring the end gap (fig.21). The values should be:

| Piston ring  | Fitting mm  | Max. wear mm |
|--------------|-------------|--------------|
| Compression  | 0,30 ÷ 0,50 | 0,80         |
| Oil scrapper | 0,25 ÷ 0,50 | 0,80         |

21

Check that the rings move freely in the grooves and check the ring/groove clearance using a feeler gauge (fig.22).

If the clearance exceeds the values shown in the table, renew the piston and the piston rings.

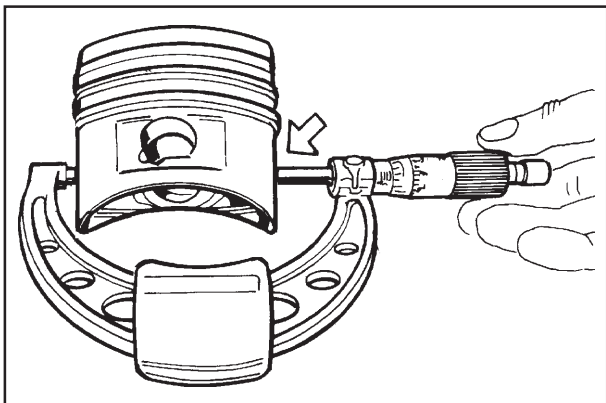


| Piston ring      | Max. wear mm |
|------------------|--------------|
| 1st Compression  | A = 0,22     |
| 2nd Compression  | B = 0,18     |
| 3rd Oil scrapper | C = 0,16     |

**!** Piston rings must always be renewed after dismantling the piston.

22

Piston diameter check: The diameter of the piston must be measured at approximately 18 mm from the base (fig.23).



**Ø 84,920 ÷ 84,927**

Check the clearance between cylinder and piston, if it is greater than 0.120 mm both cylinder and piston must be replaced. Assembly clearance between piston pin and piston in millimetres:

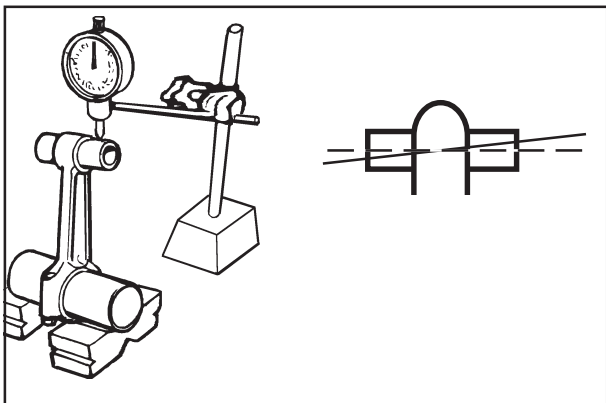
| Ø Piston pin mm | Clearance mm  | Max. wear mm |
|-----------------|---------------|--------------|
| 21,997 ÷ 22,002 | 0,003 ÷ 0,013 | 0,050        |

23

**Connecting rods**

The connection between the connecting rod small end and the wrist pin is without a bushing. Assembly clearance between connecting rod small end and piston pin in millimetres:

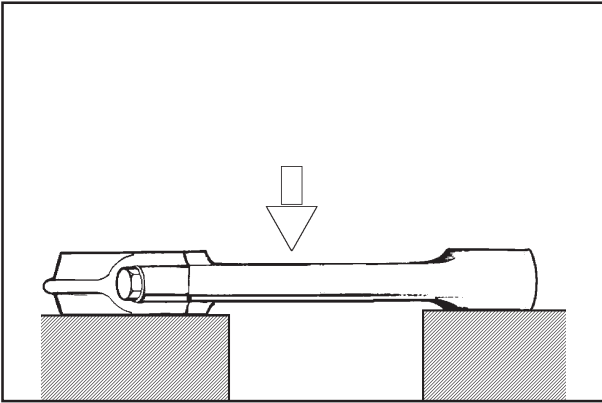
| Ø Piston pin mm | Clearance mm  | Max. wear mm |
|-----------------|---------------|--------------|
| 21,997 ÷ 22,002 | 0,023 ÷ 0,038 | 0,070        |



Checking parallelism between the two axes of the connecting rod (fig.24):

1. Fit the wrist pin in the hole in the small end of the connecting rod and fit a calibrated pin into the big end (with bush fitted).

24

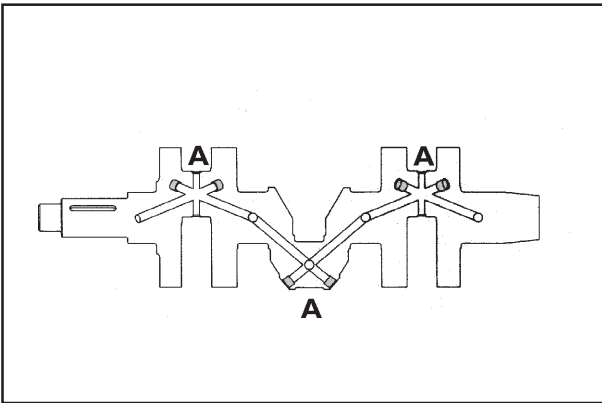


25

2. Position the calibrated pin on two prisms arranged on a check surface.

3. Use a dial gauge to check that the discrepancy between readings at the ends of the calibrated pin is no more than 0.05 mm; should deformation exceed this value (max. 0.10mm) the connecting rod must be straightened.

This operation is performed by placing the connecting rod on a parallel surface and applying slight pressure mid-way along the convex side of the stem (fig.25).



26

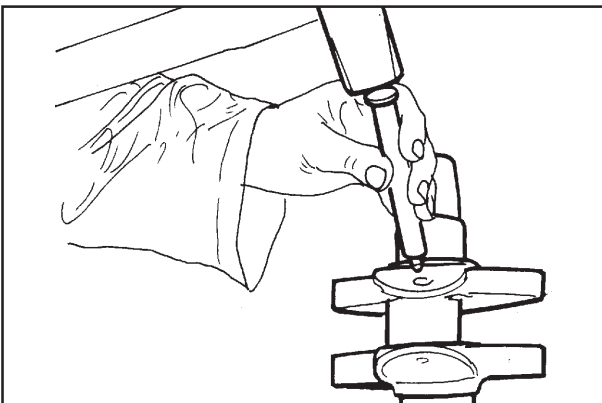
**Crankshaft**

Whenever the engine is dismantled, particularly for the replacement of cylinders and pistons due to wear caused by the aspiration of dust, it is good practice to check the condition of the crankshaft.

1. Remove the plugs "A" from the oil passages (fig.26).

2. Use an appropriately shaped steel punch to clean the inside of the oil passages and the collection traps. If the deposits are particularly resistant, immerse the whole crankshaft in petrol or paraffin before proceeding with the operations.

3. When the oil passages and traps have been thoroughly cleaned, close the openings with new plugs (fig.27).

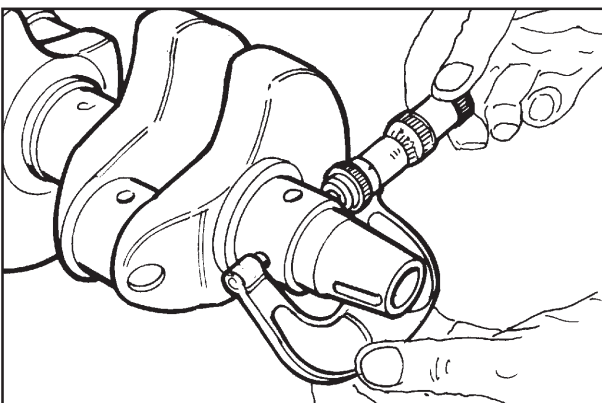


27

**Checking crankshaft dimensions**

Once the crankshaft has been thoroughly cleaned, use a micrometer to check the wear and ovality of the main journals and crank journals across two sections at right angles to each other (fig.28).

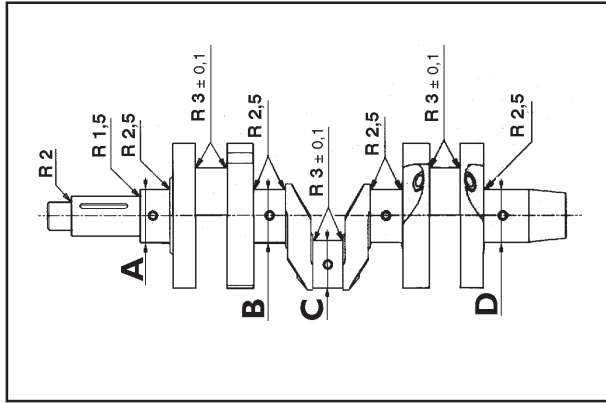
If wear exceeds 0.08 mm (fig.29) grind the crankshaft to the dimensions shown in the table:



28

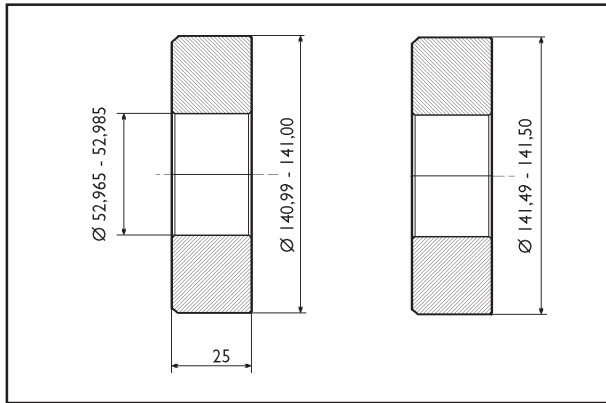
| Dimensions | STD mm | -0,25 mm | -0,50 mm | -0,75 mm |
|------------|--------|----------|----------|----------|
| A - B - D  | 50,005 | 49,755   | 49,505   | 49,255   |
|            | 50,015 | 49,765   | 49,515   | 49,265   |
| C          | 44,994 | 44,744   | 44,494   | 44,244   |
|            | 45,010 | 44,760   | 44,510   | 44,260   |

Undersize bearing bushes are already available at the necessary sizes without requiring any adjustment by boring.



During grinding take care not to remove the shim adjustment material from the main journal thrust face to avoid changing the crankshaft end float; also ensure that the grinding wheel radii are as specified in figure 29 so as not to create crack initiation sections on the crankshaft.

29



**Central main bearings**

In order to facilitate assembly the central main bearings are of different external diameters (fig. 30) and are machined with a bevelled edge to assist their insertion into the crankcase.

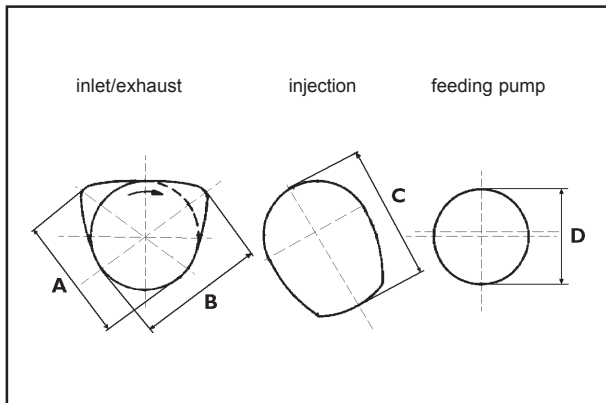
Check the dimensions of the shells and renew them if they are worn or deformed.

Also check the condition of the oil passages and, if necessary, clean them with paraffin or petrol and dry with compressed air.

**Oil seal rings**

Check that the rings have not hardened around the internal contact edge and that they show no signs of cracks or wear.

30



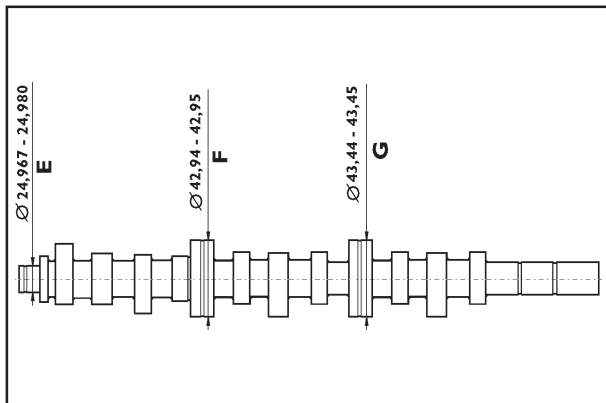
**Camshaft**

Check the cams and bearing journals for scoring and wear. Measure the dimensions and compare them to the values in the table below and shown in figures 31 and 32.

Camshaft dimensions fig. 31.

| Cam       | Measurement | Dimensions mm |
|-----------|-------------|---------------|
| Timing    | A B         | 34,69 ÷ 34,74 |
| Injection | C           | 35,00 ÷ 35,04 |
| Fuel pump | D           | 25,00 ÷ 25,20 |

31



Assembly clearance between the journals and their housings should be (fig. 32):

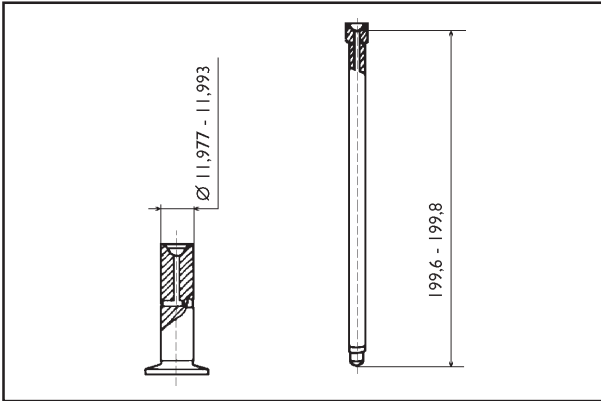
| Measurement | Clearance mm  |
|-------------|---------------|
| E           | 0,040 ÷ 0,074 |
| F           | 0,07 ÷ 0,105  |
| G           | 0,07 ÷ 0,105  |

32



Renew the camshaft if the cams or journals show wear in excess of 0.1mm.





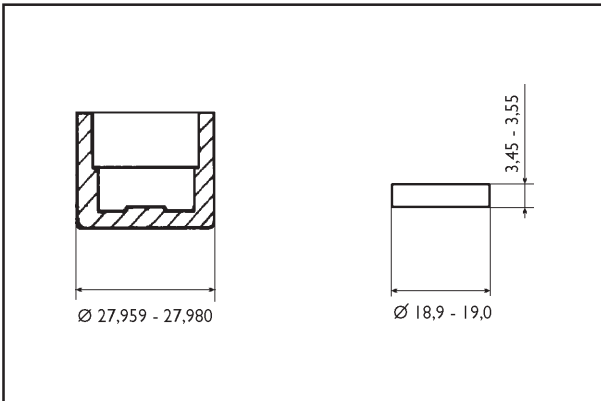
33

**Tappets and push rods**

Make sure that the tappet surfaces (fig.33) are free from wear and present no signs of scoring or seizure, otherwise, renew. Assembly clearance between tappets and their housings should be:

| Fitting mm    | Max. wear mm |
|---------------|--------------|
| 0,014 ÷ 0,046 | 0,10         |

The push rods must be straight and with the spherical surfaces at either end in good condition (fig.33). Make sure that the lubrication holes inside the tappets and push rods are free of dirt.



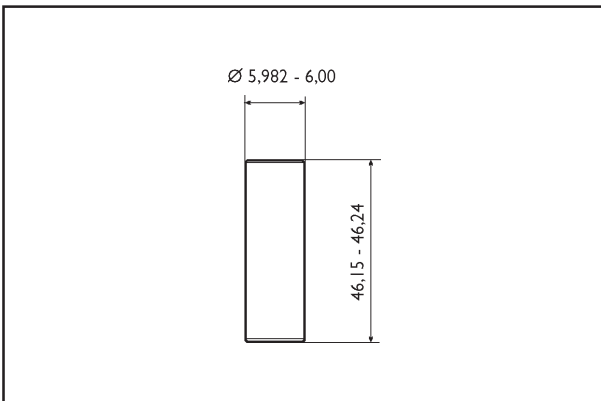
34

**Injection pump plug nuts and control rods**

Renew the parts if the surface wear is greater than 0.10mm (fig.34).

Assembly clearance between control rods and their housings in the crankcase:

| Fitting mm   | Max. wear mm |
|--------------|--------------|
| 0,02 ÷ 0,059 | 0,10         |

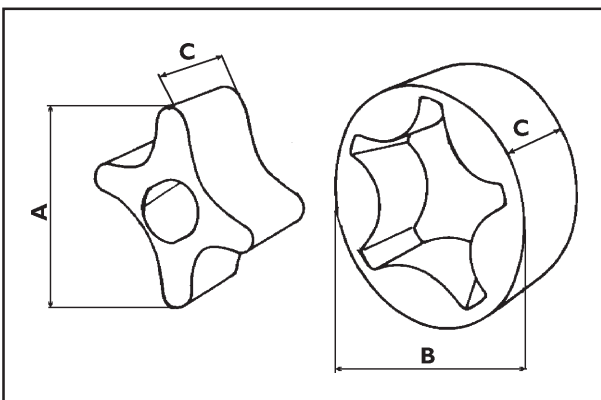


35

**Fuel pump push-rod**

Check that the surfaces of the fuel pump push-rod, fig. 35, are free of wear, scoring, or signs of seizure, otherwise, renew. Assembly clearance between fuel pump push-rod and its housing in the crankcase:

| Fitting mm   | Max. wear mm |
|--------------|--------------|
| 0,05 ÷ 0,098 | 0,120        |

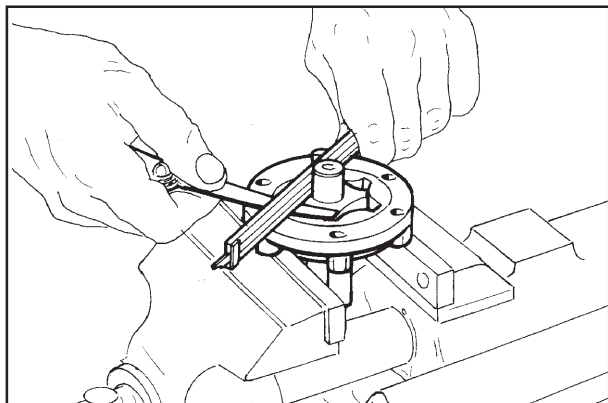


36

**Oil pump**

Check the rotors and renew them if they have worn lobes or centres. Check the extent of pump wear by taking the measurements indicated in figure 36.

| Measurement | Dimensions mm   | Max. wear mm |
|-------------|-----------------|--------------|
| A           | 40,208 ÷ 40,233 | 40,180       |
| B           | 57,25 ÷ 57,255  | 57,15        |
| C           | 15,97 ÷ 15,99   | 15,92        |



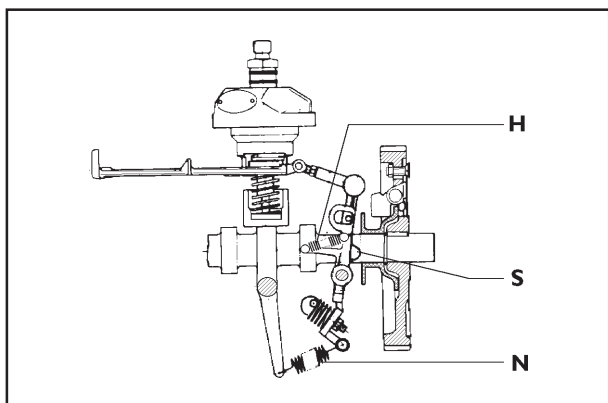
The clearance between the external rotor of the oil pump and the cover facing surface must be:

| Fitting mm  | Max. wear mm |
|-------------|--------------|
| 0,27 ÷ 0,47 | 0,60         |

End float of rotors (fig.37):

| Fitting mm  | Max. wear mm |
|-------------|--------------|
| 0,01 ÷ 0,06 | 0,10         |

37



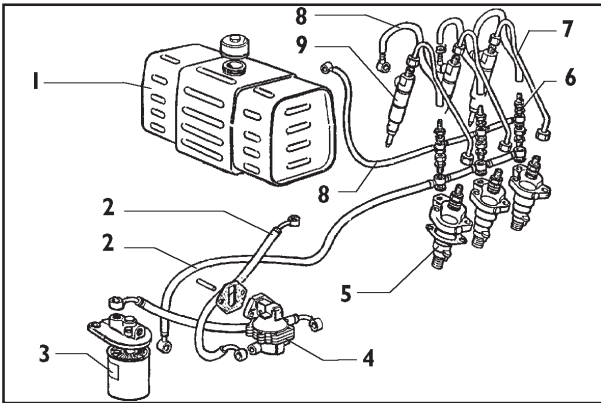
#### Governor lever and spring

Check that the shoes (S, fig.38) are level and that the springs have not lost their elasticity. Renew any excessively worn parts after consulting the spare parts catalogue.

Supplement and governor spring dimensions (fig.38):

| Spring         | Lenght mm    | Lenght under load mm | Load kg | Nr of windings |
|----------------|--------------|----------------------|---------|----------------|
| Governor (N)   | 32 ÷ 34      | 52 ÷ 54              | 1,9     | 10             |
| Supplement (H) | 25,75 ÷ 26,2 | 38,7                 | 0,6     | 25,5           |

38



39

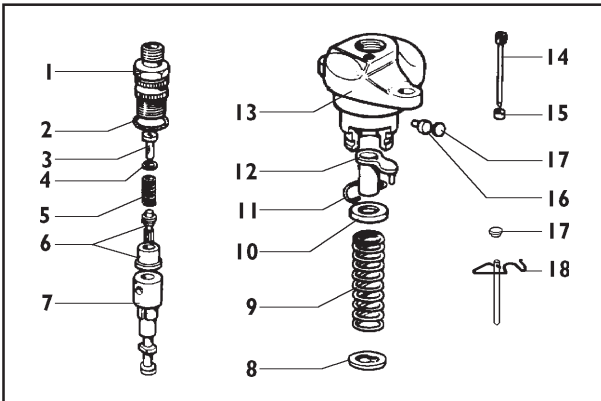
### Fuel circuit

Fuel feeding can be either gravity type or forced, with a mechanical double diaphragm pump operated a cam located on the camshaft. Fuel is filtered by a filter in the fuel tank or through an external filter cartridge.

The fuel circuit is bled of air automatically.

Components of figure 39:

1. Fuel tank - 2. Fuel filter - 3. Fuel supply lines - 4. Fuel injection pumps - 5. Bleed off connection - 6. Fuel injectors - 7. Injection lines - 8. Fuel return lines - 9. Fuel sully pump.

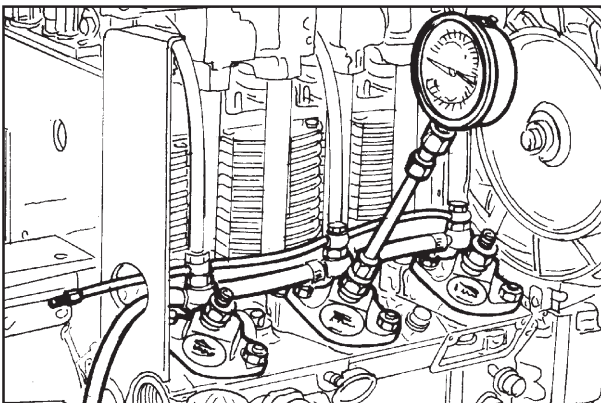


40

### Injection pumps

Components of figure 40:

1. Delivery connection - 2. O-ring - 3. Filler - 4. Washer - 5. Valve spring - 6. Delivery valve - 7. Injection plunger - 8. Lower plate - 9. Spring - 10. Top plate - 11. Retaining ring - 12. Adjustment sleeve - 13. Pump body - 14. Sleeve securing pin - 15. Distance ring - 16. Eccentric pin - 17. Cap - 18. Clip for BOSCH pump type PF30.



41

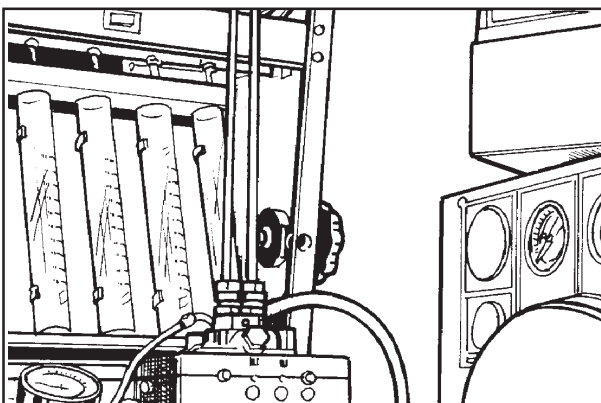
### Checking injection pumps

Before dismantling the injection pumps check for pressure leak of the pumping unit, plunger and valve, as follows:

1. Connect a pressure gauge with 600 Kg/cm<sup>2</sup> full scale to the diesel delivery line (fig.41).
2. Set the control sleeve (nr. 12, fig.40) to a mid-point delivery position.
3. Turn the flywheel slowly until the plunger has completed a full compression stroke.
4. Take the pressure gauge reading. If it is below 300 Kg/cm<sup>2</sup> the complete plunger unit must be changed.

During the test the reading on the gauge will show a progressive pressure increase to a maximum value and then will fall suddenly and stop at a lower pressure. Replace the valve if the fall in pressure exceeds 50 Kg/cm<sup>2</sup> and continues to fall slowly.

The pressure drop from 200 Kg/cm<sup>2</sup> to 150 Kg/cm<sup>2</sup> must occur in a time interval of no less than 7 seconds.



42

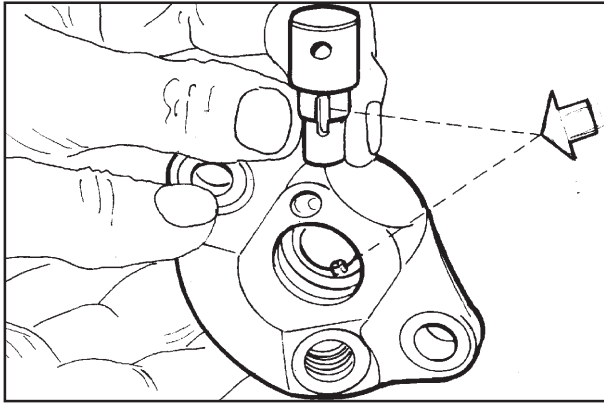
### Injection pump setting (fig.42)

Set the maximum quantity delivered by the pump by turning the eccentric pin using a screwdriver (nr. 16, fig.40).

With the control sleeve at 10mm from the stop position and the pump running at 1,500 rpm, the quantity of fuel for 1,000 shots must be between:

23 ÷ 25 cc

20 ÷ 22 cc (BOSCH)



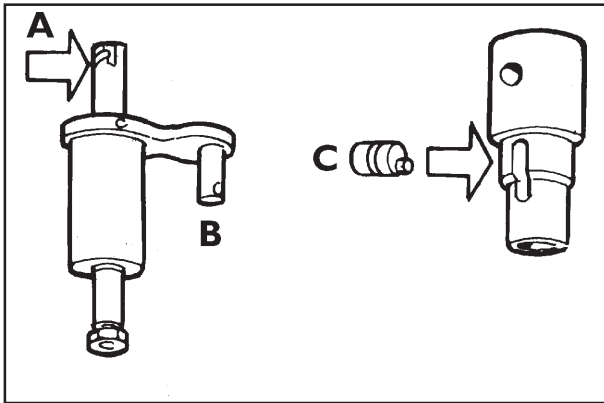
43



The difference between the deliveries of the two pumps when locked must not exceed **0.5 cc.**

Also check:

1. That the distance between the injection cams in the rest position (bottom dead centre) and the pump supporting face is between **52.8 and 54.4 mm** as shown on the data plate;
2. That the stroke of the piston with injection cams in the rest position (bottom dead centre), to the start of delivery is between **2 and 2.1 mm.**

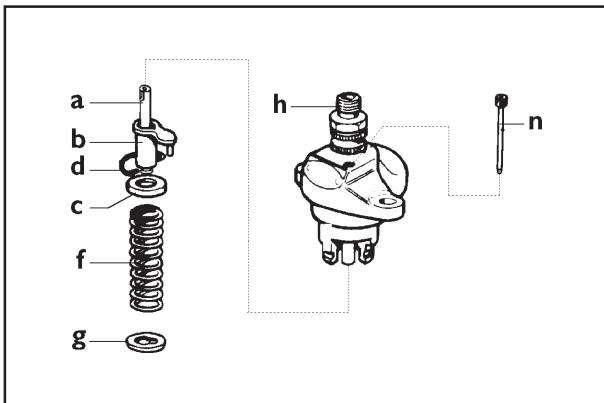


44

**Assembly of injection pumps**

If it proves necessary to disassemble the injection pumps they must be reassembled following the instructions listed below:

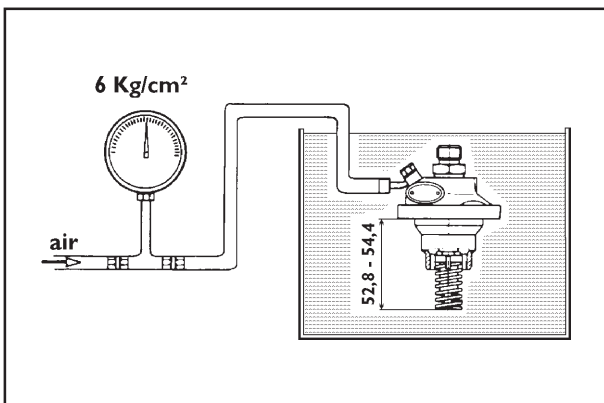
1. Insert barrel into pump casing with the fuel inlet hole aligned with the feeding connection (fig.43). This is the only possible position because of the stud on the pump body. Make sure that the seating face between the barrel and the pump are free of dirt.
2. Insert delivery valve, copper gasket, spring, washer, filler, O-ring, and temporarily tighten the delivery connection.
3. Insert plunger, with helical profile (A, fig.44) on the opposite side of the sleeve pin (B, fig.44), into the internal groove of the control sleeve (make sure the helical profile is turned towards the fuel inlet and eccentric pin (C, fig.44).
4. Complete pump assembly with plunger (a, fig.45), control sleeve (b), upper washer (c), retaining ring (d), spring (f) and secure all with the spring holder washer (g)
5. Tighten delivery valve holder (h, fig.45) to  $4.5 \div 5$  kgm torque.
6. Check, by compressing the spring through its various work positions, that the control sleeve (b, fig.45) turns freely and does not stick or encounter resistance throughout its full stroke; any irregular movement will give rise to hunting of engine speeds.
7. Secure the control sleeve using the pin (n, fig.45) screwed into pump housing.



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Always check the injection pump calibration after the delivery connection (h, fig.45) has been dismantled.

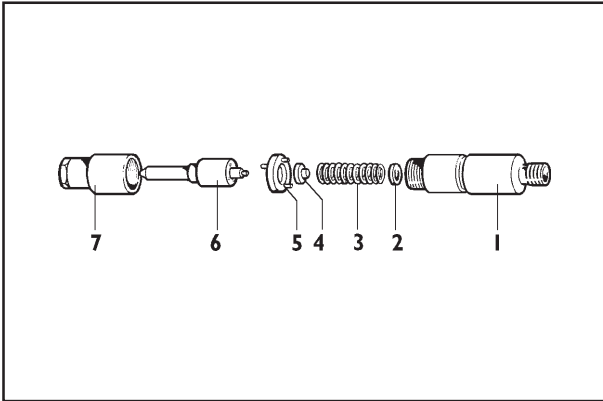


46

**Testing air tightness**

Feed pressurized air at 6 Kg/cm<sup>2</sup> into the fuel supply union and completely immerse the pump in oil or diesel fuel for about 20 ÷ 30 seconds (fig.46); check that no air bubbles are released.

N.B.: Tightness can be checked by compressing the springs to 52.8 ÷ 54.4 mm, which corresponds to the bottom dead centre working position of the pump.



47

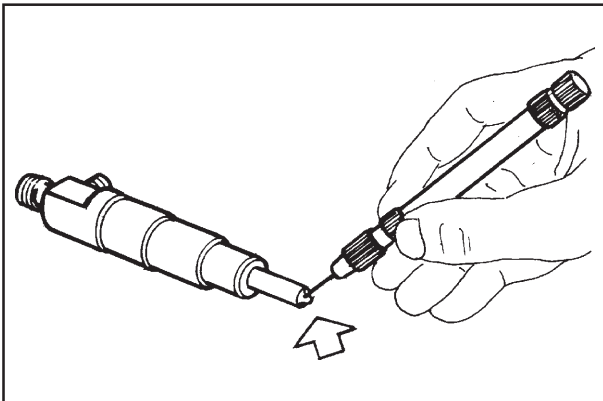
### Injectors

Details of fig.47:

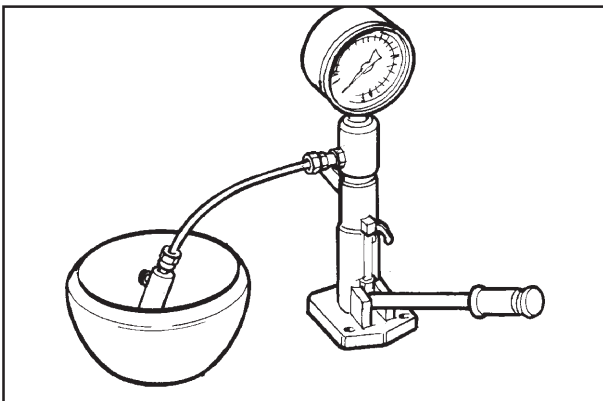
1.Injector casing - 2.Adjusting shim - 3.Spring - 4.Rod - 5.Distance ring with locating pin - 6.Nozzle - 7.Ring nut

### Checking and setting the injectors

1. Clean the nozzle holes with 0.25mm gauge steel wire (fig.48).
2. Place the injector on the test bench (p.n. 00365R0430, fig.49) bypass the pressure gauge and operate the lever rapidly. The nozzle should chatter audibly and spray correctly.
3. Connect the pressure gauge while pressing the lever slowly and steadily until injection occurs.  
The opening pressure registered on the gauge should be 230 Kg/cm<sup>2</sup> (200 Kg/cm<sup>2</sup> on silenced versions).  
Change the adjusting shims (nr. 2, fig. 47) in order to achieve correct adjustment.
4. Testing fortightness: Operate test bench hand lever until the pressure gauge reads 20 Kg/cm<sup>2</sup> below the opening pressure of the needle valve. The nozzle can be considered well sealed if there no Diesel fuel accumulates at the nozzle tip after 10 seconds.



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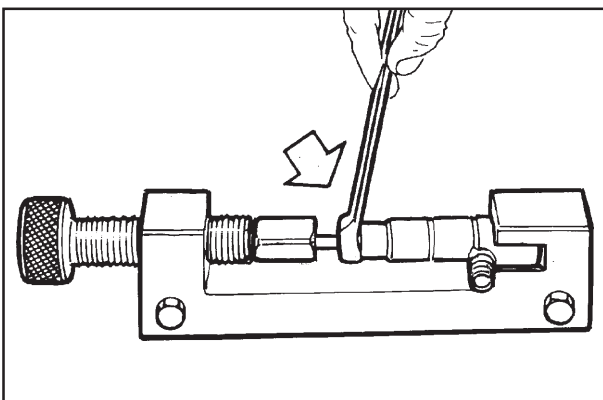


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### Disassembly and re-assembly of injectors

Unscrew the ring nut on the injector nozzle using a ring wrench and a special tool as illustrated in figure 50 serving to release the pressure exerted by the spring on the ring nut.

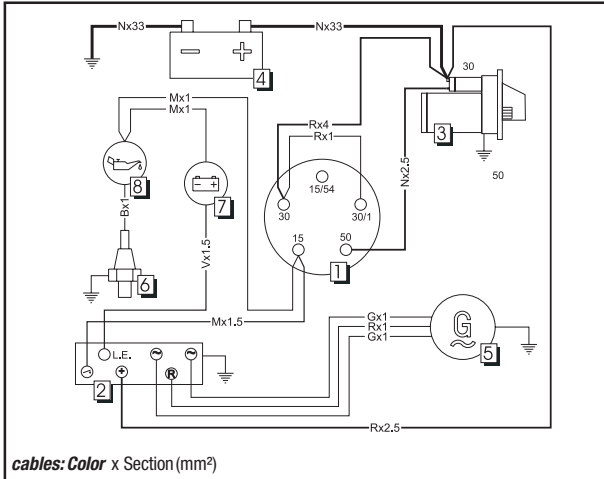
1. Visual check: make sure that the seat of the needle shows no signs of hammering or excess roughness, that the needle is not worn or damaged, and that the holes are free of carbon deposits.
2. Smoothness test: the needle, previously immersed in diesel and inserted into the nozzle casing, must be pulled out to a third of the length of the guide while holding the nozzle in a vertical position. When the needle is released it should return freely to its seat by the effect of its own weight.



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Reassemble the injector following the assembly order shown in figure 47; during reassembly make sure that the locating elements on distance ring 5 (fig.47) are correctly inserted to the corresponding holes. Torque the nozzle securing ring nut to:

**kgm 3,5 (Nm 34,3)**



cables: Color x Section (mm<sup>2</sup>)

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**Plant specifications**

**Starter motor:** Left rotation, 12V, power 2.2 kW

**Built-in alternator:** 400W

**Voltage regulator:** Electronic with controlled diodes and connection for battery charge indicator light

**External alternator:** 12V - 400W

**Recommended battery:** Refer to tables in chapters 4

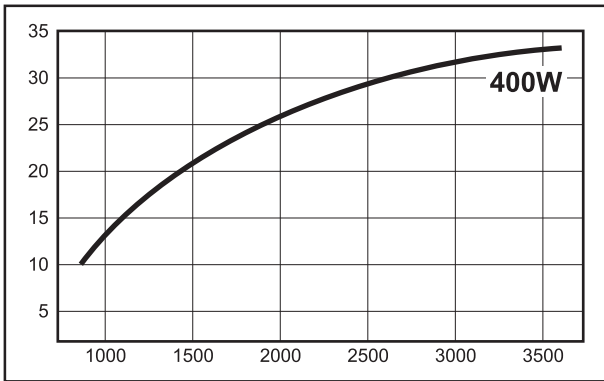
**Flywheel ring gear:** Check teeth for wear or damage. Fit crown wheel to flywheel by pre-heating to 200-250°C.

**Description (fig. 51)**

1. Ignition key (optional)
2. Voltage regulator
3. Engine starter
4. Battery (not included)
5. Alternator
6. Pressure switch
7. Battery recharge warning light (optional)
8. Oil pressure warning light (optional)

**Cables color (fig. 51)**

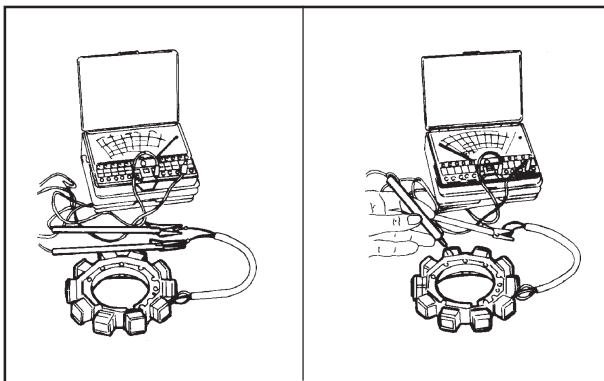
- |          |       |
|----------|-------|
| <b>M</b> | Brown |
| <b>N</b> | Black |
| <b>A</b> | White |
| <b>V</b> | Green |
| <b>R</b> | Red   |



52

**Checking electrical equipment**

1. Make sure that the connections between the voltage regulator and alternator are correctly made and in good condition.
2. Disconnect the starter motor wire from the battery terminal and connect a dc ammeter (fig.51).
3. Connect a dc voltmeter to the battery terminals (fig.51).
4. Turn over the engine a few times without load or connect an 80÷100W lamp load across the battery to restrict voltage to lower than 13V.
5. Accelerate the engine to 3000 rpm. The current shown by the ammeter must be in line with the values indicated in figure 52.
6. Disconnect the load from the battery (if it was previously connected) and keep the engine running at the above indicated speed for a few minutes, the battery voltage should slowly increase until it reaches approximately 14.2V. At the same time the charge current should drop to around 2A in a period of time that depends on the whether the battery is fully charged or not.
7. If the charging current is absent or is lower than the value indicated above, proceed by checking the alternator and if necessary, renewing the voltage regulator.



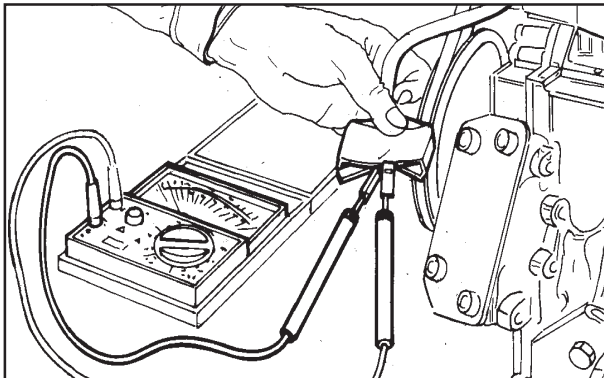
53

54

**Checking the alternator**

Check:

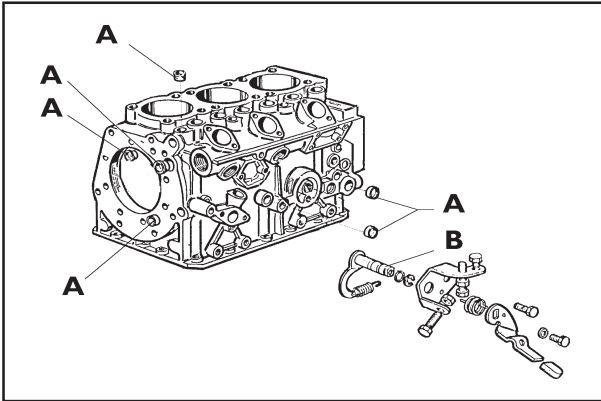
1. with motor stopped: the continuity of the windings (fig.53) by connecting an ohmmeter and ensuring that resistance is zero, and the insulation between the windings and ground (fig. 54) by ensuring that the ohmmeter gives a reading of infinite resistance. If these readings are not obtained the stator must be renewed.
2. with motor running: use a multimeter to check the charge current between the two yellow wires (fig.55). Bring the engine up to 3000 rpm - the multimeter should give a reading of 80V. If the values are more than 10V below this value, the rotor is demagnetized and the alternator must be renewed.



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**! Important:**

1. The alternator will not deliver current when the yellow wires are disconnected.
2. The alternator will burn out if the yellow wires are connected to ground.
3. The voltage regulator may be damaged if the ground connection or other circuit connections are not made properly.
4. The alternator and the voltage regulator will burn out instantly if the battery connections are inverted.



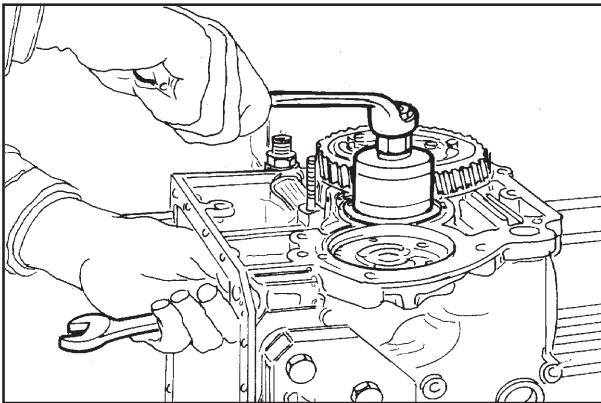
56



These instructions are valid for engines up-dated prior to the publication of this manual. Any modifications must be checked on the technical news-sheets.

Before assembling the engine carefully clean all parts with paraffin and dry them with compressed air. Lubricate moving parts to prevent seizing when starting up. Replace the gaskets with new ones each time the engine is assembled.

Use torque wrenches to ensure that the correct tightening torques are applied.



57

#### Preparing the crankcase

Clean the mating surfaces of sealing compound residues or other foreign material using a copper scraper or fine emery stone. Make sure that the oil passages are open and free of built-up deposits.

1. Fit the plugs (A, fig. 56) in their holes.
2. Insert the internal accelerator lever (B, fig. 56) into the crankcase with its spring taking care to protect the oil seal O-ring from damage.

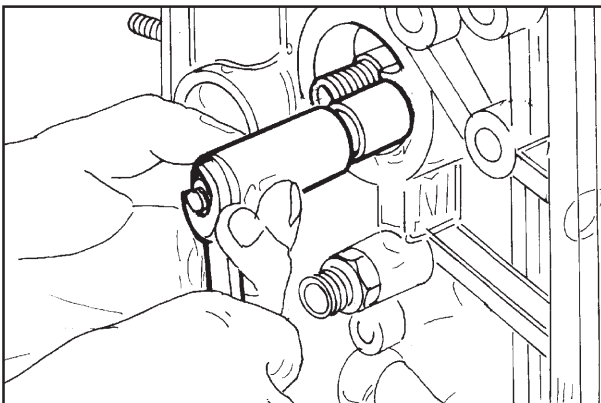
Complete the external assembly with plate, spring, lever, etc. as shown in figure 56.

3. Mount the timing system side bearing bush using either a standard press or a made-to-measure punch as shown in figure 57.

Fit the bush by matching the groove with the seat on the crankcase.

Bushes with standard or smaller internal diameters can be ordered as required.

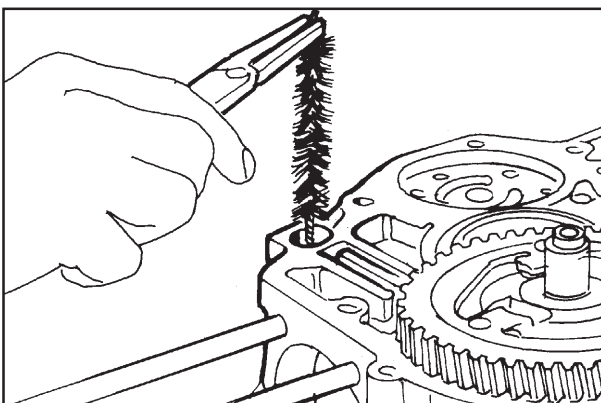
4. Insert the complete oil pressure indicator valve into its housing (fig. 58). Make sure that the valve ball seat is free of dirt that could reduce the effectiveness of the pressure seal.
5. Insert the cylinder studs and the centring pins.
6. Fit the vent restrictor element (fig. 59).



58



A warped oil retainer may allow the introduction of air into the engine thus causing crankcase ventilation problems. Use genuine oil retainers with the LOMBARDINI.

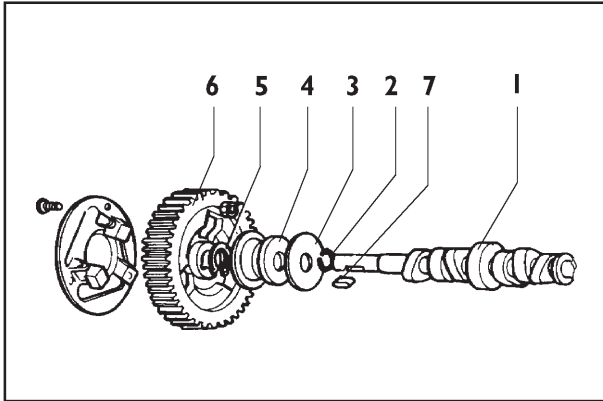


59

#### Camshaft

Prepare the camshaft assembly (fig.60) as described below:

1. Fit adjustment shim (nr. 3) and governor washer (nr. 4) onto the camshaft.
2. Fit snap ring (nr. 5) and key (nr. 7) into their respective seats.
3. Preheat (180 ÷ 200 °C) gear (nr. 6) complete with flyweights and mount it to the camshaft, making sure that it is snugly fitted against the retaining ring.
4. Insert the governor driving plate retaining ring (nr. 2).



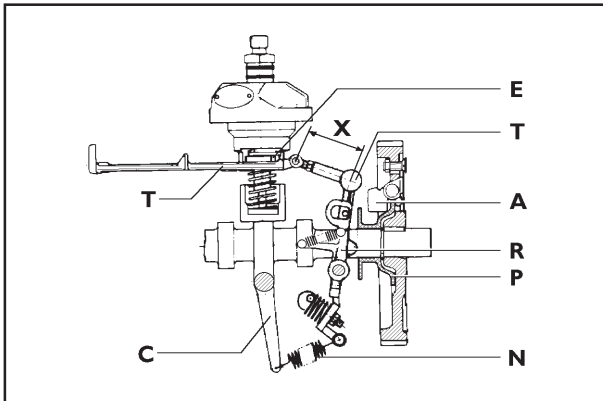
60

The speed governor is of the centrifugal type with flyweights keyed directly onto the end of the camshaft gear (fig. 60).

Flyweights (A) impelled outward by centrifugal force, cause a moving plate (P) to shift axially. The plate operates a lever (R) which is connected, through tie rods (T) to the control sleeves (E) of the injection pumps.

Spring (N) placed under tension by accelerator control lever (C), contrasts the action of the centrifugal force of the governor.

The balance between the two forces keeps the engine speed virtually constant with respect to load variations.



61

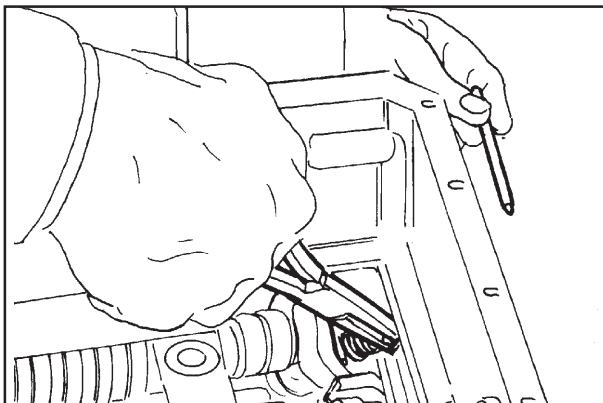
#### Governor tie rod adjustment

The length of the tie rod, measured between the centredistance of holes (X, fig. 61), must be:

**mm 32,5 ± 1 turn**



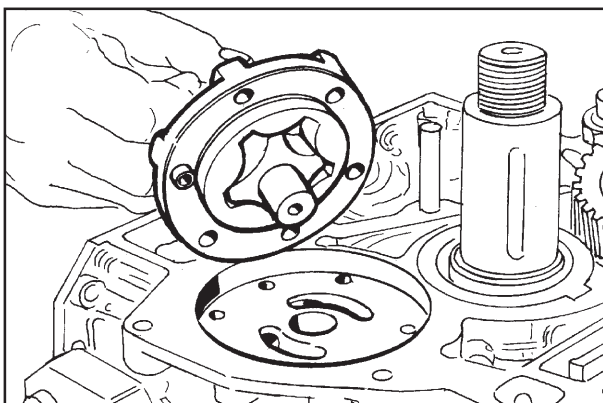
The accuracy of this setting will serve to eliminate hunting of engine speed, difficulty in starting, and power fall-off.



62

#### Assembly

1. Fit the tappets into their housings in the crankcase
2. Fit the governor lever and tie rod, simultaneously with the camshaft, into the crankcase (fig. 62)
3. Insert the governor lever fulcrum pin from the outside of the crankcase and secure it with the relative screw (fig. 62).  
The lever must be free to effect its full stroke without sticking.
4. Insert the spring between the governor lever and the accelerator, making sure that it is correctly installed.



63

#### Oil pump

See at page 25 if you wish to check the rotors.

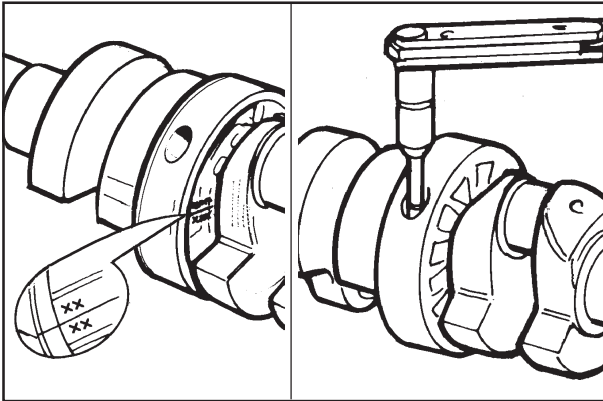
Fit the external oil pump rotor with the bevel toward the inside of the cover (fig. 63).

Mount the pump to the crankcase ensuring that the locating pin is correctly seated.

Torque the fixing bolts to:

**kgm 0,9 ÷ 1 (Nm 8,8 ÷ 9,8)**





64

65

**Central main bearings**

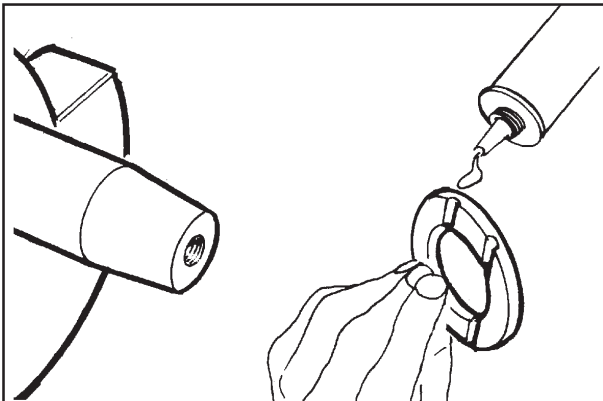
Fit the shells into their seats and coat with a thin film of oil.

Fit the bearing with outside diameter of 141mm onto the central journal - timing-case side, and the 141.5mm diameter bearing onto the central journal - flywheel side.

Make sure the reference numbers match up on each shell (fig. 64) and ensure that the oil passages correspond to the position of the crankcase oil passage openings.

Torque the bearing assembly bolts (fig. 65) to:

**kgm 2,2 (Nm 21,6)**



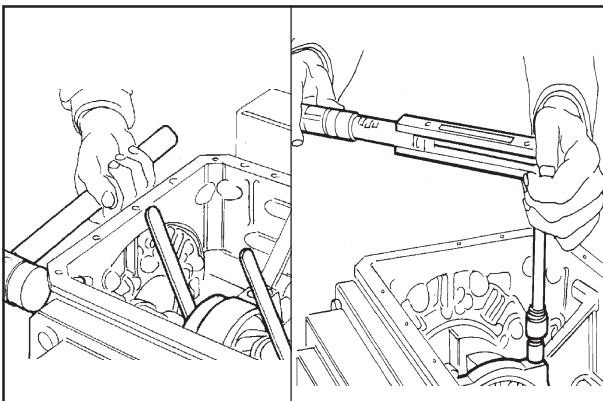
66

**Crankshaft**

Use an adhesive to mount the crankshaft clearance adjustment ring onto the inside of the crankcase - timing case side, ensuring that the milled grooves in the ring are facing the crankshaft (fig. 66). Insert the crankshaft into the crankcase using tool code 00365R0910 as shown in figure 67; make sure that the bearing oil passages are matched to the crankcase oil passages.

Torque the bearing screws (fig. 68) to :

**kgm 2,2 (Nm 21,6)**



67

68

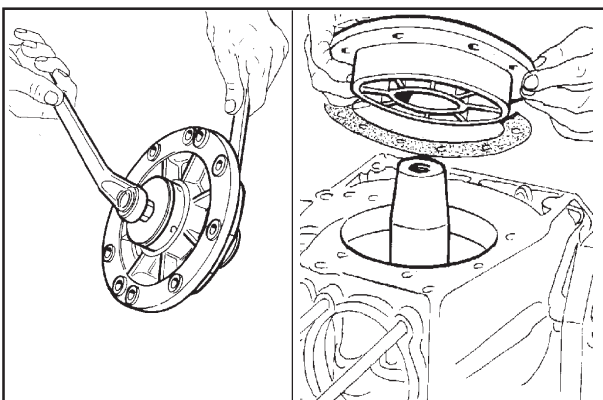
**Main bearings - flywheel side**

Fit the bush to the bearing using a normal punch of appropriate diameter as shown in figure 69. Insert the bush arranging the groove so that it is aligned with the seat on the bearing so that the oil passages will be correctly aligned.

Fit the oil seal ring to the bearing using a suitable diameter tubular punch.

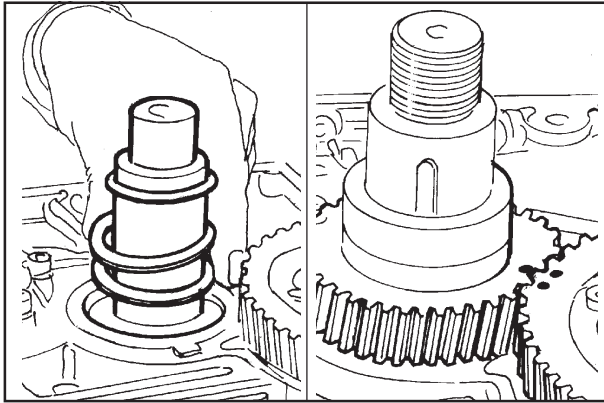
Fit the bearing into the crankcase after having first interposed a gasket (fig. 70). Torque the screws to:

**kgm 2,2 ÷ 2,4 (Nm 21,6 ÷ 23,5)**



69

70



71

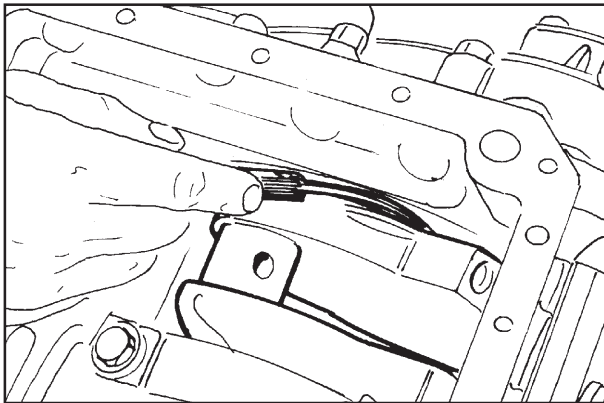
72

**Crankshaft end float**

Once the crankshaft has been inserted into the crankcase, fit the external clearance adjustment ring with the milled grooves facing toward the timing gear. Also fit the brass shims, the O-ring (fig. 71), the key, the timing gear - ensuring that the reference marks match those on the camshaft gear (fig. 72), the pulley, and the washer, and then tighten the nut securing the pulley.

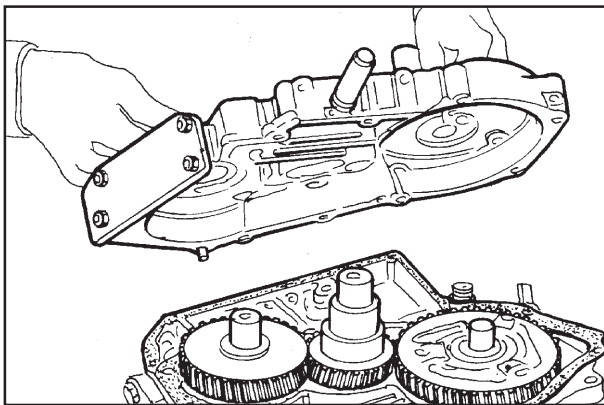
Use a feeler gauge to check the clearance between the clearance adjustment ring and the crankshaft (fig. 73); the value must be within the range:

**0,10 ÷ 0,25 mm**



73

If the value is different, fit or remove the brass shims mounted behind the crankshaft gear.



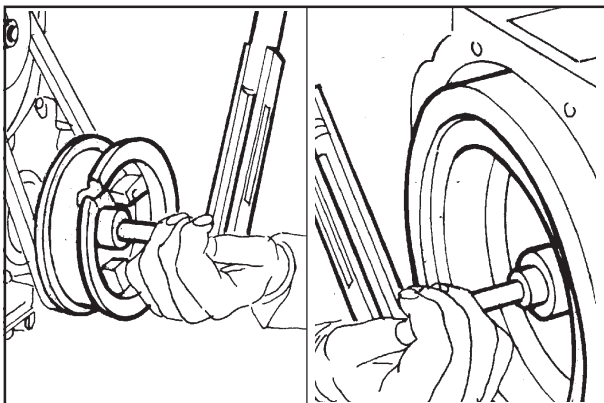
74

**Timing cover**

Check that the timing references punched on the camshaft and crankshaft gears are mutually aligned (fig. 72).

Fit the oil seal onto the cover using a normal tubular punch of appropriate diameter. Mount the cover to the crankcase (fig. 74) after first inserting a gasket between the facing surfaces; tighten the fixing screws to:

**kgm 2,2 ÷ 2,4 (Nm 21,6 ÷ 23,5)**



75

76

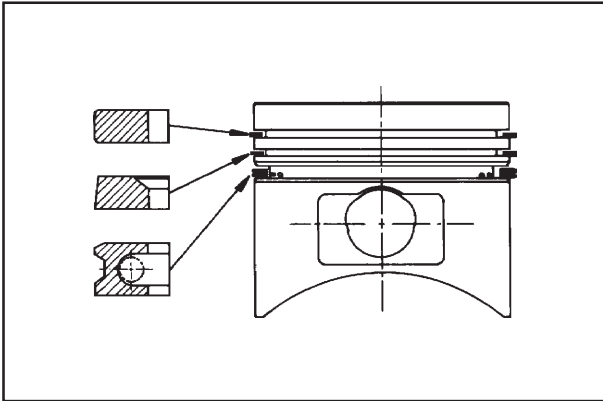
**Pulley and flywheel**

Tighten the pulley fixing bolt (fig. 75) to:

**kgm 19 ÷ 22 (Nm 186,5 ÷ 216)**

Fit the flywheel-housing and flywheel (fig. 76) and torque the latter to:

**kgm 32 (Nm 314)**



77

### Pistons

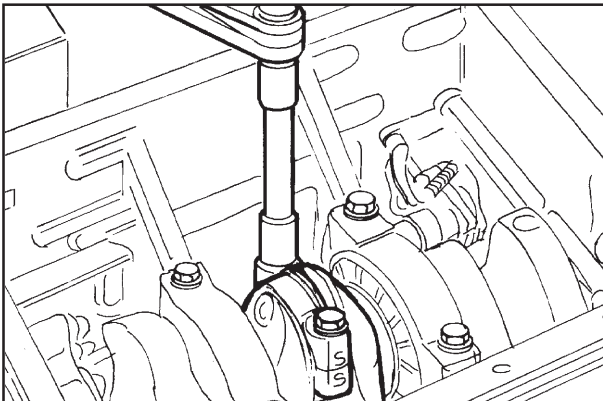


Lubricate the following parts with oil before mounting: the piston pin, the piston, the cylinder and the big-end bearing

Fit the oil rings onto the pistons (fig. 77) in the following order:

1. Chromed compression seal ring
2. Torsional compression seal ring (with internal bevel facing upward)
3. Expander oil scraper ring (external bevel facing upward).

Couple the piston rods to the connecting rods manually by pressing the gudgeon pins in without heating the pistons.



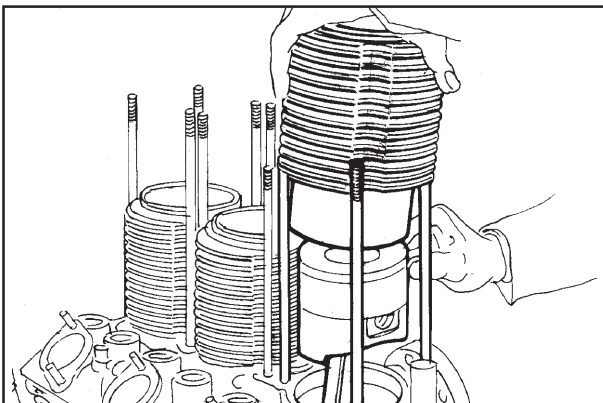
78

### Connecting rods

After having fitted the bushes into the big ends mount the connecting rods to the crankshaft pins; note that the pistons are marked with an arrow showing the direction of rotation of the engine. The combustion chamber, which is offset with respect to the central axis of the piston, must be turned to face the injector nozzle side. Mount the connecting rod big end cap ensuring that the reference numbers are aligned with those punched on the connecting rod itself (fig. 78). Torque the fixing bolts to:

**kgm 3,6 ÷ 3,8 (Nm 35,3 ÷ 37,3)**

Now fit the oil pan after first inserting the appropriate gasket between the facing surfaces.



79

### Cylinder barrels

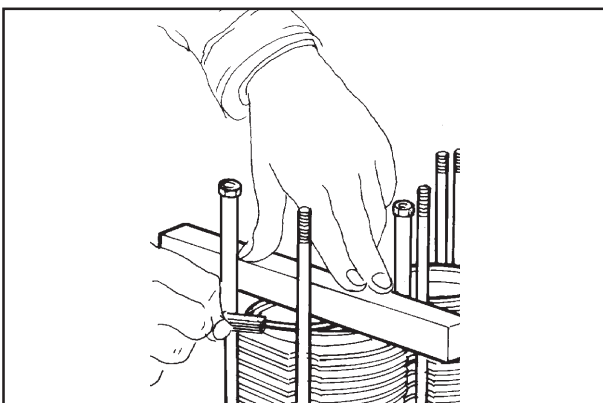
Before fitting the cylinders turn the piston rings so that the end gaps are arranged at intervals of 120° with the end gap of the first compression ring aligned with the axis of the gudgeon pin.

The lower face of the cylinders are chamfered to permit the easy insertion of the piston rings. The operation can be simplified, however, using a normal piston collar tool (code 00365R0770) as shown in figure 79.

Mount the cylinders to the crankcase as shown in figure 80 and then bring the pistons up to their respective TDC (top dead centre) positions. The following must now be checked:

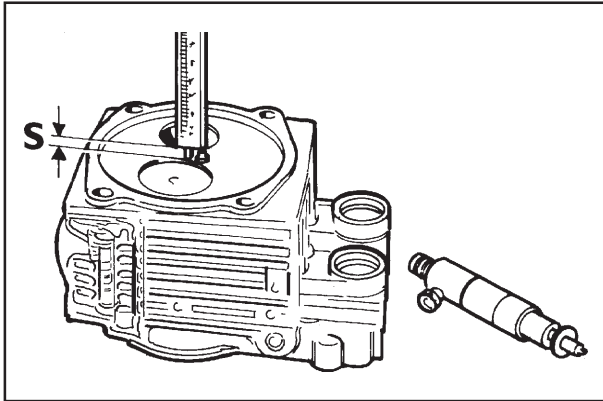
1. that the dots punched on the flywheel (TDC) correspond to the reference mark on the flywheel-housing
2. that the pistons protrude over the top surface of the cylinders (fig. 80) by a distance of:

**0,10 ÷ 0,20 mm**



80

This distance is adjusted with special shims that are inserted between the bottom surface of the cylinder barrel and the crankcase (0.1 - 0.2 - 0.3 mm)

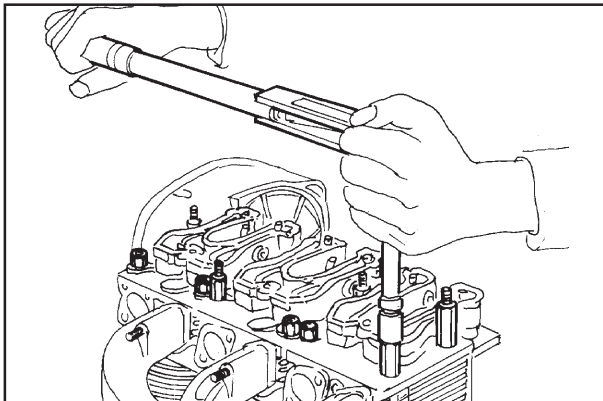
**Checking injector protrusion**

Before mounting the heads to the cylinders fit the injectors into their housings and, after having secured them temporarily, check the protrusion of the nozzles from the head faces (fig.81). Protrusion **S** should be:

**1,75 ÷ 2,25 mm**

This value is adjusted by inserting copper washers between the injectors and the injector supporting faces on the heads (fig. 81).

81

**Cylinder heads**

For checking and overhaul of the cylinder heads refer to page 19. Fit the push rods and oil sealing O-rings on the cover pipes and proceed to install the cylinder heads with the relative gaskets on the facing surfaces.

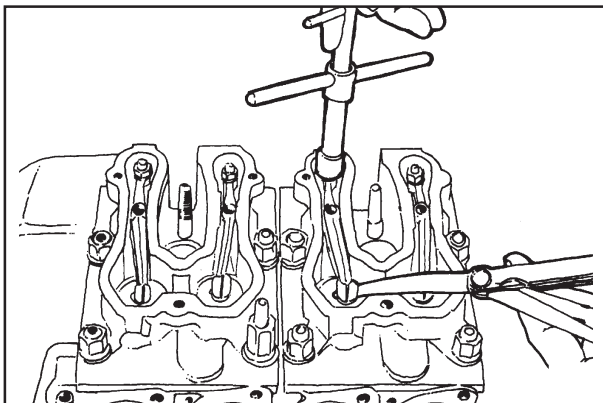


Make sure that the oil seal rings are correctly seated in the heads to avoid the risk of oil leaks.

Align the heads using a metal bar or the exhaust manifold (fig.82). Following a cross pattern tighten the head nuts in increments of 1 kgm until you reach the value:

**4,2 kgm (Nm 41,2)**

82

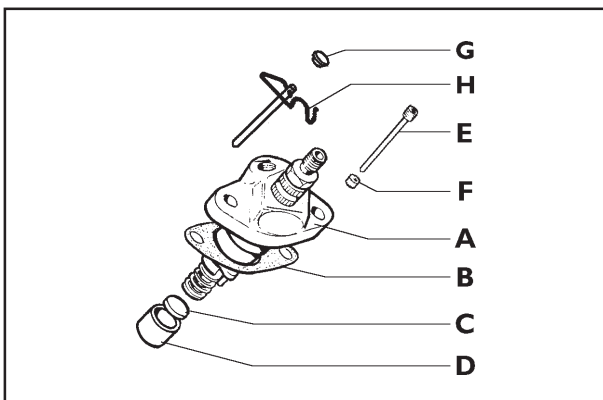
**Valve clearance**

The clearance between valves and rockers with the engine cold (fig.83) is:

**0,15 mm  
intake/exhaust**

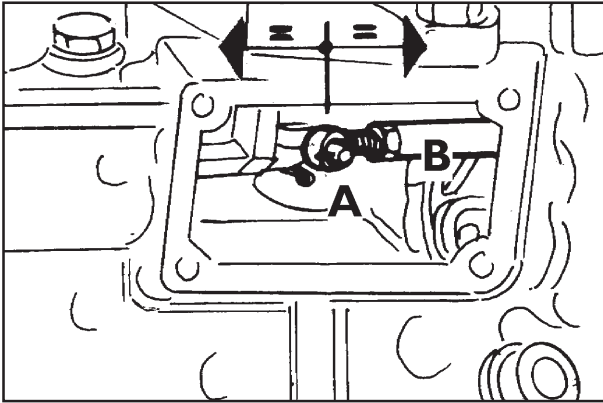
This clearance is to be adjusted with the pistons at their respective TDC compression positions.

83

**Injection pumps**

1. Insert the injection pump tappet (D) and spacer (C) into the housings in the crankcase (fig.84).
2. Assemble the injection pumps (A fig. 84) on the crankcase and secure them on the adjustment sleeve by means of the appropriate pins (E or H fig. 84) on PF30 BOSCH pumps. Then, place the advance adjustment shims (B, fig. 84) between the crankcase and the pump.
3. Fix the injection pump connection rod (A, fig.85) to the speed governor lever tie rod (B, fig.85)
4. Secure the injection pumps to the crankcase, taking care to turn the first injection pump around through approximately 3/4 of a turn in a clockwise direction.

84



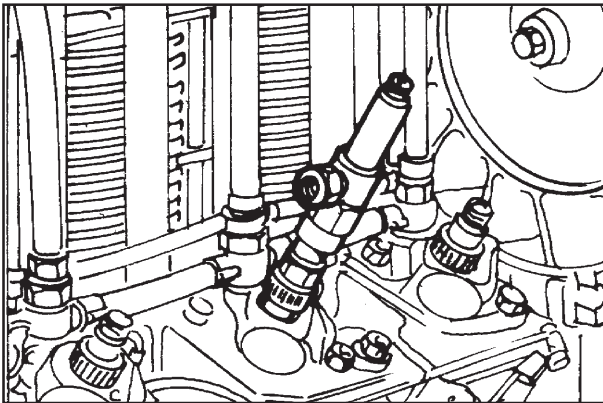
85

5. Release the control sleeves:

- on the traditional pumps by loosening the pins (E, fig.84) and inserting the appropriate distance collars (F, fig.84).
- on the BOSCH type PF30 pumps by removing the pins (H, fig.84) and closing the hole on the pump body using plug G.



Important: injection pumps should be released only after they have been connected to the governor tie rod and secured to the crankcase. If one or both pumps must be changed, in order to guarantee the same fuel delivery for each pump the pump remaining on the crankcase must be locked using the pins (E or H, fig.84). Alternatively the above steps must be performed in their entirety.

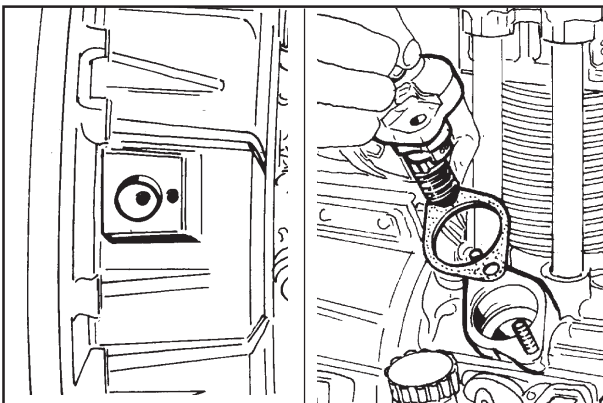


86

**Injection check**

1. Connect the fuel tank to the injection pumps.
2. Set the speed control lever to Max. and the piston to the start of compression (cylinder nr. 1 on timing gear side).
3. To eliminate the injection delay caused by the milling on the pumping elements, bring the injection pump connection rod (A, fig.85) to a position mid-way between minimum and maximum.
4. Fit the special tool, p.n. 00365R0940, to the delivery valve holder (timing case side) as shown in figure 86.
5. Turn the flywheel slowly until the column of diesel fuel inside the special tool starts to move. This indicates the start of static injection.

For variable advance pumps, the reference mark on the flange bell (fig.87) must match the intermediate point (\*) between TDC and "IP" (start of dynamic injection) punched onto the flywheel (fig. 89). On traditional pumps the static start of injection (\*) is the same as the start of dynamic injection (IP).



87

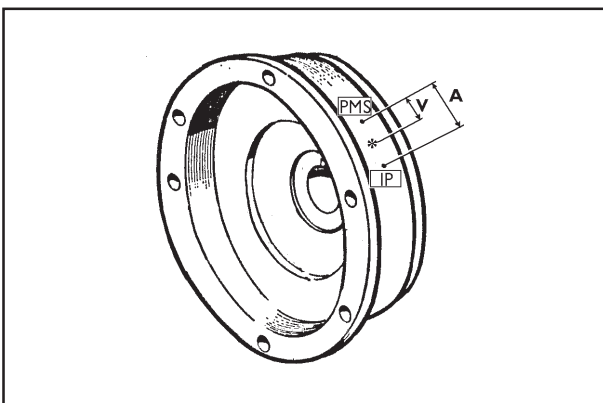
88

Should the reference mark (\* or IP) fall short of the notch on the flange bell, this indicates that injection is too advanced so that the injection pump must be removed and then reassembled with shims (gaskets) between the pump and the crankcase (fig.88).

Should the reference mark (\* or IP) fall after the TDC reference mark, this indicates that injection is too retarded. In this case proceed as above but this time removing shims.

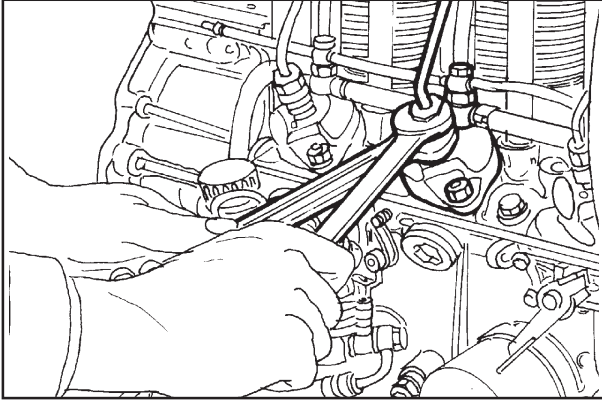
Now repeat the injection timing check for all injection pumps. Note that every 0.1mm shim inserted beneath the pump corresponds to 2.75mm rotation of the flywheel.

Should the flywheel need changing, determine TDC and mark the start of static and dynamic injection as shown in the table:



89

| Version       | I.P.          | (*)           |
|---------------|---------------|---------------|
| standard      | 24° = 51,5 mm | 19° = 40,7 mm |
| whisper quiet | 22° = 47,2 mm | 13° = 27,9 mm |



90

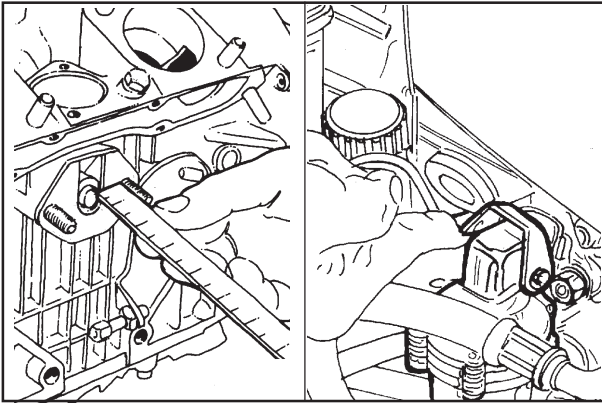
**Injectors and injector pipes**

Mount injectors to heads placing copper gaskets in between (see pag. 36).

Connect the injectors to the pumps by way of the injection lines.



Important: always use two wrenches to loosen or tighten the unions on the injector pipes (fig.90) thereby ensuring that the position of the delivery valve holder on the pumps is not changed (see pag.27).



91

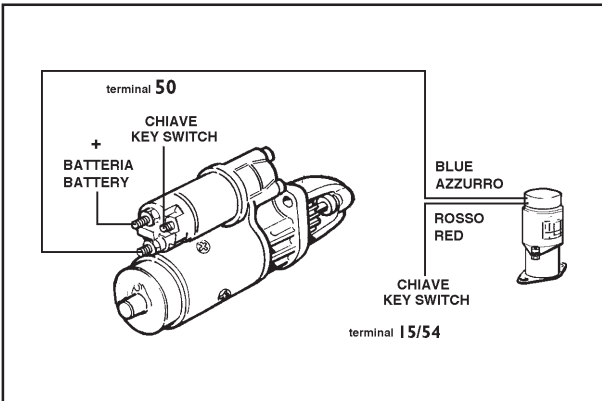
92

**Feed pump**

1. Insert the fuel feed pump tappet into its housing and make sure that it moves freely.
2. Fit the 0.2 and 1mm adjustment gaskets.
3. With the fuel pump excenter in rest position the tappet should protrude from the gasket surface (fig. 91) by:

**1,3 ÷ 1,7 mm**

4. With the fuel feed pump cam in the rest position mount the pump and actuate it manually (fig. 92).

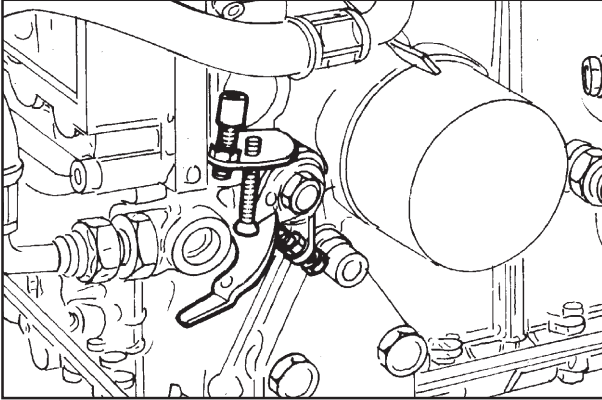


93

**Electric shut off**

If the engine is equipped with an electric shut off, insert the electromagnet into the crankcase taking care to position the engine shut-off lever in the STOP position; make sure that the injection pump connection lever moves freely along its entire stroke.

Make the electrical connections as shown in diagram 93.

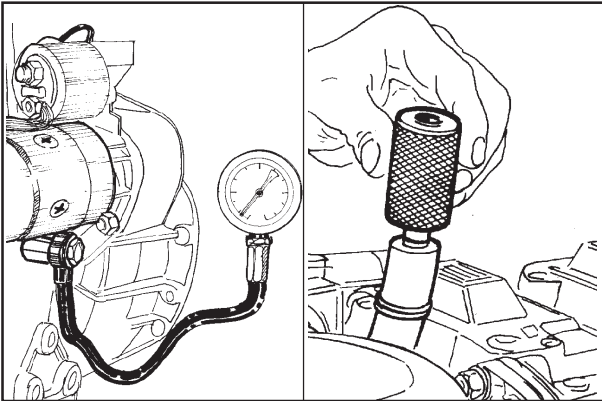


94

**Speed adjustment (fig.94)**

When the engine is hot set idle speed at 1000 rpm and maximum no-load speed at:

- 3150 rpm for engines at 3000 rpm  
3750 rpm for engines at 3600 rpm

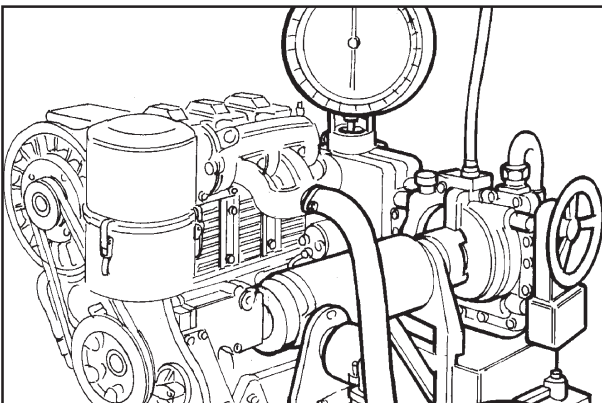


95

96

**Checking oil pressure**

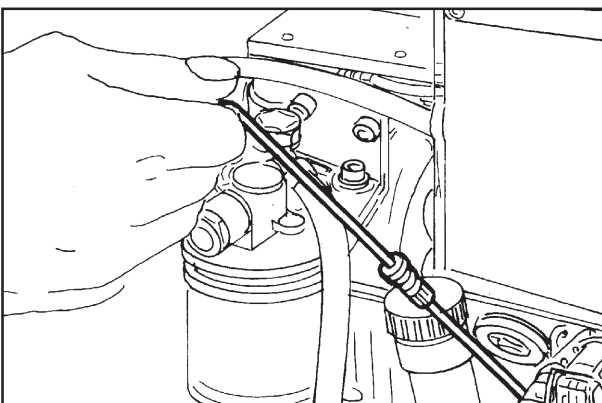
1. Remove the bolt from the hole in the crankcase and fit a pressure gauge with 0 to 10 kg/cm<sup>2</sup> full scale (fig.95)
2. Start the engine, accelerate to 3000 rpm and wait for the oil to reach a temperature of 70 to 80°C.
3. The pressure reading must be between 2.5 and 4 kg/cm<sup>2</sup>.
4. Reduce engine speed to minimum; the pressure should not fall below 1 ÷ 1.5 Kg/cm<sup>2</sup> with oil temperature of 80°C.



97

**Checking for oil leaks**

1. Remove the exhaust gas collection pipe from the inlet manifold and close the connection with a plug (fig.96).
2. Start the engine and let it run for a few minutes. The high pressure generated in the crankcase will show up any oil leaks.
3. Reconnect the exhaust gas collection pipe to the inlet manifold.

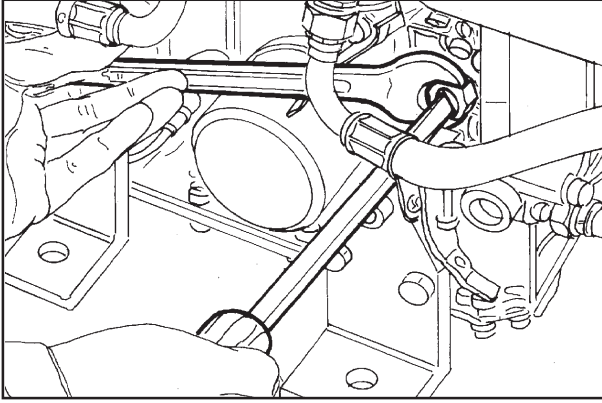


98

**Dyno testing of engine**

After you have placed the engine on the brake (fig.97) perform the following:

1. Check the oil level (fig.98).
2. Start the engine and let it idle.
3. Check the oil pressure on the pressure gauge (fig.95)
4. Run in engine before testing it at full power.



Running-in table

| Time (min) | RPM       | Load |
|------------|-----------|------|
| 5          | 2000      | 0    |
| 15         | 3000/3600 | 0    |
| 30         | 3000/3600 | 30%  |
| 30         | 3000/3600 | 50%  |
| 30         | 3000/3600 | 70%  |
| 5          | 3000/3600 | 100% |

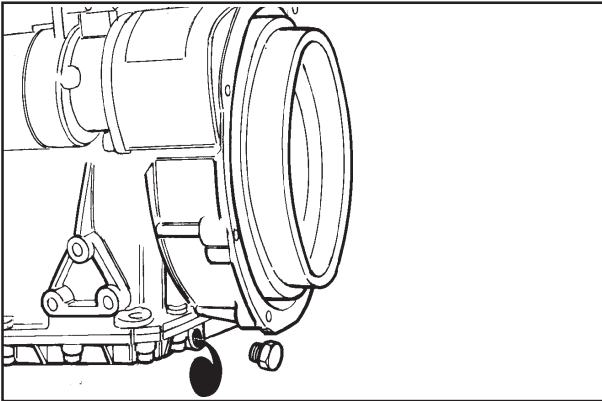
Engine power curves are reported at page 12.



In order to check that the setting is correct, without tools, accelerate the engine a few times with no load and check the exhaust fumes.

Delivery of diesel fuel is correctly calibrated when the exhaust gas is slightly coloured by smoke; change the adjustment if necessary by turning the adjustment screw (fig.99).





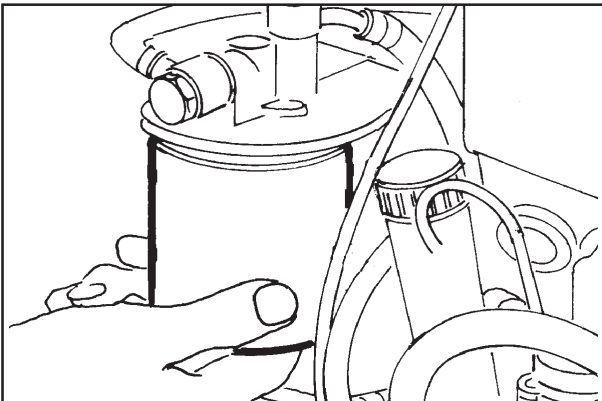
100

### Storage

Prepare engines as follows for storage over 30 days

#### Temporary protection (1/6 months)

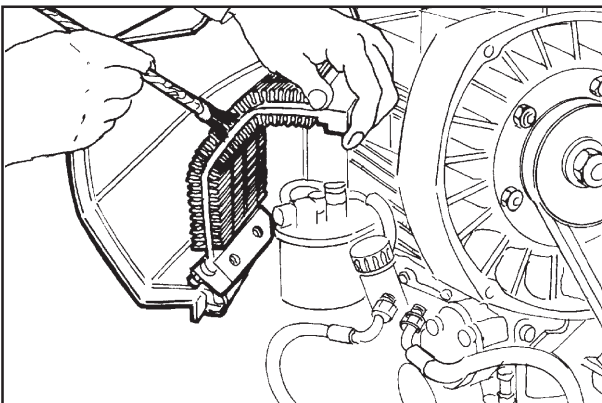
- Let engine run at idling speed in no-load conditions for 15 minutes.
- Fill crankcase with protection oil MIL-1-644-P9 and let engine run at 3/4 full speed for 5/10 minutes.
- When engine is warm empty oil pan and fill with standard new oil (fig. 100)
- Remove fuel tube and empty the tank
- Remove fuel filter, replace cartridge if dirty and refit (fig. 101).
- Carefully clean cylinder fins, heads and fan (fig. 102).
- Seal all openings with tape.
- Remove injectors, pour a spoonful of oil type SAE 30 into the cylinders and rotate manually to distribute the oil. Refit injectors.
- Spray oil type SAE 10W into exhaust and intake manifolds, rocker arms, valves, tappet etc. Grease all unpainted parts.
- Loosen belt
- Wrap the engine in a plastic film.
- Store in a dry place, if possible not directly on the soil and far from high voltage electric lines.



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#### Permanent protection (over 6 months)

- The following is recommended apart from the above instructions:
- For the lubrication and injection system as well as for moving parts use rustproof oil type MIL-L-21260 P10 grade 2, SAE 30 (Ex. ESSO RUST - BAN 623 - AGIP, RUSTIA C. SAE 30) Let the engine run with rustproof oil and drain any excess.
- Coat external unpainted surfaces with antirust type MIL-C-16173D - grade 3 /Ex. ESSO RUST BAN 398 - AGIP, RUSTIA 100/F).



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#### How to prepare the engine for operation




- Clean engine outside
- Remove protections and covers
- Remove antirust with an appropriate solvent or degreaser.
- Remove injector, fill with standard oil, turn crankshaft by a few revolutions, remove oil pan and drain the protective oil.

| Couplings                          | Spiel (mm)    | Grezen (mm) |
|------------------------------------|---------------|-------------|
| Camshaft and central bearings      | 0,070 ÷ 0,105 | 0,2         |
| Camshaft and flywheel side bearing | 0,040 ÷ 0,074 | 0,2         |
| End gap of compression rings       | 0,30 ÷ 0,45   | 0,8         |
| End gap of oil scraper rings       | 0,25 ÷ 0,40   | 0,8         |
| Connecting rod and wrist pin       | 0,023 ÷ 0,038 | 0,07        |
| Rocker arm and pin                 | 0,03 ÷ 0,06   | 0,15        |
| Fuel pump push rod and housing     | 0,05 ÷ 0,098  | 0,12        |
| Injection pump tappets and housing | 0,020 ÷ 0,059 | 0,1         |
| Tappets and housings               | 0,014 ÷ 0,046 | 0,1         |
| Oil pump rotor and housing         | 0,27 ÷ 0,47   | 0,6         |
| Pistons and wrist pin              | 0,003 ÷ 0,013 | 0,05        |
| Inlet valve guide to stem          | 0,030 ÷ 0,050 | 0,1         |
| Exhaust valve guide to stem        | 0,045 ÷ 0,065 | 0,1         |

| Adjustments                    | MIN (mm)     | MAX (mm) |
|--------------------------------|--------------|----------|
| Crankshaft end float           | 0,10 ÷ 0,25  | 0,25     |
| Rocker arm end float           | 0,05 ÷ 0,130 | 0,5      |
| Valve clearance                | 0,15         | 0,15     |
| Valve depth from cylinder head | 0,8 ÷ 1,0    | 1,3      |
| Injector protrusion            | 1,75 ÷ 2,25  | 2,25     |
| Piston protrusion              | 0,10 ÷ 0,20  | 0,20     |



| Tightening torques                   | kgm       | (Nm)          |
|--------------------------------------|-----------|---------------|
| Big ends                             | 3,6 ÷ 3,8 | (35,3 ÷ 37,3) |
| Timing cover                         | 2,2 ÷ 2,4 | (21,6 ÷ 23,5) |
| Injector ring nut                    | 3,5       | (34,3)        |
| Injectors                            | 2 ÷ 2,3   | (19,6 ÷ 22,6) |
| Injection pump                       | 2 ÷ 2,3   | (19,6 ÷ 22,6) |
| Oil pump                             | 0,9 ÷ 1,0 | (8,8 ÷ 9,8)   |
| Pulley                               | 19 ÷ 22   | (186,5 ÷ 216) |
| Injection pump connection            | 4,5 ÷ 5   | (44,1 ÷ 49)   |
| Central bearing halfshells           | 2,2       | (21,6)        |
| Central main bearings                | 2,2       | (21,6)        |
| Main engine bearings - flywheel side | 2,2 ÷ 2,4 | (21,6 ÷ 23,5) |
| Cylinder heads                       | 4,2       | (41,2)        |
| Injection pipe                       | 1,5 ÷ 2,5 | (14,7 ÷ 24,5) |
| Flywheel                             | 32        | (314)         |

| Standard screw tightening torques |  |       |  |       |  |       |
|-----------------------------------|--|-------|--|-------|--|-------|
| Denomination                      |  = 8.8<br>R ≥ 800 N/mm <sup>2</sup> |       |  = R10 = 10.9<br>R ≥ 1000 N/mm <sup>2</sup> |       |  = R12 = 12.9<br>R ≥ 1200 N/mm <sup>2</sup> |       |
|                                   | Diameter x pitch mm  | Nm    | kgm  | Nm    | kgm  | Nm    |
| 4 x 0,70                          | 3,6  | 0,37  | 5,1  | 0,52  | 6  | 0,62  |
| 5 x 0,80                          | 7  | 0,72  | 9,9  | 1,01  | 11,9   | 1,22  |
| 6 x 1,00                          | 12   | 1,23  | 17   | 1,73  | 20,4   | 2,08  |
| 7 x 1,00                          | 19,8   | 2,02  | 27,8   | 2,84  | 33   | 3,40  |
| 8 x 1,25                          | 29,6   | 3,02  | 41,6   | 4,25  | 50   | 5,10  |
| 9 x 1,25                          | 38   | 3,88  | 53,4   | 5,45  | 64,2   | 6,55  |
| 10 x 1,50                         | 52,5   | 5,36  | 73,8   | 7,54  | 88,7   | 9,05  |
| 13 x 1,75                         | 89   | 9,09  | 125  | 12,80 | 150  | 15,30 |
| 14 x 2,00                         | 135  | 13,80 | 190  | 19,40 | 228  | 23,30 |
| 16 x 2,00                         | 205  | 21,00 | 289  | 29,50 | 347  | 35,40 |
| 18 x 2,50                         | 257  | 26,30 | 362  | 37,00 | 435  | 44,40 |
| 20 x 2,50                         | 358  | 36,60 | 504  | 51,50 | 605  | 61,80 |
| 22 x 2,50                         | 435  | 44,40 | 611  | 62,40 | 734  | 74,90 |
| 24 x 3,00                         | 557  | 56,90 | 784  | 80,00 | 940  | 96,00 |



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