HR euro 2-3

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UPDATES / INDEX Pag. 1 ÷ 22 U/I

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UPDATES

ISSUE n° - 2

DATE LAST ISSUE -28/03/03

Chapter	Date issue	Issue n°	DESCRIPTION
A/I	20/11/02	1	UPDATES / INDEX
0	10/10/01	0	FOREWORD
1	20/11/02	1	IDENTIFICATION
2	20/11/02	1	TECHNICAL SPECIFICATIONS
3	20/11/02	1	MAINTENANCE
4	20/11/02	1	SYSTEM DIAGRAMS
5	20/11/02	1	DISASSEMBLY
6	20/11/02	1	CHECKS AND REPAIRS
7	28/03/03	2	ASSEMBLY
8	28/03/03	1	TABLES
9	20/11/02	1	RUNNING TESTS AND ADJUSTMENTS
10	20/11/02	1	APPLICATIONS
11	28/03/03	1	SPECIAL TOOLS
12	28/03/03	1	LABOR TIME GUIDE

UPDATES CHAPTERS

CHAPTER n° - U/I ISSUE n° - 1

DATE LAST ISSUE - 20/11/02

Date issue	Issue n°	Prepared by:	Verified by:	Approved by:	DESCRIPTION
20/11/02	1	Girotto P.	Bianchetti R.	Baroncini F.	Registration pages modification to adjust it in compliance with the regulations in force.

UPDATES CHAPTERS

CHAPTER n° - 0 ISSUE n° - 0

DATE LAST ISSUE - 10/10/01

Date issue	Issue n°	Prepared by:	Verified by:	Approved by:	DESCRIPTION
20/11/02	0	Girotto P.	Bianchetti R.	Baroncini F.	

UPDATES CHAPTERS

CHAPTER n° - 1 **ISSUE n° - 1**

DATE LAST ISSUE - 20/11/02

Date issue	Issue n°	Prepared by:	Verified by:	Approved by:	DESCRIPTION
20/11/02	1	Girotto P.	Bianchetti R.	Baroncini F.	Attached code and denomination for HR94HI3.

UPDATES CHAPTERS

CHAPTER n° - 2 ISSUE n° - 1

DATE LAST ISSUE - 20/11/02

Date issue	Issue n°	Prepared by:	Verified by:	Approved by:	DESCRIPTION
20/11/02	1	Girotto P.	Bianchetti R.	Baroncini F.	Attached details for HR494HI3.

UPDATES CHAPTERS

CHAPTER n° - 3 **ISSUE n° - 1**

DATE LAST ISSUE - 20/11/02

Date issue	Issue n°	Prepared by:	Verified by:	Approved by:	DESCRIPTION
20/11/02	1	Girotto P.	Bianchetti R.	Baroncini F.	Overhaul paragraphs has been made by remaking up pages.

UPDATES CHAPTERS

CHAPTER n° - 4 **ISSUE n° - 1**

DATE LAST ISSUE - 20/11/02

Date issue	Issue n°	Prepared by:	Verified by:	Approved by:	DESCRIPTION
20/11/02	1	Girotto P.	Bianchetti R.	Baroncini F.	Attached details for HR494HI3.

UPDATES CHAPTERS

CHAPTER n° - 5 **ISSUE n° - 1**

DATE LAST ISSUE - 20/11/02

Date issue	Issue n°	Prepared by:	Verified by:	Approved by:	DESCRIPTION
20/11/02	1	Girotto P.	Bianchetti R.	Baroncini F.	Attached details for HR494HI3.

UPDATES CHAPTERS

CHAPTER n° - 6 ISSUE n° - 1

DATE LAST ISSUE - 20/11/02

Date issue	Issue n°	Prepared by:	Verified by:	Approved by:	DESCRIPTION
20/11/02	1	Girotto P.	Bianchetti R.	Baroncini F.	Attached details for HR494HI3.

UPDATES CHAPTERS

CHAPTER n° - 7 **ISSUE n° - 2**

DATE LAST ISSUE - 28/03/03

Date issue	Issue n°	Prepared by:	Verified by:	Approved by:	DESCRIPTION
20/11/02	1	Girotto P.	Bianchetti R.	Baroncini F.	Attached details for HR494HI3.
28/03/03	2	Girotto P.	Bianchetti R.	Baroncini F.	Attached assembly charts.

UPDATES CHAPTERS

CHAPTER n° - 8 ISSUE n° - 1

DATE LAST ISSUE - 28/03/03

Date issue	Issue n°	Prepared by:	Verified by:	Approved by:	DESCRIPTION
28/03/03	1	Girotto P.	Bianchetti R.	Baroncini F.	Tourque value deleted because already mentionated in the spesific chapters.

UPDATES CHAPTERS

CHAPTER n° - 9 **ISSUE n° - 1**

DATE LAST ISSUE - 20/11/02

Date issue	Issue n°	Prepared by:	Verified by:	Approved by:	DESCRIPTION
20/11/02	1	Girotto P.	Bianchetti R.	Baroncini F.	Attached details for HR494HI3.

UPDATES CHAPTERS

CHAPTER n° - 10 **ISSUE n° - 1**

DATE LAST ISSUE - 20/11/02

Date issue	Issue n°	Prepared by:	Verified by:	Approved by:	DESCRIPTION
20/11/02	1	Girotto P.	Bianchetti R.	Baroncini F.	Attached use at low temperature.

UPDATES CHAPTERS

CHAPTER n° - 11 **ISSUE n° - 1**

DATE LAST ISSUE - 28/03/03

Date issue	Issue n°	Prepared by:	Verified by:	Approved by:	DESCRIPTION
28/03/03	1	Girotto P.	Bianchetti R.	Baroncini F.	Attached pins for flyweel assembly.

UPDATES CHAPTERS

CHAPTER n° - 12 ISSUE n° - 1

DATE LAST ISSUE - 28/03/03

Date issue	Issue n°	Prepared by:	Verified by:	Approved by:	DESCRIPTION
28/03/03	1	Girotto P.	Bianchetti R.	Baroncini F.	Substitute code operation.

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0.0 WORKSHOP PROCEDURES

The models illustrated can be identified by the code indicating the bore, number of cylinders and aspiration type (see Chap. 1 'Identification').

In the event of a fault, check that the problem is not due to some external factor before proceeding to dismantle the engine.

If it is necessary to dismantle the engine, label all those parts which must be fitted in a certain position, so as to avoid problems and save time during reassembly.

DURING DISASSEMBLY AND REASSEMBLY, THE ENGINE MUST BE SUPPORTED ON A SUITABLE PURPOSE-BUILT STAND OF THE TYPE INDICATED IN CHAPS. 5 AND 7.

Fix the engine to the stand using the bolts provided with the stand or similar.

WARNING: TO SUPPORT OR MOVE THE ENGINE, ALWAYS USE A COMMERCIAL PURPOSE-BUILT STAND OF THE TYPE INDICATED IN CHAPS. 5 AND 7.

WARNING: RISK OF CRUSHING AND/ OR SHEARING OF LIMBS DURING ENGINE ROTATION ON STAND.

WARNING: ALWAYS USE THE CORRECT TOOLS FOR THE TASK. DO NOT USE UNSUITABLE TOOLS TO AVOID RISK OF PERSONAL INJURY AND DAMAGING COMPONENTS.

If difficulty is encountered separating parts during disassembly, use only gentle blows with a synthetic rubber or wooden mallet or use a metal hammer and interpose soft material (synthetic resin, wood).

Keep the component parts of different assemblies separate and label any unmarked parts to facilitate reassembly.

If you use abrasive materials (emery cloth, etc.) to clean any parts, always clean the parts thoroughly afterwards using a suitable solvent to remove any abrasive particles (see para. 3.7).

Lubricate all moving parts with a suitable lubricant prior to reassembly (see para. 3.5).

When reassembling the engine, renew all seals, gaskets, spring washers, tab washers, and any parts which appear worn or defective.

DANGER: ALWAYS TAKE SUITABLE PRECAUTIONS WHEN HANDLING LUBRICANTS, THREAD-LOCKING COMPOUNDS, REFRIGERANTS, FUEL AND SOLVENTS ETC. AND AVOID INGESTION, INHALATION OF FUMES AND CONTACT WITH THE EYES AND SKIN.

0.1 USING THE WORKSHOP MANUAL

0.1.1 Importance of the manual

This workshop manual is published for use in **"VM"** Service Centers and contains instructions for the servicing, repair and overhaul of **HR/HT2-3** engines.

We recommend that you follow all the instructions in this manual scrupulously, as the effectiveness of any servicing operation depends on the correct and methodical application of the information contained herein.

If you run into difficulties or setbacks, **VM MOTORI S.p.A. SERVICE DEPARTMENT** will be happy to provide you with the necessary advice and assistance.

VM MOTORI S.p.A. declines any liability for any injury or damage resulting from incorrect or unsuitable operations.

VM MOTORI S.p.A. reserves the right to make any modifications aimed at improving its products without prior notification.

Please ensure that any amendments or updates you may receive are kept with the original version of this manual.

0.1.2 Conserving the manual

When using the manual, take care not to damage or deface it.

Do not tear or remove pages from the manual, or overwrite any parts of the manual for any reason.

Keep the manual in safe place protected from excess heat and humidity.

0.1.3 Consulting the manual

This manual comprises:

- COVER PAGE IDENTIFYING THE TYPE OF ENGINE
- TABLE OF CONTENTS
- INSTRUCTIONS AND/OR NOTES ON THE PRODUCT

The **COVER PAGE** indicates the engine model dealt with in the manual.

The **TABLE OF CONTENTS** indicates the CHAPTER and PARAGRAPH to be consulted for information about a particular topic.

The **INSTRUCTIONS AND/OR NOTES ON THE PRODUCT** define the safe working practices, correct procedures and skills required to service the engine correctly.

Please note that some of the illustrations in the manual, which are included to help you identify the parts described in the text, show standard engines and therefore may differ in some respects from the engine in your possession.

0.1.4 Symbols used in the manual

The Safety symbols and notices shown below are used throughout this manual to draw the reader's attention to the hazards associated with particular procedures and operations which could result in damage to the engine or personal injury, or to indicate good working practices.

GENERAL OPERATIONAL NOTE

Safety notices (rectangular): you must use the protection shown in the notices when carrying out the operation in question to avoid risk of personal injury:

PROTECT YOUR HANDS (WEAR GLOVES)

PROTECT YOUR EYES (WEAR SAFETY GOGGLES)

PROTECT RESPIRATORY PASSAGES (WEAR A MASK)

Danger warning signs (triangular) (General warning of risk of personal injury or damage to the engine):

DANGER (GENERAL HAZARD - RISK OF PERSONAL INJURY OR DAMAGE TO THE ENGINE)

DANGER (ELECTRICAL HAZARD - RISK OF ELECTROCUTION OR DAMAGE TO THE ENGINE)

DANGER (HIGH TEMPERATURE HAZARD - RISK OF BURNS OR DAMAGE TO THE ENGINE)

Prohibition notices (circular) denoting operations which are expressly prohibited to avoid risk of personal injury.

THE OPERATION INDICATED IN THE TEXT IS STRICTLY PROHIBITED

IT IS STRICTLY PROHIBITED TO CARRY OUT MAINTENANCE WORK IN THE PRESENCE OF MOVING PARTS.

IT IS STRICTLY PROHIBITED TO REMOVE OR TAMPER WITH THE SAFETY DEVICES.

PAY ATTENTION TO THE SYMBOLS AND ADHERE TO THE INSTRUCTIONS IN THE ADJACENT TEXT.

USE TORQUE WRENCH.

USE ANGULAR TORQUE WRENCH.

0.2 ORDERING ORIGINAL REPLACEMENT PARTS

To help us provide a fast and efficient service, always specify the following information when ordering replacement parts:

- **Engine type** as indicated on nameplate;
- **Serial number** as indicated on nameplate and stamped on crankcase;
- **Part number** and drawing of component required
- **Quantity** of each item required

Otherwise you can place your order through INTERNET site: http://www.vm-motori.it

0.3 QUALITY SYSTEM CERTIFICATION ISO 9001 ; QS-9000 ; ISO 14001

VM MOTORI has obtained and maintains the official certification of its quality system in compliance with UNI EN ISO 9001 and in according with the prescriptions of Ford, Chrysler and GM car manufacturing association for the production of Diesel engines, set down in Quality System Standard QS 9000.
The company has also obtained the certification of its environmental management system, in accordance with ISO 14001 standards.
This is the result of an operating programme that has involved all levels of the company in a drive for constant structural improvement.
Quality policy and the environment, with particular reference to the principle of continuous improvement, are essential components of VM's top management functions in accordance with internationally accepted quality and environment management systems, in the full respect of the environment and the population.
Customer satisfaction, productivity and motivation of the employees as the sum of all services rendered outside and inside the company are the most important elements of VM's concept of quality.
All VM's employees are committed to the quality policy and the protection of the environment.
Regular training ensures that their qualifications are constantly brought up to date. VM regards quality as a dynamic process of continuous improvement in all activities in order to achieve the company's goals.

0.4 REFERENCE STANDARDS USED FOR DRAFTING

This manual has been drafted according to the following **"UNI STANDARD: 10653 and 10893"**

Certified Company:
ISO 9001; QS-9000; ISO 14001

ICIM

ISO 9001 - Cert. n° 0295/1
QS-9000 - Cert. n° 0842/1

ICIM

ISO 14001 - Cert. n° 0043A/0

QS-9000
One World - One Quality System

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IDENTIFICATION Pag. 1 ÷ 4 1

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1.1 IDENTIFICATION DATA

The engine identification data can be found in the following positions:

- engine nameplate showing identification data (fig. 1.1).

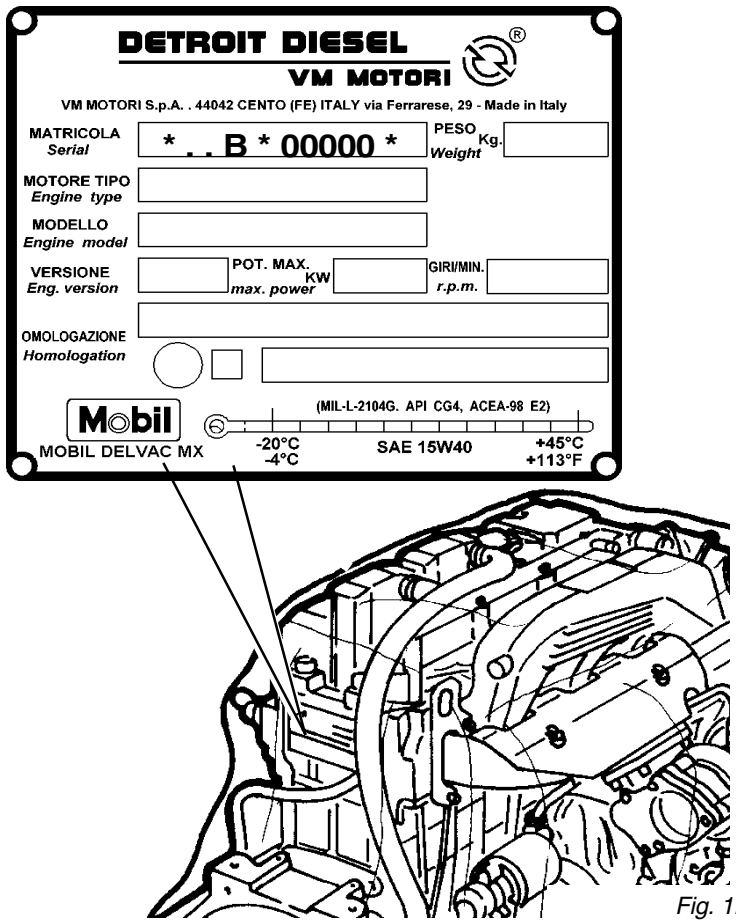

Fig. 1.1

- serial number stamped on the engine crankcase (fig. 1.2)

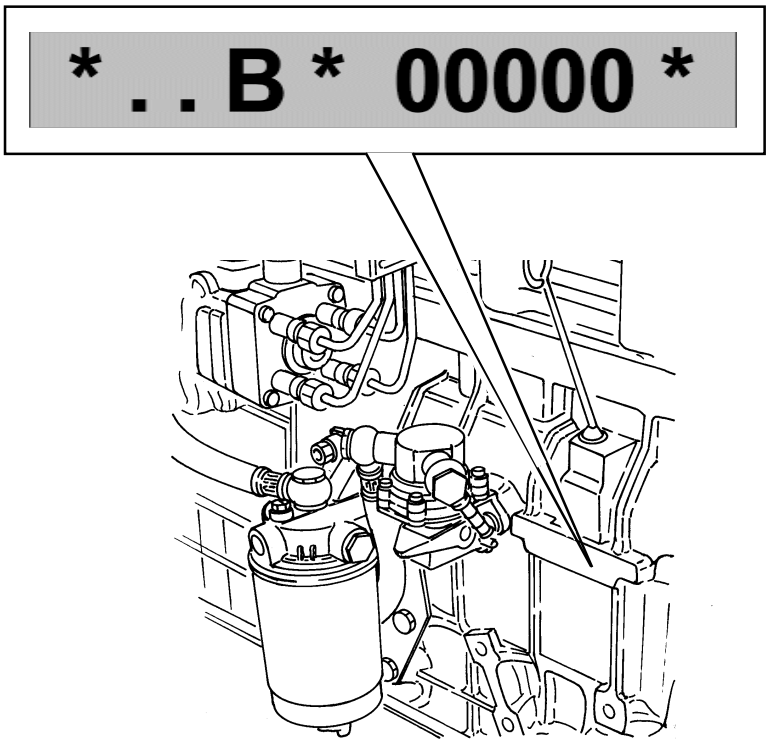

Fig. 1.2

1.2 ENGINE TYPE IDENTIFICATION

The engine series HR/HT2-3 for application that require EURO 2 and EURO 3 homologation are identified by a code that refer to the engine tipe.

DESIGNATION	CODE
HR494HT2	64 B
HR494HT3	64 B/3
HR494HI3	10 C
HR694HT2	65 B
HR694HT3	65 B/3

/1 : Omologation at rpm 3.000
/3 : " " " 2.600
/4 : " " " 2.300
64B : " " " 3.200

Engine identification/conformity data fpr EPA norms:

A label on the flywheel bell housing indicates the identification engine data (Fig. 1.3)

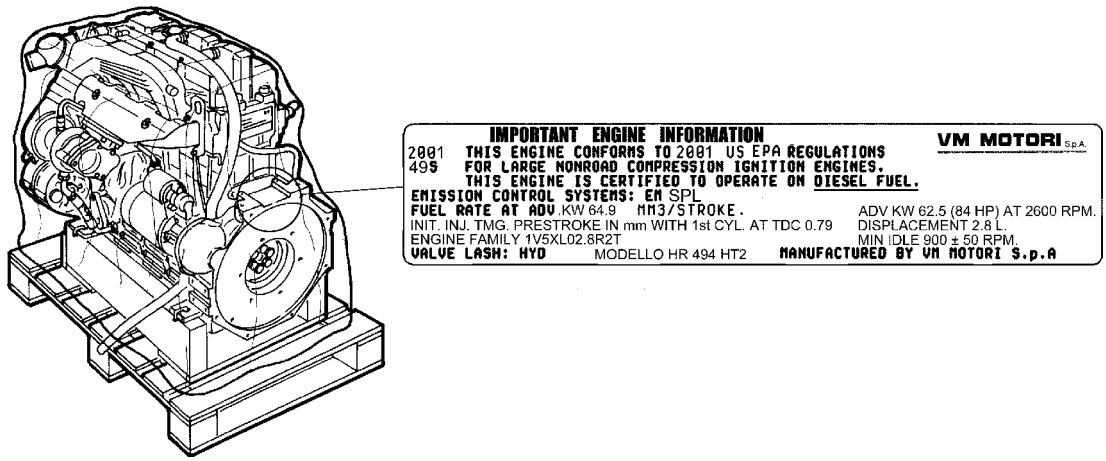

Fig. 1.3

1.3 MANUFACTURER IDENTIFICATION

MANUFACTURER: VM MOTORI S.p.A.
Via Ferrarese, 29
44042 CENTO (FERRARA) ITALIA
TEL. 051 / 6837511
FAX. 051 / 6837517 / 6837584

TECHNICAL SPECIFICATIONS Pag. 1 ÷ 14 2

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2.1 ENGINE DIMENSION *(FIG. 2.1)*

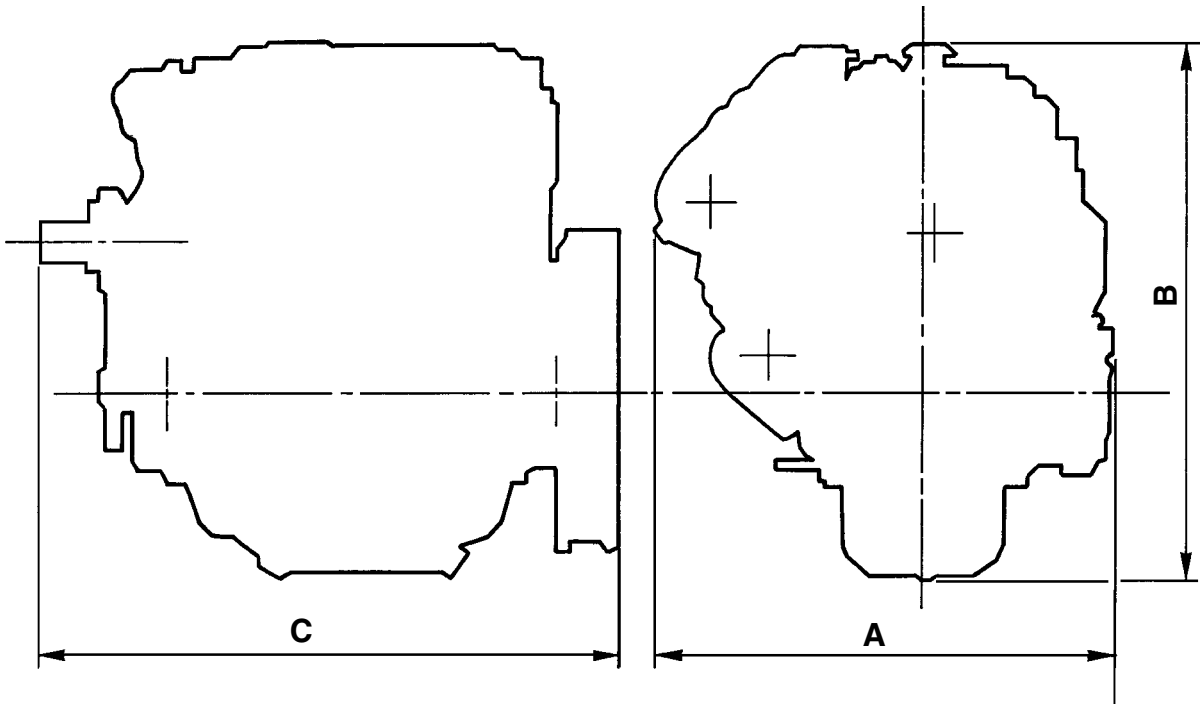


Fig. 2.1

ENGINE TYPE		A	B	C
HR494HT2	mm.	611	672	722
HT494HT3	mm.	600	710	730
HR494HI3	mm.	600	680	730
HR694HT2	mm.	638	709	943
HR694HT3	mm.	620	710	965

2.1.1 INCLINATION MAX *(FIG. 2.1.1)*

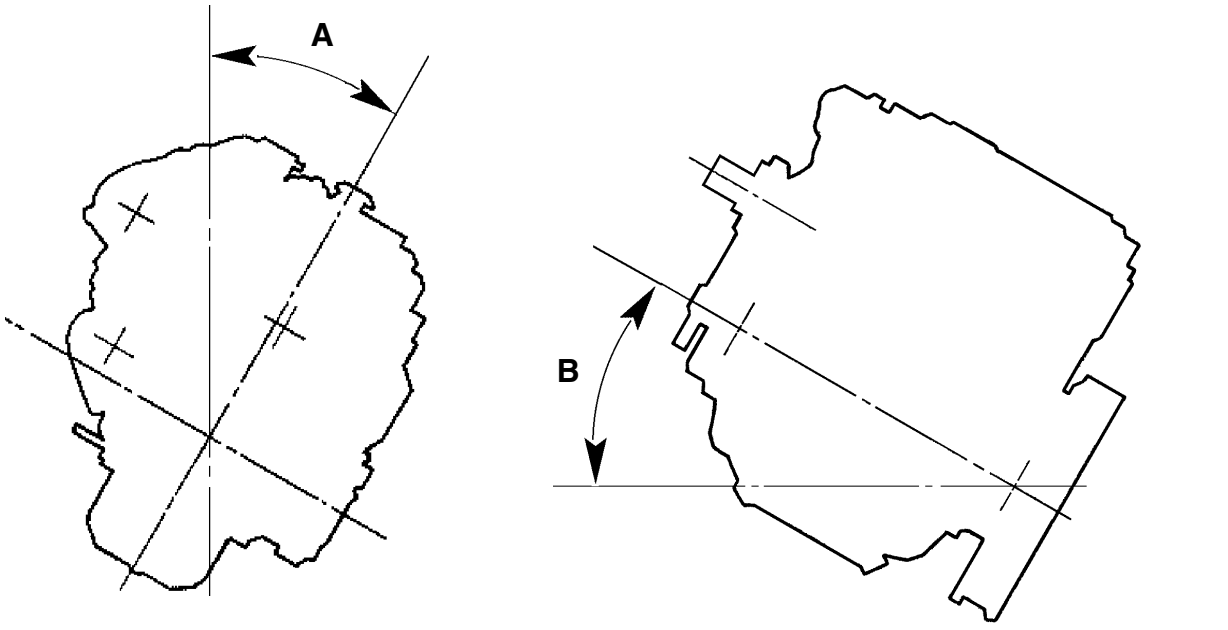


Fig. 2.1.1

ENGINE	A = Transverse in both directions	B = Longitudinal flywheel up	B = Longitudinal flywheel down
HR494	30°	35°	35°
HR694	30°	23°	23°

2.2 TECHNICAL DATA

ENGINE TYPE	UNITS OF MEASUR.	494 HT2	494 HT3	494 HI3	694 HT2	694 HT3
NUMBER CYLINDERS	N°	4	4	4	6	6
BORE	mm	94	94	94	94	94
STROKE	mm	100	100	100	100	100
TOTAL DISPLACEMENT	cm^3	2.776	2.776	2.776	4.164	4.164
MAXIMUM ENGINE SPEED	rpm/min	3.200	2.600	3200	3.200	2.600
QUANTITY OF OIL IN THE SUMP	Kg.	5.8	5.8	5.8	7.5	7.4
MIN. OIL PRESSURE (WITH ENGINE HOT) WITH ENGINE AT IDLING	kPa bar	120÷160 1.2÷1.6	120÷160 1.2÷1.6	120÷160 1.2÷1.6	120÷160 1.2÷1.6	120÷160 1.2÷1.6

POWER	RPM	HR494HT2	HR694HT2	HR494HT3	HR494HI3	HR694HT3
EEC 80/1269 Kw (Cv)	1200	30.5(41.5)	54.5(40.0)	27.7(37.6)	32.2(44)	57.0(41.9)
	1500	37.0(50.0)	82.0(60.3)	38.4(52.0)	43(58.5)	79.0(58.1)
	1800	44.0(60.0)	102.0(75.0)	48.3(65.5)	51.9(70.5)	98.0(72.0)
	2300	55.0(75.0)	127.0(93.4)	55.0(75.0)	65(88.5)	126.5(93.0)
	2600	59.0(80.0)	135.0(99.0)	59.0(80.0)	72(98)	135.0(99.0)
	3000	65.5(89.0)	147.0(108.0)		75(102)	
	3200	68.5(93.0)	149.5(110.0)		77(105)	

ELETTRICAL POWER OBTAINABLE AT 3000 RPM/MIN - 50Hz

	Elettrical power				
	SAE J 1995		Continuous		*
	KVA	KW	KVA	KW	%
HR494HT2	60	48	66	53	
HR694HT2	90	79	82	72	

a) Power ratings are expressed in accordance with SAE J 1995 and refer to the engine after running in for approx. 50 hours.
b) Production tolerances on the indicated power ratings: ± 5%
c) New engines perform 4% less power.
d) Continuous duty power ratings can be overloaded by 10%.
e) Emergency duty power ratings cannot be overloaded.
f *) The alternator output values given are those stated by the manufacturer.

ENGINE TYPE	Units of measur.	HR494HT2	HR694HT2	HR494HT3	HR494HI3	HR694HT3
COMPRESSION PRESSURE	kPa bar	2800÷3200 28÷32	2800÷3200 28÷32	2800÷3200 28÷32	2800÷3200 28÷32	2800÷3200 28÷32
MAXIMUM PRESSURE DIFFERENCE BEETWEN THE CYLINDERS	kPa bar	500 5	500 5	500 5	500 5	500 5
FIRING ORDER		1-3-4-2	1-5-3-6-2-4	1-3-4-2	1-3-4-2	1-5-3-6-2-4
INJECTION ORDER		1-3-4-2	1-5-3-6-2-4	1-3-4-2	1-3-4-2	1-5-3-6-2-4
VALVE CLEARANCES (●)	mm					
IDLE SPEED	rpm	900÷950	800÷850	900÷950	900÷950	800÷850
MAXIMUM LOAD SPEED	rpm	3.200	3.200	2.600	3.200	2.600
DRY WEIGHT	Kg.	250	350	250	250	350
COMPRESSION RATIO		21.5:1	21.5:1	21.5:1	21.5:1	21.5:1
INJETION		undirect	undirect	undirect	undirect	undirect
ASPIRATION		turbocharger	turbocharger	turbocharger	turbocharger	turbocharger
COOLING		water cooled	water cooled	water cooled	water cooled	water cooled
DIRECTION OF ROTATION VIEWED FROM FLYWHEEL		counter clockwise	counter clockwise	counter clockwise	counter clockwise	counter clockwise

(●) The engine don't have need of the valve registration.
(Hidraulic tappets)

HR 494 HT2 EQUIPMENT			
Injection pump:	BOSCH with LDA mechanical		
Injector:	BOSCH screwed		
Injection pressure:	165 bar (16500 kPa)		
Injection advance:	See table page. 6-22		
Injection pump calibration:	**Capacity x 1000 delivery mm³**	**Press. into bar**	**Advance**
	59 ± 1.5 a 1500 giri/min	6	3.2
	62 ± 1.5 a 1000 giri/min	4.1	0.9
	58 ± 1.5 a 600 giri/min	2.5	0

HR694HT2 EQUIPMENT			
Injection pump:	BOSCH with LDA mechanical		
Injector:	BOSCH screwed		
Injection pressure:	165 bar (16500 kPa)		
Injection advance:	See table page. 6-22		
Injection pump calibration:	**Capacity x 1000 delivery mm³**	**Press. into bar**	**Advance**
	68 ± 1.5 a 1600 giri/min	6.8	4.3
	69.5 ± 1.5 a 1000 giri/min	5.3	1.5
	44.5 ± 1.5 a 600 giri/min	4	0

SCHEDA TARATURA POMPA INIEZIONE ROTATIVA MARCA BOSCH

(Bosch rotary injection pump calibration chart)

CODICE VM POMPA MODIFICATA (modified pump VM part/n°):	35022090F	RICAVATA DA CODICE VM (Obtained from VM part/n°):	/

PRESCRIZIONI DEL BANCO PROVA VM *(VM test bench prescriptions)*

INIET. BANCO BOSCH (Bosch bench injector): **1 688 901 110**	Bosch base pump variation: **0 460 404 101**
TARATI A (Setted at): **225 ±3 bar**	PUNZ.TARGHETTA (Name plate punching):
TUBI INIEZ.BOSCH (Bosch inject.pipes): **1 680 750 028 (ISO 4093-2)**	**L379-2**
TIPO FLUIDO (liquid type): **SHELL S-9365 - press.(0.3 ±0.05 bar)**	UTILIZZ.SU MOTORE (Used on engine): **HR494HT3 (64B/3)**
TEMPERATURA FLUIDO (liquid temp.) : **40° ±1°**	TARATO A GIRI/MIN (setted at rpm1'): **2600**

NOTE (Notes): **(matricola pompa utilizzata: 653532)**

N° GIRI (POMPA) rpm (Pump)	**ANTICIPO (mm)** Advance (mm)	**PRESSIONE INTERNA (Bar)** Internal Pressure	**PORTATA x 1000 MANDATE (cc)** Flow rate x 1000	**PRESSIONE SOVRALIM. (Bar)** Boost pressure
1300	**2.7** ±0.5	**6.5** ±0.4	**67** ±3	**1**
1000	**1**±0.5	**5.1** ±0.4	**70** ±2.5	**1**
750	**0**	**4** ±0.4	**60** ±3	**0,4**
600	**0**	**3.5** ±0.4	**63.5** ±2.5	**0**
100	**0**	**0.7** ±0.2	**>91**	**0**

GIRI AL MINIMO (POMPA) Min.speed (Pump)	**GIRI A VUOTO (POMPA)** Idle speed (Pump)
450	**1450**

Verificato (Verified) API :	DATA-Date:
Ferrari	14/12/02

Approvato (Approved) EMI:	DATA-Date:
Marchesini	14/12/02

SCHEDA TARATURA POMPA INIEZIONE ROTATIVA MARCA BOSCH

(Bosch rotary injection pump calibration chart)

CODICE VM POMPA MODIFICATA (modified pump VM part/n°):	15022188F	RICAVATA DA CODICE VM (Obtained from VM part/n°):	35022090F

PRESCRIZIONI DEL BANCO PROVA VM *(VM test bench prescriptions)*

INIET. BANCO (bench injector): **168 8901 022**	base pump variation: **0 460 404 101**
TARATI A (Setted at): **130 bar**	PUNZ.TARGHETTA (Name plate punching):
TUBI INIEZ (inject.pipes): **1 680 750 073 L= 840 mm (ISO 4093-2)**	**VE 4/11F - VM441**
TIPO FLUIDO (liquid type): **SHELL S-9365 - pressione (0.3 + 0.05 bar)**	UTILIZZ.SU MOTORE (Used on engine): **HR494HI3 (10C/4)**
TEMPERATURA FLUIDO (liquid temp.) :	TARATO A GIRI/MIN (setted at rpm1'): **2300**

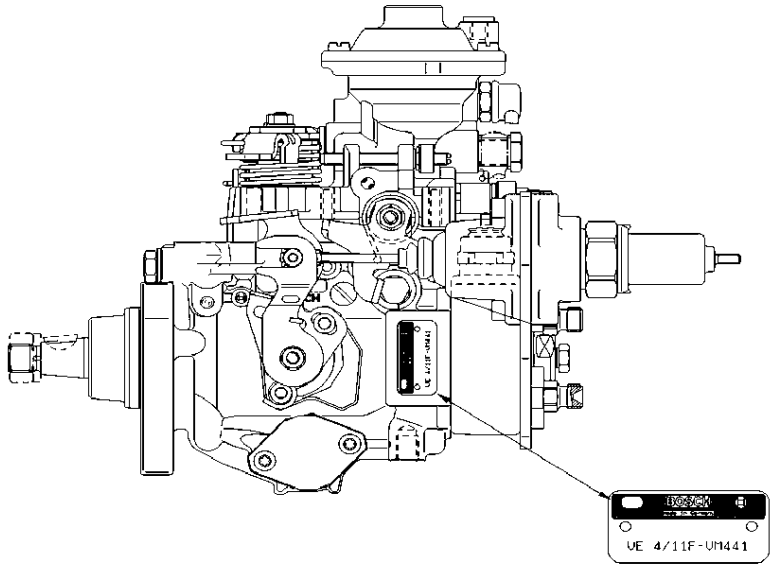
NOTE (Notes): .....

N° GIRI (POMPA) rpm (Pump)	**ANTICIPO (mm)** Advance (mm)	**PRESSIONE INTERNA (Bar)** Internal Pressure	**PORTATA x 1000 MANDATE (cc)** Flow rate x 1000	**PRESSIONE SOVRALIM. (Bar)** Boost pressure
1200	**1**	**5** ±0.3	**58** ±3	**1**
1150	**1.5** ±0.2	**5.5** ±0.3	**72** ±3	**1**
1000	**1.0** ±0.6	**5** ±0.3	**73** ±3	**1**
750	**0**	**3.1** ±0.3	**60,5** ±3	**0,4**
600	**0**	**2.1** ±0.2	**59.5** ±2	**0**
100	**0**	**0.8** ±0.3	**80** ±3	**0**

GIRI AL MINIMO (POMPA) Min.speed (Pump)	GIRI A VUOTO (POMPA) Idle speed (Pump)
450	**1275**

Verificato (Verified) API :	DATA-Date:
Ferrari	25/11/02

Approvato (Approved) EMI:	DATA-Date:
Marchesini	25/11/02



SCHEDA TARATURA POMPA INIEZIONE ROTATIVA MARCA BOSCH

(Bosch rotary injection pump calibration chart)

CODICE VM POMPA MODIFICATA (modified pump VM part/n°):	15022189F	RICAVATA DA CODICE VM (Obtained from VM part/n°):	35022090F

PRESCRIZIONI DEL BANCO PROVA VM *(VM test bench prescriptions)*

INIET. BANCO (bench injector): **168 8901 022**	base pump variation: **0 460 404 101**
TARATI A (Setted at): **130 bar**	PUNZ.TARGHETTA (Name plate punching):
TUBI INIEZ (inject.pipes): **1 680 750 073 L= 840 mm (ISO 4093-2)**	**VE 4/11F - VM440**
TIPO FLUIDO (liquid type): **SHELL S-9365 - pressione (0.3 + 0.05 bar)**	UTILIZZ.SU MOTORE (Used on engine): **HR494HI3 (10C/3)**
TEMPERATURA FLUIDO (liquid temp.) :	TARATO A GIRI/MIN (setted at rpm/'): **2600**

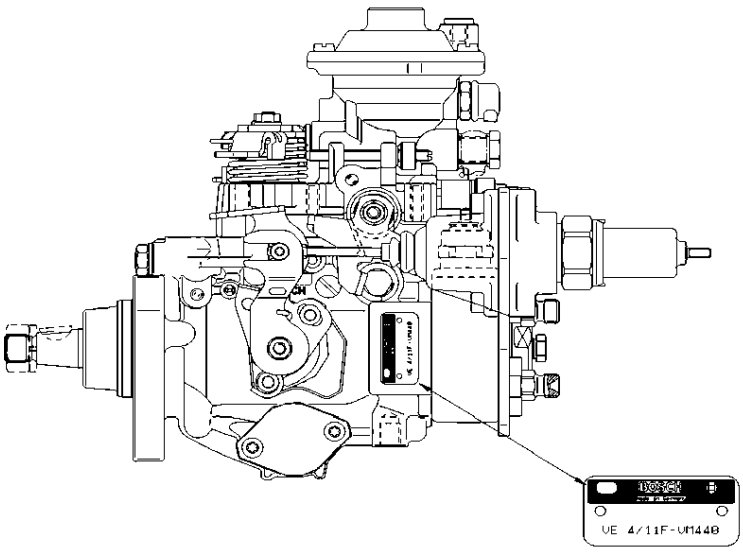
NOTE (Notes):

N° GIRI (POMPA) rpm (Pump)	**ANTICIPO (mm)** Advance (mm)	**PRESSIONE INTERNA (Bar)** Internal Pressure	**PORTATA x 1000 MANDATE (cc)** Flow rate x 1000	**PRESSIONE SOVRALIM. (Bar)** Boost pressure
1400	**1,8**	**5.4** ±0.3	**60.5** ±3	**1**
1300	**2.0** ±0.2	**6** ±0.3	**71.5** ±3	**1**
1000	**1.0** ±0.6	**5** ±0.2	**73** ±2	**1**
750	**0**	**3.1** ±0.3	**60,5** ±3	**0,4**
600	**0**	**2.1** ±0.2	**59.5** ±3	**0**
100	**0**	**0.8** ±0.3	**80** ±15	**0**

GIRI AL MINIMO (POMPA) Min.speed (Pump)	**GIRI A VUOTO (POMPA)** Idle speed (Pump)
450	**1425**

Verificato (Verified) API :	DATA-Date:
Ferrari	25/11/02

Approvato (Approved) EMI:	DATA-Date:
Marchesini	25/11/02



SCHEDA TARATURA POMPA INIEZIONE ROTATIVA MARCA BOSCH

(Bosch rotary injection pump calibration chart)

CODICE VM POMPA MODIFICATA (modified pump VM part/n°):	15022190F	RICAVATA DA CODICE VM (Obtained from VM part/n°):	35022090F

PRESCRIZIONI DEL BANCO PROVA VM *(VM test bench prescriptions)*

INIET. BANCO (bench injector): **168 8901 022**	base pump variation: **0 460 404 101**
TARATI A (Setted at): **130 bar**	PUNZ.TARGHETTA (Name plate punching):
TUBI INIEZ (inject.pipes): **1 680 750 073 L= 840 mm (ISO 4093-2)**	**VE 4/11F - VM443**
TIPO FLUIDO (liquid type): **SHELL S-9365 - pressione (0.3 + 0.05 bar)**	UTILIZZ.SU MOTORE (Used on engine): **HR494HI3 (10C/3)**
TEMPERATURA FLUIDO (liquid temp.) :	TARATO A GIRI/MIN (setted at rpm): **2600**

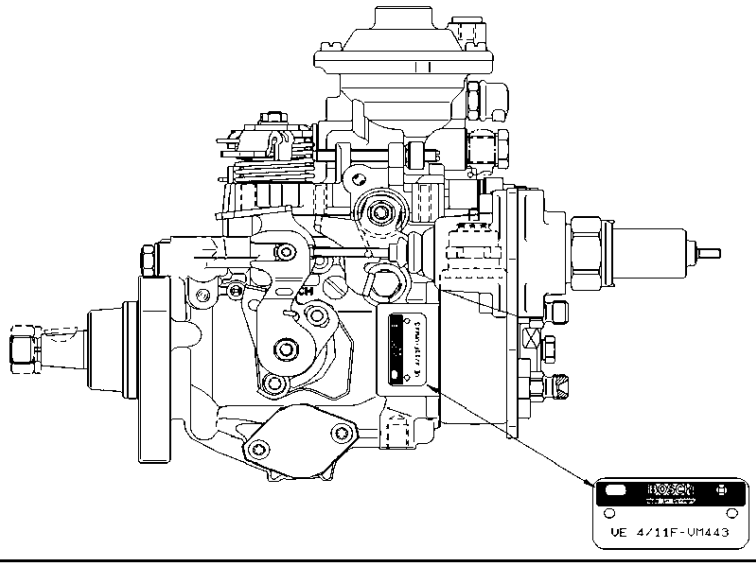
NOTE (Notes): **Versione 08A REFORM-WERKE**

N° GIRI (POMPA) rpm (Pump)	**ANTICIPO (mm)** Advance (mm)	**PRESSIONE INTERNA (Bar)** Internal Pressure	**PORTATA x 1000 MANDATE (cc)** Flow rate x 1000	**PRESSIONE SOVRALIM. (Bar)** Boost pressure
1400	**1.8** ±0.6	**5.4** ±0.3	**59** ±3	**1**
1300	**2.0** ±0.2	**6** ±0.3	**69** ±3	**1**
1000	**1.0** ±0.6	**5** ±0.2	**71.5** ±2	**1**
750	**0**	**3.9** ±0.3	**62,5** ±3	**0,4**
600	**0**	**3.4** ±0.3	**64** ±3	**0**
100	**0**	**0.6** ±0.3	**80** ±15	**0**

GIRI AL MINIMO (POMPA) Min.speed (Pump)	**GIRI A VUOTO (POMPA)** Idle speed (Pump)
450	**1425**

Verificato (Verified) API :	DATA-Date:
Ferrari	25/11/02

Approvato (Approved) EMI:	DATA-Date:
Marchesini	25/11/02



SCHEDA TARATURA POMPA INIEZIONE ROTATIVA MARCA BOSCH

(Bosch rotary injection pump calibration chart)

CODICE VM POMPA MODIFICATA (modified pump VM part/n°):	15022174F	RICAVATA DA CODICE VM (Obtained from VM part/n°):	35022070F

PRESCRIZIONI DEL BANCO PROVA VM *(VM test bench prescriptions)*

INIET. BANCO BOSCH (Bosch bench injector): **1 688 8901 022**	Bosch base pump variation: **0 460 416 085**
TARATI A (Setted at): **130 bar**	PUNZ.TARGHETTA (Name plate punching):
TUBI INIEZ.BOSCH (Bosch inject.pipes): **1 680 750 073 (ISO 4093-2)**	**VE 6/11F-VM631**
TIPO FLUIDO (liquid type): **SHELL S-9365 - press.(0.3 ±0.05 bar)**	UTILIZZ.SU MOTORE (Used on engine): **HR694HT3 (65B/3)**
TEMPERATURA FLUIDO (liquid temp.) : **40° ±1°**	TARATO A GIRI/MIN (setted at rpm/1'): **2600**

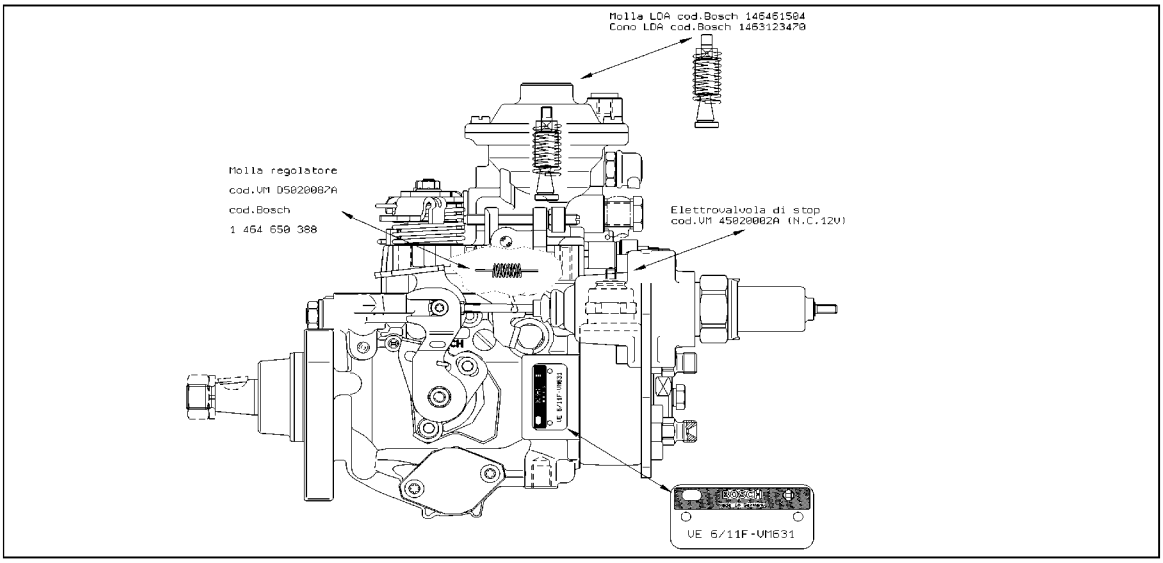
NOTE (Notes): .....

N° GIRI (POMPA) rpm (Pump)	ANTICIPO (mm) Advance (mm)	PRESSIONE INTERNA (Bar) Internal Pressure	PORTATA x 1000 MANDATE (cc) Flow rate x 1000	PRESSIONE SOVRALIM. (Bar) Boost pressure
1440			**1.5** ±1.5	**1,0**
1300	**2.5** ±0.5	**6.0** ±0.4	**75.0** ±2	**1,0**
1100	**1.0** ±0.5			
1000	**0.8** ±0.5	**5.0** ±0.4	**76.0** ±2	**1,0**
750	**0.3** ±0.2	**4.2** ±0.4	**70.5** ±3	**0,4**
600		**3.8** ±0.4	**36.0** ±3	**0,0**
100			**76.0** ±2	**0,0**

GIRI AL MINIMO (POMPA) Min.speed (Pump)	GIRI A VUOTO (POMPA) Idle speed (Pump)
375	**1440**

Verificato (Verified) API :	DATA-Date:
Ferrari	20/02/03

Approvato (Approved) EMI:	DATA-Date:
Marchesini	20/02/03



SCHEDA TARATURA POMPA INIEZIONE ROTATIVA MARCA BOSCH

(Bosch rotary injection pump calibration chart)

CODICE VM POMPA MODIFICATA (modified pump VM part/n°):	15022187F	RICAVATA DA CODICE VM (Obtained from VM part/n°):	35022090F

PRESCRIZIONI DEL BANCO PROVA VM *(VM test bench prescriptions)*

INIET. BANCO (bench injector): **168 8901 022**	base pump variation: **0 460 404 101**
TARATI A (Setted at): **130 bar**	PUNZ.TARGHETTA (Name plate punching):
TUBI INIEZ (inject.pipes): **1 680 750 073 L= 840 mm (ISO 4093-2)**	**LV 14752-1**
TIPO FLUIDO (liquid type): **SHELL S-9365 - pressione (0.3 + 0.05 bar)**	UTILIZZ.SU MOTORE (Used on engine): **HR494HI3 (10C)**
TEMPERATURA FLUIDO (liquid temp.) :	TARATO A GIRI/MIN (setted at rpm/1'): **3200**

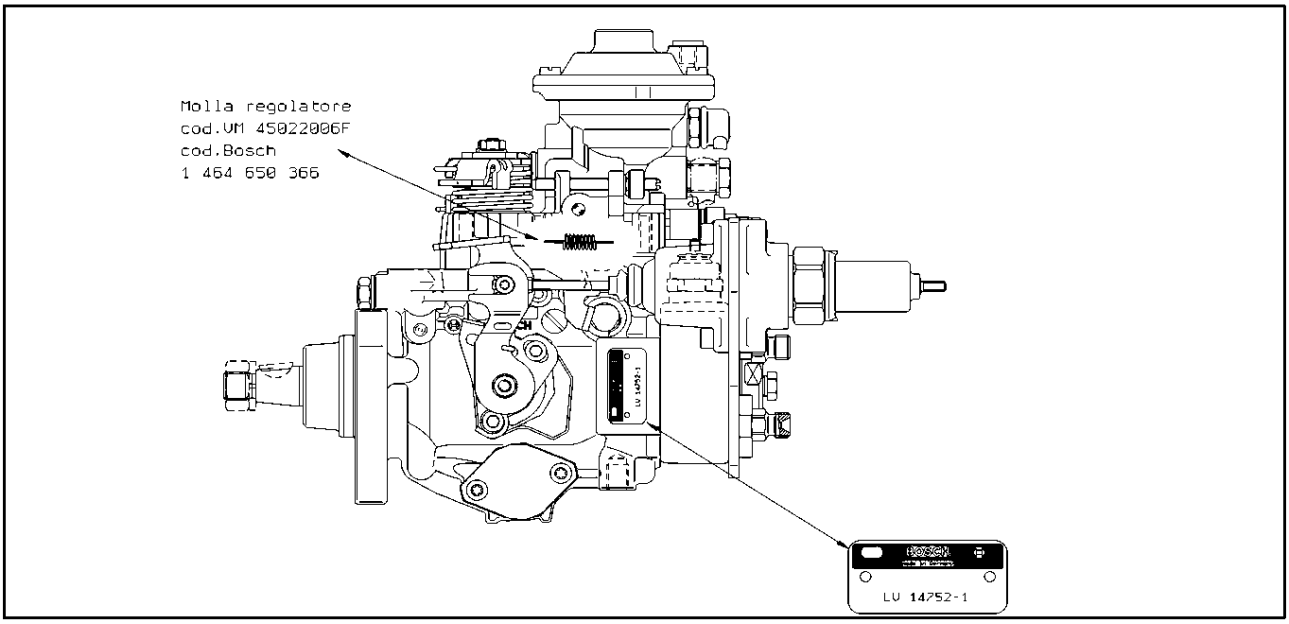
NOTE (Notes):

N° GIRI (POMPA) rpm (Pump)	**ANTICIPO (mm)** Advance (mm)	**PRESSIONE INTERNA (Bar)** Internal Pressure	**PORTATA x 1000 MANDATE (cc)** Flow rate x 1000	**PRESSIONE SOVRALIM. (Bar)** Boost pressure
1700	**1,8** ±0.6	**5,5** ±0.3	**33** ±3	**1**
1600	**3,2** ±0.6	**7** ±0.3	**68** ±3	**1**
1500	**2,9** ±0.6	**6,8** ±0.3	**68,5** ±3	**1**
1300	**2,0** ±0.2	**6** ±0.3	**71,5** ±3	**1**
1000	**1,0** ±0.6	**5** ±0.2	**73** ±2	**1**
750	**0**	**3,1** ±0.3	**60,5** ±3	**0,4**
600	**0**	**2,1** ±0.3	**59,5** ±3	**0**
100	**0**	**0,8** ±0.3	**80** ±3	**0**

GIRI AL MINIMO (POMPA) Min.speed (Pump)	**GIRI A VUOTO (POMPA)** Idle speed (Pump)
450	**1720**

Verificato (Verified) API :	DATA-Date:
Ferrari	25/11/02

Approvato (Approved) EMI:	DATA-Date:
Marchesini	25/11/02



Glow plugs:	
Manufacturer:	BOSCH type
Operating voltage:	12V
Power supply:	1 POLO
Operating current after 20":	7.2A

MAINTENANCE

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3

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3.1 STORAGE

WARNING:
ALL ENGINES WHICH REMAIN IDLE ARE SUBJECT TO RUST AND CORROSION OF MACHINED SURFACES WHICH ARE NOT PROTECTED BY PAINT. THE DEGREE OF CORROSION DEPENDS ON THE CLIMATIC CONDITIONS TO WHICH THE ENGINE IS EXPOSED. THE INDICATIONS BELOW ARE THEREFORE INTENDED ONLY AS A GENERAL ONLY TO PROTECTING THE ENGINE FROM CORROSION.

3.2 TEMPORARY PROTECTION

1) Prepare a container with a mixture of 10% **MOBILARMA 523** (ML-L-21269) and diesel fuel, disconnect the fuel feed and diesel fuel return lines from the fuel tank and connect them to this container.
2) Run the engine at low speed for a few minutes.
3) Run the engine for about 10 minutes at a speed between ½ and ¾ of nominal rpm so that the pipelines, nozzles, pumps and filters are completely filled with the protective mixture.
4) Stop the engine and wait for it to cool down.
5) Reconnect the pipelines to the fuel tank.
6) Completely refill the diesel fuel service tank.
7) Spray the specific protective oil for electrical contacts into the non-protected contact points.

For disposal of used oils contact an authorised disposal company.

3.3 PERMANENT PROTECTION (six months or longer)

1) Drain the oil from the sump and refill with new oil.
2) Prepare a container with a 10% mixture of **MOBILARMA 523** (ML-L-21260) and diesel fuel, disconnect the fuel feed and diesel fuel return lines from the fuel tank and connect them to this container.
3) Run the engine at low speed for a few minutes.
4) Run the engine for about 10 minutes at a speed between ½ and ¾ of nominal rpm so that the pipelines, nozzles, pumps and filters are completely filled with the protective mixture.
5) Stop the engine and wait for it to cool down.
6) Reconnect the pipelines to the fuel tank.
7) Completely refill the service diesel fuel tank.
8) Loosen the trapezoidal belt driving the alternator.
9) Spray the specific protective oil for electrical contacts into the non-protected contact points.

3.4 THREAD-LOCKING COMPOUNDS AND/OR SEALANTS

VM recommends use of the products as indicated below:

BRAND	FOR EUROPE	FOR USA
Loctite	222	222
Loctite	510	51
Loctite	573	510
Loctite	601	603
Loctite	986	586 - 620
Dow Corning	791	

3.5 LUBRIFICANTS

Specifications

API CF-4, CH-4,CH,SH
ACEA-98 E2,B4,B3,A2
(CCMC D5-PD2)
MB 228.1
MAN 271
VOLVO VDS
MACK EO-L
RVI E2R
MIL-L-2104 G
ALLISON C-4
VW 501/505

SAE 15 W - 40

La VM prefers Mobil **MOBIL DELVAC MX**

NOTE DISPOSAL OF WASTE MATERIAL MUST BE CARRIED OUT IN CONFORMITY WITH ESTABLISHED LEGISLATION IN THE COUNTRY OF INSTALLATION.

IDENTIFICATION OF DANGERS

EFFECTS OF OVEREXPOSURE: No relevant effects expected.

FIRST AID MEASURES

CONTACT WITH EYES: Rinse immediately with copious amount of water and seek medical advice.

CONTACT WITH SKIN: Wash with soap and water.

INHALATION: No problems expected.

INGESTION: Not considered to be a problem. However, if more than 1/2 liter is swallowed or a feeling of discomfort is noted, administer 1 or 2 glasses of water and call a doctor or an ambulance. Do not induce vomit or administer substances orally to unconscious persons.

A. How to Select Lubricating oil

Lubricant Selection in North America

The selection of the proper lubricating oil is important to achieve the long and trouble-free service which Detroit Diesel engines are designed to provide.

The proper lubricating oil for all Detroit Diesel engines is selected based on SAE viscosity grade and API (American Petroleum Istitute) service designation.

Only oils licensed to display the American Petroleum Institute (API) symbol shown should be used. See Figure B.

Lubricant Requirements

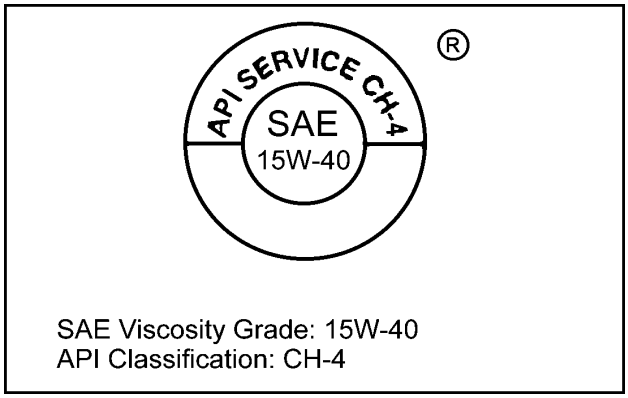


Figure B. API Lubricant Service Mark

Lubricants meeting these criteria have provided maximum engine life when used in conjunction with specified oil drain and filter maintenance schedules.

API CF-4 or CG-4 oil may be used when CH-4 oils are not available; however, their use may require a reduction in oil drain interval depending upon the application and the fuel sulfur level.

At ambient temperatures below -20°C (-4°F) when sufficient starter speed cannot be achieved with SAE 15W-40 oils, the use of 5W-XX and 10W-XX oils, where XX is 30 or 40, is allowed to improve startability, provided they are API CH-4 and have demonstrated field performance in DDC engines. These oils must possess a HT/HS of 3.7 cp minimum.

Monograde oils should not be used in DDC HR-HT2 engines regardless of API Service Classification.

DISPOSAL

The product can be incinerated, according to standard regulations.

Wear protective gloves when handling the product.

Operate according to standard regulations in the country of use and in relation to the characteristics of the product at the moment of disposal.

3.6 COOLANTS

Inhibited Ethylene Glycol

% VOL	TEMPERATURE		Density kg/dm³ a 15 °C
	FREEZING POINT	BOILING POINT	
10	- 4	101	1.014
20	- 10	102	1.028
30	- 17	104	1.042
40	- 27	106	1.056
50	- 40	109	1.070
60	- 47	114	1.084

To obtain the best operating conditions we recommend using a coolant mixture with a solution of 50% fresh demineralised water and 50% anti-rust anti-freeze liquid (inhibited ethylene glycol) that meets the reguirements of ASTM standard D 3306.

Inhibited ethylene glycol is a special ethylene glycol liquid used for permanent type antifreeze mixture for use in internal combustion engine cooling circuits and for any other heat exchange circuit operating at low temperature.

The antifreeze also features efficient anti-rust and corrosion properties for cooling circuit metals. It does not contribute to temperature-related deterioration of the rubber hoses or couplings which connect the various circuit components.

HAZARDS

Ingestion of ethylene glycol can cause nausea, vomiting, stomach cramps, convulsions, pulmonary swelling, cardiopulmonary side-effects (metabolic acidosis), pneumonia and kidney defects which can be lethal.
The lethal single dose for humans is approximately 100 ml.
Inhalation over extended periods of time of high concentrations of vapours or mist is also harmful.
This product is harmful if swallowed.

FIRST AID

CONTACT WITH EYES: bathe thoroughly with water immediately. If irritation occurs, seek medical attention.

CONTACT WITH SKIN: wash with soap and water. Remove any contaminated clothing. Wash contaminated clothing before re-use.

INHALATION: Bring the person outside the exposed area. If irritation occurs in the respiratory system, or in the event of vertigo, nausea or unconsciousness, seek medical attention immediately. In the event of respiratory arrest, carry out artificial respiration immediately

INGESTION: induce vomiting immediately with ipecac syrup followed by 1 or 2 glasses of water and seek medical assistance. If ipecac syrup is not available, induce vomiting under the supervision of medical personnel. Never induce vomiting or attempt to put substances into the mouth if the person is unconscious.

DISPOSAL

WASTE DISPOSAL:
Wear impermeable gloves and drain the cooling circuit into a suitable receptacle. Dispose of coolant in conformity with established legislation and in accordance with the type of product.

3.7 SOLVENTS

VM Motori prescribes the following products or equivalents.

3.7.1 Pickling diluent

SUBSTANCE

Chemical composition
Mixture of aromatic hydrocarbons ketones, dichloropropane, isobutyl alcohol.

Commercial name
Diluente Decapaggio 15

Formula

Kemler number
33

ONU number
1203

CHARACTERISTICS - INGREDIENTS

Acetone mixture	15% - 25%
Isopropyl alcohol mixture	10% - 20% Xn R 20
Dichloropropane mixture	15% - 25% Xn R 20
Totuol mixture	35% - 45% Xn R 20

Component identification numbers:

	n° CEE	n° CAS
Acetone	606-001-00-8	67-64-1
Isopropyl alcohol	603-003-00-0	67-63-0
Dichloropropane	602-020-00-0	78-87-5
Totuol	601-021-00-3	108-88-3

HAZARDS

Highly inflammable.

Harmful if inhaled and in contact with skin.

Injurious to health if ingested.

R 11 - Highly inflammable

R 20 - Harmful if inhaled.

Skin	irritant
Eyes	irritant
Ingestion	harmful
Inhalation	harmful

FIRST AID

CONTACT WITH SKIN

Remove contaminated clothing. Wash affected parts of the body with cold or tepid water immediately. Use neutral soap if available.

CONTACT WITH EYES

Rinse immediately with copious amounts of fresh water for at least 15 minutes. Seek medical advice.

INHALATION

Take patient away from the sources of fumes and keep outside in fresh air. Apply artificial respiration if the patient stops breathing.

Seek medical advice.

INGESTION

Rinse out mouth with water without swallowing. Do not induce vomiting. Seek medical advice.

EXPOSURE CONTROL - PERSONAL PROTECTION

Maximum exposure limit LV mg/mc. 491

According to DPR n° 303 19/03/65 medical examinations are required every three months.

RESPIRATORY PROTECTION

Full mask facepiece respirator with filter for highly concentrated organic vapor.

HAND PROTECTION

Solvent-resistant gloves.

EYE PROTECTION

Goggles providing splash and spray protection.

SKIN PROTECTION

Overalls and apron.

Do not eat, drink or smoke in areas where solvents are used.

3.7.2 Trichloroethane

Chemical name

1,1,1 - Trichloroethane

Synonyms: Tri-Ethane 377 - Tri-Ethane 348

EEC No.	602-013-00-2
Einecs No.	200-766
Cas No.	71-55-6

Contains:

< 5% Polymer stabilizer (the product does not contain significant concentrations of substances classified as hazardous for health).

HAZARDS

Major hazards

Harmful if inhaled

Specific hazards

A concentration significantly higher than that permitted in the work area could cause damage to the central nervous system and collapse.

FIRST AID

General information

Show this safety sheet to the doctor in charge.

Avoid contact with solvents and adopt protective measures whenever possible in accordance with general standards of industrial hygiene.

Inhalation

Take patient outside in fresh air. Administer oxygen.

Contact with skin

Remove all contaminated clothing, shoes, etc.. Wash immediately with plenty of water and soap. Seek medical advice.

Contact with eyes

Rinse thoroughly with copious amounts of water for at least 15 minutes while keeping the patient's eyes wide open.

Seek medical advice.

Ingestion

Drink plenty of water. Do not induce vomiting.

Seek immediate medical advice.

Do not administer any substances whatsoever if the patient loses consciousness.

Protection while administering first aid

Wear protective clothing to avoid contact with skin. Solvents can remove natural oils from skin.

EXPOSURE CONTROL - PERSONAL PROTECTION

Work area design

Ensure that the work area is adequately ventilated, particularly if the area is enclosed.

Control parameters

OSHA PEL 8 hr - TWA = 350 ppm

OSHA STEL 15 min = 450 ppm

Personal protection

Respiratory protection

If the work area is insufficiently ventilated, use a suitable respirator.

For emergency rescue operations and when working in storage tanks, use self-contained breathing apparatus.

Hand protection

Solvent-resistent gloves.

Eye protection

Safety goggles/faceshield visor

Skin and body protection

Protective clothing, solvent-resistent apron.

Remove and wash contaminated gloves and clothing before re-use.

Hygiene

Avoid contact with eyes, skin and clothing.

Do not eat, drink or smoke during use.

3.8 FUEL (European market)

Use diesel fuel conforming to the specifications given below.

When filling the fuel tank, use a funnel fitted with a metal mesh to filter out any solid impurities which could otherwise block the injector nozzles.

Do not use diesel fuel mixed with water and/or other substances.

ALWAYS USE A HIGH QUALITY DIESEL FUEL OF CERTIFIED ORIGIN WHICH MEETS CUNA STANDARDS (NC 630.01).

WARNING:
THE USE OF DIESEL FUEL WHICH DOES NOT MEET THE ABOVE STANDARDS WILL CAUSE DAMAGE TO THE FUEL INJECTION SYSTEM AND CONSEQUENTLY TO THE ENGINE ITSELF AND WILL INVALIDATE THE WARRANTY.

3.8.1 FUEL (North American market)

Use diesel fuel conforming to the specifications given below.

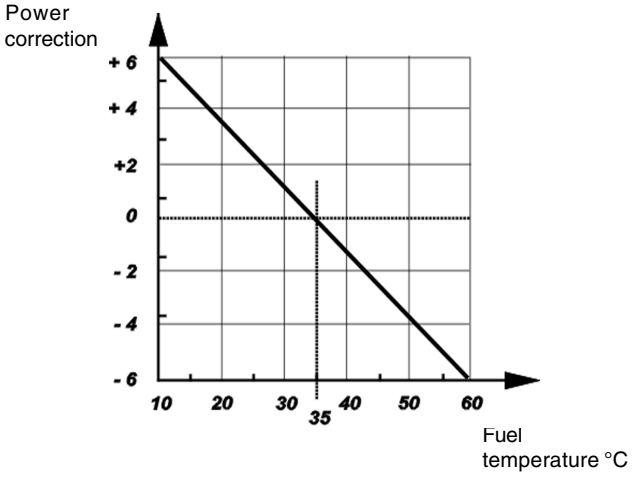
When filling the fuel tank, use a funnel fitted with a metal mesh to filter out any solid impurities which could otherwise block the injector nozzles.

Do not use diesel fuel mixed with water and/or other substances.

ALWAYS USE A HIGH QUALITY DIESEL FUEL OF CERTIFIED ORIGIN WHICH MEETS CUNA STANDARDS (NC 630.01).

WARNING:
THE USE OF DIESEL FUEL WHICH DOES NOT MEET THE ABOVE STANDARDS WILL CAUSE DAMAGE TO THE FUEL INJECTION SYSTEM AND CONSEQUENTLY TO THE ENGINE ITSELF AND WILL INVALIDATE THE WARRANTY.

Effect of fuel temperature on engine power.
The normal temperature is +35 (95) °C (°F) (0%).



3.9 POWER ADJUSTMENT FOR VARIATION OF FUEL PROPERTIES (European market)

FUEL PROPERTIES - Power output correction according to the properties of the fuel used.

The specified power output ratings are valid for fuel with the following properties:

Energy value
42 700 kJ/kg

Temperature before fuel supply pump: 35 °C

Density
0.84 kg/dm^3 at 15 °C

If the fuel deviates from these values, consult the graph below to determine the power correction factor (in %).
Apply these factors to calculate engine power.

3.9.1 POWER ADJUSTMENT FOR VARIATION OF FUEL PROPERTIES (North American market)

FUEL PROPERTIES - Power output correction according to the properties of the fuel used.

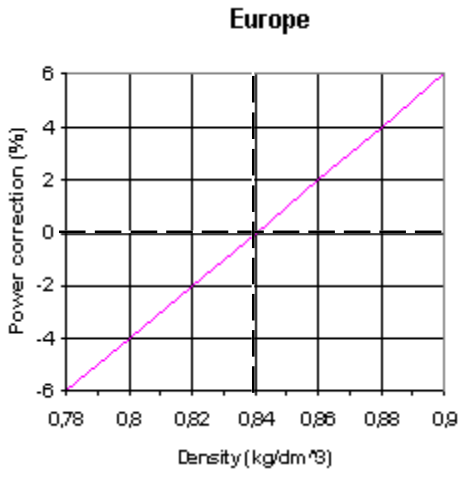
The specified power output ratings are valid for fuel with the following properties:

Temperature before fuel supply pump: 35 °C

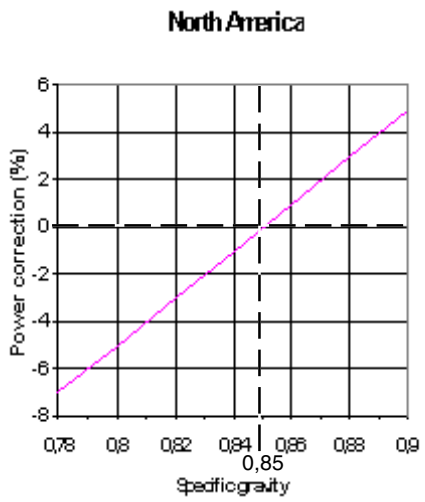
Density
0.85 kg/dm^3 at 15 °C

If the fuel deviates from these values, consult the graph below to determine the power correction factor (in %).
Apply these factors to calculate engine power.

Effect of fuel density on engine power.
Normal value 0.84 kg/dm^3 at +15 (59) °C (°F) (0%).



Effect of fuel density on engine power.
Normal value 0.85 kg/dm^3 at +15 (59) °C (°F) (0%).



3.10 POWER ADJUSTMENT FOR VARIATION OF COMBUSTION AIR PROPERTIES

(European market)

AIR PROPERTIES - Power output correction according to air properties

The specified power ratings are valid for air with following properties (as per ISO 3046):

Air pressure	100kPa (1000 mbar)
Air temperature	25 °C
Humidity	30%, normally aspirated engines only (humidity is eliminated in the heat of turbochargers).

If the air deviates from these values, consult the graph below to determine the power correction factor.

Apply these factors to calculate the engine power.

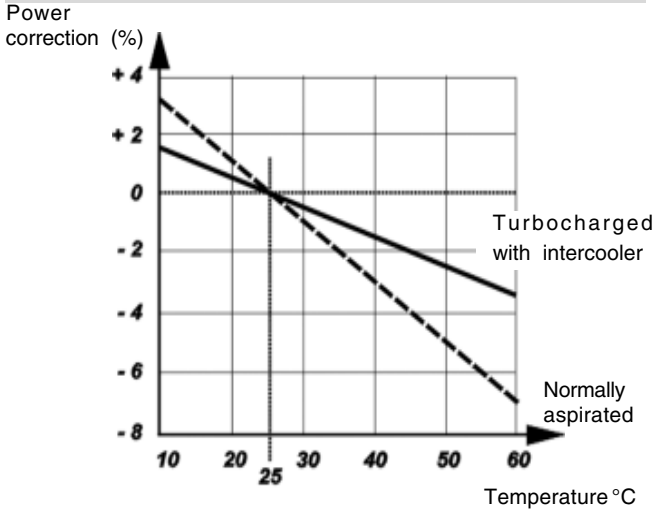
Note: if the engine is used at air pressures (e.g. high altitudes) and/or temperatures exceeding the above standard values, the engine will have to be derated in order to compensate for the lower air pressure.

Reduced air density will negatively affect engine performance.

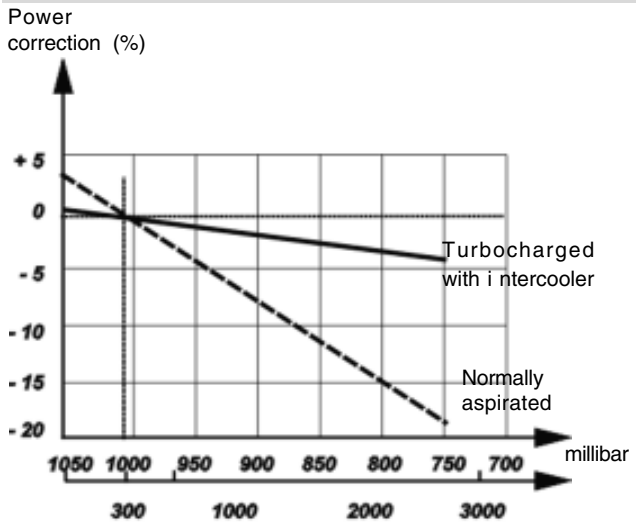
Incomplete combustion will result in black exhaust fumes and increased fuel consumption. There is also a risk of overrevving and overheating of the turbocharger.

To avoid these problems, the engine must be derated in accordance with “Derating of engine”.

Effect of intake air temperature on engine performance
Normal value: +25 (77) °C (°F) (0%).



Effect of intake air pressure on engine power
Normal value: 100 kPa (1000 mbar) (0%)



m = meters above sea level

3.10.1 POWER ADJUSTMENT FOR VARIATION OF COMBUSTION AIR PROPERTIES

(North American market)

AIR PROPERTIES - Power output correction according to air properties

The specified power ratings are valid for air with following properties (as per SAE J1995):

Air pressure	99kPa (990 mbar)
Air temperature	25 °C

If the air deviates from these values, consult the graph below to determine the power correction factor.

Apply these factors to calculate the engine power.

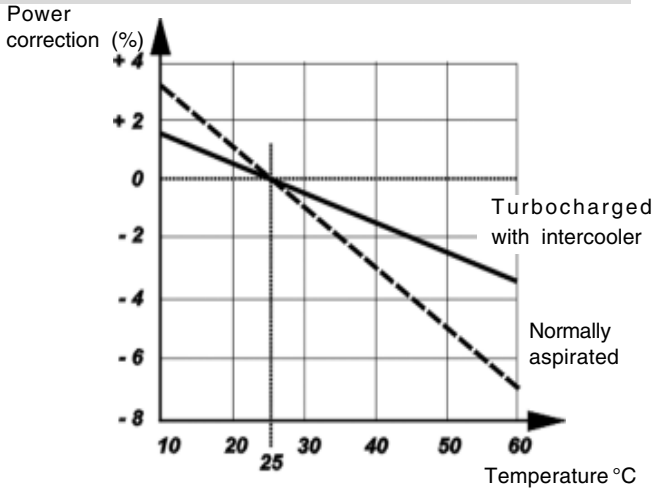
Note: if the engine is used at air pressures (e.g. high altitudes) and/or temperatures exceeding the above standard values, the engine will have to be derated in order to compensate for the lower air pressure.

Reduced air density will negatively affect engine performance.

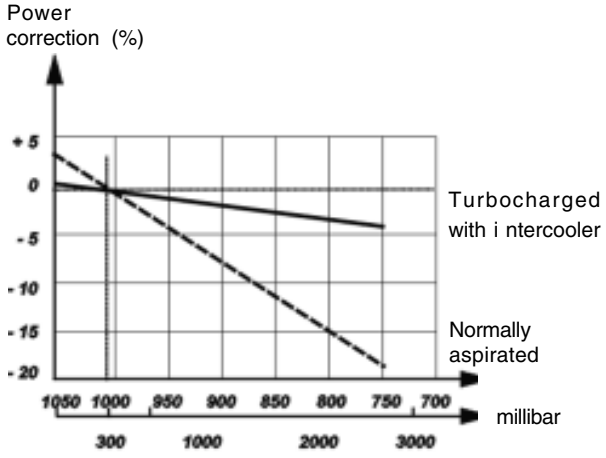
Incomplete combustion will result in black exhaust fumes and increased fuel consumption. There is also a risk of overrevving and overheating of the turbocharger.

To avoid these problems, the engine must be derated in accordance with “Derating of engine”.

Effect of intake air temperature on engine performance
Normal value: +25 (77) °C (°F) (0%).



Effect of intake air pressure on engine power
Normal value: 99 kPa (990 mbar) (0%)



m = meters above sea level

3.11 MAINTENANCE

CARRY OUT MAINTENANCE MORE FREQUENTLY WHEN THE ENGINE IS USED IN HARSH CONDITIONS (FREQUENT STOPS AND STARTS, DUSTY ENVIRONMENTS, LONG HARSH WINTERS, OPERATION UNDER NO-LOAD CONDITIONS).

IT IS STRICTLY FORBIDDEN TO CLEAN THE ENGINE WITH COMPRESSED AIR.

ADHERE SCRUPULOUSLY TO MAINTENANCE INTERVALS REPORTED BELOW.

Every 10 hours or every day

Check Engine oil level

Clean Radiator
(the radiator must be frequently cleaned using a soft brush even daily if necessary).

Clean Dry air cleaner
(carry out the maintenance operation in function of the use conditions)

After 50 hours

Change Engine oil

Change Oil filter cartridge

Check Vee belt

Check Cooling circuit

THE ABOVE MAINTENANCE INTERVAL FOR CHANGING THE ENGINE OIL APPLIES TO THE FIRST OIL CHANGE ONLY.
FAILURE TO PERFORM THIS OPERATION WILL INVALIDATE THE WARRANTY.
THE ABOVE MAINTENANCE INTERVAL FOR INSPECTING THE VEE BELT APPLIES TO THE FIRST INTERVAL ONLY.

Every 100 hours

Clean Drain water from fuel filter

Clean Radiator

Every 150 hours

Clean Fuel pump filter

Check Vee belt

Every 300 hours

Tighten Fuel line union screws and nuts

Change Engine oil
(must be changed at least once every 12 months in any event).

OWING TO THE FACT THAT THE ENGINE WORKS IN HARSCH CONDITIONS SUCH AS DUSTY ENVIRONMENTS AND HEAVY LOADS, MAKE SURE TO CHANGE THE ENGINE OIL EVERY 150 HOURS

Change Oil filter cartridge

Change Fuel filter cartridge
(the fuel filter cartridge must be renewed at least once every 12 months, regardless of the hours of duty).

Every 500 hours

Check Injectors

Check Glowplugs (when fitted)

Change Air filter cartridge

Change Coolant mixture
(must be performed at least once every 24 months in any event).

Every 1000 hours

Clean Fuel tank

Change Alternator drive belt

Every 2000 hours

Change Starter motor brushes

Check Turbocharger

After 4000 hours

Overhaul Partial engine

After 8000 hours

Overhaul Major engine

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SYSTEM DIAGRAMS Pag. 1 ÷ 8 4

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4.1 COOLING SYSTEM

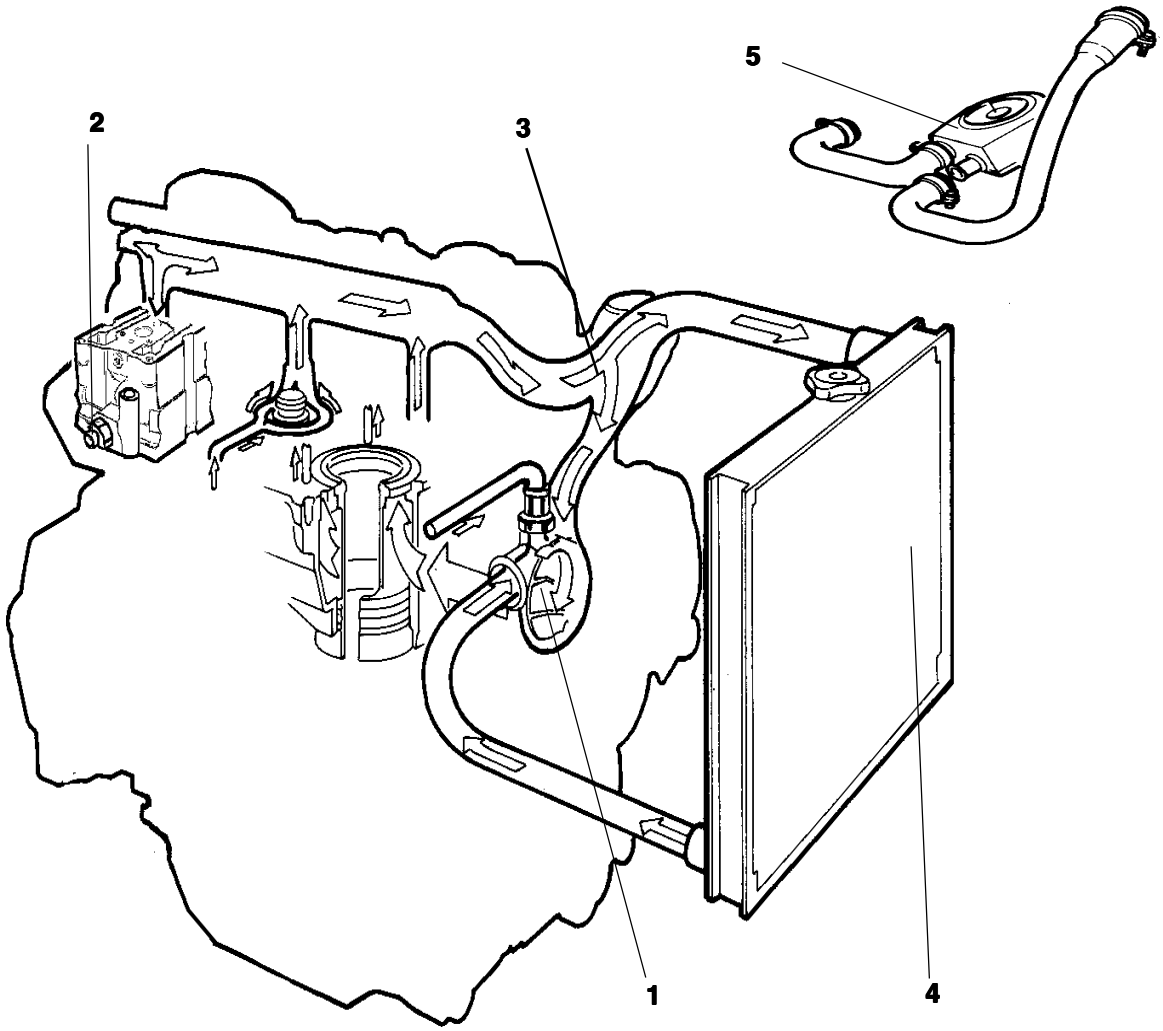


Fig. 4.1

KEY:

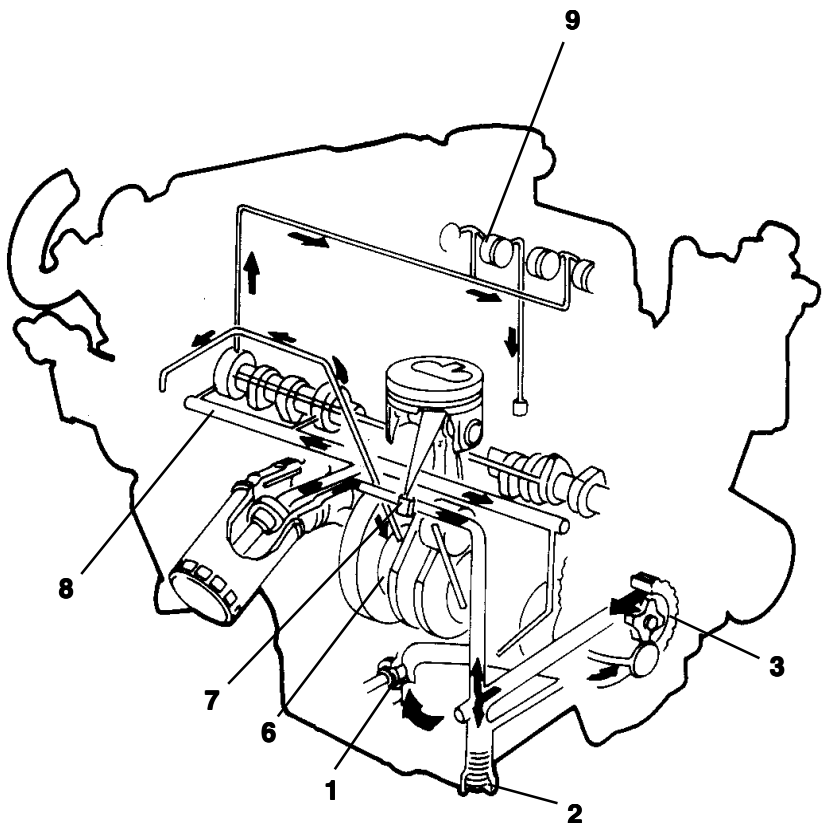
1) Water pump
2) Max. water temperature indicator
3) Thermostat valve
4) Radiator
5) Water-cooled oil cooler

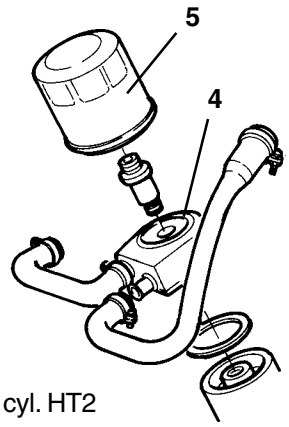
WARNING! OIL, FUEL, COOLANT MIXTURES, ETC. ARE HARMFUL IF INGESTED.

COOLING SYSTEM CAPACITY (excluding radiator)

HR494HT2-3/HI3:	5.0 Liters
HR694HT2-3:	7.5 Liters
STANDARD THERMOSTAT VALVE SETTING:	
Start of valve opening	+80 °C (+ 176°F)
End of valve opening	+90 °C (+ 194°F)

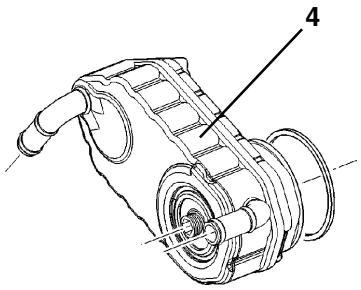
4.2 LUBRIFICATION SYSTEM





4-6 cyl. HT2

4 cyl. HT3/HI3



6 cyl. HT3

Fig. 4.2

The lubricating oil is forced around the system by a rotor pump and filtered before being sent to the various points requiring lubrication. The oil from the pump is sent through a pressure regulating valve to the filter and then to the crankshaft main bearings, and through external pipes to the rocker arms and the turbocharger.

A thermostatic valve in the circuit sends hot oil (80÷85 °C) (176÷185°F) to the oil cooler (if installed).

WARNING! OIL, FUEL, COOLANT MIXTURES, ETC. ARE HARMFUL IF INGESTED.

KEY

1) Oil pick-up pipe
2) Pressure relief valve
3) Oil pump
4) Water cooled oil cooler
5) Filter cartridge
6) Crankshaft main bearings
7) Oil jet valve
8) Camshaft bearing/s
9) Rocker arms

4.3 FUEL SYSTEM

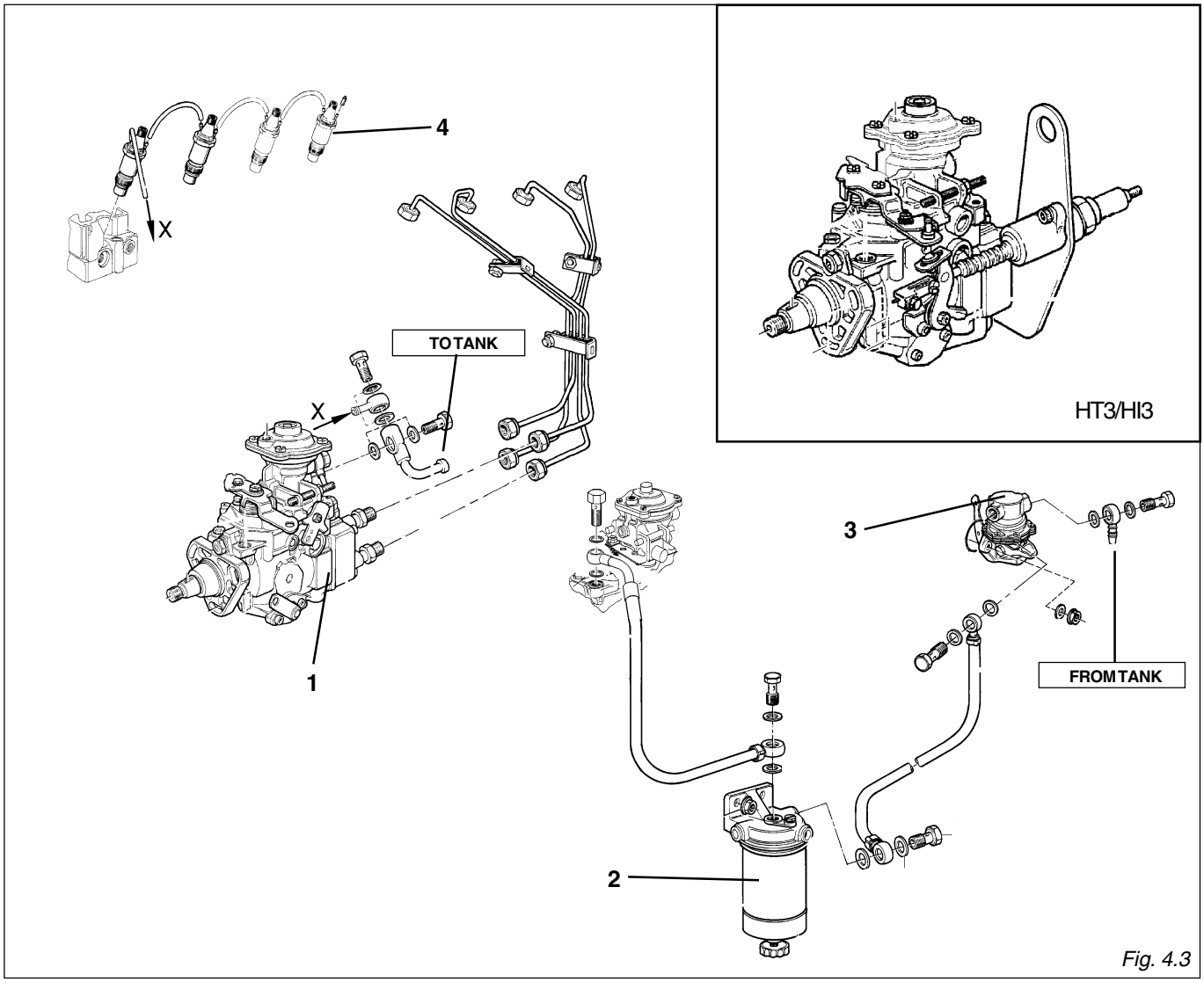


Fig. 4.3

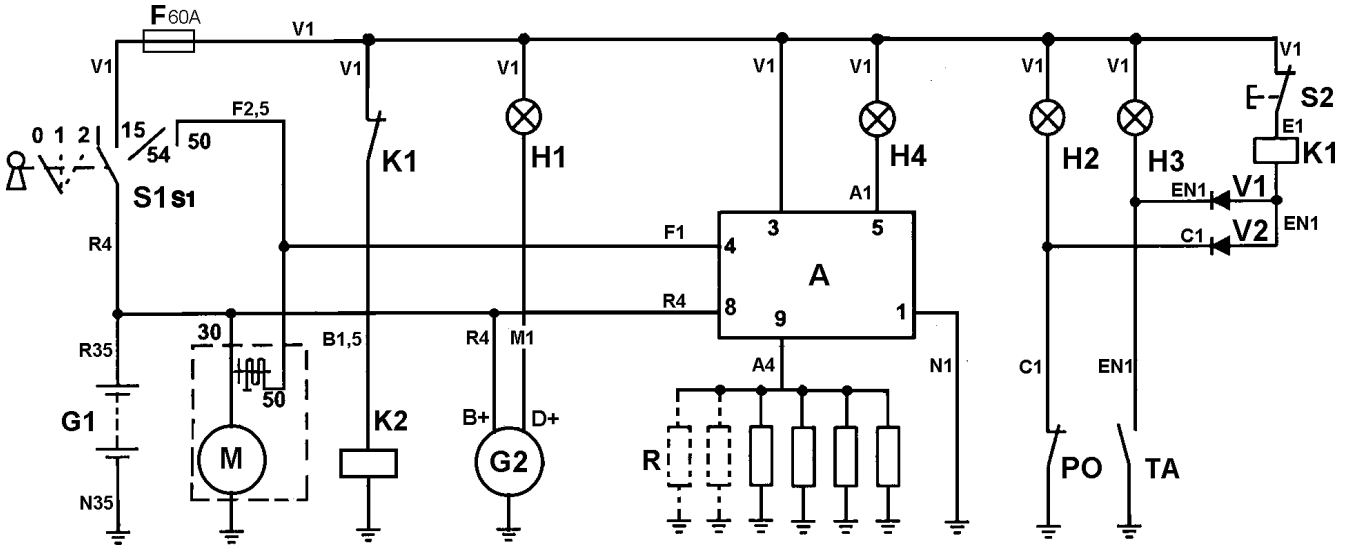
KEY

1) Injection pump
2) Fuel filter
3) Fuel supply pump
4) Injector

WARNING! OIL, FUEL, COOLANT MIXTURES, ETC. ARE HARMFUL IF INGESTED.

4.4 ELECTRICAL SYSTEM

4.4.1 HR494HT2 - HR694HT2 a 12 V



A ORENGE
B WHITE
C PINK
D GREY
E GREEN
F BLUE
G YELLOW
H LIGHT BLUE
M BROWN
N BLACK
R RED
V VIOLET

S1

CONT / POS	30	15/54	50
0			
1	X	X	
2	X	X	X

Fig. 4.4

KEY

G1	battery
G2	alternator (rev-counter preset)
S1	ignition keywitch
S2	safety device inhibit buttoncurezze
F	fuse
H1	alternator charge indicator lamp
H2	low oil pressure waring lamp
H3	high water temperature warning lamp
H4	glowplug indicator lamp (1,2W)
M	starter motor
K1	stop relay
K2	fuel line solenoid valve
A	preheater control unit
R	glow plugs
V1	diode
V2	diode
PO	oil pressure switch
TA	water temperature thermostat

4.4.2 HR494HT3 / HI3 - HR694HT3 a 12 - 24 V

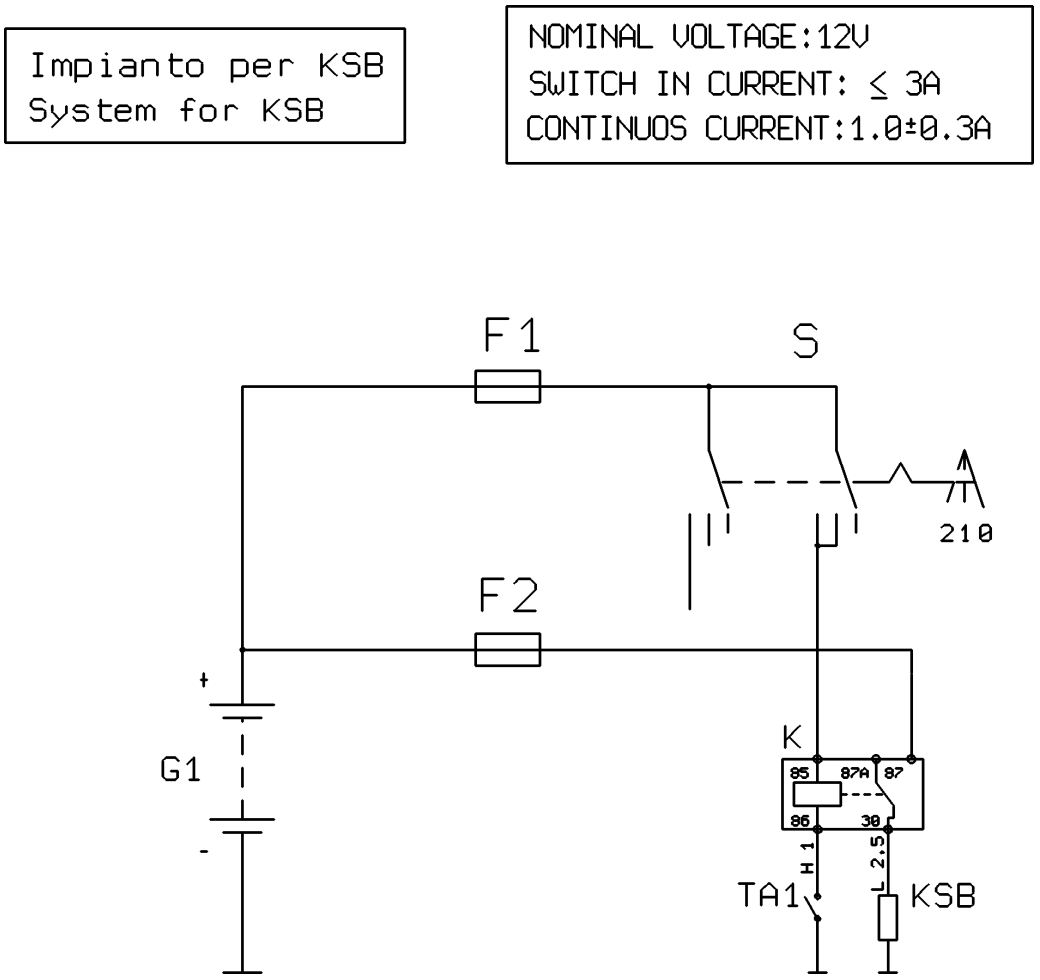


Fig. 4.5

KEY

G1	battery
S	ignition keywitch
F1	fuse
F2	fuse
TA1	water temperature trasmitter
KSB	cold start device
K	relay

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5.0 INTRODUCTION

The following instructions refer to engine models available at the time of publication of this manual.

Before proceeding with the complete or partial disassembling of the engine, check that the problem is not due to some external cause.

WHERE VM SPECIAL TOOLS ARE NOT SPECIFIED IN THE DISASSEMBLY PROCEDURES, USE STANDARD COMMERCIAL TOOLS OF THE TYPE ILLUSTRATED.

5.0.1 Mounting the engine on the stand

Mount the engine on a commercial stand as shown in figure 5.0.

Secure the engine by means of the assembling arms and bolts provided with the stand (or using mounting bolts of the same type).

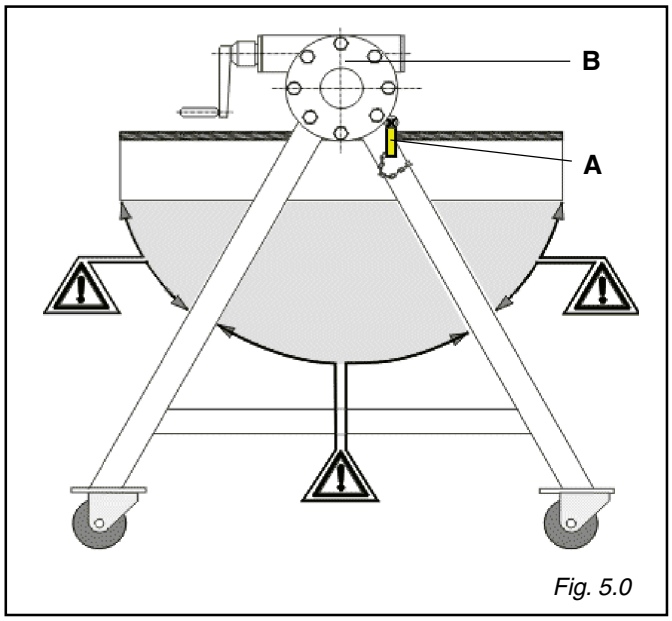

Fig. 5.0

WARNING: THE STAND MUST BE EQUIPPED WITH A REDUCTION GEAR AS SHOWN IN THE FIGURE TO SLOW DOWN ENGINE ROTATION AND CONTROL ROCKING.

WARNING: REMEMBER TO INSERT THE LOCK PIN (A) AND CHECK THAT IT EFFECTIVELY LOCKS T HE ENGINE IN POSITION.

WARNING: RISK OF CRUSHING AND/ OR SHEARING OF LIMBS DURING ROTATION OF ENGINE ON STAND.

NEVER INTRODUCE PARTS OF THE BODY OR FOREIGN OBJECTS IN THE AREA SHADED GREY IN FIGURE 5.0.

5.1 ROCKER COVER (FIG. 5.1 - 5.2 - 5.3)

In order to remove the breather hose **C** unscrew the screw **A** that fix the clamp **B.**

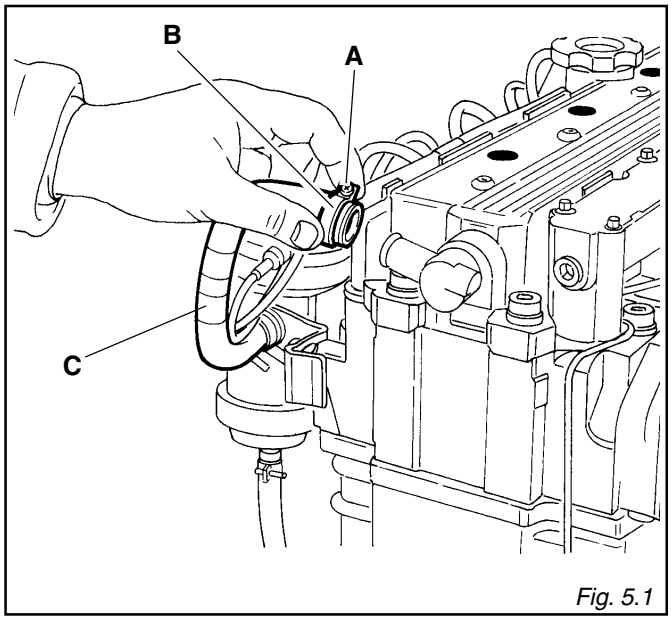

Fig. 5.1

Unscrew the bolts **D** securing the rockre cover **E** (Fig. 5.2).

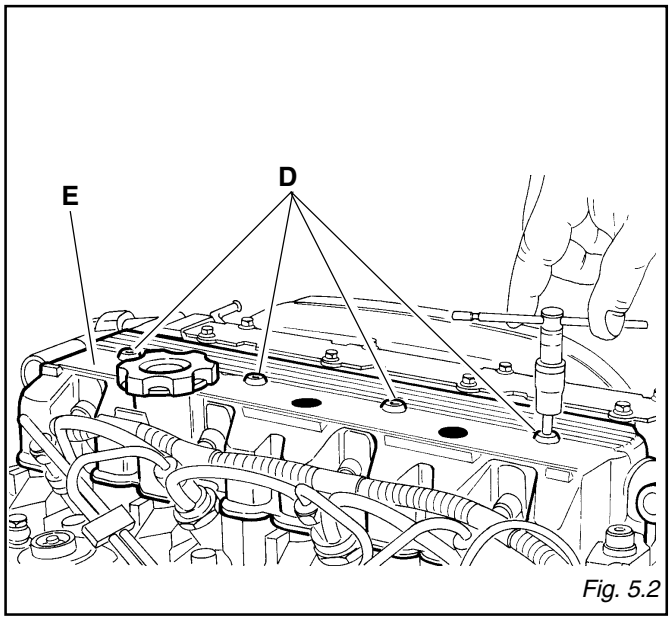

Fig. 5.2

IF NECESSARY, INSERT A SCREWDRIVER IN THE SLOTS AND TO REMOVE THE COVER AS SHOWN AT FIG.5.3.

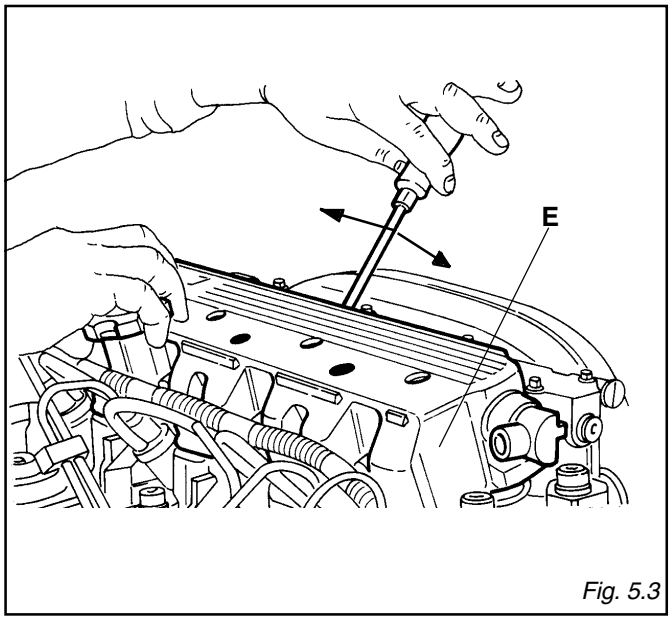

Fig. 5.3

5.2 FUEL INJECTION PIPES (Fig. 5.4)

Unscrew union nuts **A** and **B** in order to remove fuel injection pipes **C**.

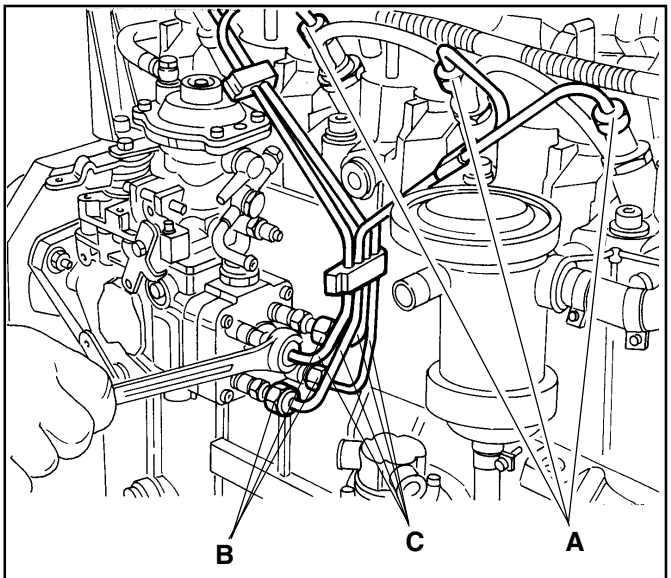

Fig. 5.4

5.3 FUEL SPILL RETURN (FIG. 5.5)

Remove the fuel spill return **D**.

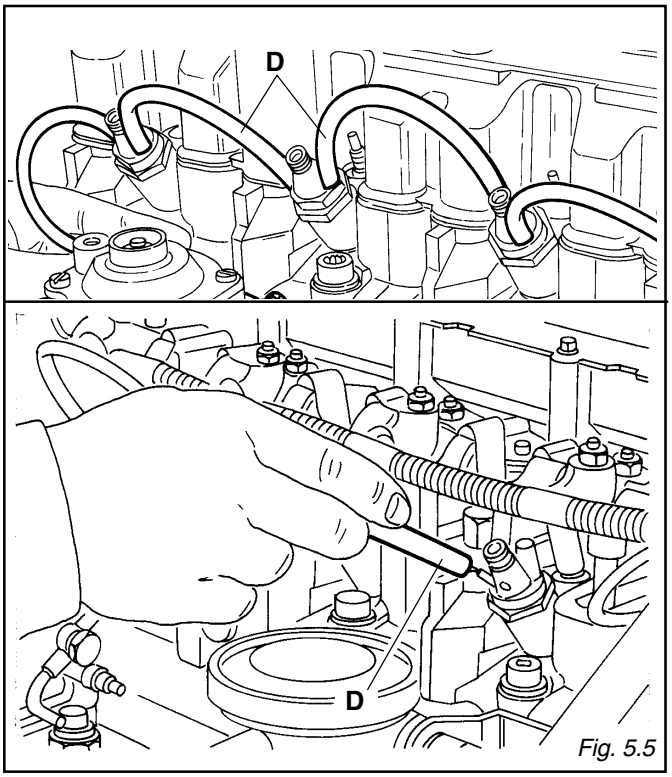

Fig. 5.5

5.4 INJECTOR (FIG. 5.6 - 5.7)

Insert special tool **A** (Tab.11.1 Ref. **G**) on the injector **B** (fig. 5.6).

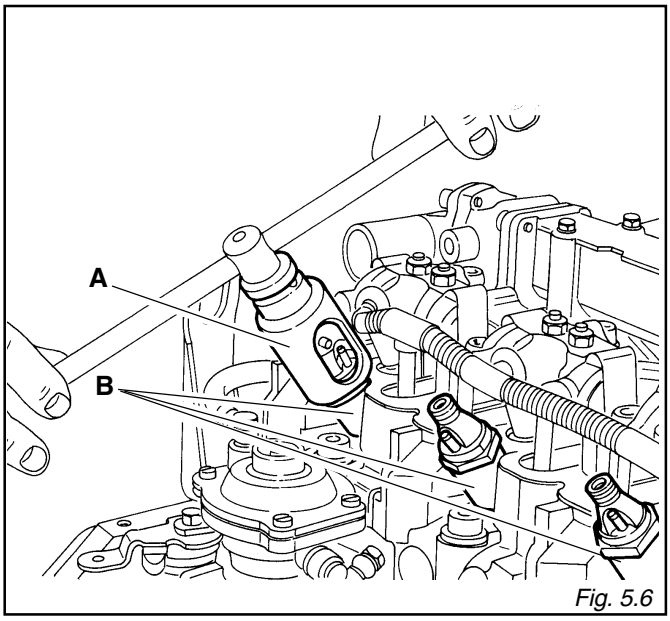

Fig. 5.6

Unscrew and remuve the injectors **B** (fig. 5.7).

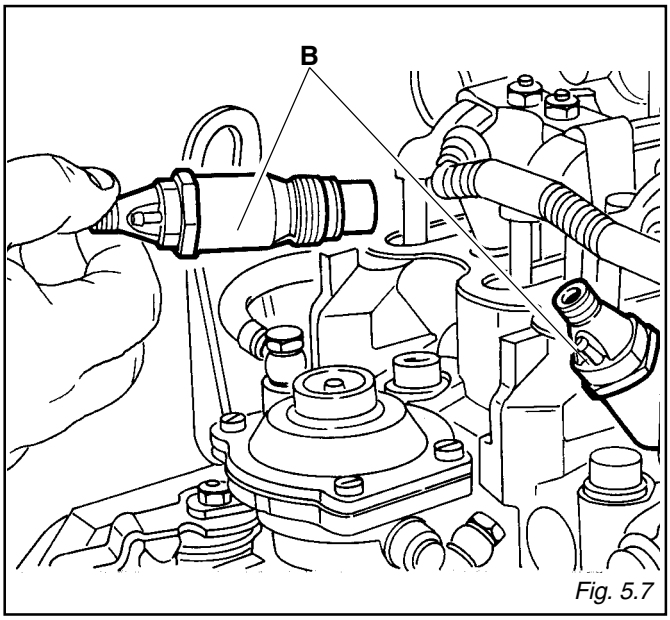

Fig. 5.7

5.5 OIL SEPARATOR (FIG. 5.8 - 5.9 - 5.10)

In order to remove the breather hose **C** unscrew the screw **A** that fix the clamp **B.** (Fig. 5.8)

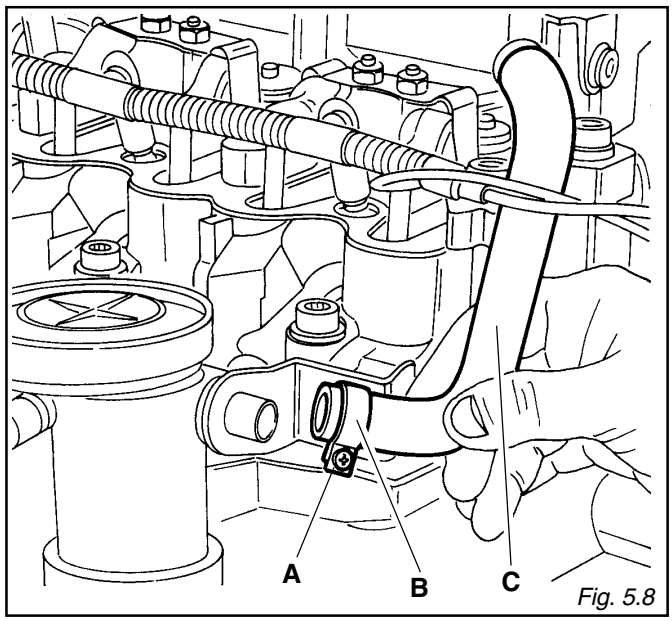

Fig. 5.8

Unscrew the screw **D** on the clamp **E** and remove the breather hose **F** (fig. 5.9).

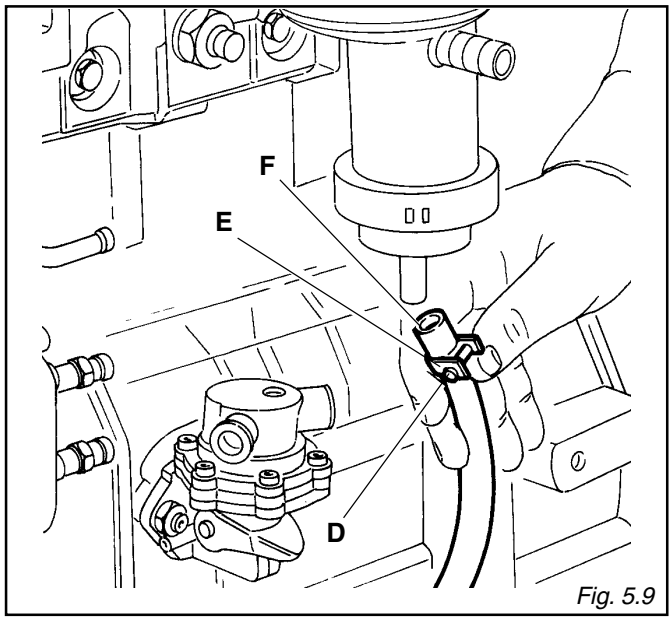

Fig. 5.9

Unscrew and remove the screw **G,** remove the support **H** and remove the oil separator.

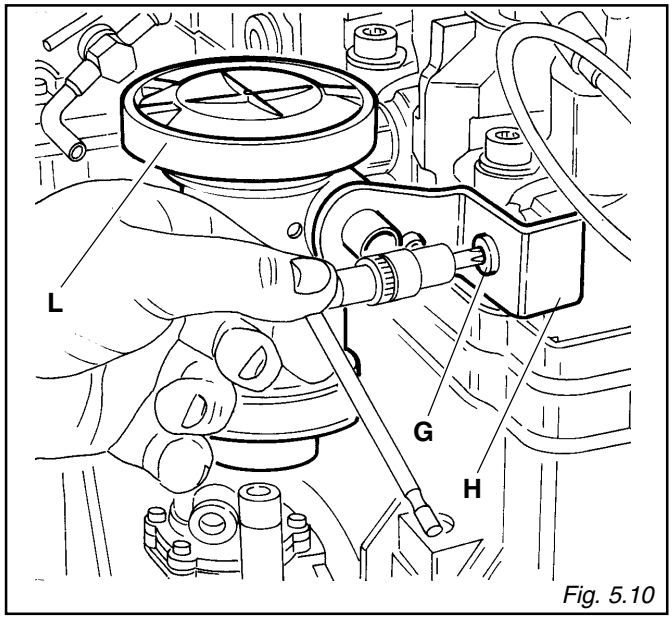

Fig. 5.10

5.6 OIL SEPARATOR COUPLING OUTLET (FIG. 5.11)

Unscrew the nut **A** on the pipe union **B.**

BEFORE REMOVING THE OUTLET PIPE OF THE OIL SEPARATOR DRAIN OIL FROM THE SUMP.

Remove the coupling outlet **C .**

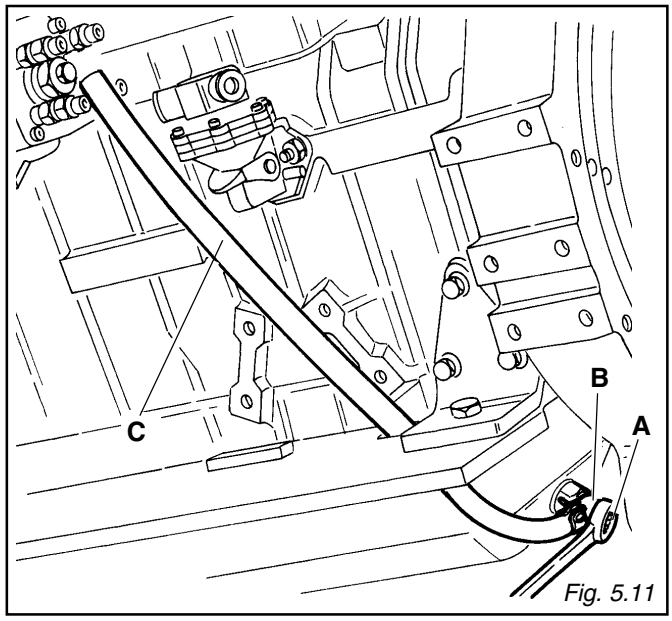

Fig. 5.11

5.7 GLOWPLUGS (FIG. 5.12 - 5.13 - 5.14 - 5.15)

Remove the cable **A**.

Unscrew and removing the glowplugs **B**.

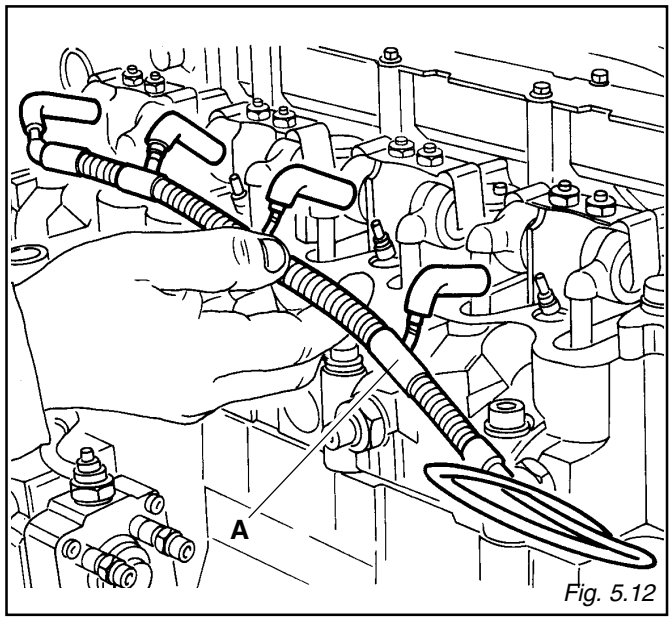

Fig. 5.12

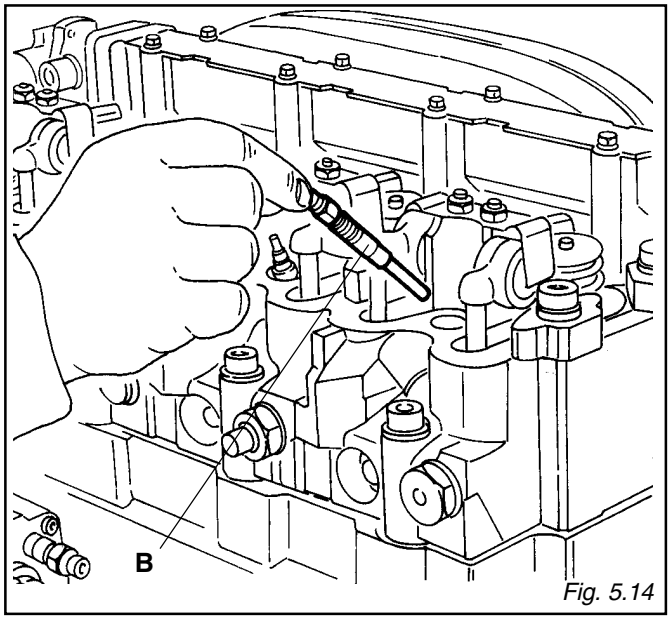

Fig. 5.14

REMOVING THE GASCKET **(C)** ***(FIG. 5.15).***

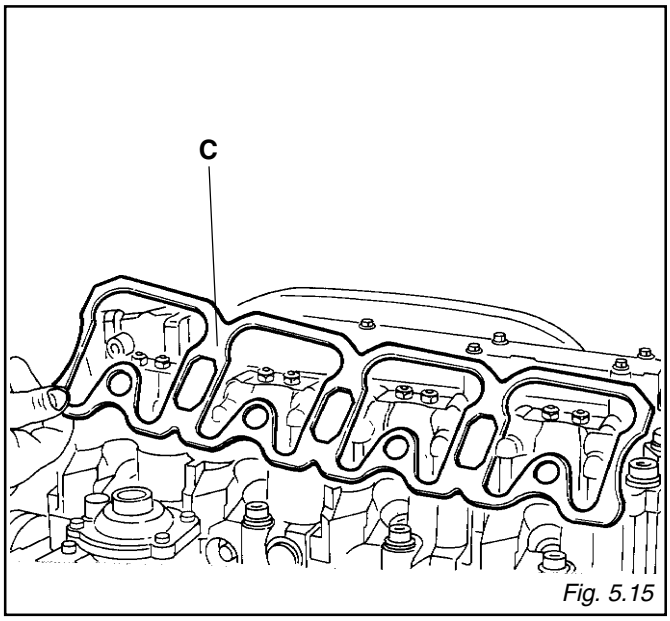

Fig. 5.15

5.8 ROCKER ARMS *(FIG. 5.16 - 5.17)*

Unscrew nuts **A** to release the rocker arms from spring **B**.

Remove the rocker arms **C** by lifting them upwards.

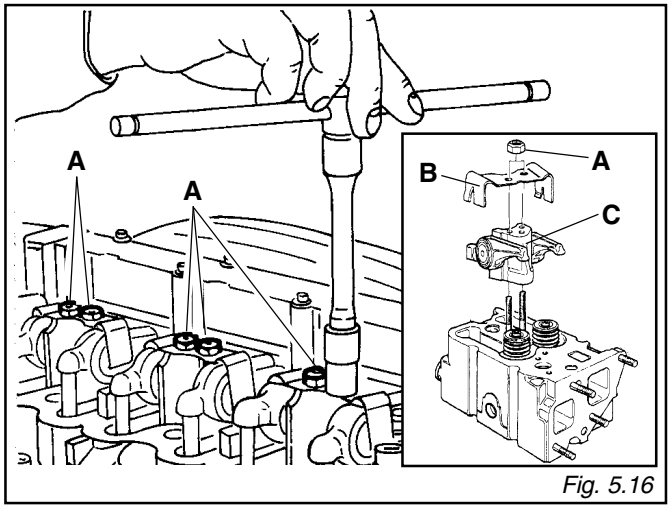

Fig. 5.16

Removing the pushrods **D**.

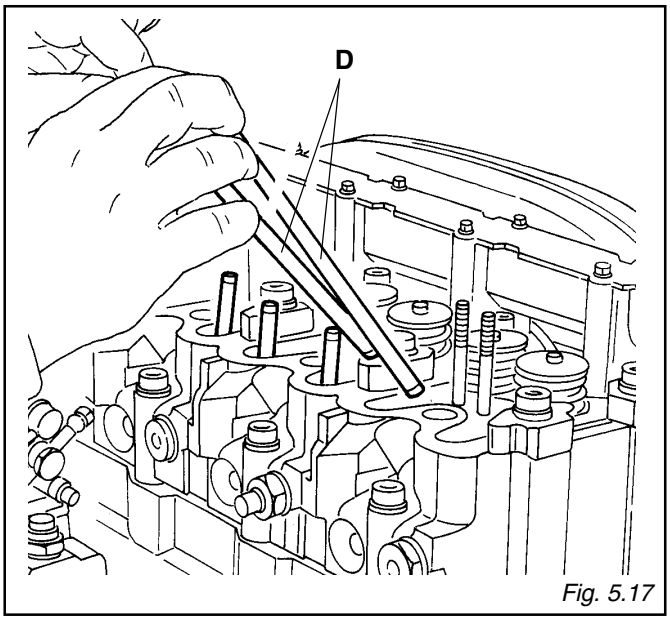

Fig. 5.17

5.9 OIL RETURN LINE FROM TURBOCHARGER (FIG. 5.18)

Unscrew and remove the bolts **A**.

Unscrew and remove the connector union **C** and revove the oil return line.

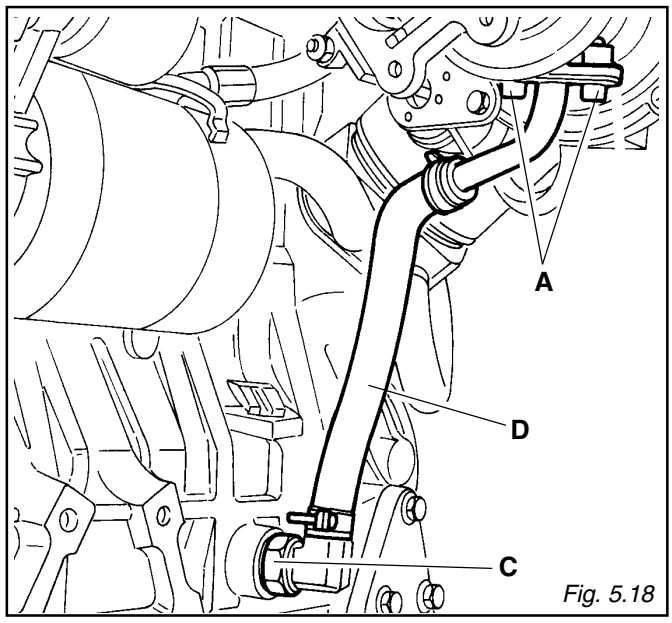

Fig. 5.18

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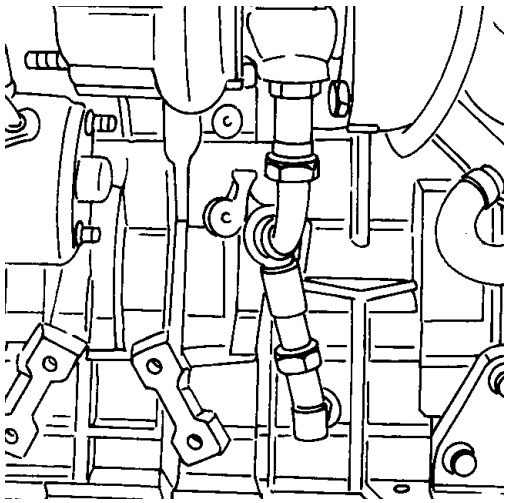
Fig. 5.18a

5.10 OIL DELIVERY LINE TO TURBOCHARGER (FIG. 5.19 - 5.20)

Unscrew the nuts **E**.

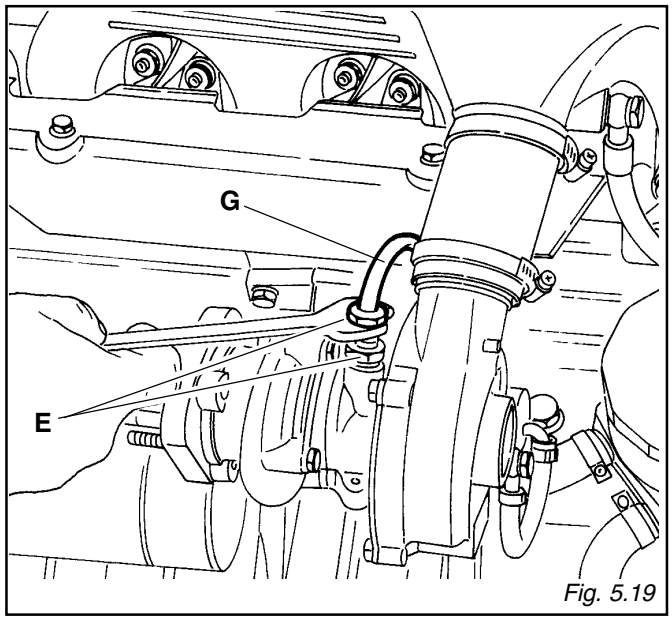

Fig. 5.19

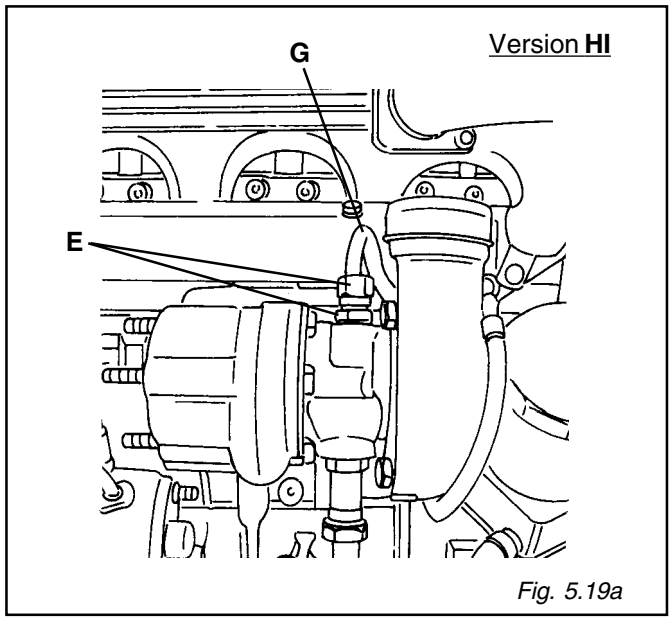

Fig. 5.19a

Unscrew the bolts **F** and removing the oil delivery line to turbocharger **G**.

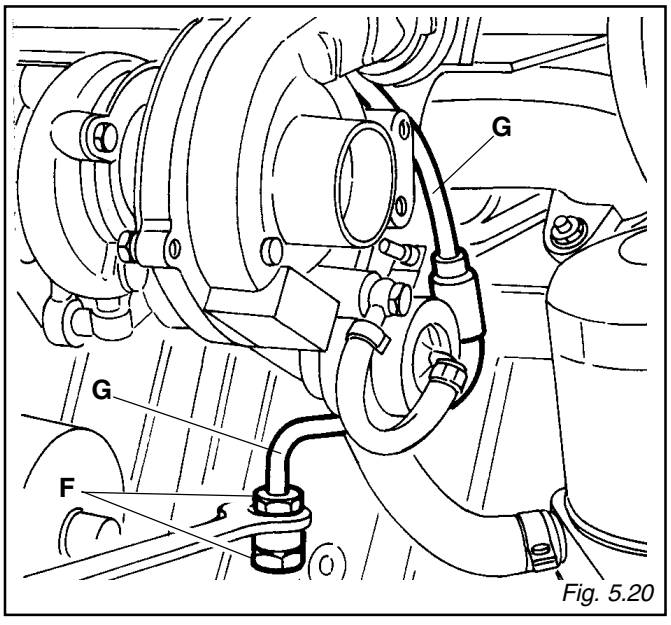

Fig. 5.20

5.11 REMOVING THE TURBOCHARGER (FIG. 5.21)

Unscrew the screw **A** that fixet the clamp **B**.

Unscrew the nuts **C** and removing the turbocharger **D**.

Removing the gascket **E**.

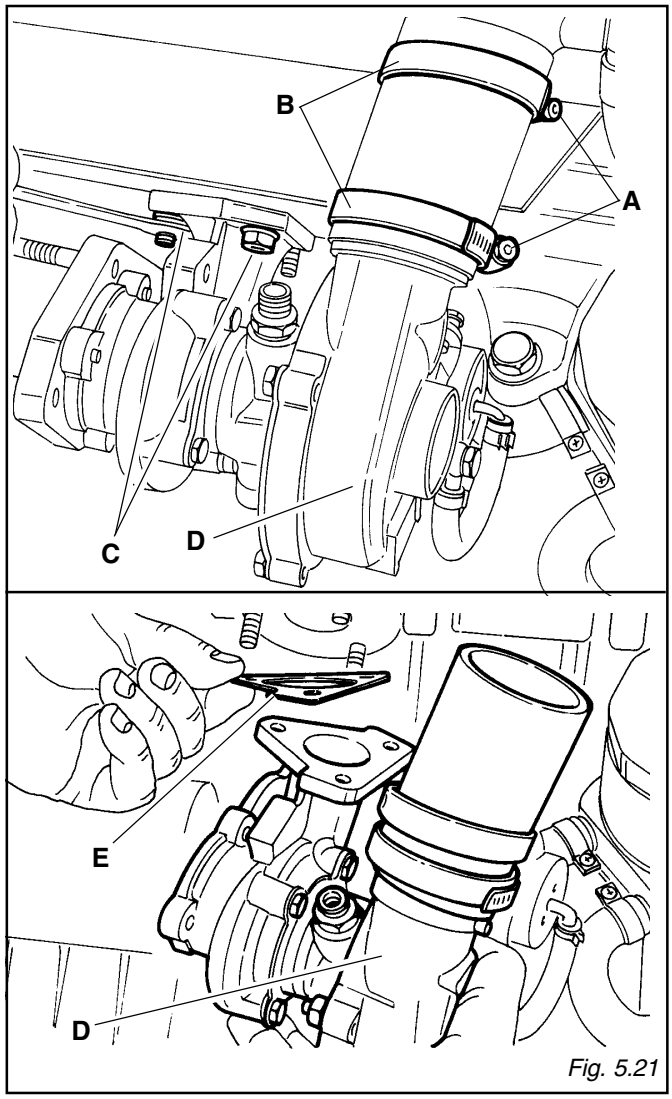

Fig. 5.21

Version **HI**

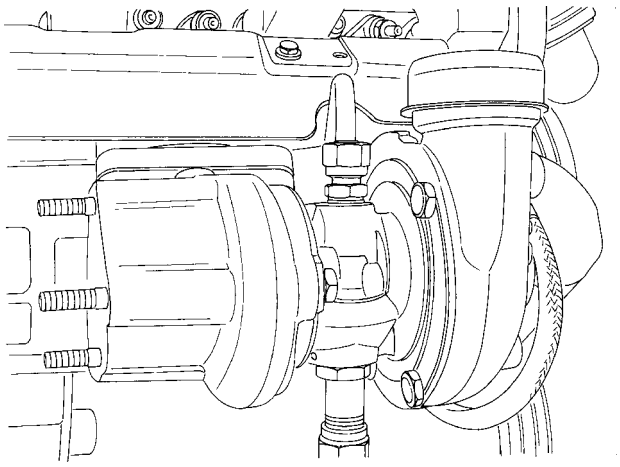

Fig. 5.21a

5.13 TURBOCARGER FLANGE (FIG. 5.23)

Unscrew and removing the bolts **A** and the nuts **B**. Removing the flenge **C** and the gasket **D**.

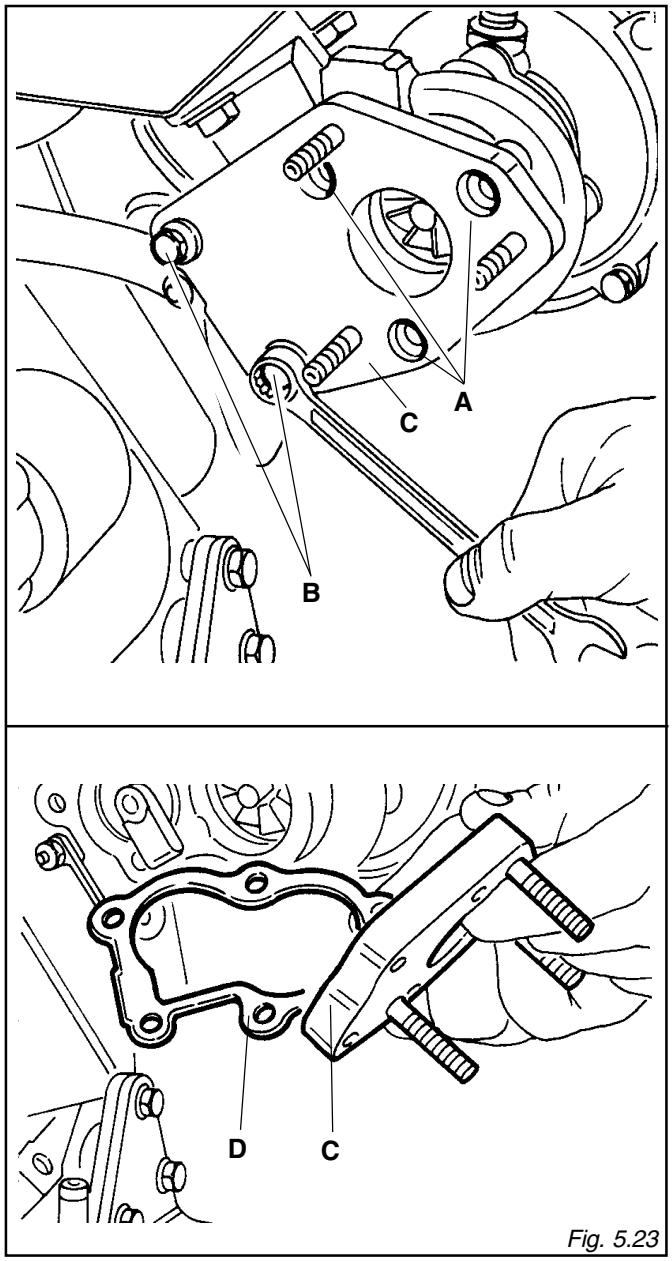

Fig. 5.23

5.14 EXHAUST MANIFOLD HEAT SHIELD (FIG. 5.24)

Unscrew and removing the blots **E** and removing the manifold heat shield **F**.

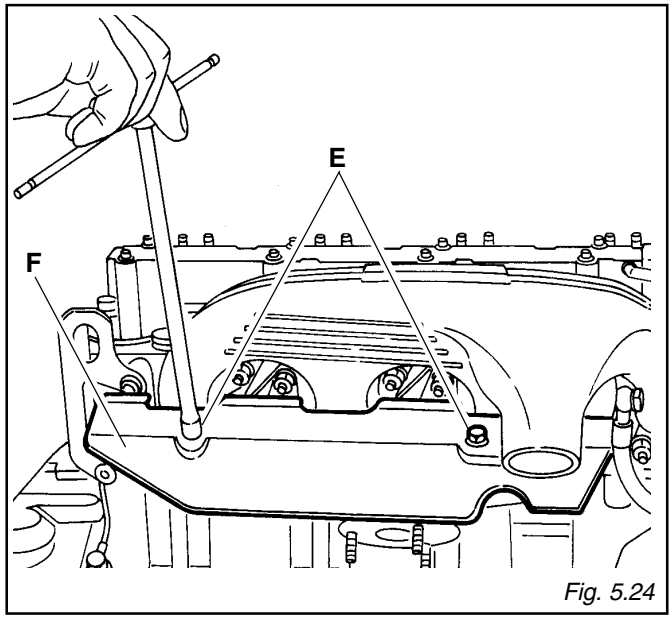

Fig. 5.24

5.15 EXHAUST MANIFOLD (FIG. 5.25 - 5.26)

Unscrew and removing the nuts **A** removing the eyebolt **B**.

Unscrew and removing the nuts **C**.

Remove the manifold **D**.

Renew the gasket.

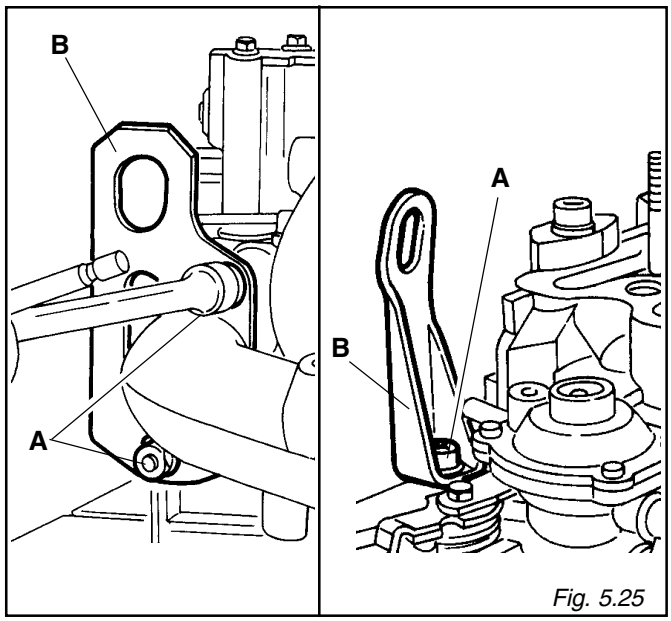

Fig. 5.25

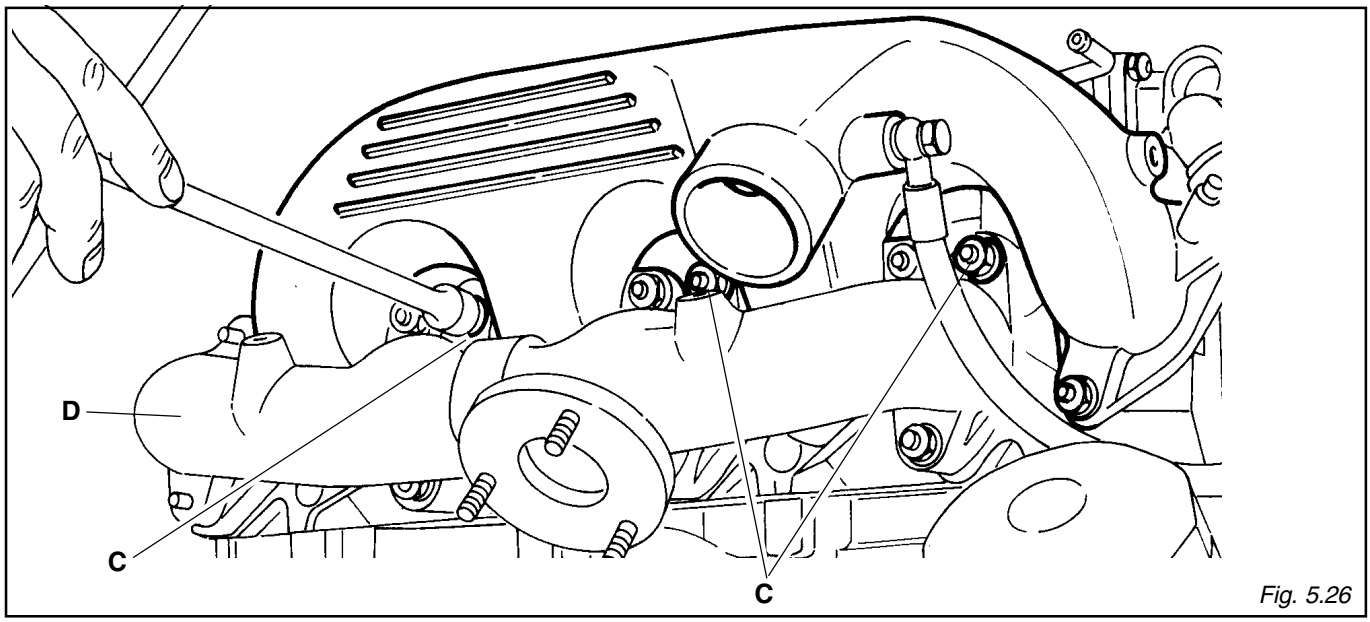

Fig. 5.26

5.16 INLET MANIFOLD (fig. 5.27 - 5.28)

Unscrew the nut **B** and **C,** remove coupling pipe **F** to LDA.

It is advisable to remove the inlet manifold **A** after having removed the exhaust manifold. Unscrew the nuts **G** and remove the inlet manifold.

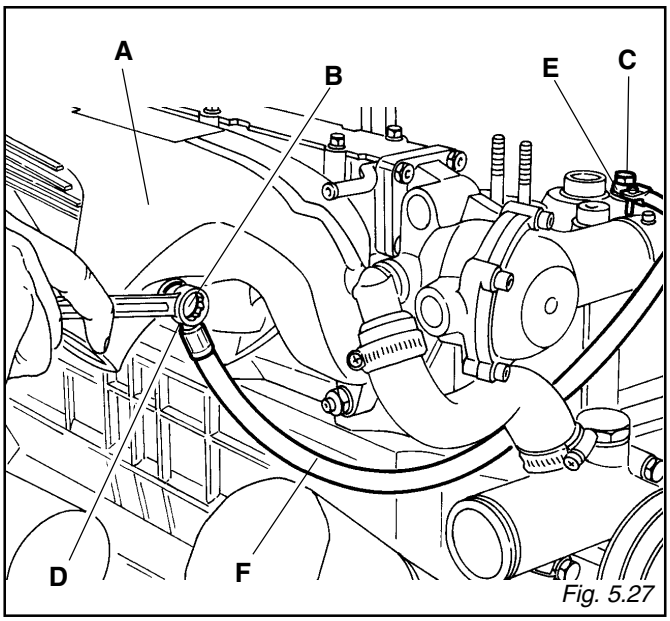

Fig. 5.27

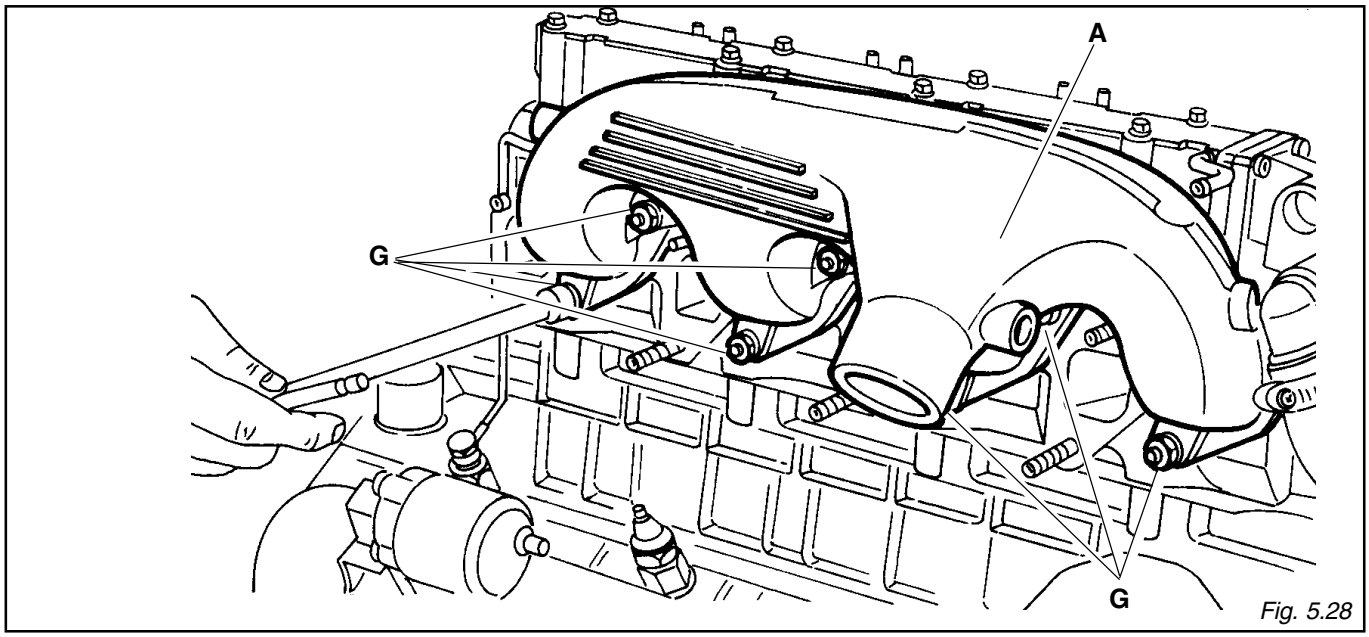

Fig. 5.28

Version **HI**

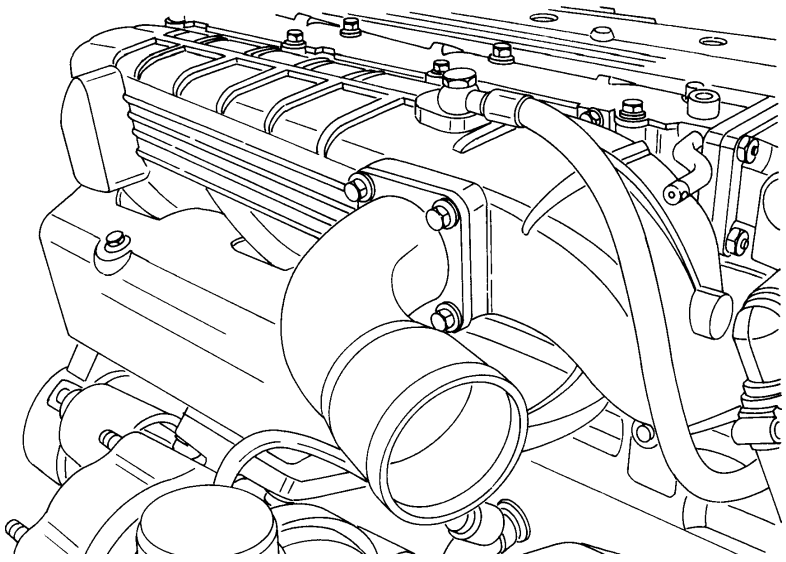
Fig. 5.28a

5.17 COOLANT PUMP PIPE COUPLING TO THERMOSTATICS VALVE (FIG. 5.29)

Unscrew the screws **A** that fixet the clamp **B**.

Remove the pipe coupling **C**.

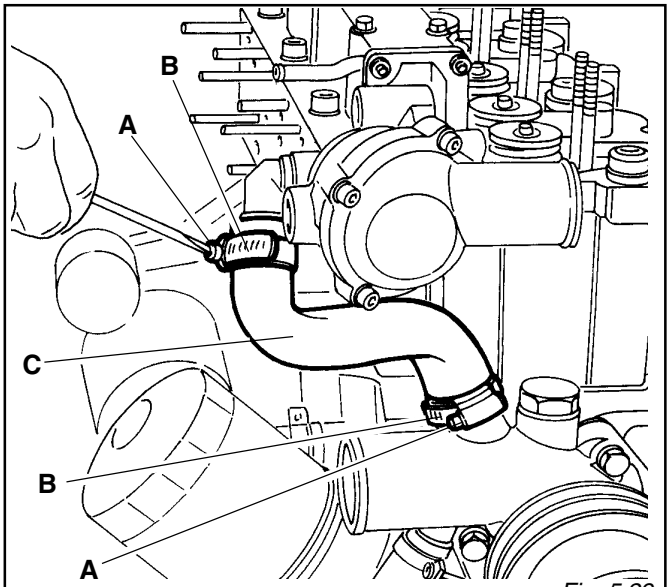

Fig. 5.29

5.18 THERMOSTATICS VALVE (FIG. 5.30)

TO MAKE IT IF NECESSARY ONLY.

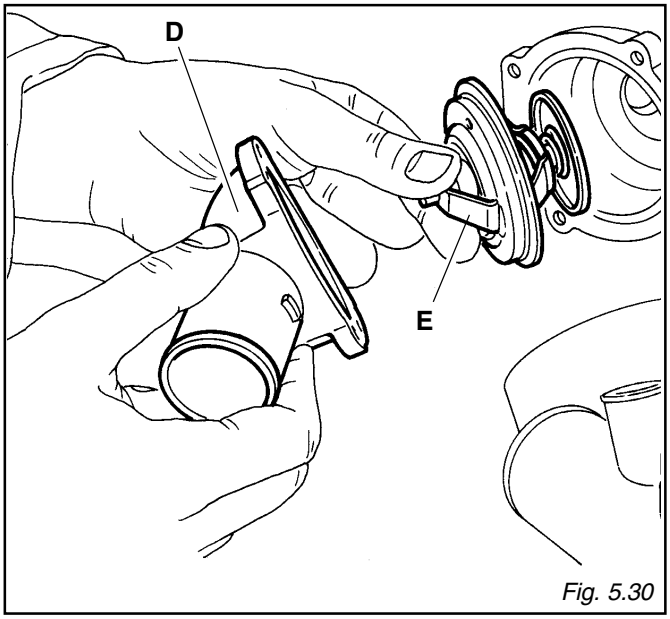

Fig. 5.30

5.19 CYLINDER HEAD COOLANT MANIFOLD *(FIG. 5.31)*

Unscrew screws **F**, and remove the manifold with the gasket **H**.

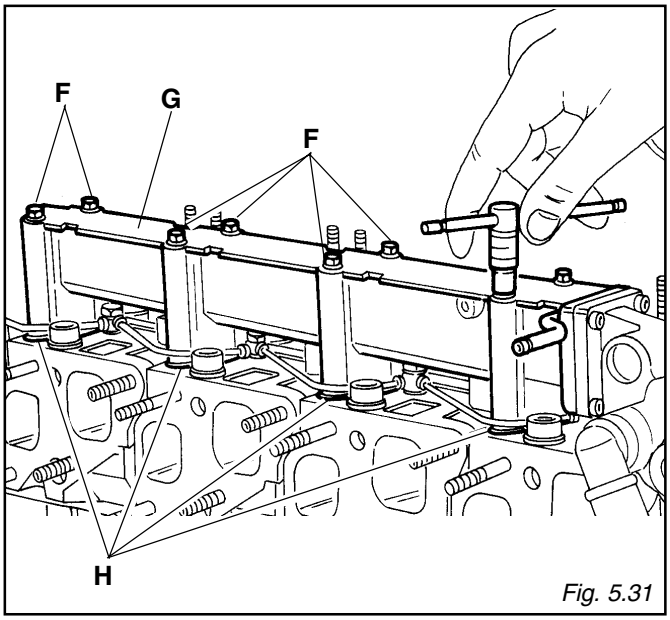

Fig. 5.31

5.20 ROCKER ARM OIL FEED PIPE (FIG. 5.32)

Unscrew unions **A**, remove the oil feed pipe **B**.

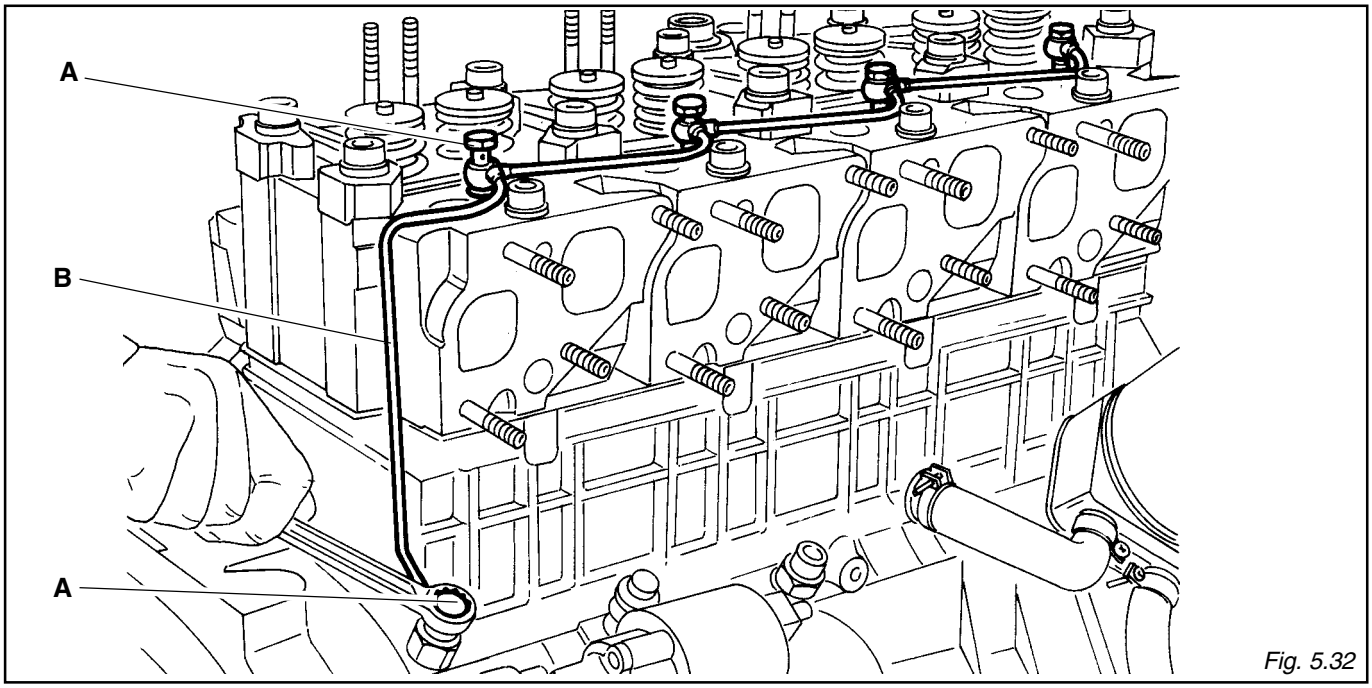

Fig. 5.32

5.21 STARTER MOTOR (FIG. 5.33)

Unscrew retaining bolts **C**, remove the starter motor **D**.

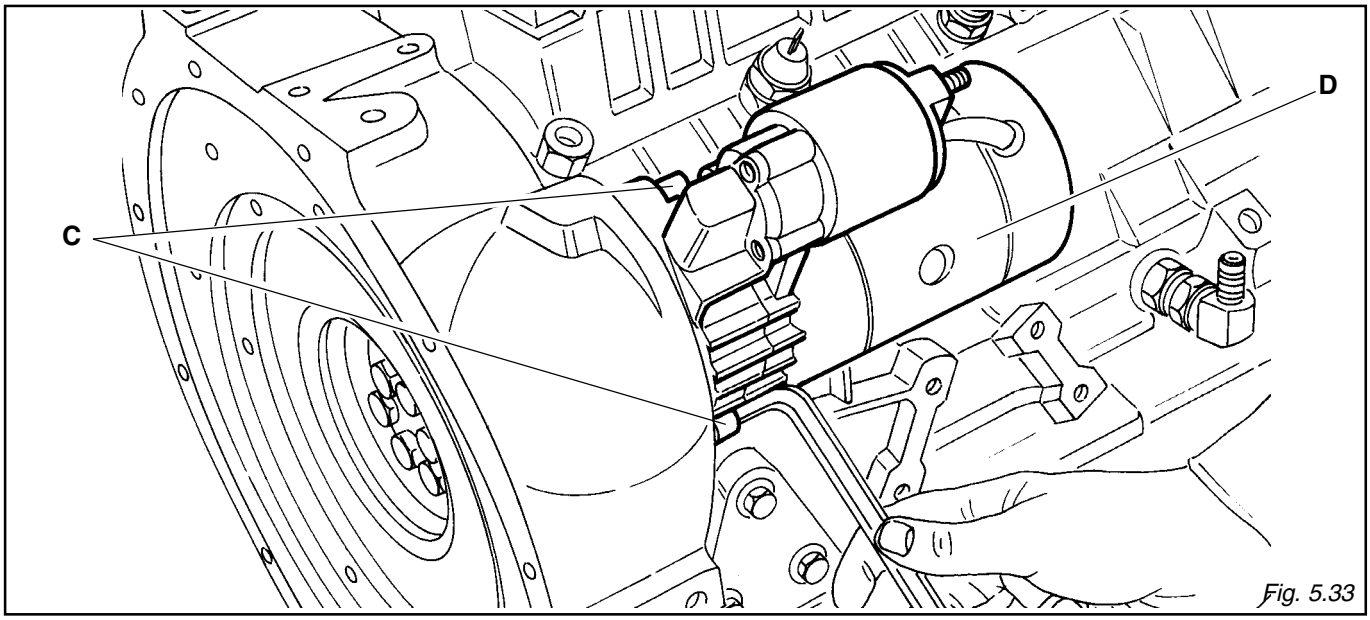

Fig. 5.33

5.22 FAN *(FIG. 5.34)*

Lock the flywheel in position using special tool **A** (TAB. 11.1 ref. V), secured with standard commercial bolts. Then unscrew bolts **B** and nut **C** which has a left-hand thread.

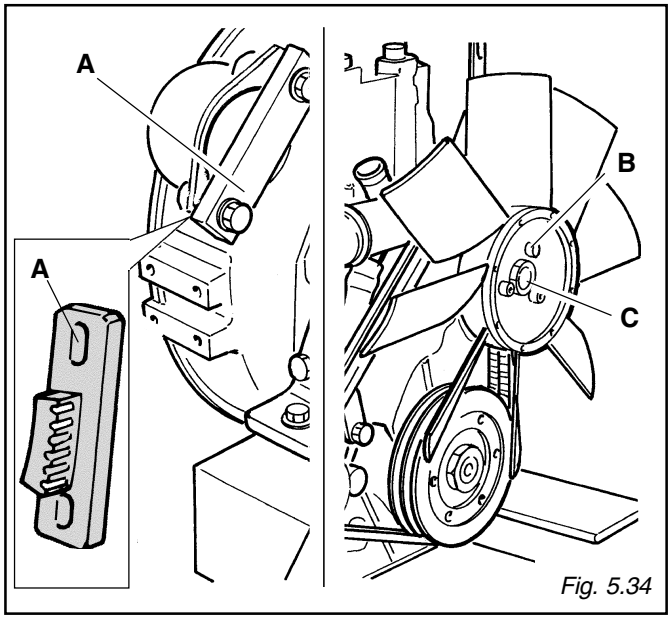

Fig. 5.34

5.23 DRIVE BELTS *(FIG. 5.35)*

Slacken the alternator adjustment nut **D** and push the alternator towards the engine to slacken the belts. Slip the drive belts from the pulleys being careful not to damage them.

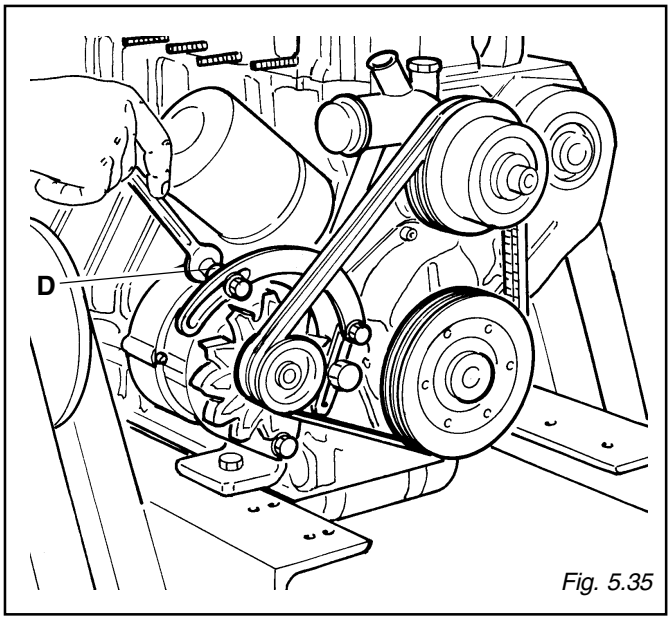

Fig. 5.35

5.24 ALTERNATOR *(FIG. 5.36)*

Remove nut **D** and the lower pivot nut and remove the alternator.

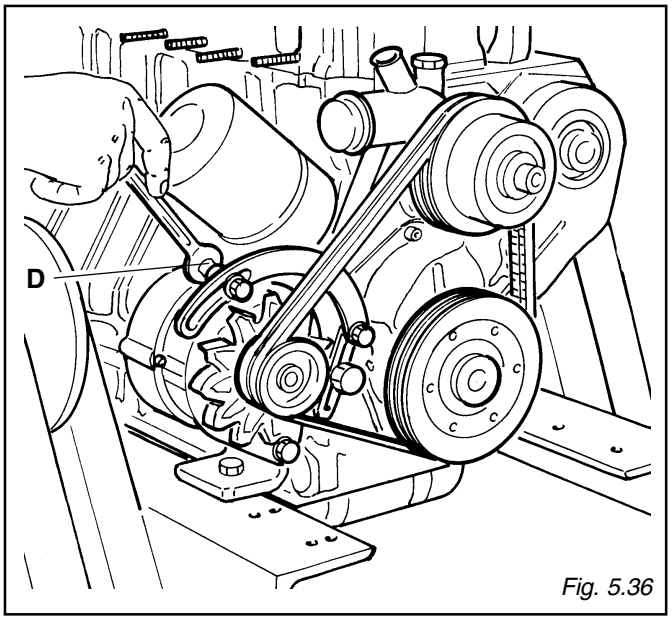

Fig. 5.36

5.25 COOLANT PUMP PULLEY *(FIG. 5.37)*

Unscrew nut **A**. Withdraw pulley **B**.

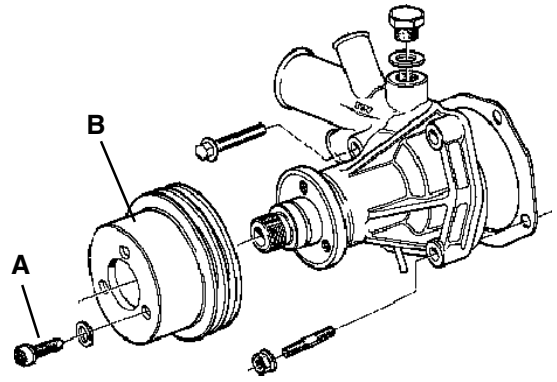

Fig. 5.37

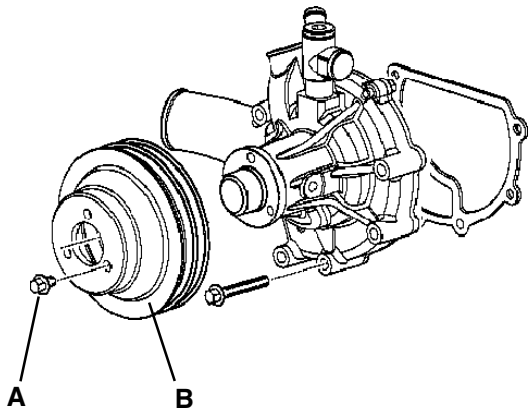

Fig. 5.37a

5.26 COOLANT PUMP *(FIG. 5.38)*

Unscrew the pump retaining bolts **C**.

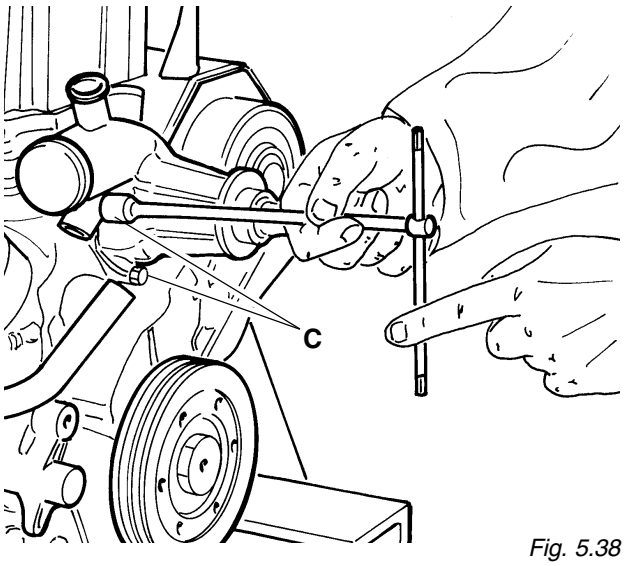

Fig. 5.38

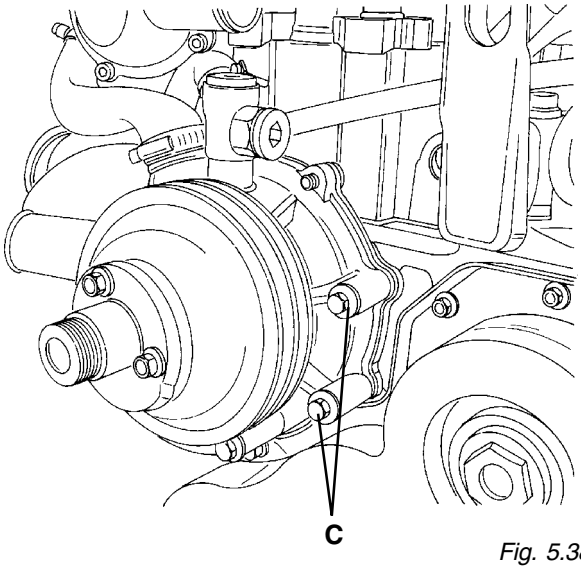

Fig. 5.38a

5.27 INJECTION PUMP *(FIG. 5.39)*

Unscrew threaded plug **A**.
Unscrew the nut inside the timing cover.

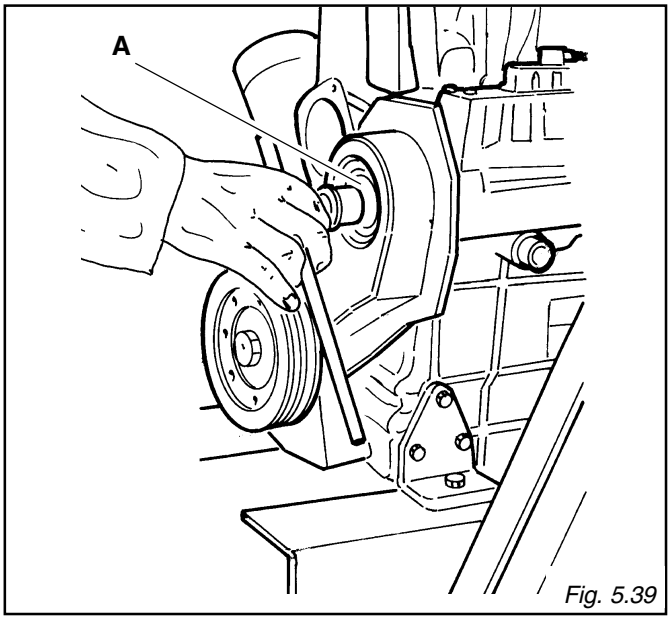

Fig. 5.39

Fit the special tool (TAB. 11.1 ref. E) as follows:

- unscrew the pump gear retaining nut **B**;
- screw ringnut **C** up to the timing cover;
- screw part **D** up to the pump gear;
- screw in nut **E** until the pump gear is separated from the tapered shaft of the pump.

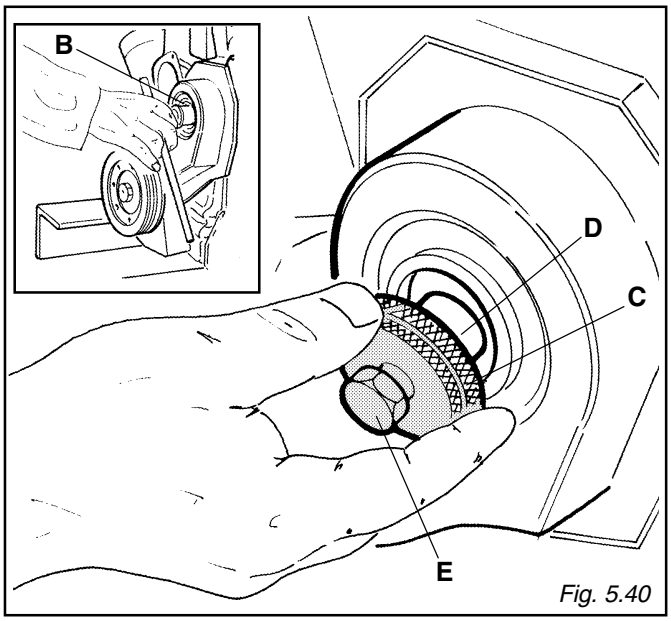

Fig. 5.40

(FIG. 5.41)

Unscrew nuts **A**.

IF ONLY THE INJECTION PUMP IS TO BE REMOVED FROM THE ENGINE, THE USE OF SPECIAL TOOL (FIG. 5.16) IS ESSENTIAL AS IT PREVENTS THE PUMP GEAR FROM BEING DISENGAGING AND THUS ENSURES THAT THE PUMP TIMING REMAINS UNCHANGED.

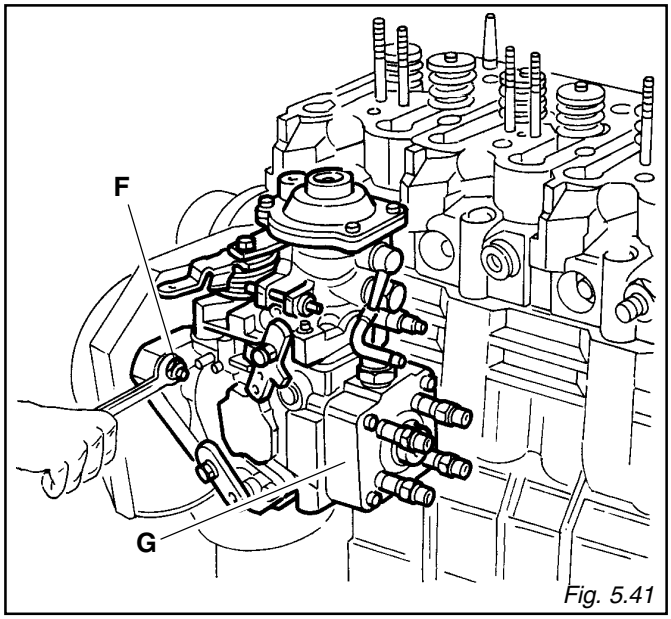

Fig. 5.41

5.28 CRANKSHAFT PULLEY *(FIG. 5.42)*

Unscrew retaining nuts **A**.

Install the special tool (TAB. 11.1 ref. A), attaching part **B** to the pulley with standard commercial bolts **C**. Screw in bolt **D** until the pulley comes free.

TO PREVENT THE CRANKSHAFT ROTATING DURING REMOVAL OF THE CRANKSHAFT PULLEY, FIT SPECIAL TOOL (TAB. 11.1 REF. V).

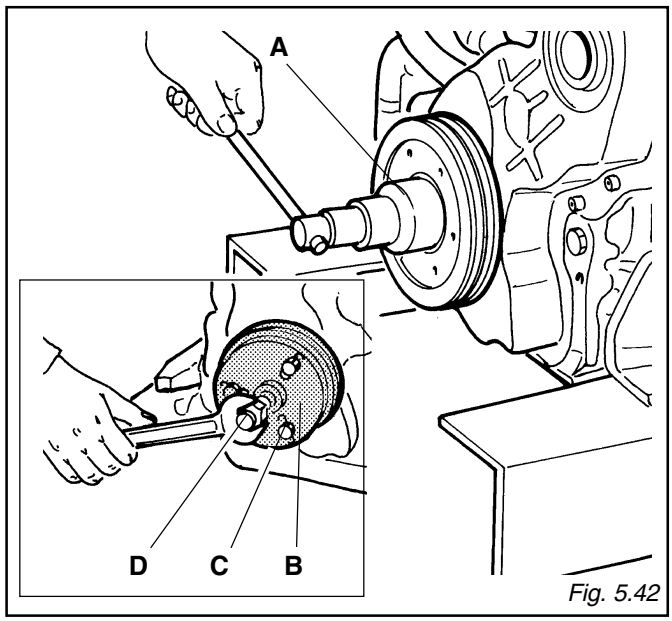

Fig. 5.42

5.29 TIMING COVER *(FIG. 5.43)*

Remove bolts **E** around the perimeter of the timing cover.

Carefully remove the timing cover.

Clean all traces of gasket compound from the timing cover/crankcase mating surfaces.

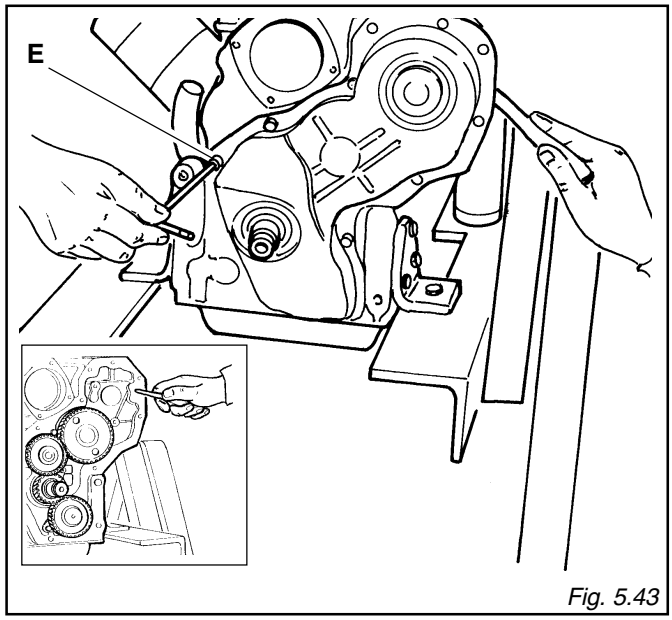

Fig. 5.43

5.30 OIL PUMP *(FIG. 5.44)*

Unscrew retaining bolts **F** and withdraw oil pump **G**.

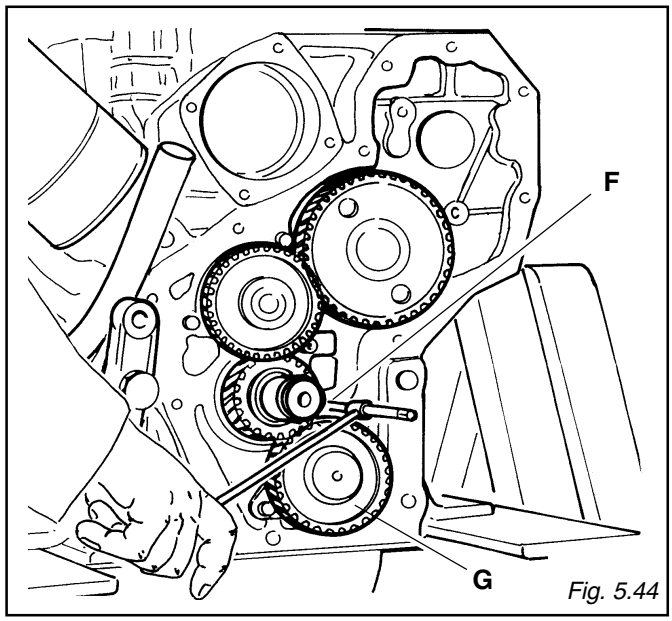

Fig. 5.44

5.31 INTERMEDIATE GEAR *(FIG. 5.45)*

Unscrew retaining bolts **A** and withdraw gear **B**.

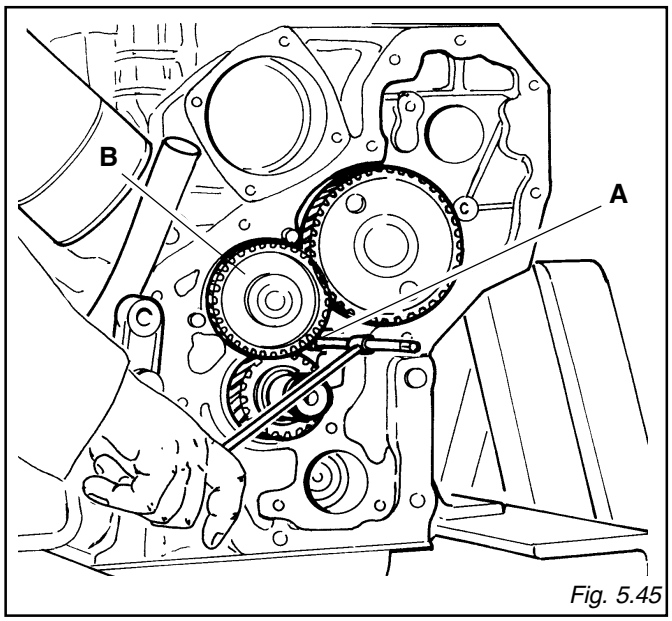

Fig. 5.45

5.32 FLYWHEEL *(FIG. 5.46)*

With special tool (TAB. 11.1 ref. V) installed to prevent flywheel from turning, unscrew flywheel bolts **C**.

To facilitate flywheel removal, use two standard commercial bolts **D** as shown in the figure.

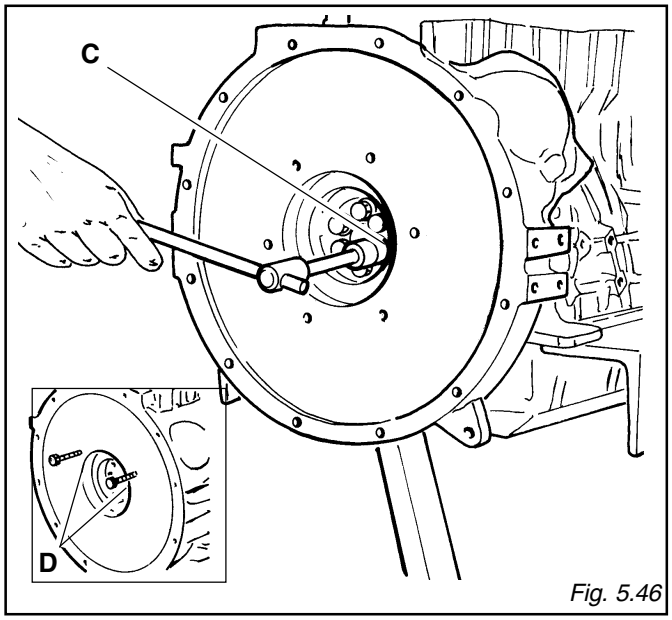

Fig. 5.46

5.33 FLYWHEEL BELL HOUSING *(FIG. 5.47)*

Remove bolts **E**.

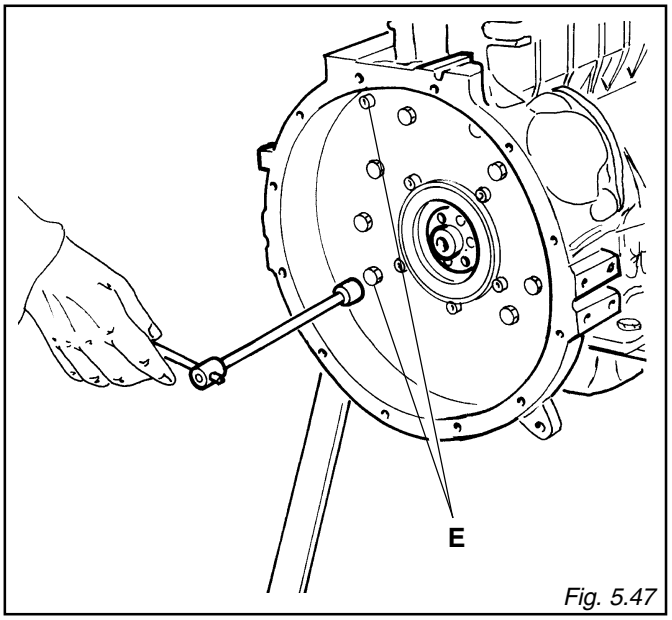

Fig. 5.47

5.34 REAR MAIN BEARING CARRIER *(FIG. 5.48)*

Unscrew nuts **A** and remove the bearing carrier taking care not to exert any radial force.

THE REAR MAIN BEARING CARRIER MAY BE REMOVED TOGETHER WITH THE FLYWHEEL BELL HOUSING BY LEAVING NUTS IN FIG. 5.48 AND UNSCREWING THE BOLTS (A) IN FIG. 5.47.

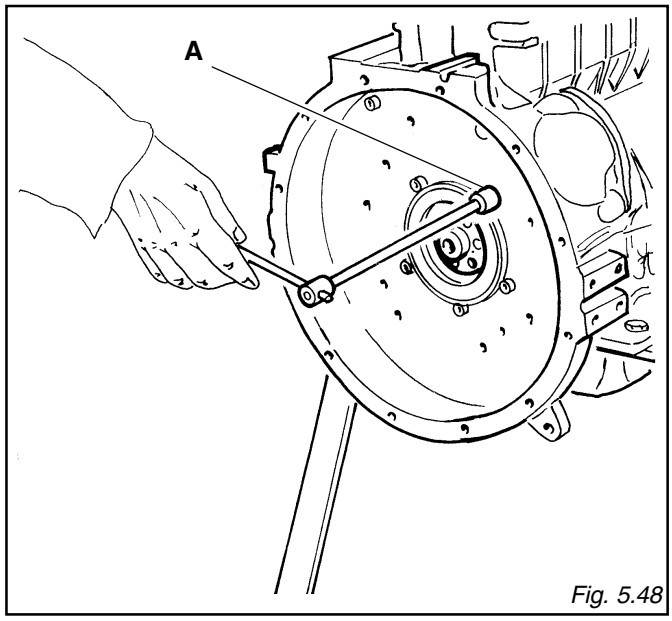

Fig. 5.48

5.35 CYLINDER HEAT *(FIG. 5.49 - 5-50)*

Unscrew and remove the bolts **A** .

Unscrew and remove the blts **B** remove the clamps **C** and the cylinder head distance pieces **D**.

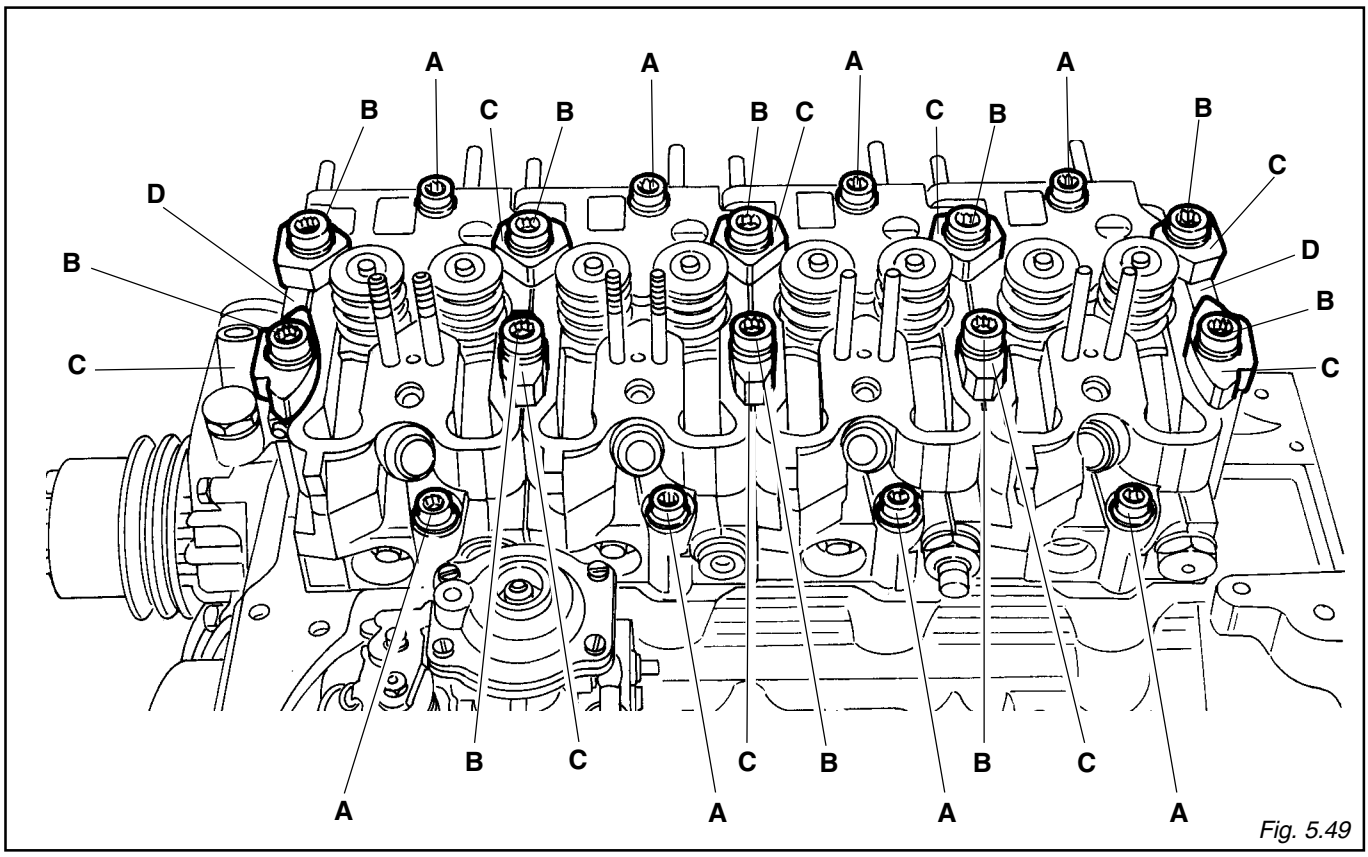

Fig. 5.49

Remove cylinders head **E** and gasket **F**

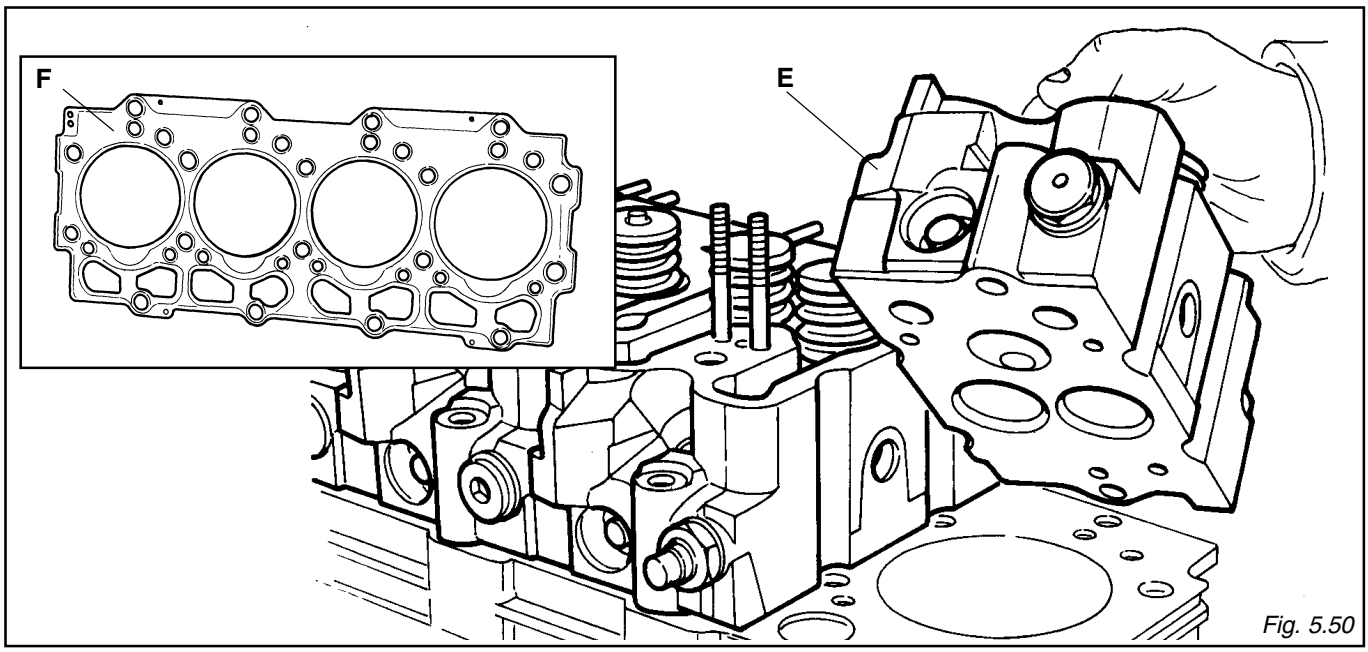

Fig. 5.50

5.36 HYDRAULIC TAPPETS (FIG. 5.51 - 5.52 - 5.53 - 5.54)

Remove aligning yokes **A** .
Install VM special tool (TAB. 11.1 ref. N) through openings in the block and fit the tool firmly in the head of the tappet. Push down and twist the tool of 90°.
At this point the hydraulic tappet is hooked.
Pool the tappet out of the bore with a twisting motion.
If all the tappets have to be removed, identify them to ensure installation in the original location.

NOTE: IF THE ENGINE IS EQUIPPED WITH MECHANICAL TAPPETS, REMOVAL IS PERFORMED IN A LATER STEP

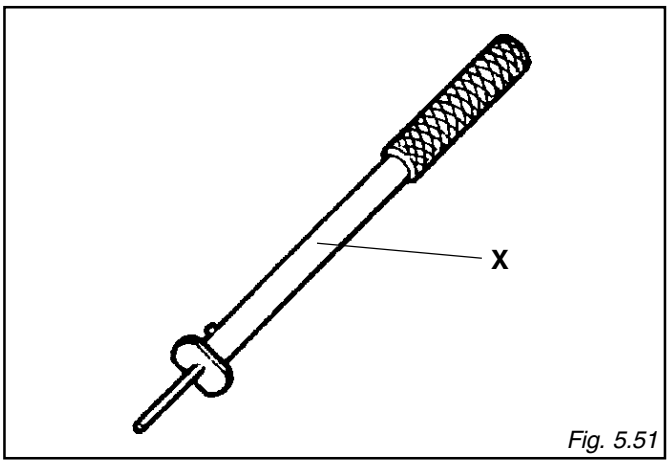

Fig. 5.51

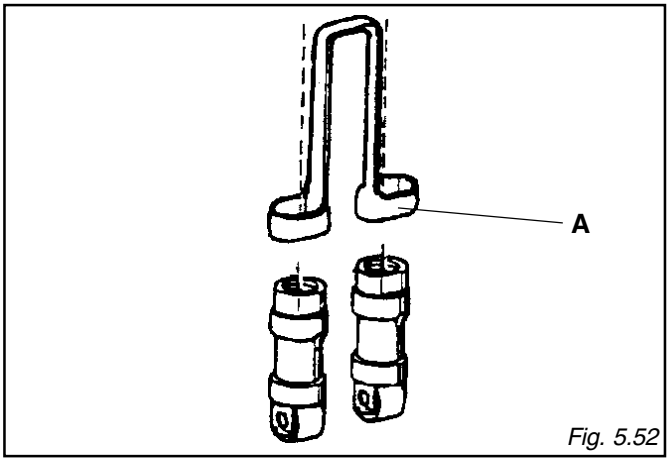

Fig. 5.52

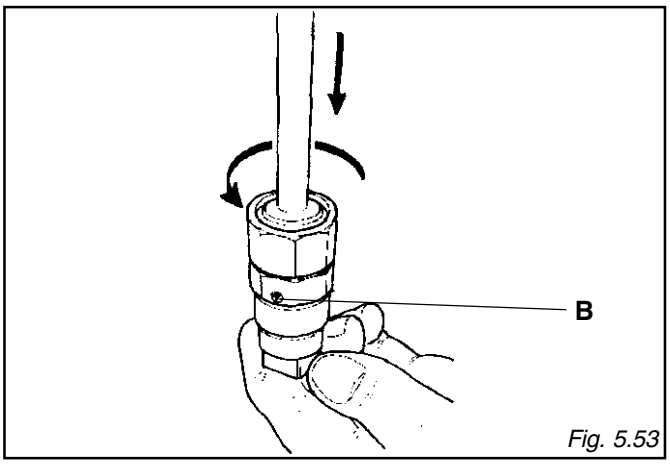

Fig. 5.53

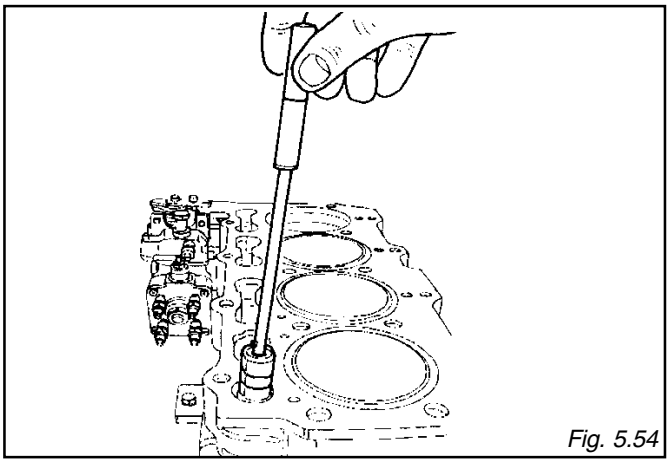
Fig. 5.54

5.37 OIL FILTER CARTRIDGE *(FIG. 5.55)*

Unscrew and remove the oil filter cartridge using a commercial oil filter wrench **A**.

BE CAREFUL NOT TO DEFORM THE CARTRIDGE MOUNTING.

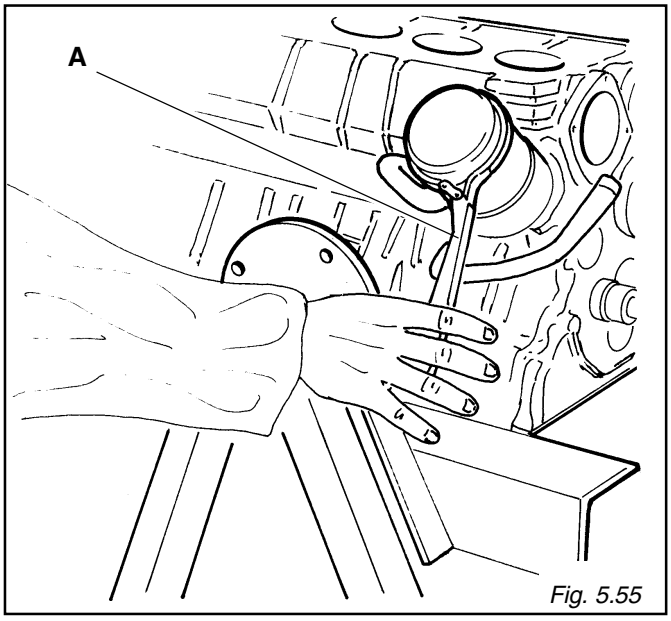

Fig. 5.55

5.38 OIL COOLER *(FIG. 5.56)*

Unscrew the internal union **B**.

Slacken off the water hose clamps **C**.

Remove the oil cooler complete with the water hoses.

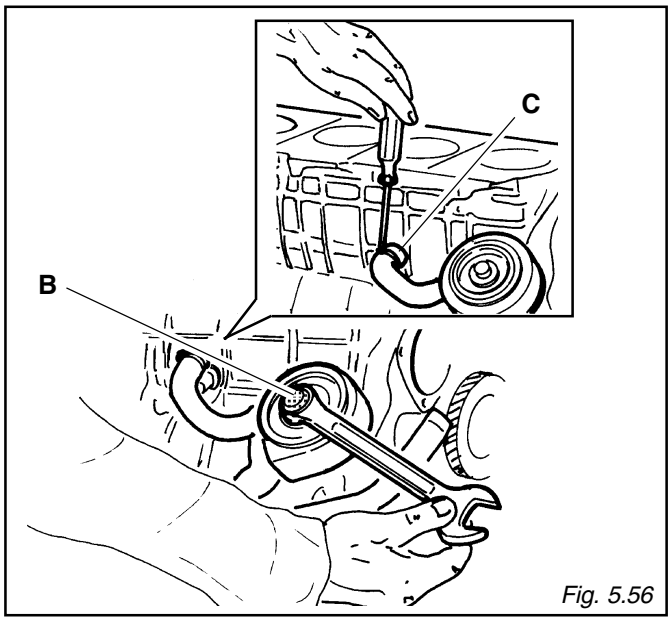

Fig. 5.56

5.39 FUEL PUMP *(FIG. 5.57)*

Unscrew bolts **D**.

Remove pump **E**.

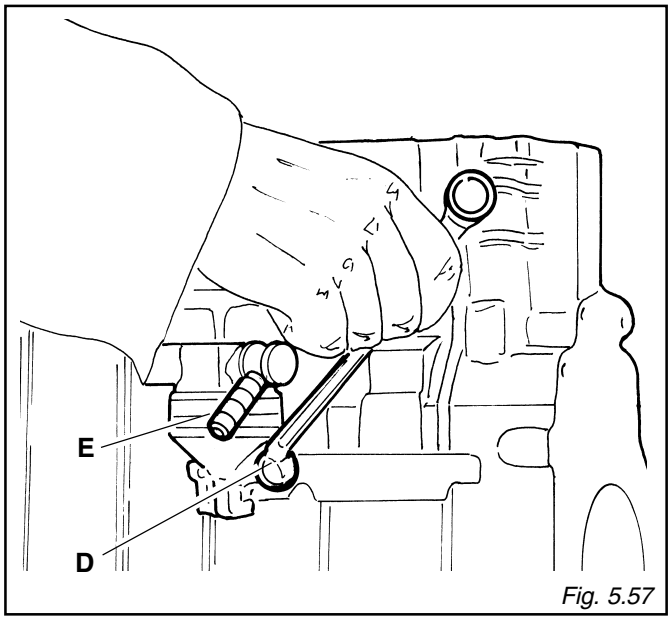

Fig. 5.57

5.40 SUMP PAN *(FIG. 5.58)*

Turn the engine upside down.

Unscrew bolts **A** and remove the sump pan **B**.

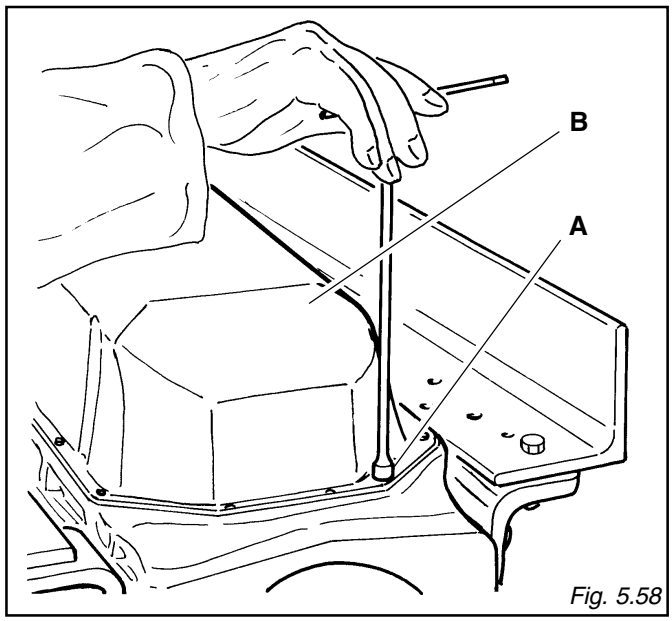

Fig. 5.58

5.41 OIL PICK-UP PIPE *(FIG. 5.59)*

Unscrew bolts **C** and remove pipe **D**.

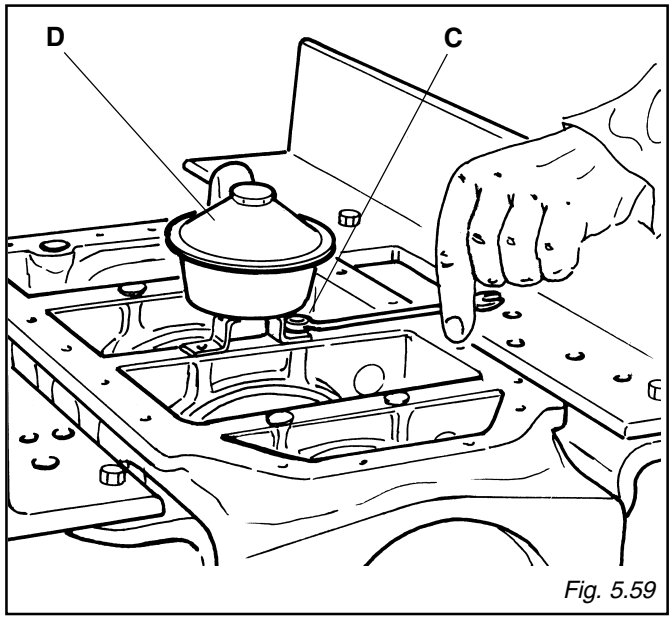

Fig. 5.59

5.42 CONNECTING ROD - PISTON COMPLETE WITH RINGS - CYLINDER LINERS *(FIG. 5.60)*

Turn the crankshaft so that the connecting rod to be removed is at bottom dead center.

Unscrew bolts **E** and remove big-end bearing cap **F**. Using a suitable implement of soft material (wood or rubber), push the connecting rod/piston assembly up the bore and out of the cylinder block. Repeat this operation for each piston.

IT IS GOOD PRACTICE TO REASSEMBLE THE CAPS AND CONNECTING RODS AFTER REMOVAL AND NUMBER THEM CONSECUTIVELY ACCORDING TO THEIR POSITION.

ONLY REMOVE THE PISTONS FROM THE CONNECTING RODS IF ABSOLUTELY NECESSARY. TO DO THIS, REMOVE THE CIRCLIPS AND GUDGEON PINS.
PISTON RINGS MUST BE REMOVED USING A COMMERCIAL PISTON RING REMOVAL TOOL.

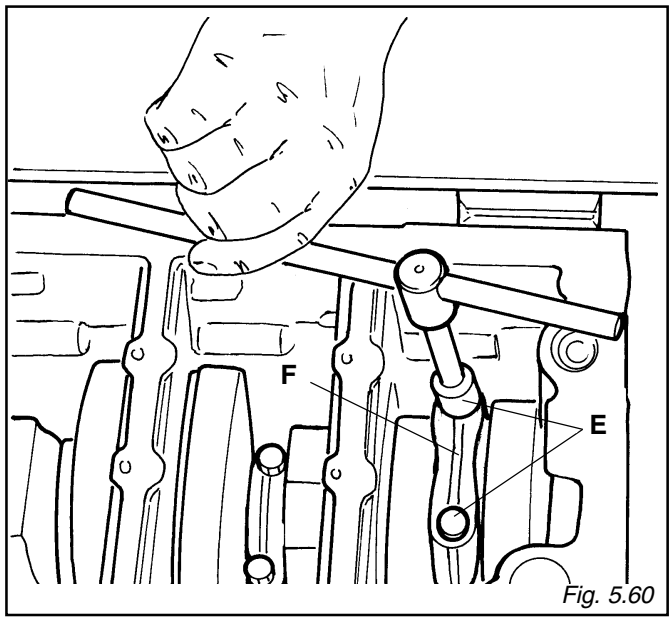

Fig. 5.60

5.43 CENTER MAIN BEARING CARRIER *(FIG. 5.61)*

First remove the oil feed unions **A**.

Remove the main bearing cap bolts **B**.

IT IS ADVISABLE TO NUMBER THE MAIN BEARING CAPS ACCORDING TO THEIR POSITION.

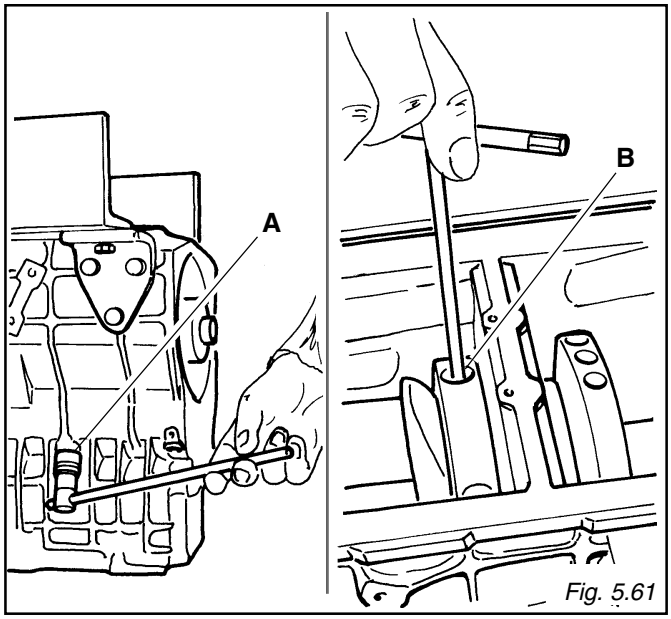

Fig. 5.61

5.44 CRANKSHAFT *(FIG. 5.62)*

Using special tool **C** (TAB. 11.1 ref. H), withdraw the crankshaft. Using the special tool will prevent scoring and abrasion of the front bearing.

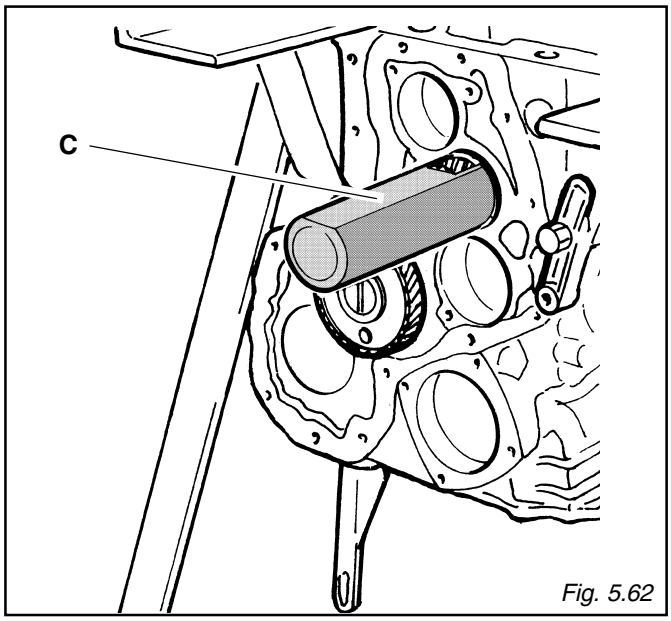

Fig. 5.62

5.45 CAMSHAFT *(FIG. 5.63 - FIG. 6.64)*

With the engine inverted, unscrew bolts **A**.

Withdraw the camshaft very gently. taking care not to damage the camshaft bearings.

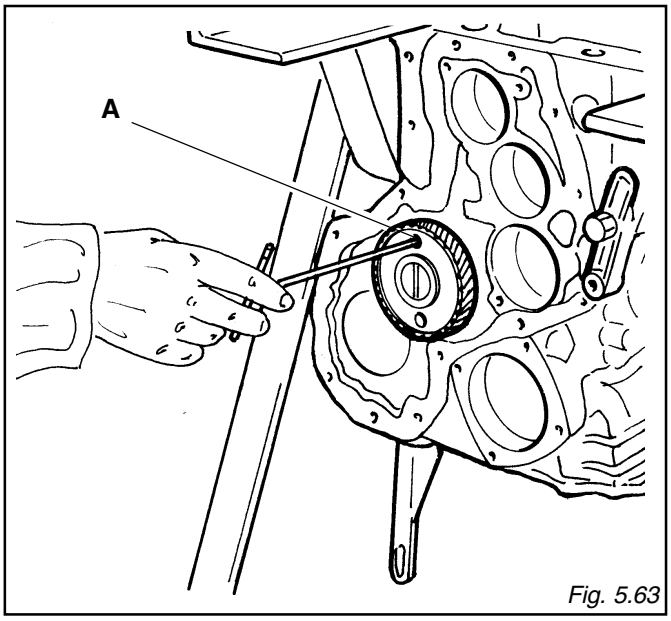

Fig. 5.63

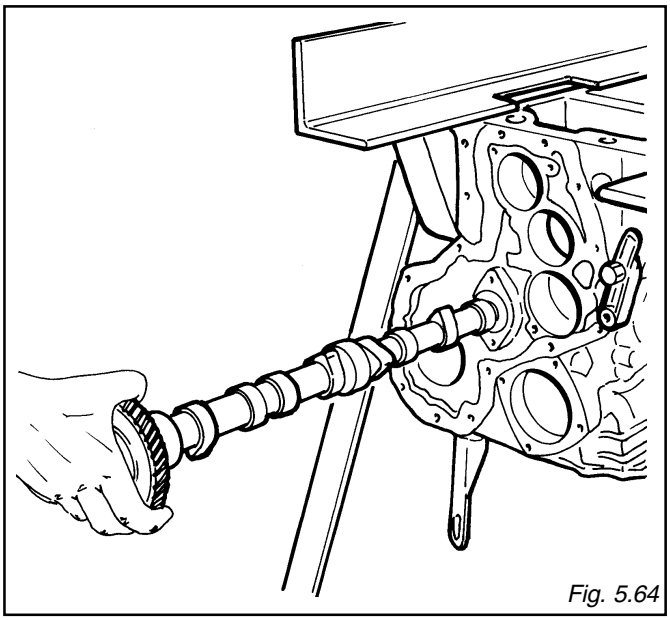
Fig. 5.64

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PÁGINA INTENCIONALMENTE BLANCA

CHECKS AND REPAIRS Pag. 1 ÷ 26 6

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6.1 CYLINDER HEAD *(FIG. 6.1)*

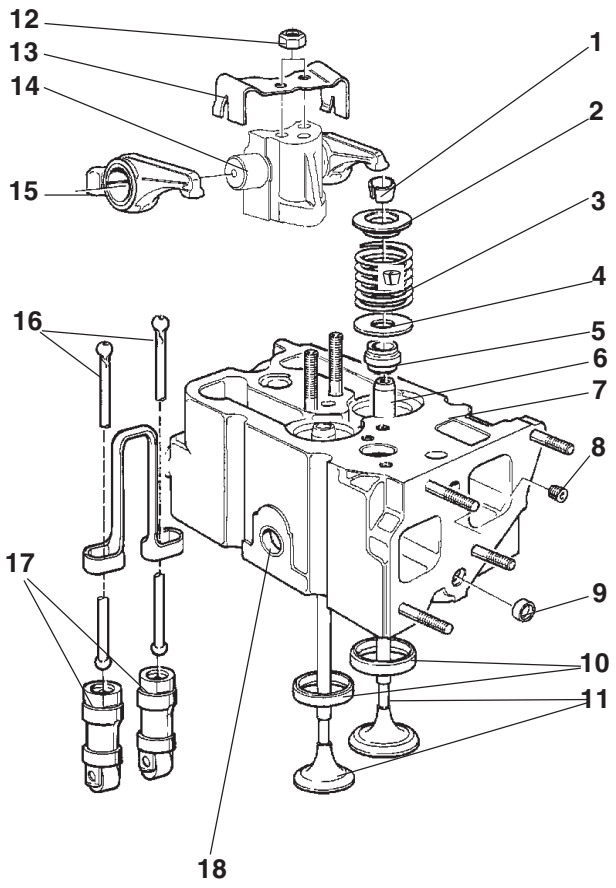


Fig. 6.1

KEY			
1)	Split collets	**10)**	Valves seats
2)	Spring cap	**11)**	Valves
3)	Valve spring	**12)**	Nut
4)	Spring seat	**13)**	Spring
5)	Valve guide seal	**14)**	Support rocker arms
6)	Worn guides	**15)**	Rocker arm
7)	Cylynder head	**16)**	Push rod
8)	Plug	**17)**	Hydraulic tappets
9)	Plug	**18)**	Plug

6.2 VALVES - SEATS - GUIDES *(FIG. 6.2 - 6.3)*

If necessary clean the valves with a wire brush or replace them if the heads are bent, worn or cracked.
Check the diameter of the valve stem, value A (fig. 6.2), and if the valve stems are worn replace the valves.
Check that the guides are not grooved inside or show signs or seizing.
To check whether the valve guides are in the right position, check value A (fig. 6.3).
Check the internal diameter of the valve guides, value B (fig. 6.3).
If there is any difference in the values, replace the head.
If value C (fig. 6.3) is lower than normal, the valve has probably broken through the seat and you will have to replace the head.

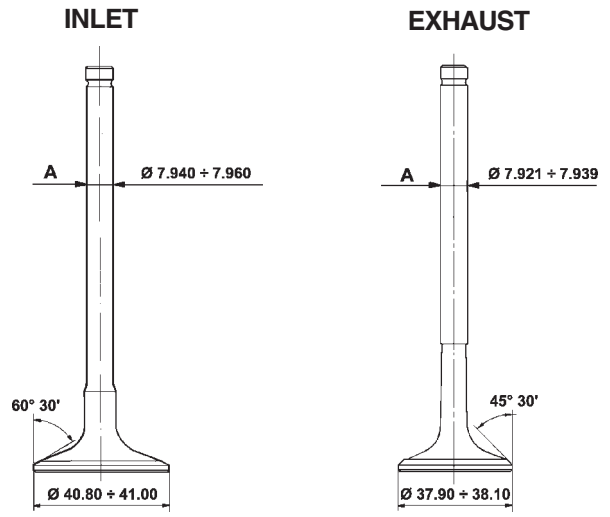
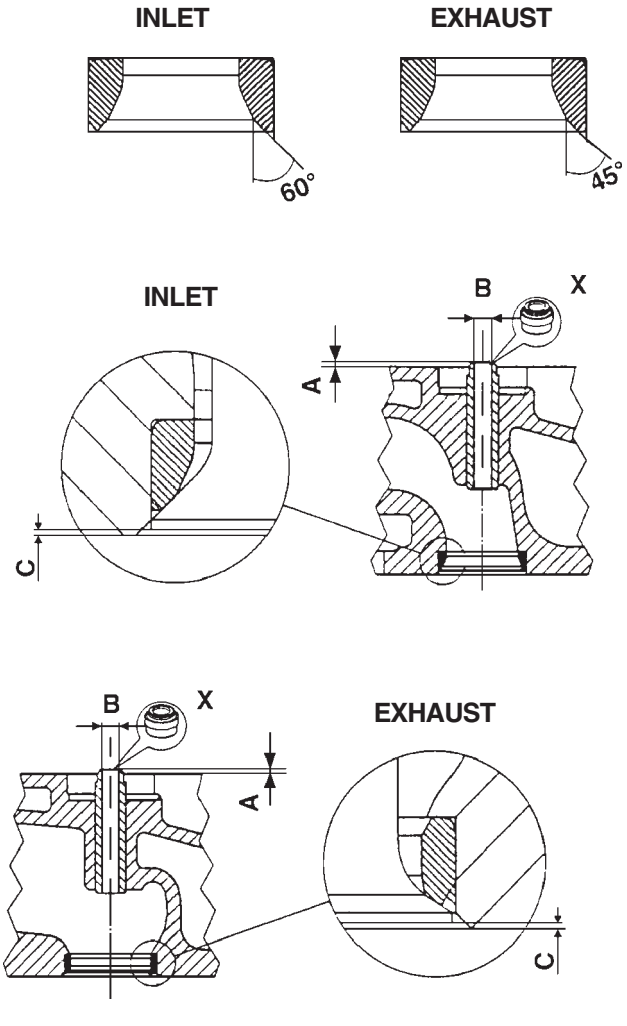


Fig. 6.2

Dimens.	At installation	
	Inlet mm	Exhaust mm
A - Fig. 6.3	2.00 ÷ 1.50	2.00 ÷ 1.50
B - Fig. 6.3	8.000 ÷ 8.015	8.000 ÷ 8.015
C - Fig. 6.3	0 ÷ 0.3	0 ÷ 0.3



X = RING SEAL

Fig. 6.3

6.3 VALVES SPRINGS *(FIG. 6.4 A - 6.4 B)*

Check that the valve springs are not cracked or have lost their resilience.

Check spring height under different load conditions.

Check that distortion **"A"** does not exceed **2** mm.

L 0 = 44 mm (free length)

L 1 = 37 mm **P 1** = 24 Kg

L 2 = 26,61 mm **P 2** = 59,6 Kg

Fig. 6.4 A

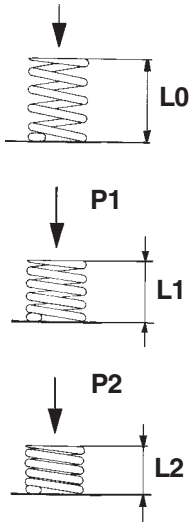


Fig. 6.4 B

6.4 CYLINDER HEAD DISTANCE PIECES *(FIG. 6.5)*

Check that the height of the distance piece **A** is as specified value: 89.92 - 90.00 mm.

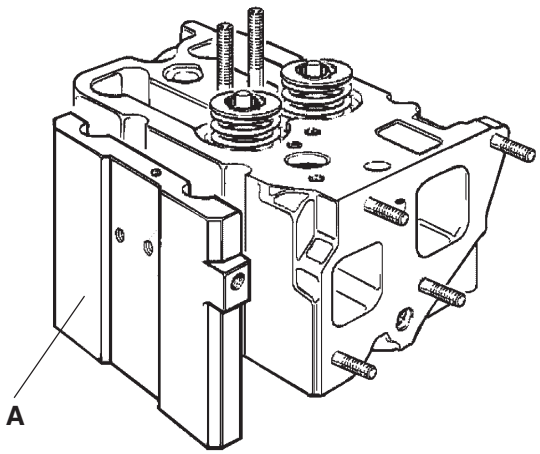


Fig. 6.5

6.5 COOLANT MANIFOLD *(FIG. 6.6)*

Inspect manifold for cracks or splits.

Check that the mating surfaces of the flanges are flat and aligned in the same plane; small discrepancies can be removed by careful regrinding.

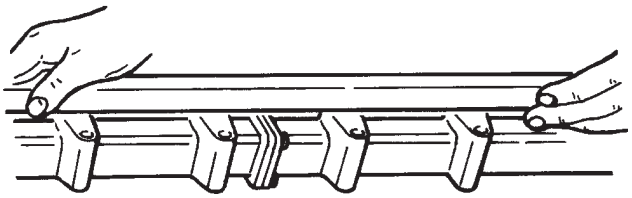


Fig. 6.6

6.6 ROCKER ARMS *(FIG. 6.7)*

Clean journals and rocker arms with solvent (see para. 3.7).

CLEAN OIL WAYS OF OIL AND SLUDGE

Check dimensions:

A = 21.979 - 22.000

B = 22.020 - 22.041

If the measured dimensions do not correspond with those specified, the rocker arms must be replaced.

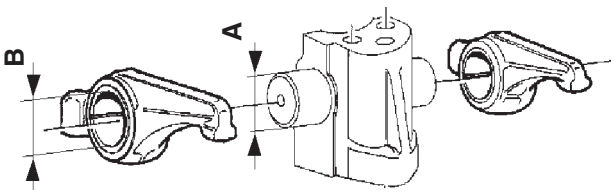


Fig. 6.7

6.7 HYDRAULIC TAPPETS *(FIG. 6.8A)*

Inspect **A** surfaces wich are in touch with push rod, engine block and camshaft to be sure they are not score or scuffed.

Check dimensions:

B = 22.195 - 22.212.

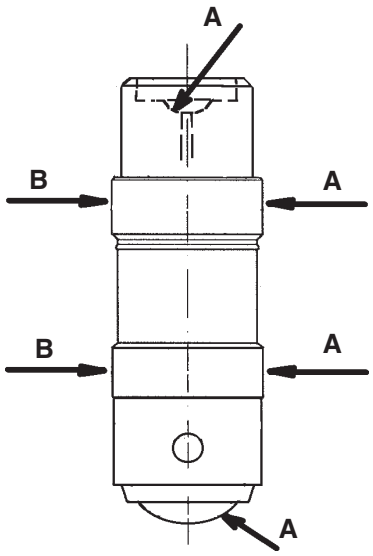


Fig. 6.8

6.8 CYLINDER LINERS *(FIG. 6.9)*

Liner internal diameter D (mm)

Maximum ovality **A - B**: 0.100 mm

Maximum taper **E - C**: 0.100 mm

When cylinder wear or scoring does not exceed the nominal dimensions **C-D-E** by more than 0.10 mm, surface roughness can be removed with fine grade emery cloth soaked in diesel fuel working in clockwise and counter-clockwise spiral directions.

Surface roughness must be between 0.8 ÷ 1.2 µ. If wear or scoring exceeds 0.10 mm, fit new liners.

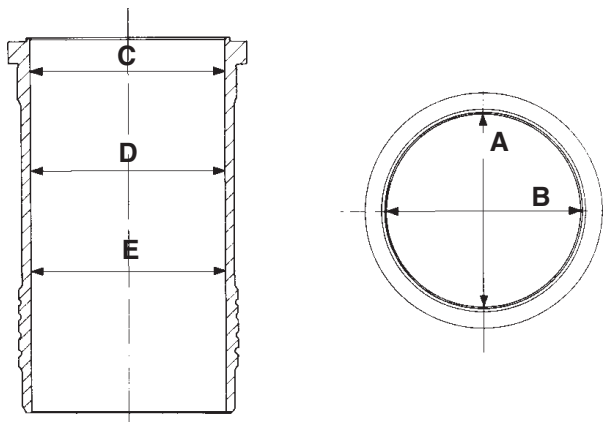


Fig. 6.9

6.9 PISTONS *(FIG. 6.10)*

Check that the working surfaces are free of any anomalies, scratches, or signs of seizing, if you do find any of the above problems, replace the faulty part.
To check the play between the rings and their seats, use a precision feeler gauge and check that the play isn't over the following limits:
compression ring **A**, cannot be measured
piston ring **B** max. 0.12 mm
oil scraper ring **C** max. 0.08 mm

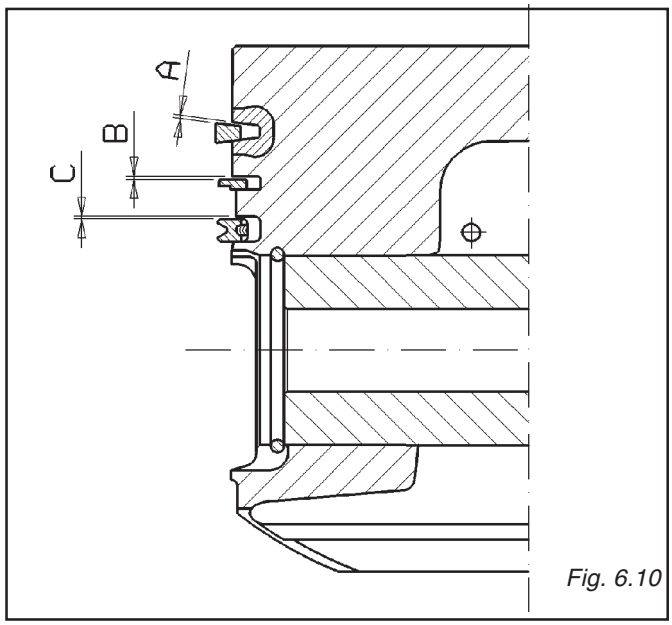


Fig. 6.10

6.9a PISTON RINGS *(FIG. 6.10a)*

Check that the piston rings are free to turn in their seats without any friction or blocking and that they show no signs of damage. If any anomalies are found, replace the rings.
To check the distance between the two ends of the rings, as shown in the figure, insert the ring in the cylinder, position it at a right angle to the working surface and use a precision feeler gauge.
The values measured should not exceed those indicated below:
compression ring **A**, max 0.5 mm
piston ring **B** max. 0.5 mm
oil scraper ring **C** max. 0.6 mm
Cylinder bore
Distance between the ends

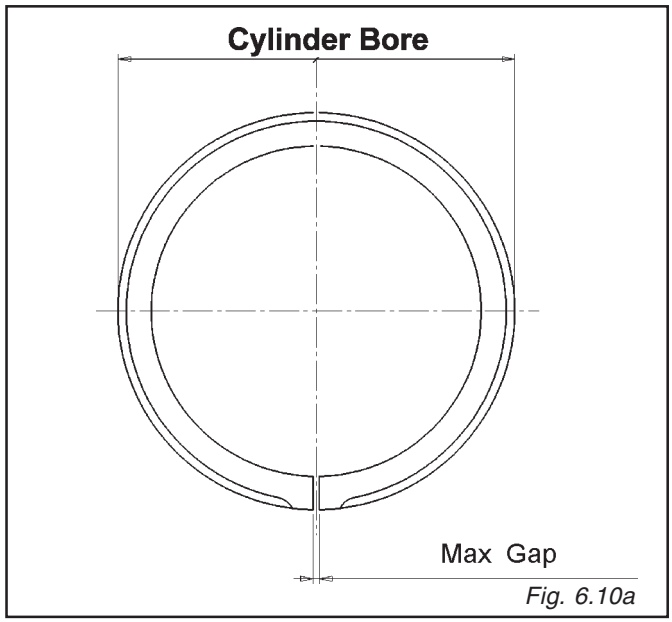


Fig. 6.10a

6.10 CRANKSHAFT *(FIG. 6.11 - 6.12 - 6.13 - 6.14)*

Immerse the crankshaft in a solvent bath and remove any sludge from the oil ways.

Inspect for cracks.

Check the spigots, mating surfaces and threads for wear, scoring and distortion.

Check that the timing gear teeth are not worn or damaged. Slight indentations can be removed using a very fine grade carborundum stone. If the timing gear needs replacing, remove using the special puller **A** **(TAB. 11.1 ref. F)**. Warm the new gear in an oven to 180 ÷ 200 °C and install taking care to align the key correctly.

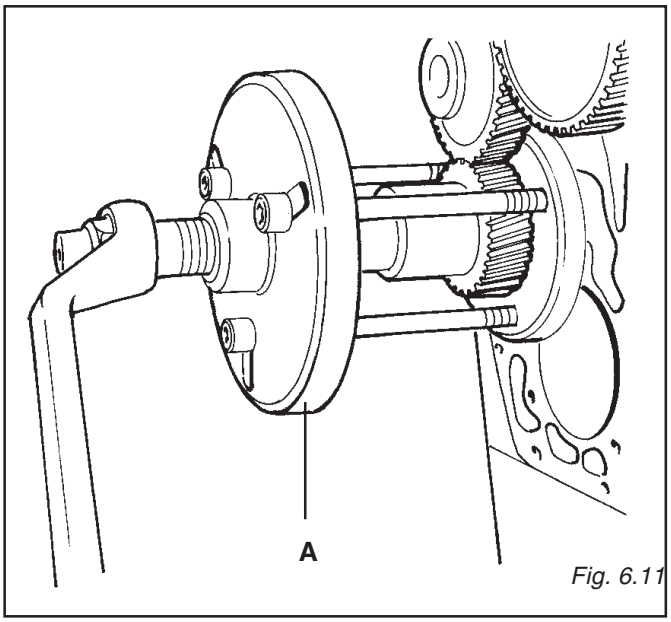


Fig. 6.11

(FIG. 6.12)

Remove the grooves caused by oil seal rings using very fine grade emery cloth to produce fine spirals in the opposite direction to crankshaft rotation. Always replace oil seals at each rebuild.

Check crankpins and journals for ovality and wear at different positions using a micrometer.

If wear exceeds **0.10** mm, the crankpins and journals will have to be reground and undersize bearings must be fitted **(TAB. 8.2.1)**.

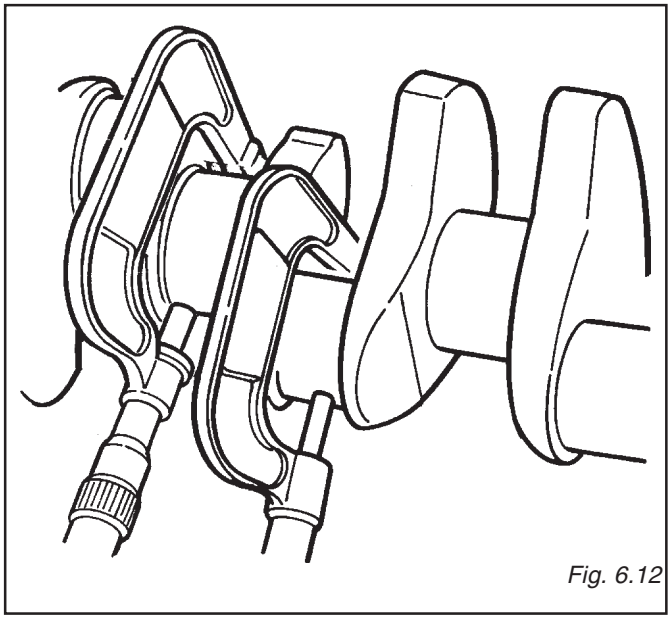


Fig. 6.12

(FIG. 6.13)

Before refitting a crankshaft that has been seized, overheated or reground, carry out a Magnaflux check for fine cracks. The surface roughness of the journals and crankpins should be **0.12 µ**. If the crankshaft needs regrinding, be careful not to remove material from the fillet radii **A-B**. After grinding, the crankshaft must be subjected to "SURSULF" surface hardening treatment (hardness HRC 53 - 57).

WHEN GRINDING THE CRANKSHAFT, DO NOT REMOVE MATERIAL FROM THRUST FACES.

THE RADIUS A - B ON THE SHAFT MUST BE:
A = 2.7 - 3 mm
B = 2.5 mm

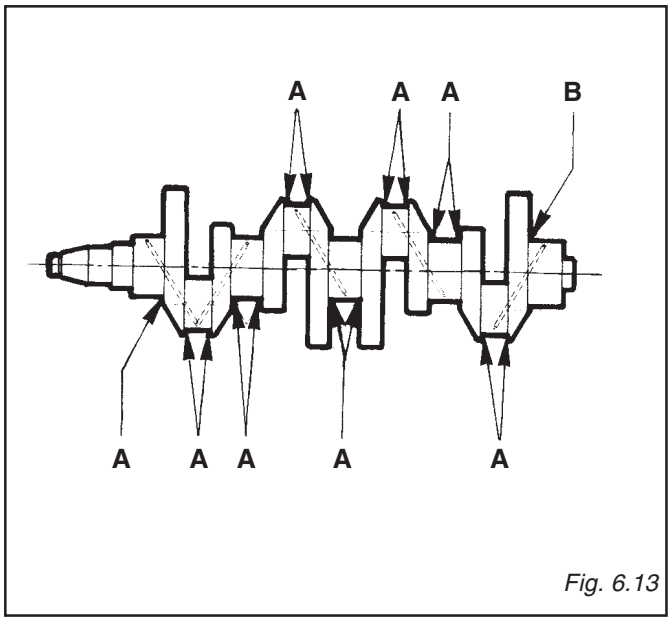


Fig. 6.13

(FIG. 6.14)

All main and big-end bearing shells, including undersize shells, are supplied in exact sizes as specified. To remove and install the front main bearing, use special tool **A** **(TAB. 11.1 ref. D)**.

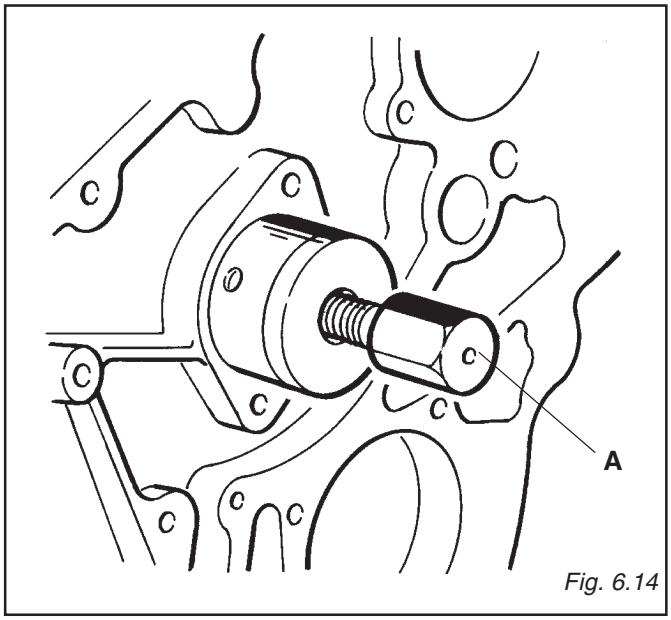


Fig. 6.14

(FIG. 6.15)

Front main bearing and journal (see TAB. 8.2.1).

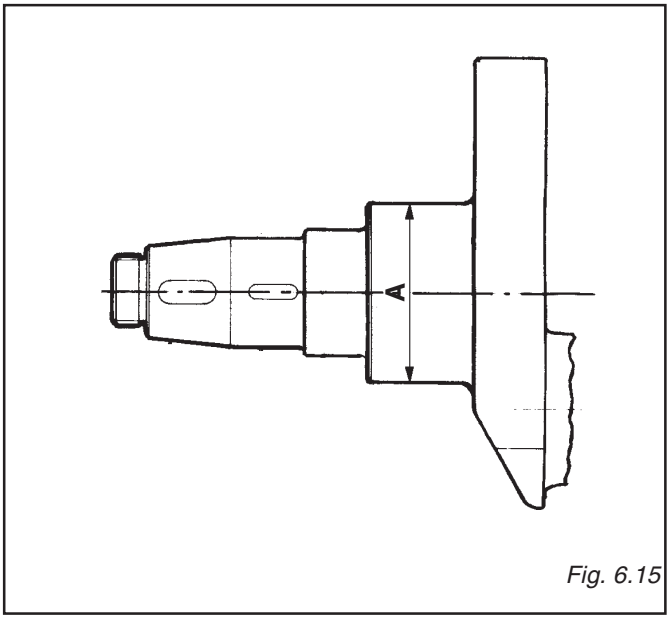


Fig. 6.15

(FIG. 6.16)

Center main bearing shells and journal (see TAB. 8.2.1).

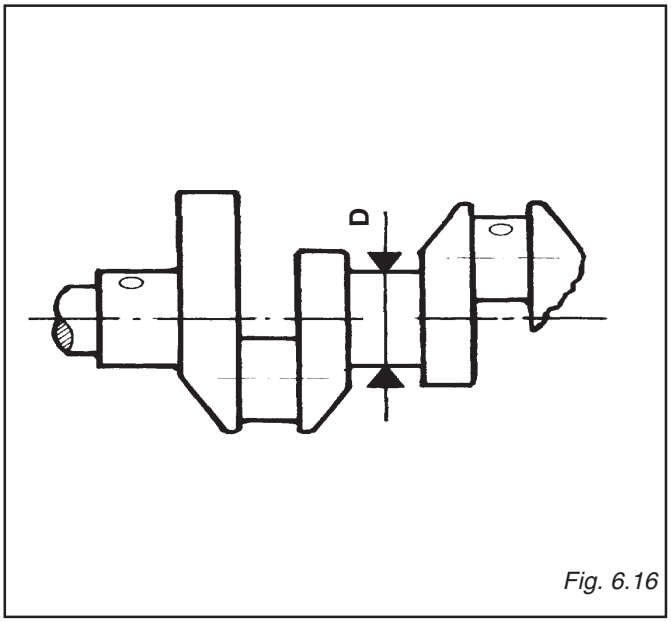


Fig. 6.16

(FIG. 6.17)

Rear main bearing shells and journal (see TAB. 8.2.1)

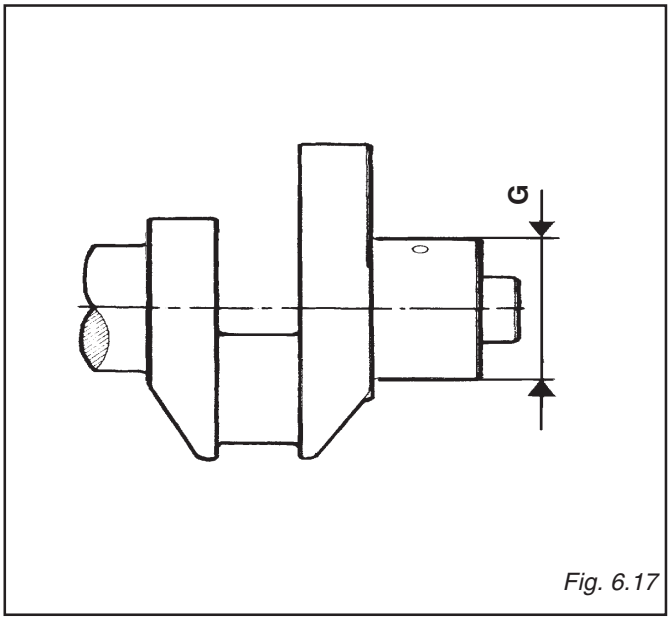


Fig. 6.17

(FIG. 6.18)

Crankpins and big-end bearing shells (TAB. 8.2.1).

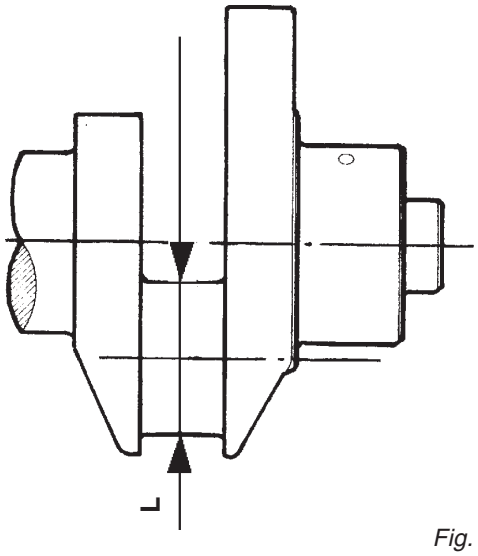
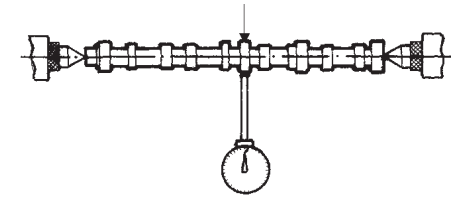


Fig. 6.18

6.11 CAMSHAFT *(FIG. 6.19)*

Inspect for signs of wear or scoring on the journals and cam lobe surfaces. Check that cam dimensions are no more than 0.05 mm less than the dimensions given in **(TAB. 8.2.2)**.



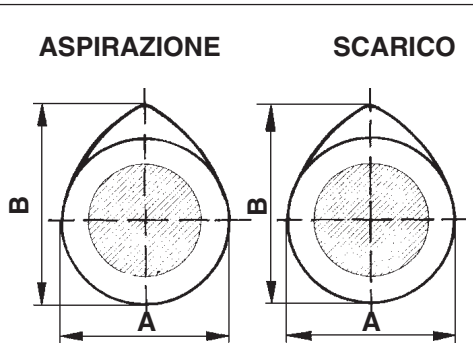


Fig. 6.19

6.12 COOLANT PUMP

Check for leakage between the pump body and the crankcase. If leaks are found, renew gasket. If the pump body shows signs of blowing or if the impeller is broken, replace the pump with the correct model selected from the replacement parts catalogue.

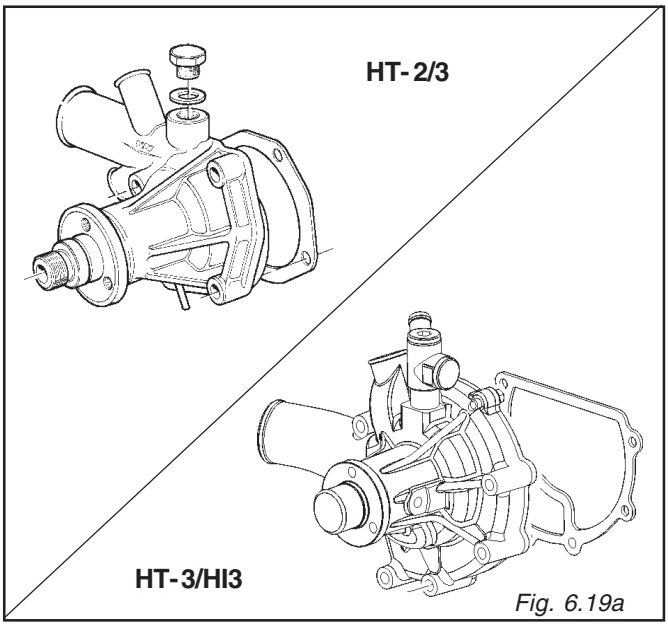


Fig. 6.19a

6.13 GUDGEON PINS AND CONNECTING RODS *(FIG. 6.20 - 6.21)*

Inspect connecting rods for wear or cracks using Magnuflux if possible. Check that the gudgeon pin is free of grooves or seizure marks.

Check parallelism of the connecting rod axes.

Deviation must not exceed **± 0.05** mm in all directions outside the gudgeon pin at a distance of 100 mm from the centerline.

If the small-end bush is replaced, make sure that the oil ways in the bush and the connecting rod are correctly aligned.

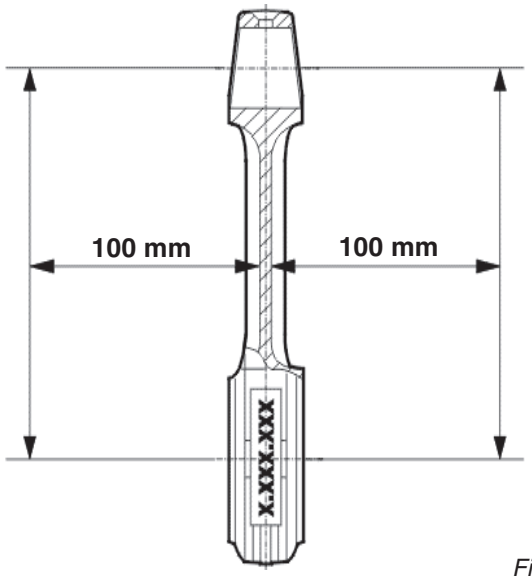


Fig. 6.20

NOTE:
THE AUTOMATIC CONNECTING ROD TIGHTENING SYSTEM LEAVES A GREEN APPEARS ON THE BIG-END CAPS. THIS MARK DOES NOT INDICATE THE WEIGHT OF THE CONNECTING ROD. ONLY ONE TYPE OF REPLACEMENT CONNECTING ROD IS AVAILABLE IN KITS FOR 3-4-6-CYLINDER ENGINES. CHECK THAT ALL THE CONNECTED RODS ARE STAMPED WITH THE SAME SELECTION CODE NUMBER.

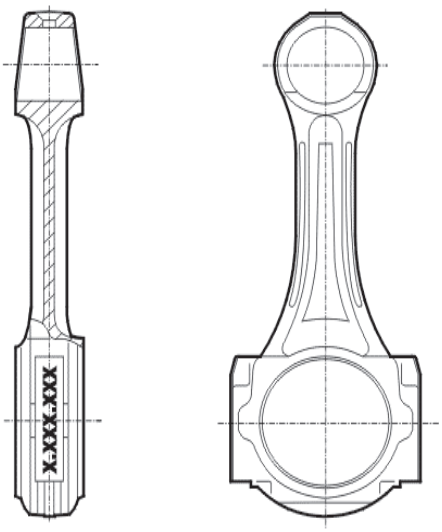


Fig. 6.21

6.15 FLYWHEEL BELL-HOUSING *(FIG. 6.22)*

Examine the condition of the mating surface, bolt holes and spigot. If internal threads are damaged, replace with Helicoil inserts. The camshaft oil seal ring **1** should be renewed each time the engine is overhauled.

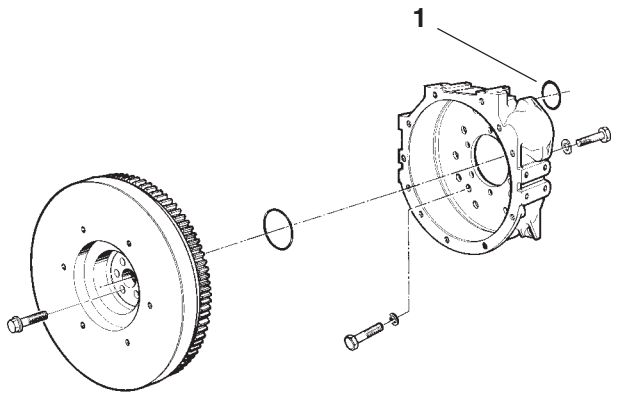


Fig. 6.22

6.16 REAR MAIN BEARING CARRIER *(FIG. 6.23)*

Inspect the surfaces of thrust washer seats for wear. Check that the run-out of the main bearing seat relative to the center line does not exceed **0.03** mm.

Check the following dimensions:

A Spigot diameter **131.930 ÷ 131.970** mm

B Bearing shell seat diameter
85.995 ÷ 85.985 mm

C Oil seal seat diameter
120.000 ÷ 120.050 mm

Seal ring **1** should be renewed each time the engine is overhauled.

Check that oil jet valve **2** functions correctly.

The opening pressure must be **150 ÷ 200 kPa (1.5 ÷ 2.0 bar)(21.7 ÷ 29 psi)**, if not, replace the jet valve. Secure by staking at three points 120° apart.

N.B. Oil jet valves are made in two pieces. Reassemble by torquing parts to **1.5 ÷ 2.0 kgm (14.7 ÷ 19.6 Nm) (11 ÷ 14.5 lbf ft).**

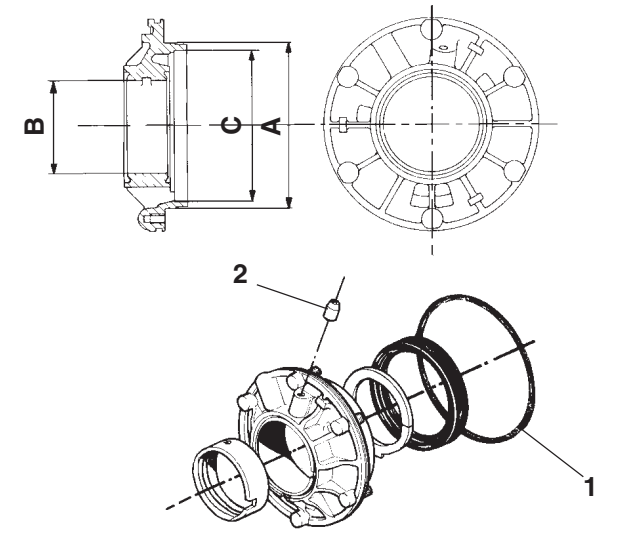


Fig. 6.23

6.17 THRUST WASHERS *(FIG. 6.24)*

Thrust washers in various thicknesses are available for adjustment of crankshaft endfloat **(see TAB. 8.2.3)**.

The thickness of the thrust washer is stamped at **A**.

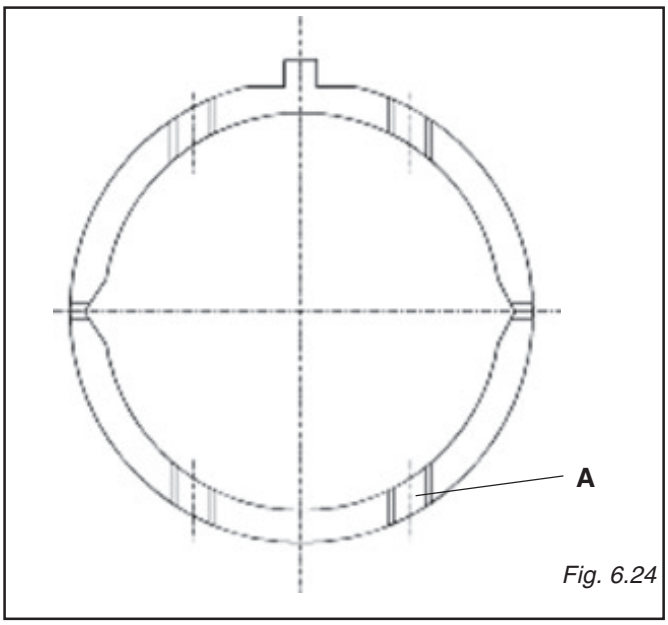


Fig. 6.24

6.18 TIMING COVER *(FIG. 6.25)*

The timing cover is supplied complete with a oil seal **A** and a plug **B** closing the injection pump gear access hole.

If oil seal **A** is to be removed for renewal, it is essential to use the correct special tool **(see TAB. 11.1 ref. l)** to prevent deformation of the timing cover.

After removing the oil seal, clean the seating **C**. Insert the new oil seal carefully to avoid damaging it.

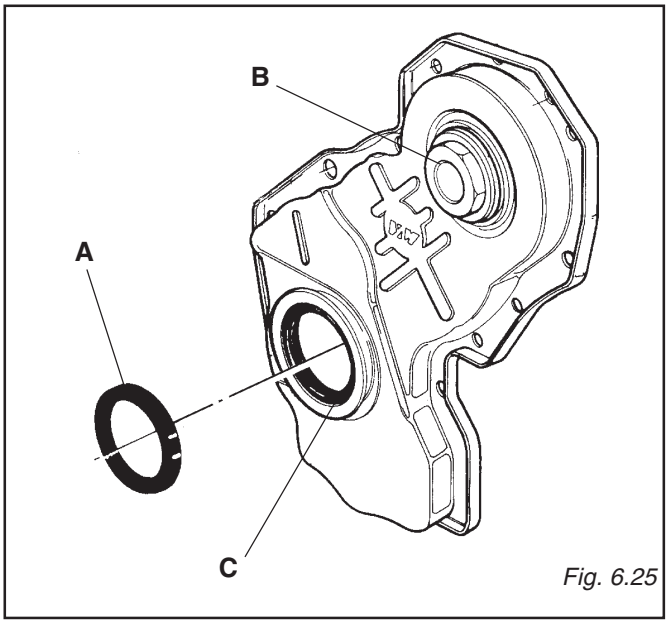


Fig. 6.25

6.19 CRANKCASE

6.19.1 Inspection *(Fig. 6.26)*

- Clean the crankcase thoroughly using a solvent (para. 3.7).
- Check condition of the cylinder head mating surface.
- Check condition of the bore mating surfaces.
- Check that internal threads are clean and are in good condition.
- Check that the oil ways are free of obstructions.
- Check that the oil ways are free from cracks and casting flaws.
- Check the diameter of the front main bearing seat **A** = (Ø 67.025 - 67.050) and **B** = (Ø 57.000 - 57.030).

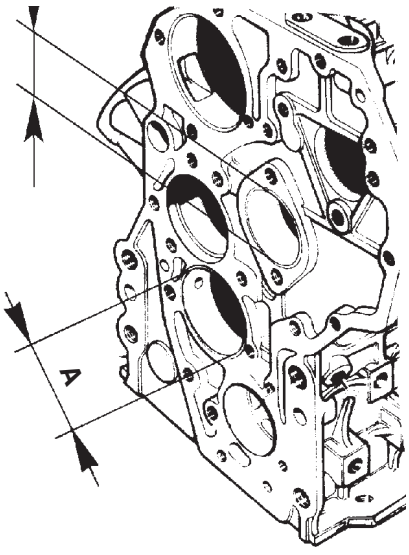


Fig. 6.26

6.19.2 Center main bearing carrier

Tighten the carrier bolts (**A**) to the prescribed torque value.

Measure the bearing seat diameter (**B**) in two perpendicularly opposed positions.

Seat diameter (Ø 66.670 - 66.697).

If the valve needs replacing, remove the bearing half shell to gain access to the old valve.

Insert the new valve in its seat with jet directed towards the piston.

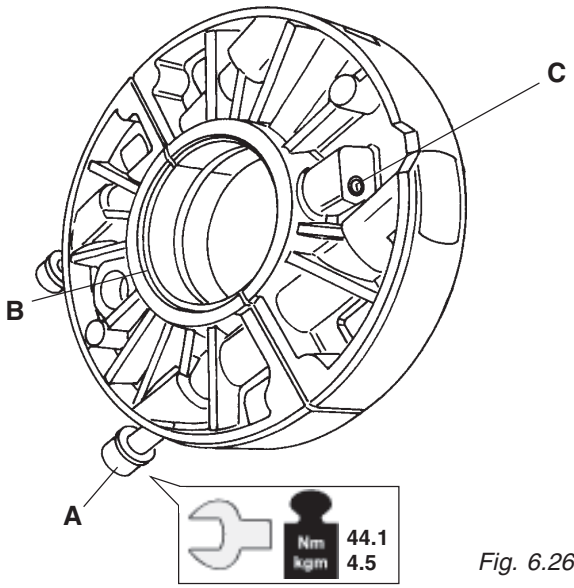


Fig. 6.26a

6.20 LUBRICATION SYSTEM

The lubrication system is illustrated and described on page 4.2.

The oil pressure regulator valve (Fig.6.28) is installed vertically in the underside of the crankcase.

To gain access to the valve, remove the sump pan.

- On engines fitted with an oil cooler (Fig.6.27 and 6.27a).

Fig. 6.27

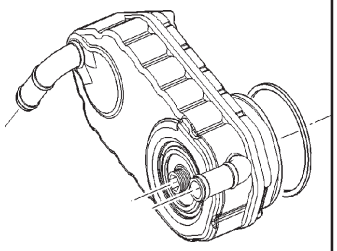


Fig. 6.27a

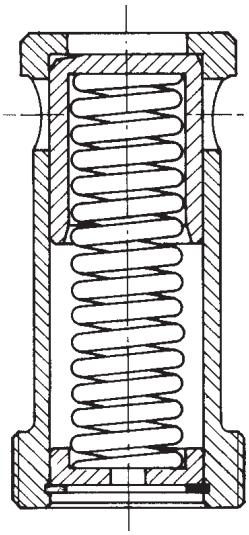


Fig. 6.28

6.21 OIL PUMP *(FIG. 6.29 - 6.30)*

Engine/pump speed ratio: 1:0.666

Dismantle the pump, clean the components and inspect for wear.

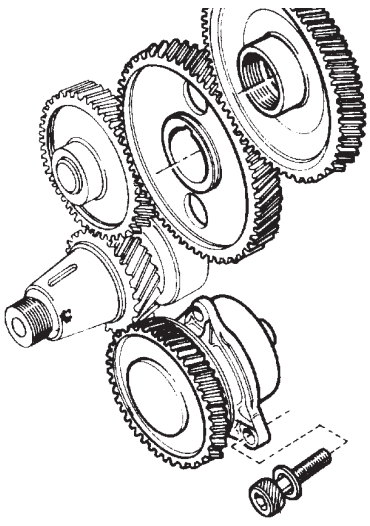


Fig. 6.29

(FIG. 6.30 - 6.31)

Dimensions and clearances

HR494HT2-3/HI3

Max. clearance **(A)** between rotors: **0.07 - 0.20** mm.

Depth of rotor housing **(C): 32.530 - 32.570** mm.

HR694HT2-3

Max. clearance **(A)** between rotors: **0.07 - 0.20** mm.

Depth of rotor housing **(C) 38.030 - 38.070** mm.

Reassemble with the bevelled end of the outer rotor towards the pump gear.

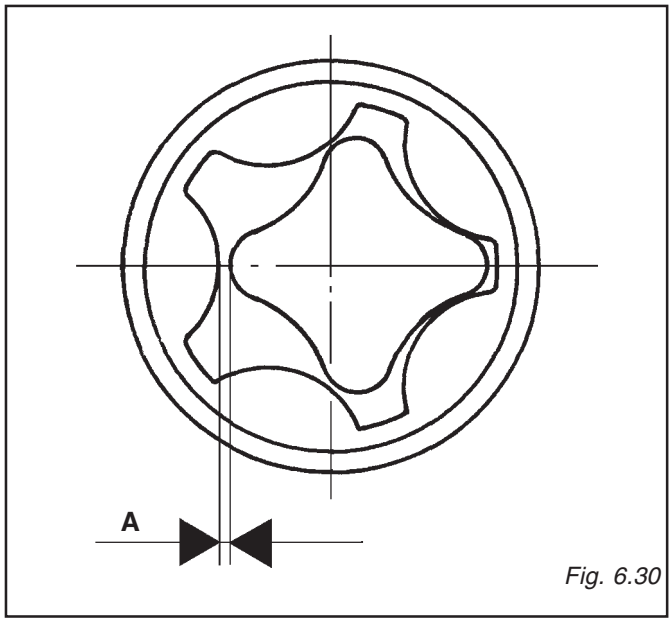


Fig. 6.30

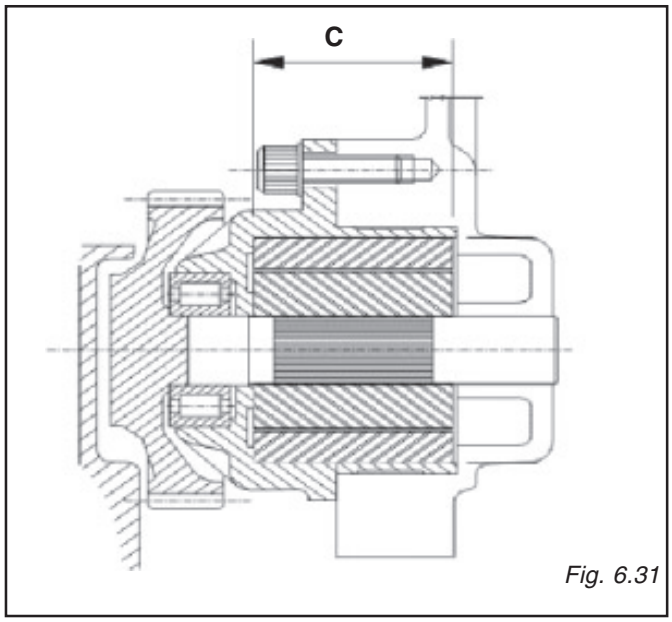


Fig. 6.31

6.22 SUMP PAN AND OIL PICK-UP *(FIG. 6.32a - 6.32b)*

Inspect the sump pan for cracks.
Check all welds for leaks and check the condition of the seals on the oil pick-up pipe.

Fig. 6.32a

ANTIFON oil sump, this doesn't need an oil gasket as it is sealed by the silicone distributed on the mating surface.

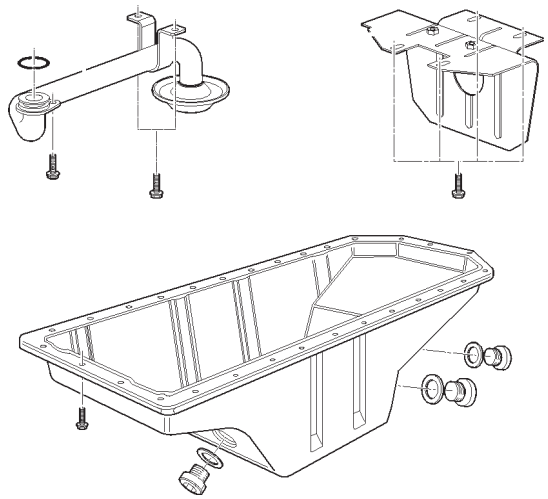


Fig. 6.32a

Fig. 6.32b

The die cast oil sump needs a gasket.

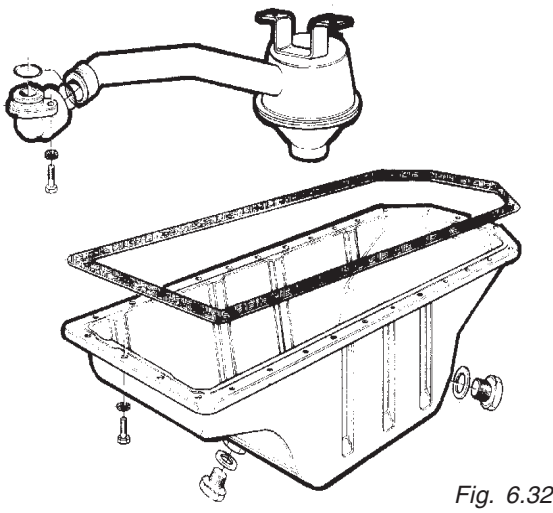


Fig. 6.32b

6.25 OIL FILTER *(FIG. 6.32)*

Renew the filter cartridge at the intervals specified in paragraph 3.11.

Oil the gasket before fitting the cartridge.

Check that the oil cooler support union is firmly secured.

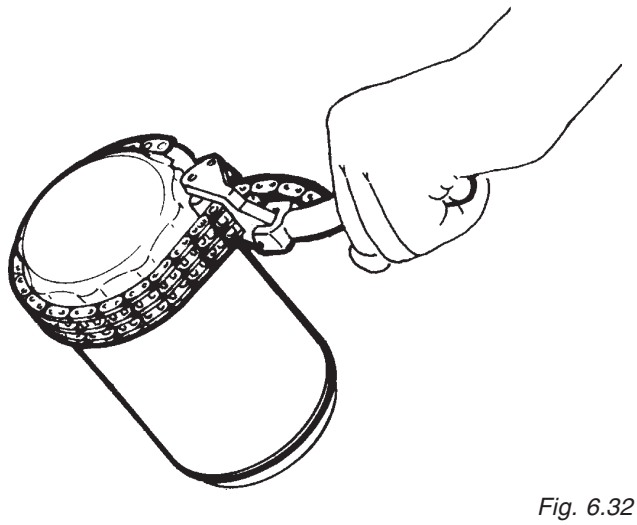


Fig. 6.32

6.24 DRY AIR FILTERS *(FIG. 6.33)*

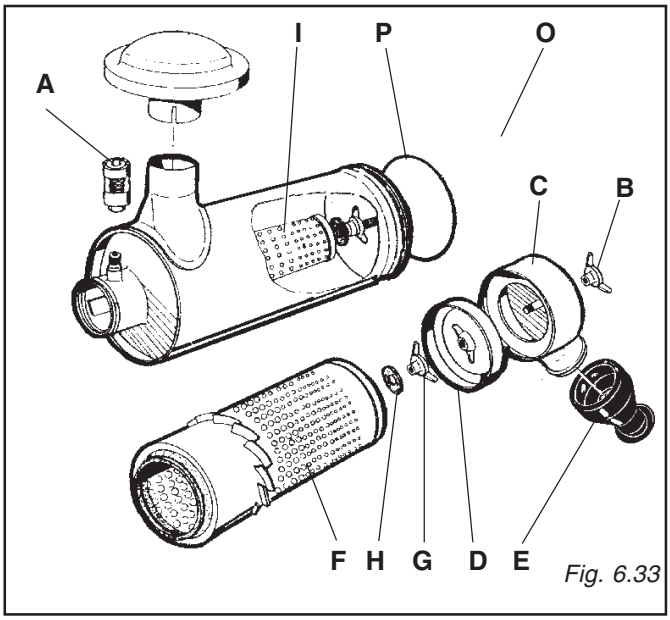


Fig. 6.33

The filter is equipped with a clog indicator **A**.

Clean or change the cartridge when the indicator color is red.

Maintenance:

Unscrew wingnut **B** and remove the dust debris from prefilter **C**.

Remove cover **D** and empty the container. On filters without expulsion valve **E** this operation should be performed daily.

Remove the cartridge **F** by unscrewing wingnut **G** and perform maintenance.

The safety cartridge **I** (if present) must only be removed when strictly necessary.

Replace the cartridge at the intervals shown in heading 3.11, chapter 3 (Maintenance).

Do not impact the cartridge against hard surfaces

Unscrew the lateral nut of the filter cover. Disassemble the filter element.

Check the air inlet ports and remove any debris.

Clean the internal cartridge with low pressure compressed air.

Use a worklight to check that there are no tears in the cartridge.

If the upper seal is torn and/or if the plastic fins are damaged, replace the cartridge.

After 3 services change the main cartridge and (if present) the safety cartridge.

Refit the cartridge in the filter, placing seal **I** beneath the wingnut.

After servicing, press button **A** to reset the clog indicator.

In the event of replacement, specify the type of filter on which the indicator is fitted.

With the engine assembled, check the inlet suction at full load and max. revs.

6.26 FUEL FILTER *(FIG. 6.34)*

Renew the cartridge at the intervals specified in paragraph 3.11.

To replace the cartridge:

Disconnect the pipe connecting the filter to the injection pump at the pump.

Replace the cartridge.

Before reconnecting the cartridge to the filter, allow 2 ÷ 3

liters of diesel fuel to flow through the filter and the fuel pipe.

Bleed the fuel system in the manner described on chapter 9.

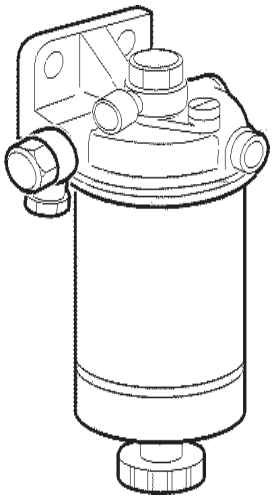


Fig. 6.34

6.27 INTERMEDIATE TIMING GEAR *(FIG. 6.35)*

Inspect the gear for signs of damage or excessive wear. If the gear needs replacing, it is advisable to replace the entire assembly. When refitting, check that there is a clearance of **0.10 ÷ 0.20** mm between the gears.

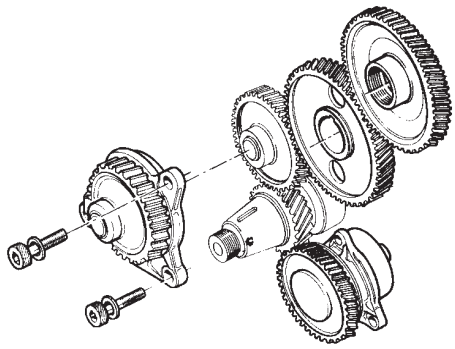


Fig. 6.35

6.28 INLET AND EXHAUST MANIFOLDS *(FIG. 6.36)*

Inspect the manifolds for cracks and distortion and replace if necessary.

Check that the flange mating surfaces are all aligned in the same plane. Grind surfaces if necessary.

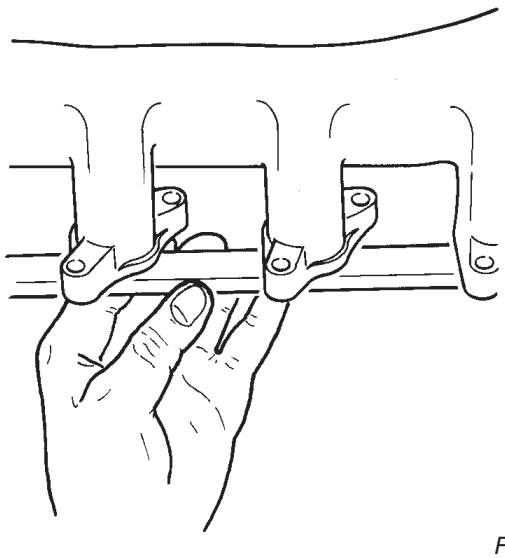


Fig. 6.36

6.29 WATER RADIATOR *(FIG. 6.36A)*

The radiator, located in the front of the engine, is supplied as optional.

Check to ensure thet the radiator has no leaks; remove the scale inside using solvents (see para 3.7). Use a soft brush to clean the dust from the fins. Clogging of the circuit piping, low water level, insufficient tension of the fan drive belt, or faulty functioning of the thermostat valve can lead to exceedingly high water temperature.

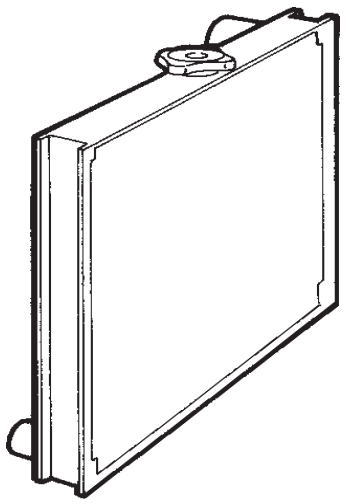


Fig. 6.36A

6.29.1 WATER-COOLED OIL COOLER *(Fig. 6.36B)*

Check the condition of the oil cooler housing and particularly the oil filter cartridge mounting. Check the condition of the coolant inlet/outlet pipes.

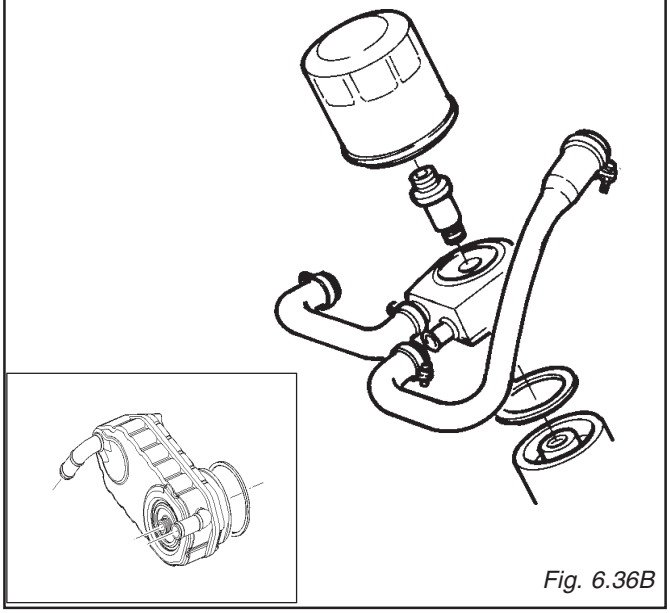


Fig. 6.36B

6.30 FUEL SYSTEM *(FIG. 6.37 - 6.37A - 6.38 - 6.39 - 6.40 - 6.41 - 6.42)*

The diaphragm type fuel pump is mounted on the crankcase. The pump is operated by an eccentric cam on the camshaft and is to be primed manually.

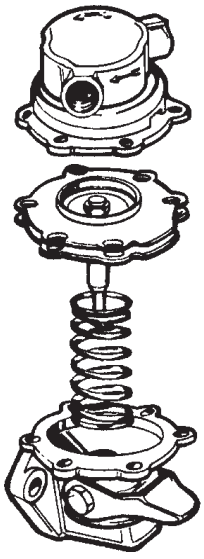


Fig. 6.37

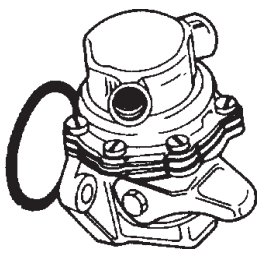


Fig. 6.37A

6.31 INJECTION PUMP *(FIG. 6.38 - 6.39 - 6.40 - 6.41)*

CHECKS

Connect the engine stop solenoid **D** to the positive terminal of a battery. Attach a pressure gauge **A** to the fuel inlet union: the fuel supply pressure must be **0.35** kg/cm^2.

Attach a second pressure gauge **B** to the fuel outlet union to measure the internal pressure.

To check the stroke of the automatic advance variator, install the device **E** (Bosch code 1688130139) on the opposite side to the variator spring.

To adjust the fuel flow rate, on a injection pump test bench, connect the limiter **LDA (C)** to a compressed air line with pressure **70** kPa.

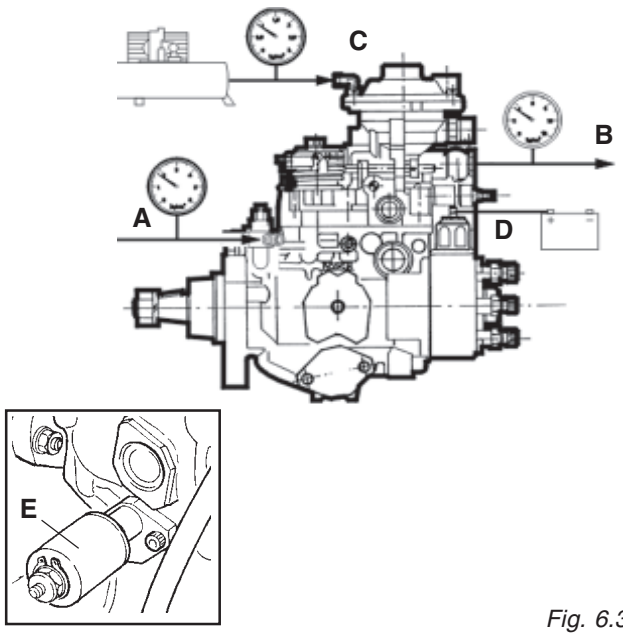


Fig. 6.38

(FIG. 6.39)

The air pressure acts on the diaphragm **1** forcing the piston **2** down thus allowing lever **3** to rotate in a clockwise direction and disengage the slide **4**.

The prescribed test values for the pumps installed on HR serie 2-3 series engines may be obtained from all authorized **BOSCH** service centers for all the pumps.

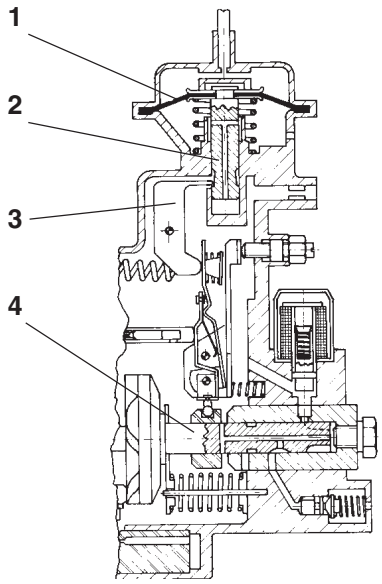


Fig. 6.39

ADJUSTMENTS

Idle speed adjustment

Turn screw **A** and set it at value listed on pag.2-5.

Maximum speed adjustment

Turn screw **B** to obtain a no-load engine speed 400 ÷ 450 rpm greater than the full-load speed.

LDA adjustment

Fuel flow rate up to 2000 rpm is set by way of adjuster **B**, turn adjuster clockwise to increase flow rate and counter-clockwise to decrease flow rate.

Delivery adjustment

For maximum flow rate is set by means of adjuster screw **A**.

Turn adjuster screw **A** clockwise to increase flow rate and counter-clockwise to decrease flow rate.

Whenever it is necessary to replace the Bosch injection pump without removing the timing cover, proceed as follows to maintain the position of the pump gear unaltered: using the reference marks on the timing cover and the pulley, bring piston no. 1 to TDC of the compression stroke.

Now turn the engine back through 25 ÷ 30° and operated as described in paragraph 5.27 of the chapter DISASSEMBLY, and then proceed with the removal of the pump.

Settings

ALL TESTS AND ADJUSTMENT OF INJECTION DELIVERY SETTINGS MUST BE PERFORMED ON THE INJECTION PUMP TEST BENCH OR WITH A DYNAMOMETER INSTALLED ON THE ENGINE.

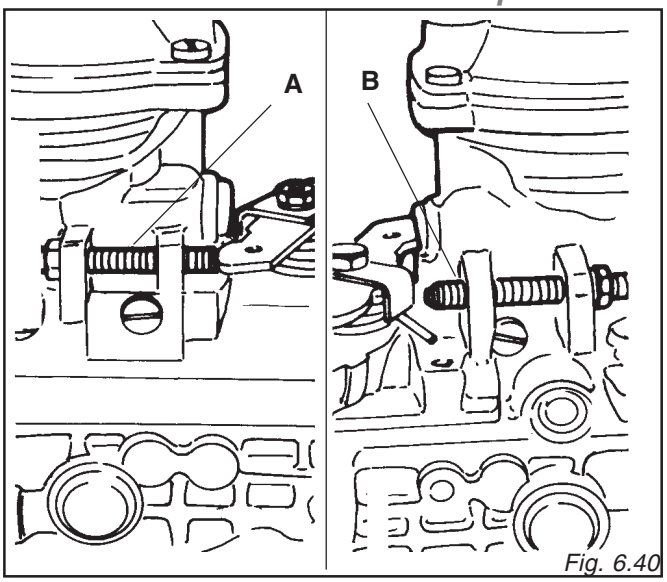


Fig. 6.40

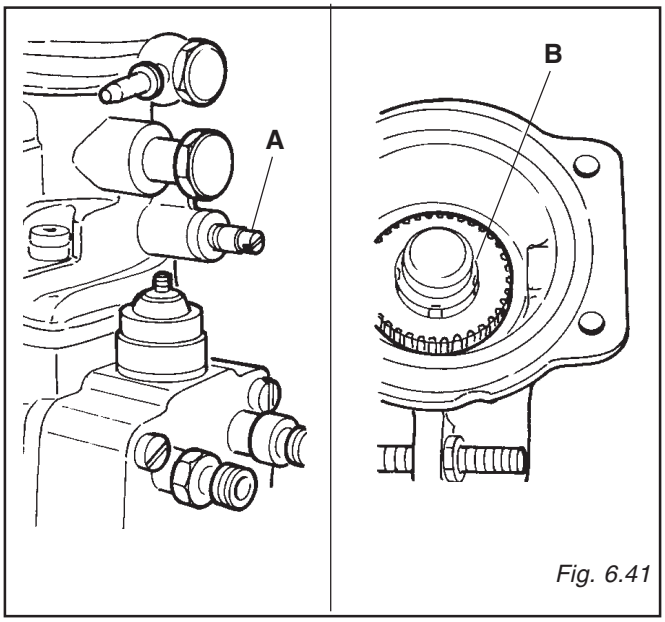


Fig. 6.41

6.32 INJECTOR *(FIG. 6.42)*

Parts:

1) Body - **2)** Waste pipe - **3)** Plug- **4**) Nozzle.

To observe the spray of the fuel into the injector, if you do not possess a test bench, you need to dismantle it from the head, screw it to the supply tubing, keep it turned towards the utmost and make the engine rotate with the start engine for a few revs.
Change the pulverisor if it drips during the control phase.
If you possess a test bench, act on the hand pump and check that the opening of the injection pressure is at the value of 165 bar (16500kPa), and that it is not dripping.

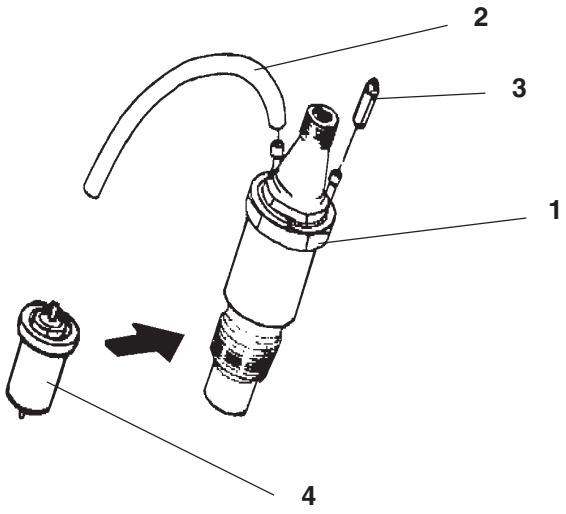


Fig. 6.42

6.33 ELECTRICAL COMPONENTS

Note:

Never disconnect the battery cables while the engine is running to avoid voltage surges which could damage the alternator diodes and electronic components.

Always disconnect the battery ground terminal before carrying out any welding on the vehicle.

6.34 STARTING *(FIG. 6.43)*

When the ignition key is turned to **(position 1)**, the glowplugs, the oil pressure control and battery charge circuits are energized. When the key is turned to **(position 2)**, the starter motor is energized. Do not operate the starter motor for more than 15 seconds at a time to avoid overheating the solenoid.
After each attempt at starting, wait a few moments before trying again in order to allow the battery to recover.

When the engine is stopped, always turn the key to position **0** so as not to discharge the battery or burn out the indicator lamps.

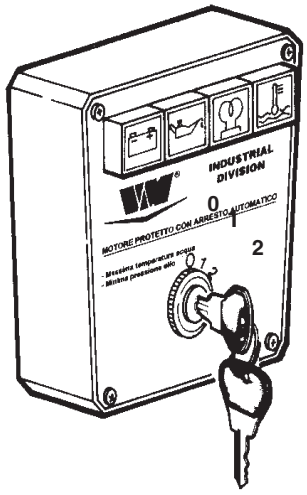


Fig. 6.43

6.35 GENERAL ELECTRICAL SYSTEM CHECK

Examine the cables and the condition of the insulation.

If the system is not functioning correctly, investigate the following possible causes:

- battery-starter motor connection cables damaged;
- red wire from starter motor to alternator damaged;
- battery discharged and/or elements damaged;
- starter motor faulty;
- voltage regulator faulty;
- alternator diode/s faulty.

6.36 BATTERY

The battery is not supplied by VM.

Minimum battery sizes are given in the following table:

Engine Type	Volt	Ah
HR494HT2-3/HI3	12 V	92
HR694HT2-3	12 V	100

Fig. 6.44

6.37 ALTERNATOR

The alternator is of the self-excited 3-phase type with integral diode rectifier.

Check:

- alternator connections.

For alternator overhaul or repair, contact your nearest authorized VM service center.

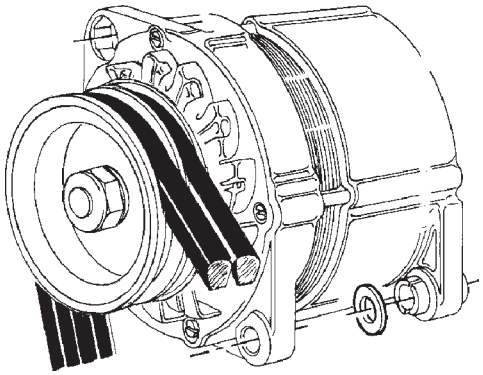


Fig. 6.45

ENGINE TYPE	ALTERNATOR
HR494HT2-3/HI3	14V - 55A
HR694HT2-3	14V - 55A

MATERIAL SUPPLY REQUEST

ENGINE TYPE	ALTERNATOR
HR494HT2-3/HI3	28V - 55A
HR694HT2-3	28V - 55A

6.38 VOLTAGE REGULATOR

The voltage regulator requires no maintenance or adjustment.

For replacement consult the Spare Parts Catalogue.

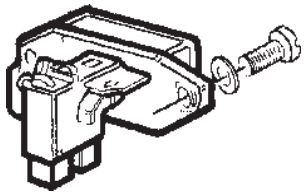


Fig. 6.46

6.39 STARTER MOTOR

Check starter motor brushes at the prescribed intervals.

Inspect the commutator for scratches and excessive wear.

For repairs or overhaul contact your nearest authorized VM service center.

ENGINE TYPE	STARTER MOTOR
HR494HT2-3/HI3	12V - 2,2KW
HR694HT2-3	12V - 2,2KW

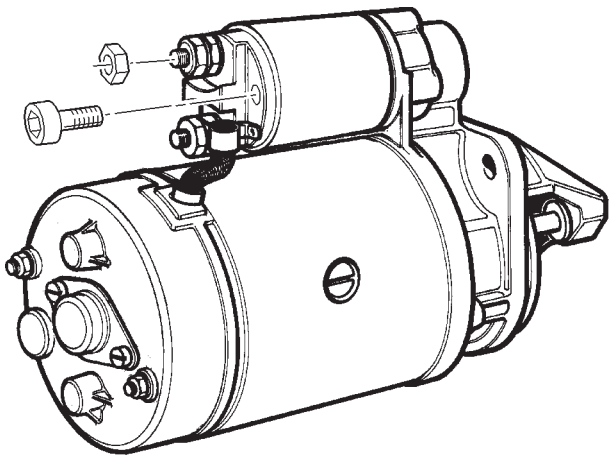


Fig. 6.47

MATERIAL SUPPLY REQUEST

ENGINE TYPE	STARTER MOTOR
HR494HT2-3/HI3	24V - 2,5KW
HR694HT2-3	24V - 2,5KW

6.40 TURBOCHARGER

VM MOTORI DECLARES THAT ANY MODIFICATIONS TO THE TURBOCHARGER WILL AUTOMATICALLY INVALIDATE THE GUARANTEE.

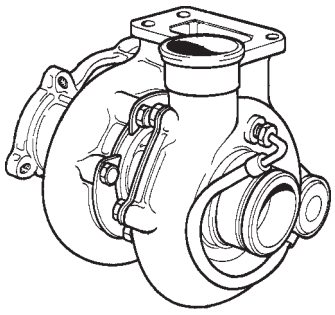


Fig. 6.48

ASSEMBLY

Pag. 1 ÷ 56

7

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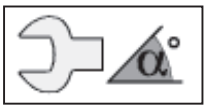
7.0 GENERAL WARNINGS

The following instructions refer to engine models available at the time of publication of this manual.

Assembly the engine components in the order indicated to save time and avoid damage.

Carefully check components before assembly following the instructions in chapter 6 “CHECKS AND REPAIRS”.

USE TORQUE WRENCH



USE ANGULAR TORQUE WRENCH

WARNING: WHEN THE ABOVE SYMBOLS APPEAR TOGETHER, THE OPERATIONS ARE TO BE PERFORMED IN THE SEQUENCE INDICATED IN THE FIGURE.

WARNING: PRIOR TO ASSEMBLY, CLEAN PARTS WITH A SUITABLE SOLVENT (SEE PARAGRAPH 3.7).

WARNING: IT IS STRICTLY FORBIDDEN TO CLEAN THE ENGINE WITH COMPRESSED AIR.

WARNING: WHEN USING TORQUE WRENCHES, ALWAYS REFER TO THE “TORQUE WRENCH SETTINGS” (PARA. 8.1).

WHERE THE USE OF VM SPECIAL TOOLS IS NOT SPECIFIED IN THE ASSEMBLY PROCEDURES, USE STANDARD COMMERCIAL TOOLS OF THE TYPE ILLUSTRATED.

7.0.1 Mounting the engine on the stand

Mount the engine on a commercial stand as shown in figure 5.0.

Secure the engine by means of the assembling arms and bolts provided with the stand (or using mounting bolts of the same type).

WARNING: REMEMBER TO INSERT THE LOCK PIN (A) AND CHECK THAT IT EFFECTIVELY LOCKS THE ENGINE IN POSITION.

WARNING: ALWAYS USE THE REDUCTION GEAR (B) TO ROTATE THE ENGINE.

WARNING: RISK OF CRUSHING AND/ OR SHEARING OF LIMBS DURING ROTATION OF ENGINE ON STAND.

NEVER INTRODUCE PARTS OF THE BODY OR FOREIGN OBJECTS IN THE AREA SHADED GREY IN FIGURE 7.0.

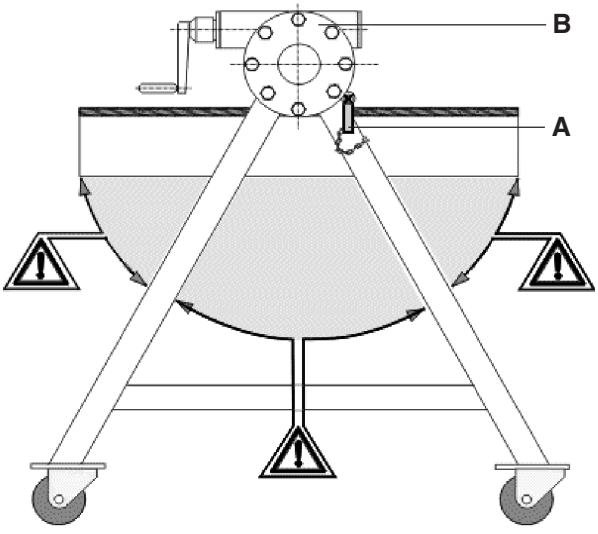
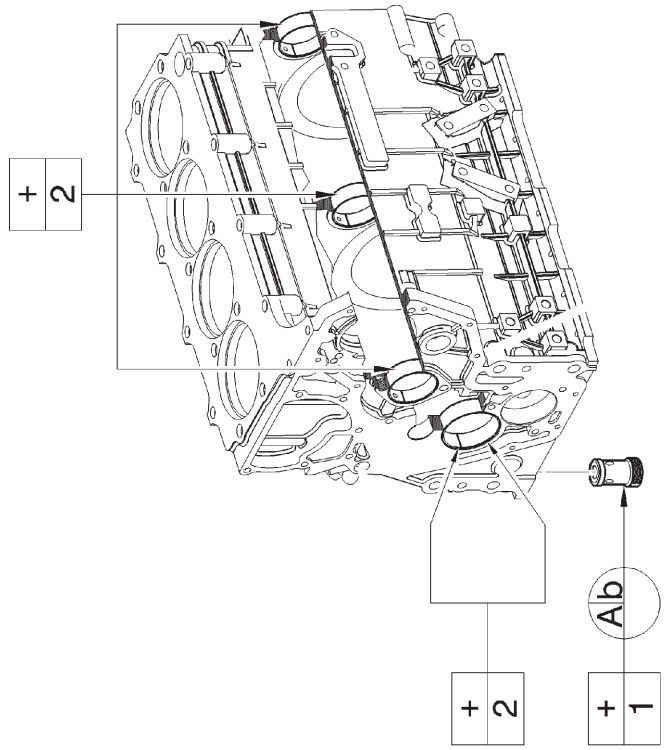


Fig. 7.0

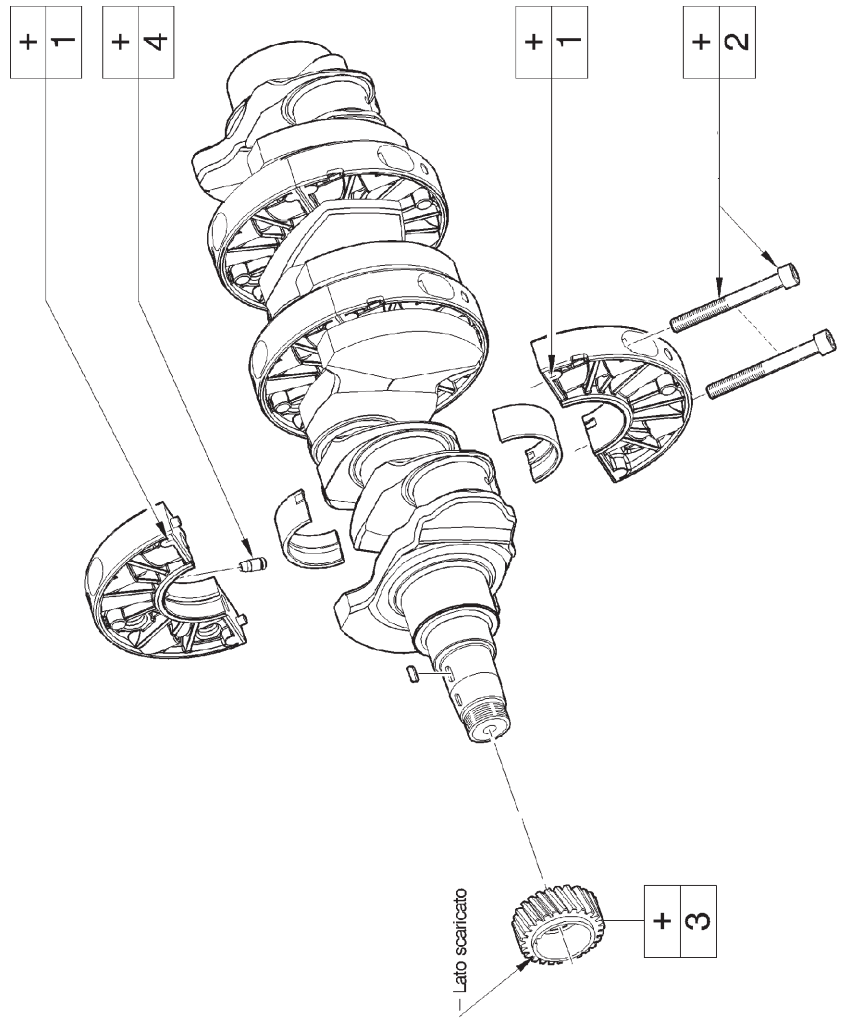
7.0.1 ASSEMBLY CHERTS



+ 2 Fix with Loctite 601 and mount by using the suitable tool.

+ 1 Fix with Loctite 510 and then remove the excess of Loctite in the oil max pressure valve area by means of a sponge.

TAB. 2328



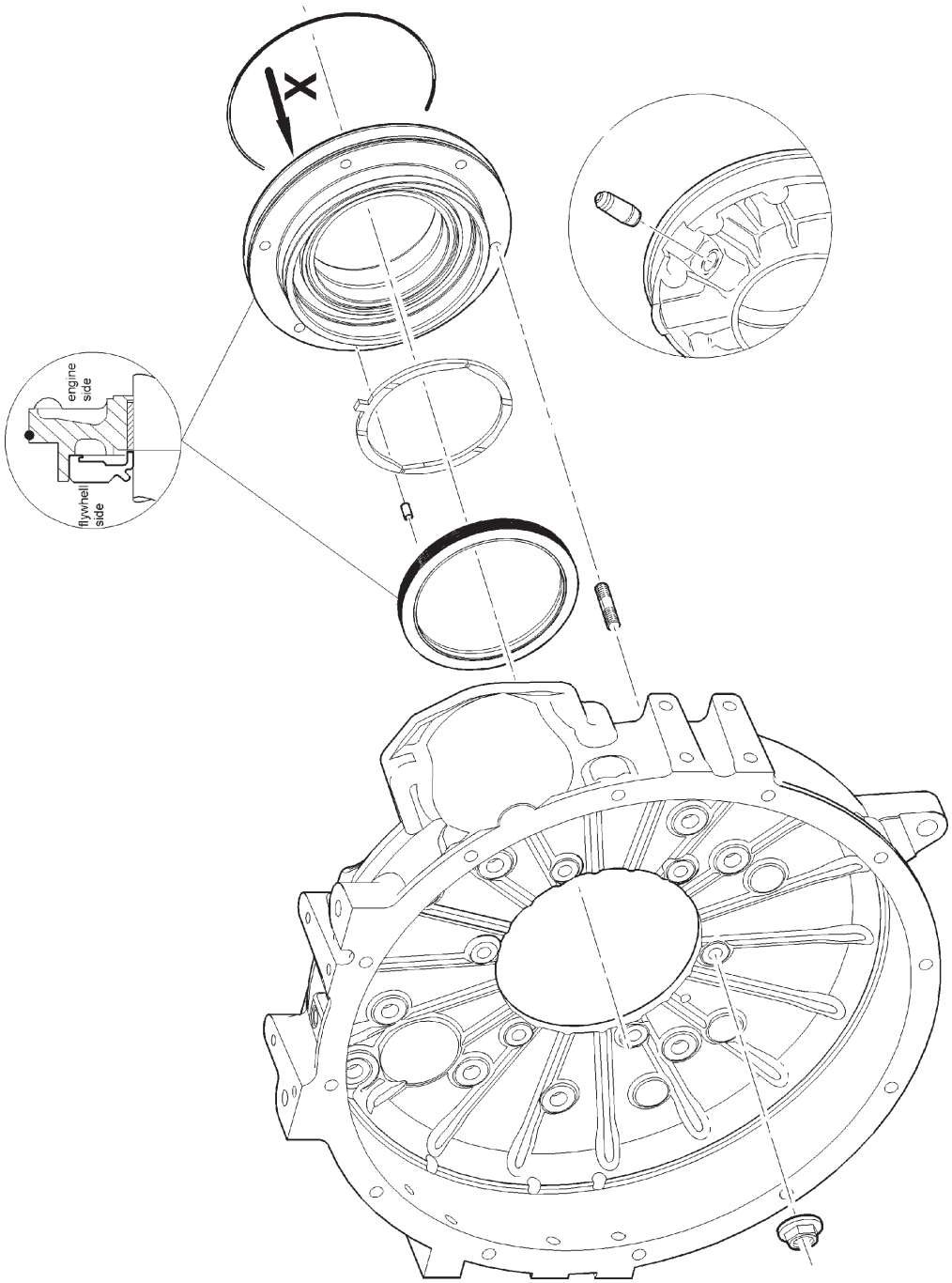
+ 4 Make sure that the valve is on its seat by checking that it is turned towards the gear

+ 3 Check that the gear discharged side is turned towards the outer side of the engine shaft.
Insert the gear after bringing it at a temperature of 200 °C

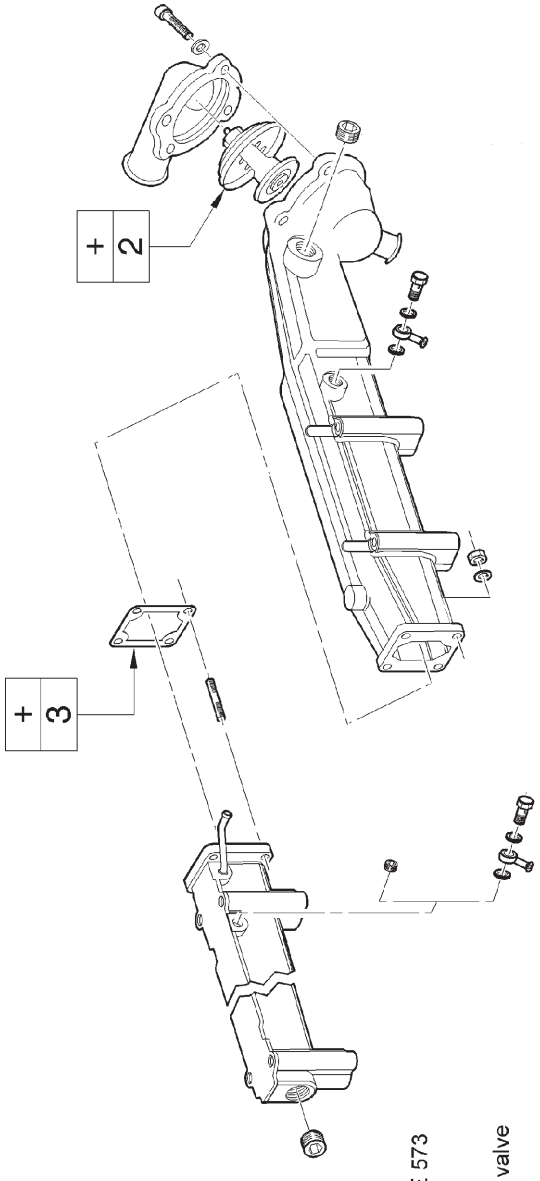
+ 2 Grease the screw threads and the relevant subheads

+ 1 Check that the notches engraved on the half-support are turned towards the gear

TAB. 2330



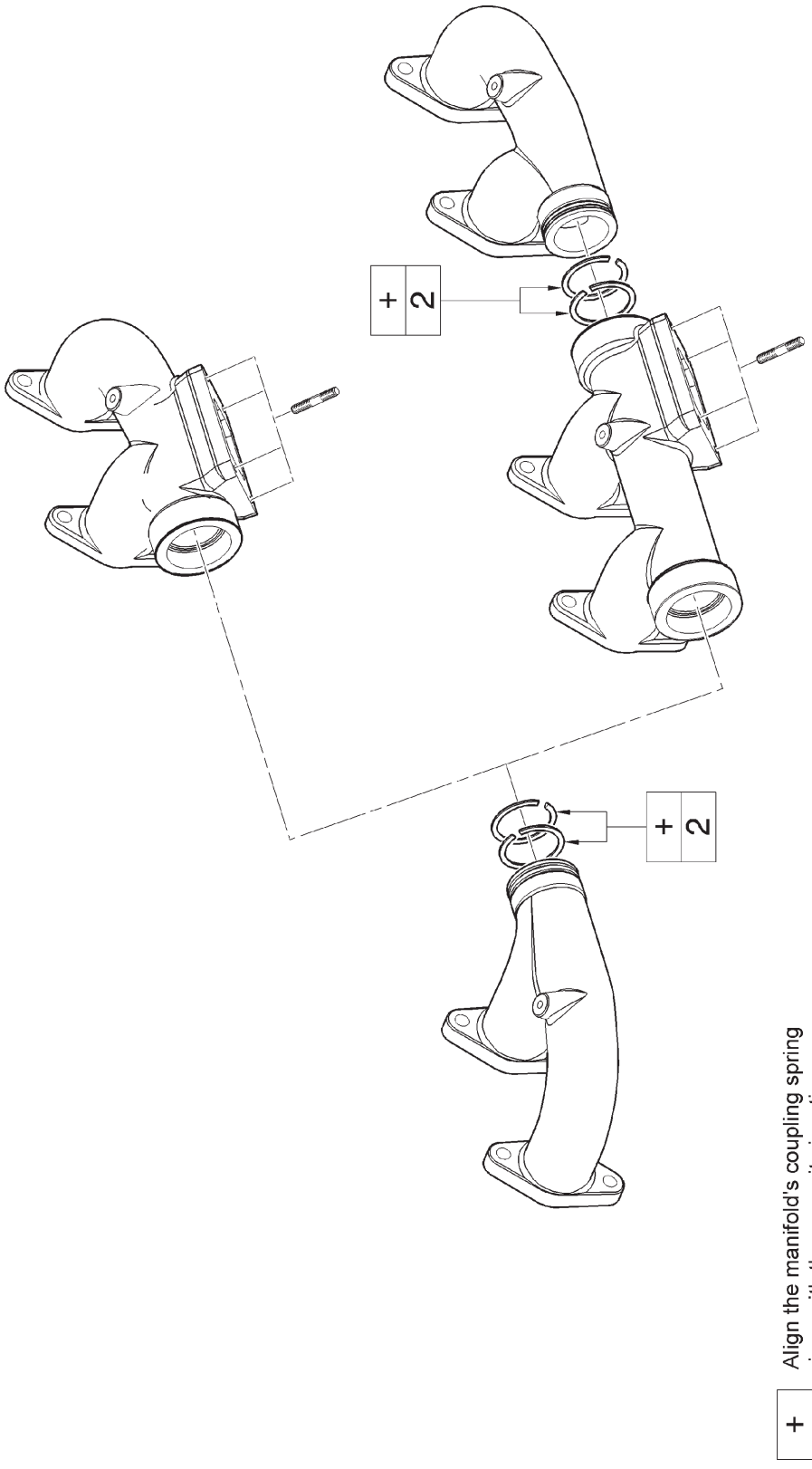
TAB. 2332



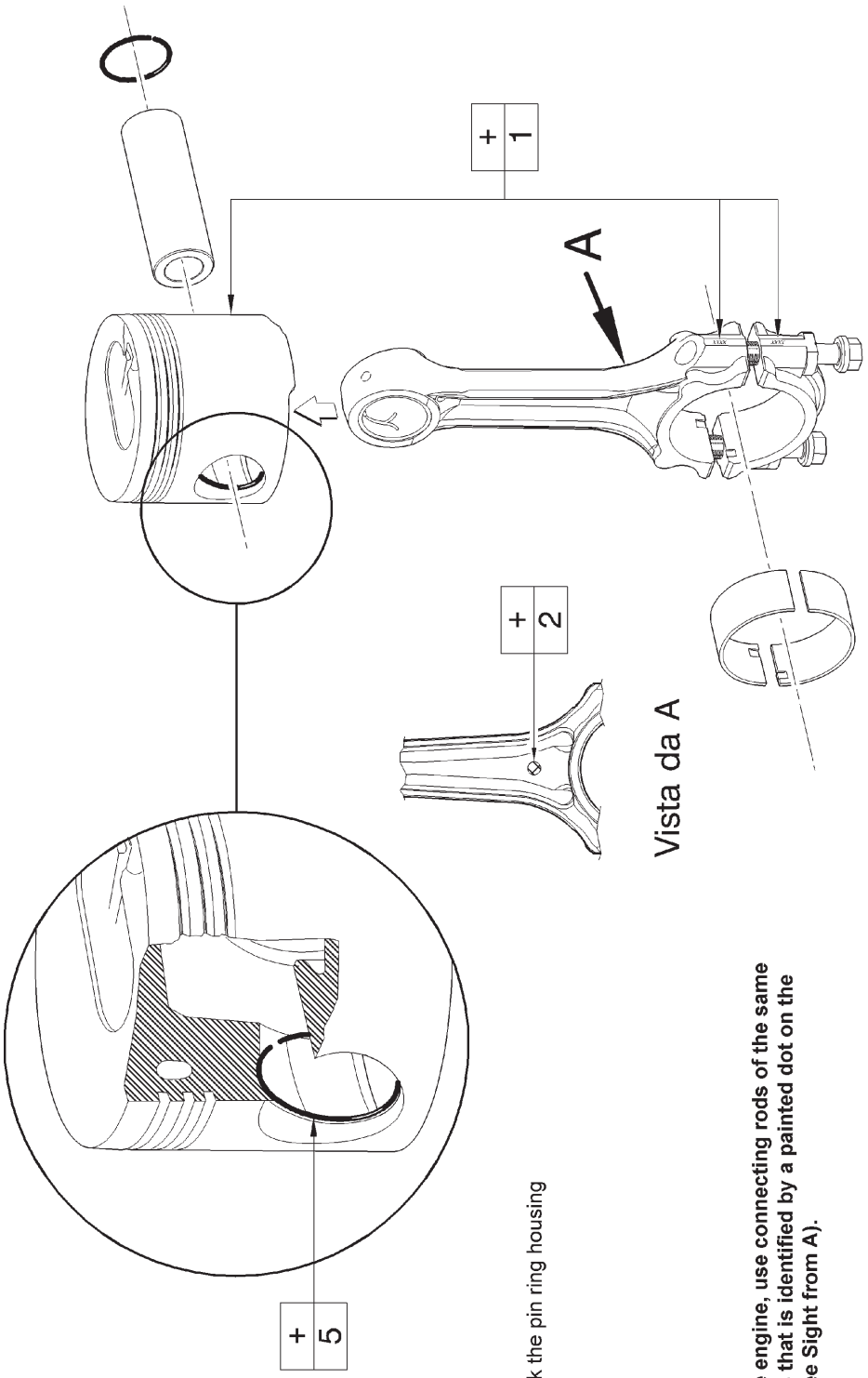
+ 3 Install the gasket on both sides by using LOCTITE 573

+ 2 Position the valve on its seat by checking that the valve nozzle is turnid upwards

TAB. 2333


+ 2
+ 2
Align the manifold's coupling spring rings with the opposite junctions
+ 2

TAB. 2352

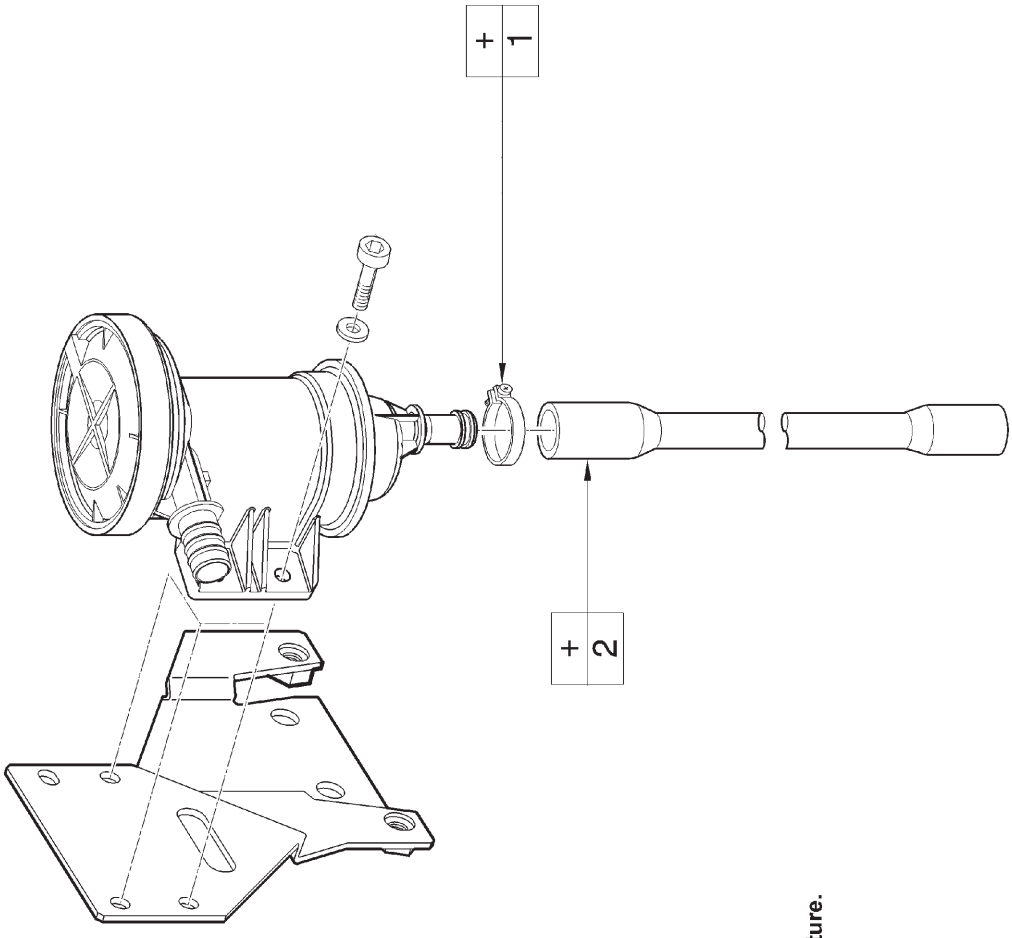


+ 5 Visually check the pin ring housing

+ 2 **On the same engine, use connecting rods of the same ewight class that is identified by a painted dot on the rod shaft (see Sight from A).**

+ 1 Assemble connecting rod and piston by checking that the combustion chamber is on the same side of the printing that is present on the connecting rod/cap back (see picture)

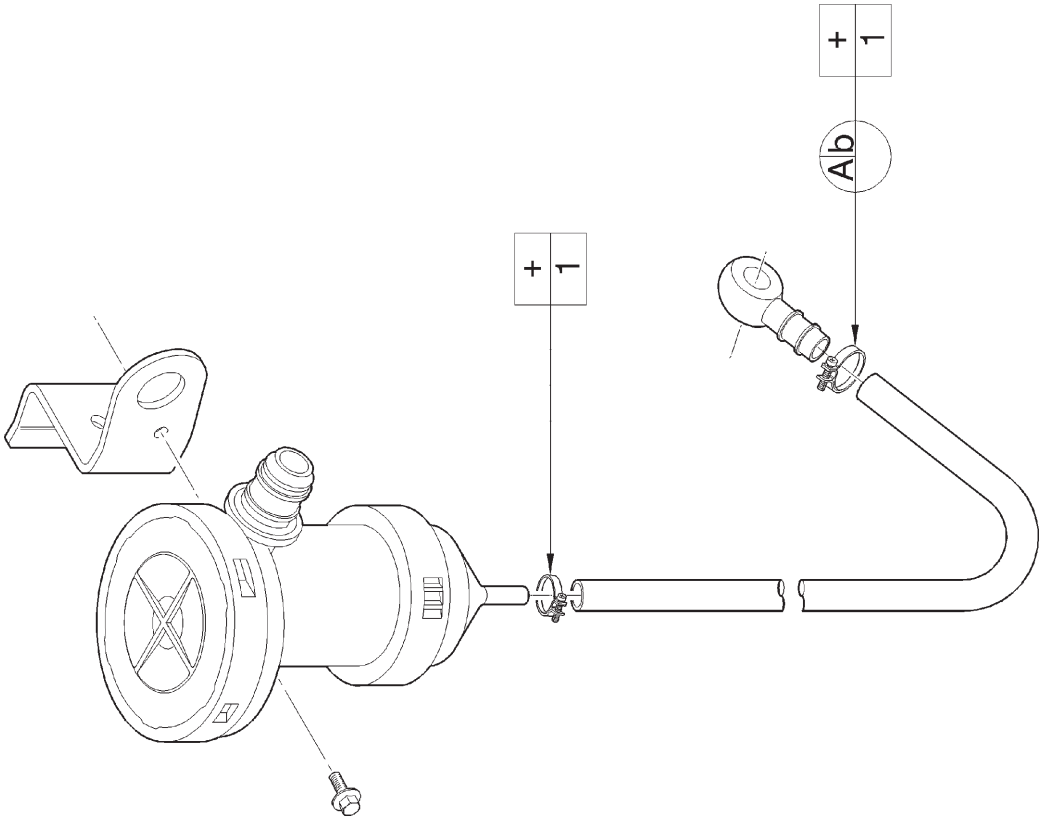
TAB. 0779



+ 2 Grease the pipe end and insert it.

+ 1 Position the clamp as shown in the picture.

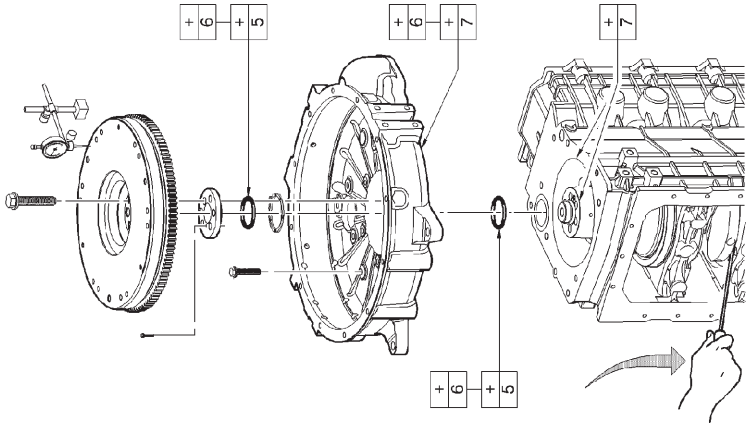
TAB. 0662 **ENGINES 694**

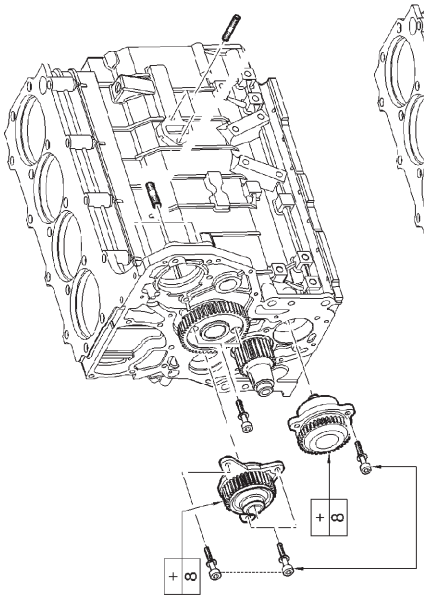


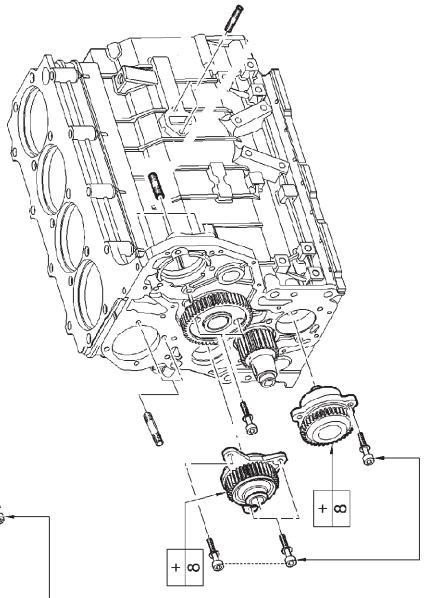
Position the clamps as shown in picture.

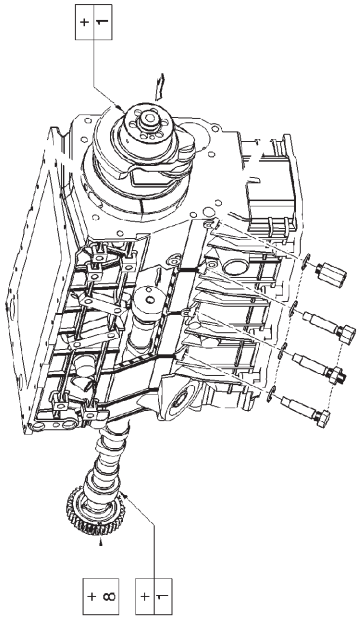
+ 1

TAB. 0663 **ENGINES 494**





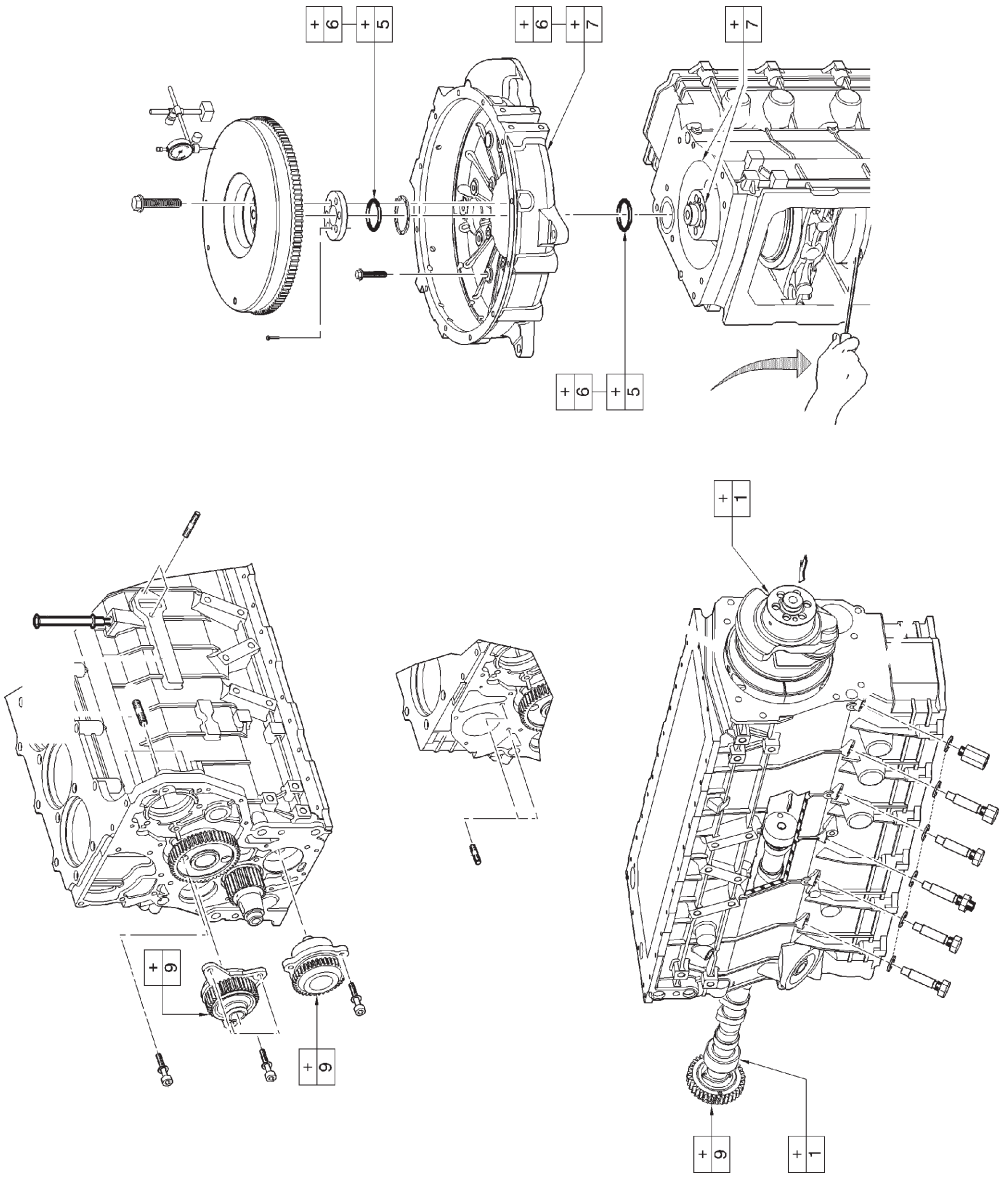




TAB. 2573

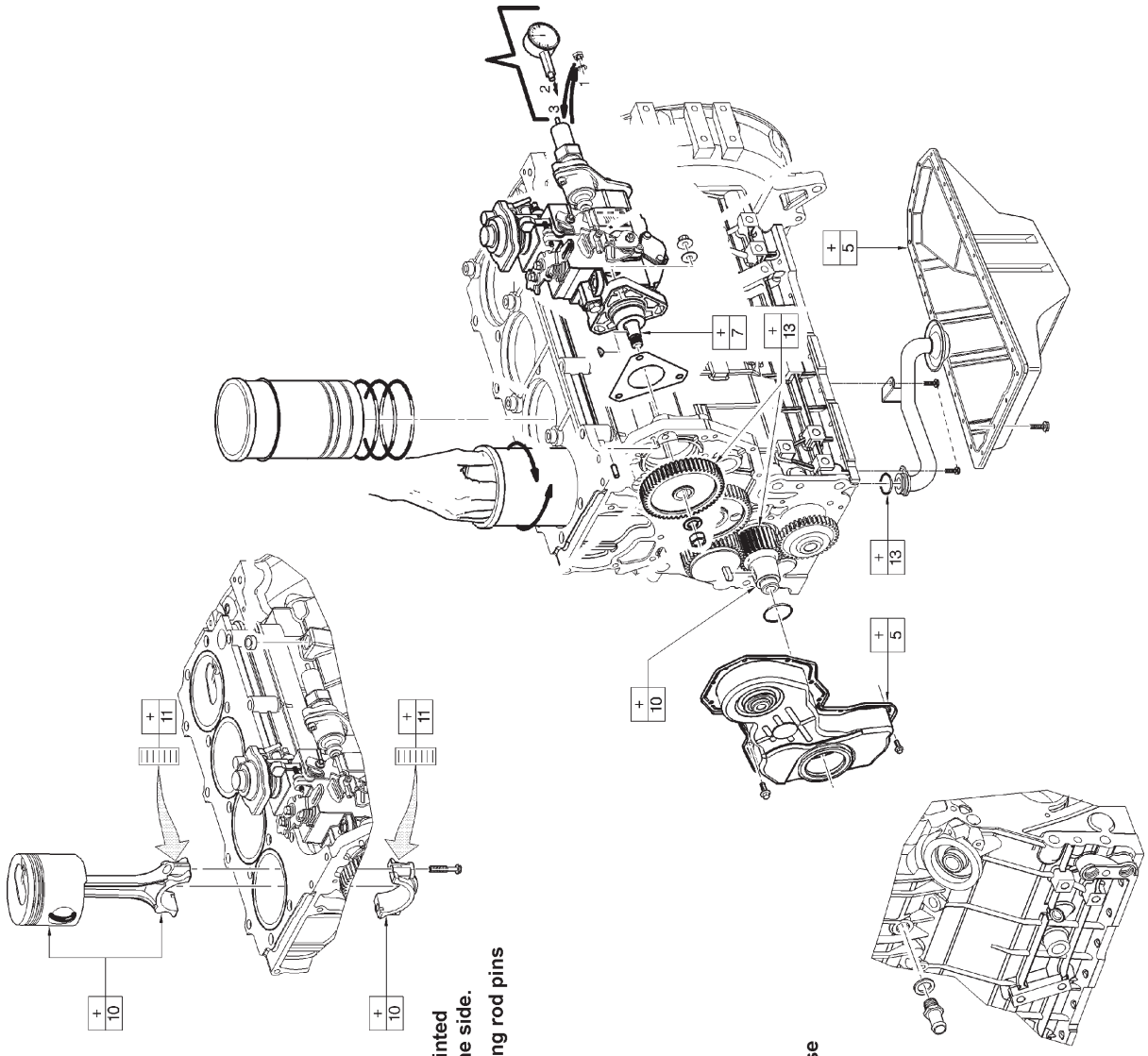
ENGINES 494

+ 8	**Make the engravings on the gear teeth by paying attention to mount them so thet they coincide.**
+ 7	Before inserting the handwheel covering bell, grease the rear part of the driving shaft, the side surface of the base support seat and the rear support O-ring. Remove the covering bell "from outside" by absolutely avoiding to tamper with the rear oil seal.
+ 6	**Check the presence of the O-ring in the relevant seats.**
+ 5	**Grease the O-rings by paying attention to distribute the grease uniformly in order to avoid that this causes shimming.**
+ 1	**During the assembly phase, grease the seats of the indicated parts on the base.**



TAB. 2579

ENGINES 694



TAB. 2574

ENGINES 494

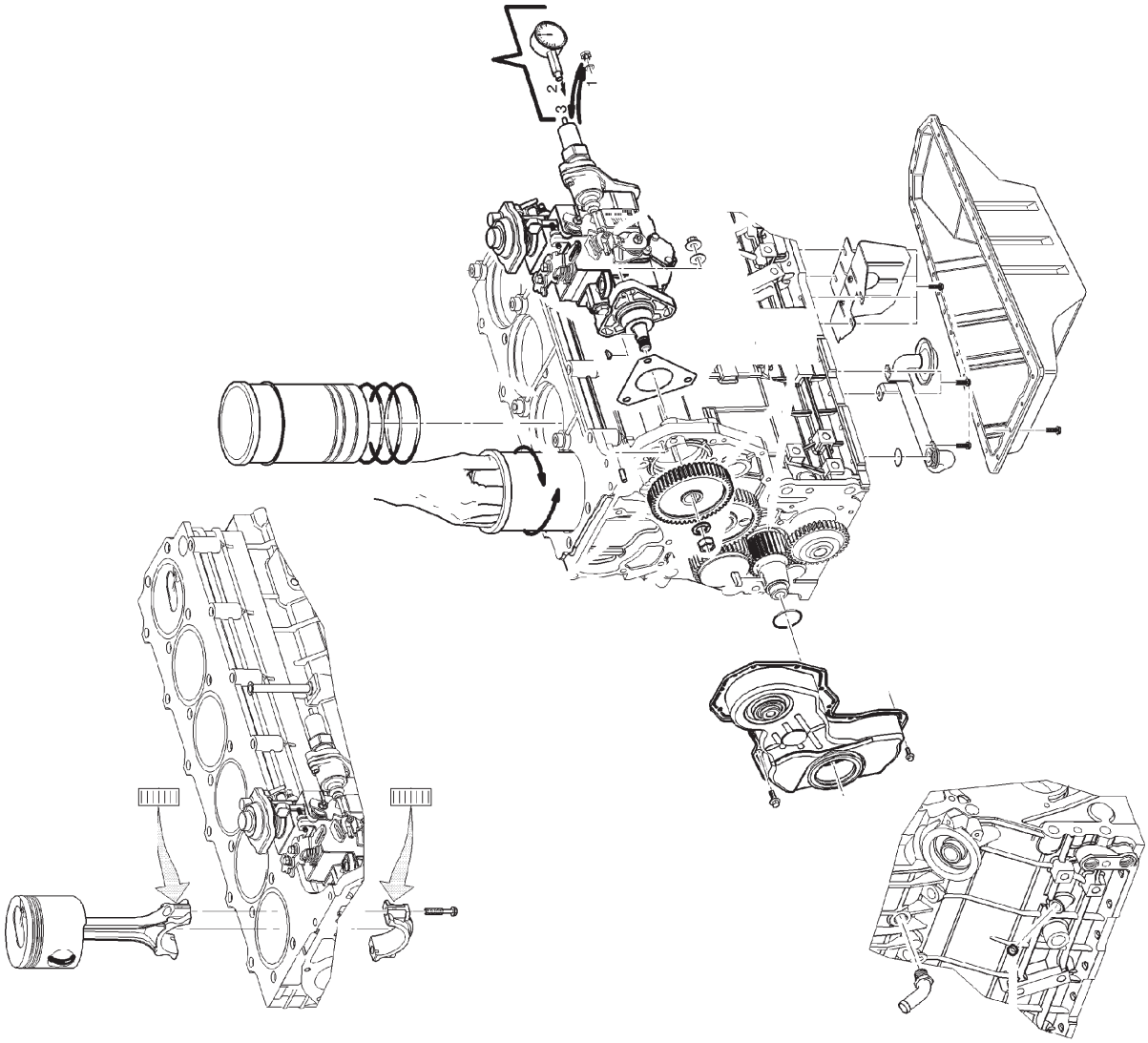
+ 13 Grease the O-ring seat before mounting the oil suction pipe and the gears before mounting the front cover.

+ 11 Insert screw caps by making sure that the coloured marks printed on any cap-rod pair have the same colour and are on the same side.

+ 10 Oil piston, screws, half-bearing, connecting rod and connecting rod pins on the crankshaft.

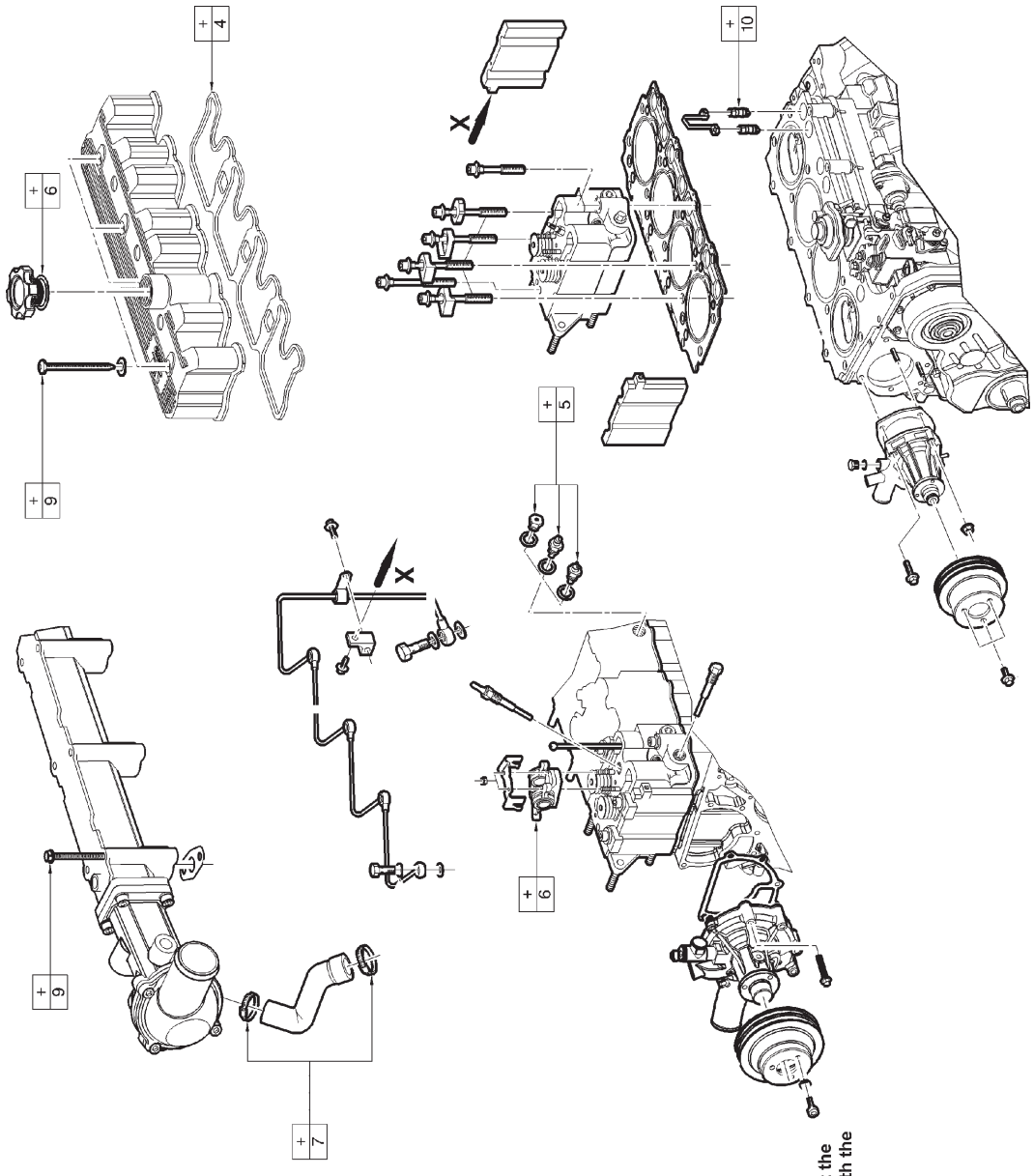
+ 7 Wash the pump threaded cone with degreaser.

+ 5 Thoroughly clean the oil sump supporting surface on the base and the cover supporting surface on the engine front side.



TAB. 2580

ENGINES 694



+ 10 Oil the tappet by means of the nozzle and mount with the suitable tools.

+ 9 Tighten the screws by starting from the centre line and proceed outwards alternately.

+ 7 Position the clamp as shown in the picture.

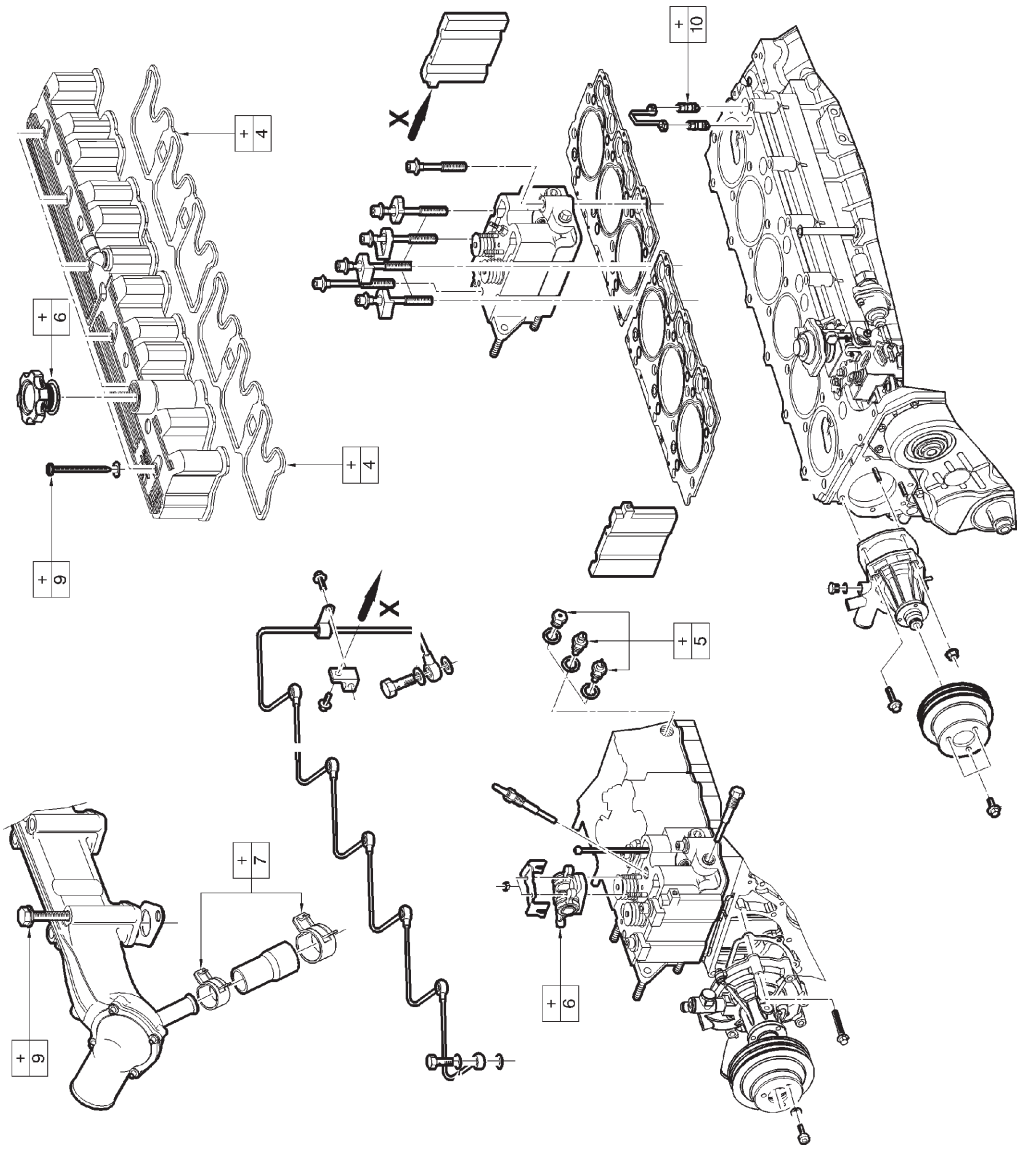
+ 6 Lubricate the rocking lever gasket and pin with engine oil.

+ 5 Apply Loctite 510 on the thread.

+ 4 Before mounting the gasket of the rocking lever cover, that the head plane has been thoroughly cleaned and position it with the writing downwards.

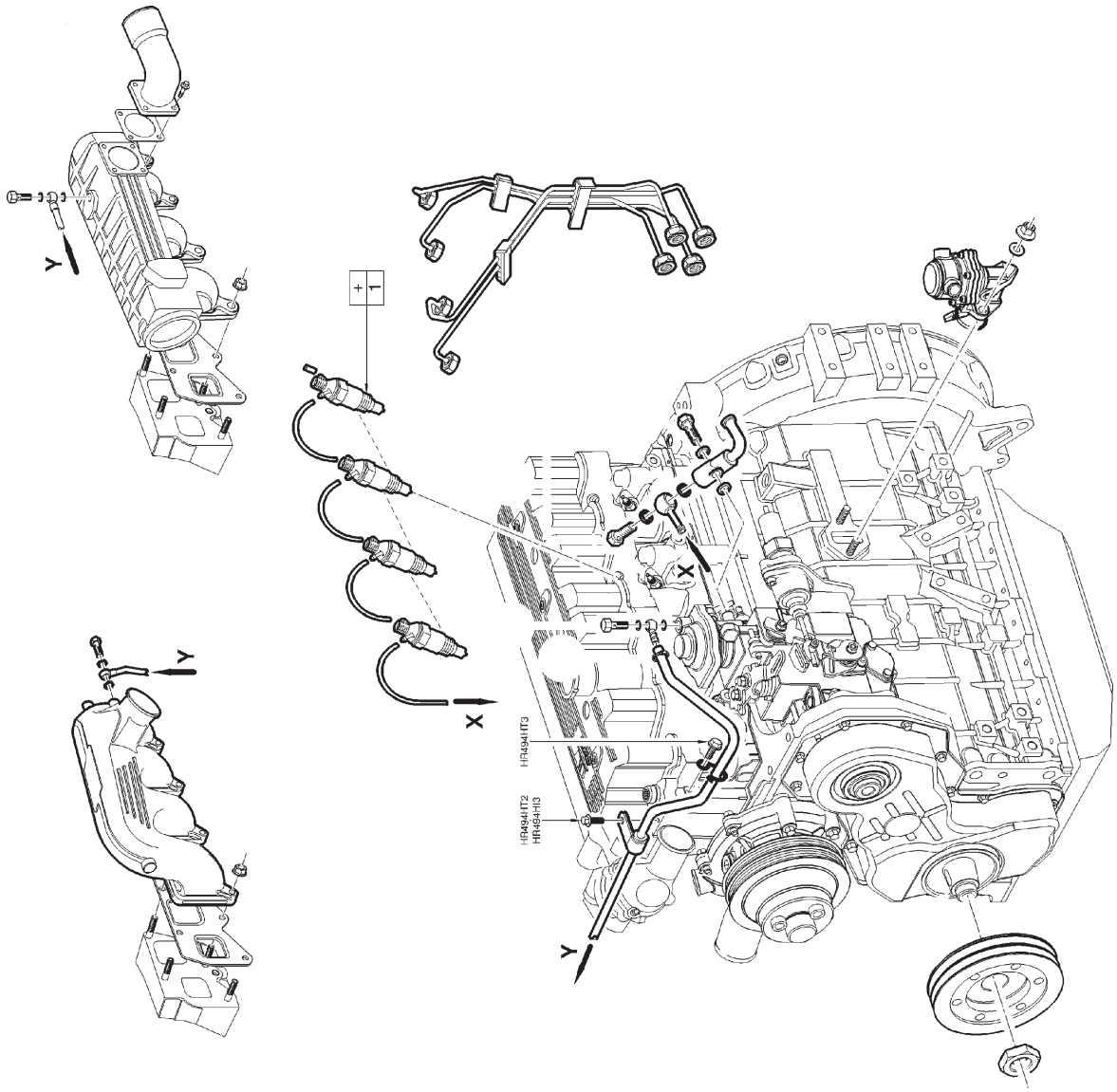
TAB. 2575

ENGINES 494



TAB. 2581

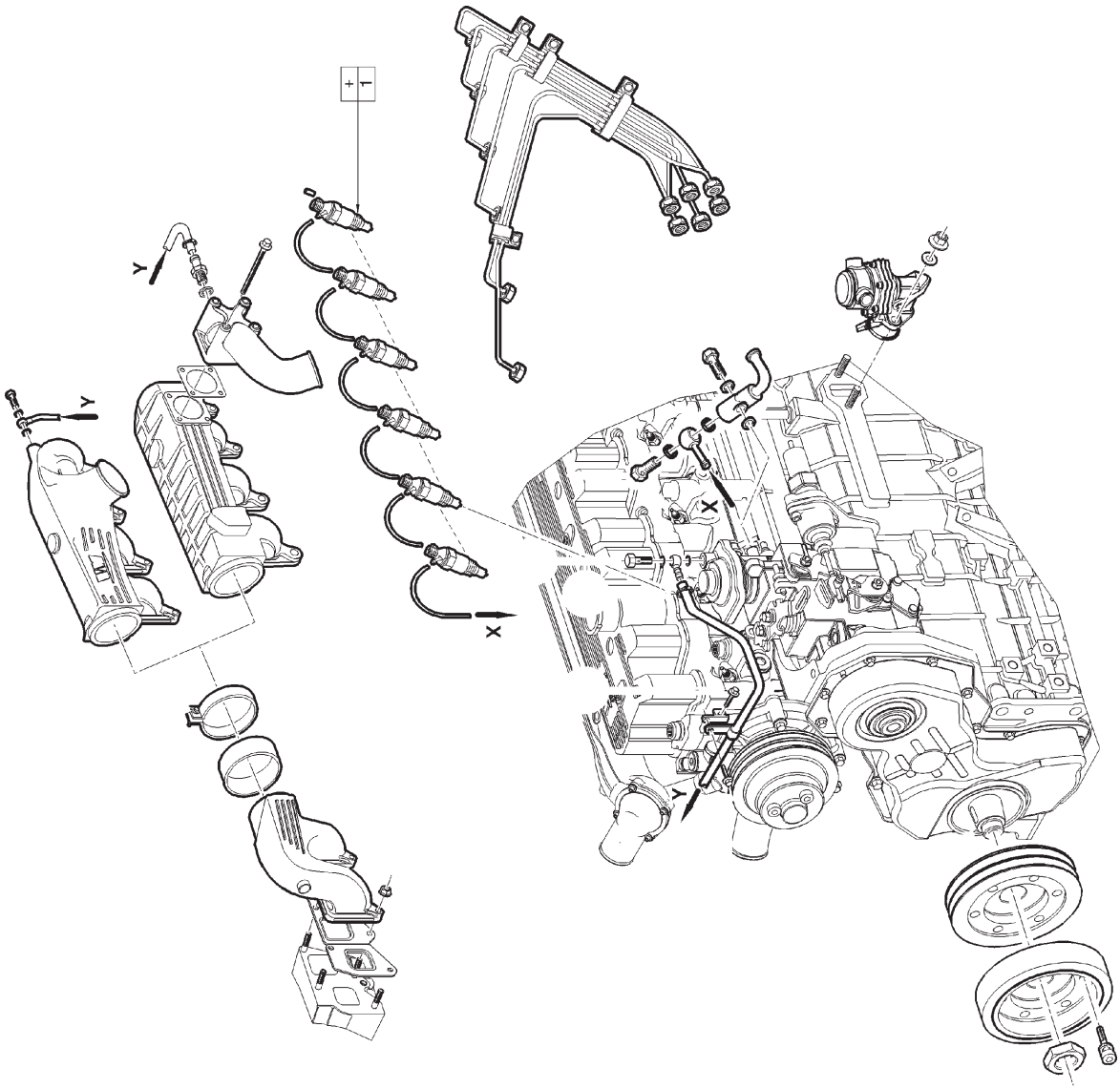
ENGINES 694



TAB. 2576

ENGINES 494

+ 1 **Lubrificate the theads with "Copeslip" type grease.**

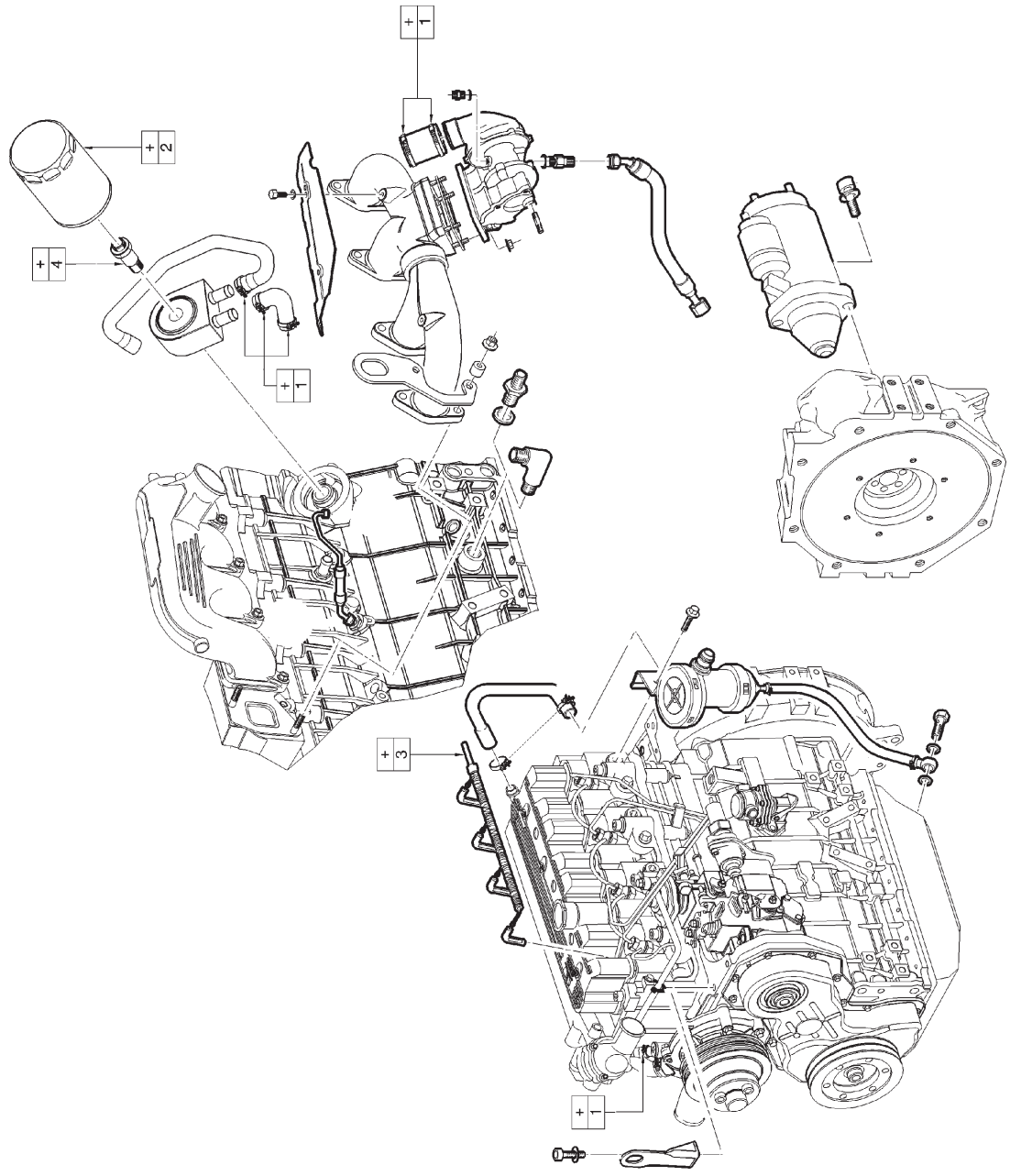


TAB. 2582

ENGINES 694

+ 1 -

Lubrificate the threads with "Copeslip" type grease.



+ 4 Oil the connector thread before mounting.

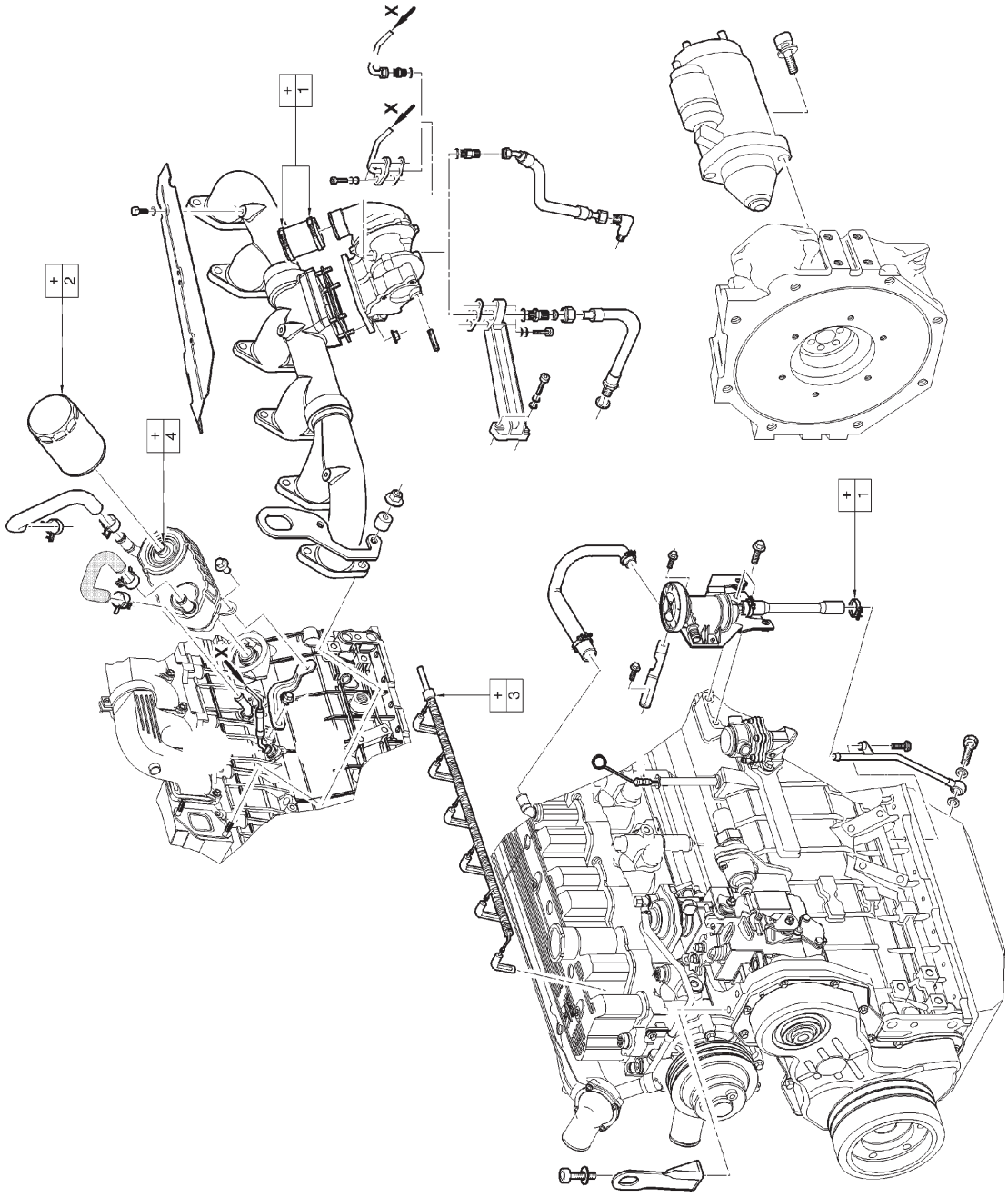
+ 3 Mount the wiring by attention that the final part is turned towards the handwheel.

+ 2 Lubricate the oil filter gasket.

+ 1 Position the clamps as shown in the picture.

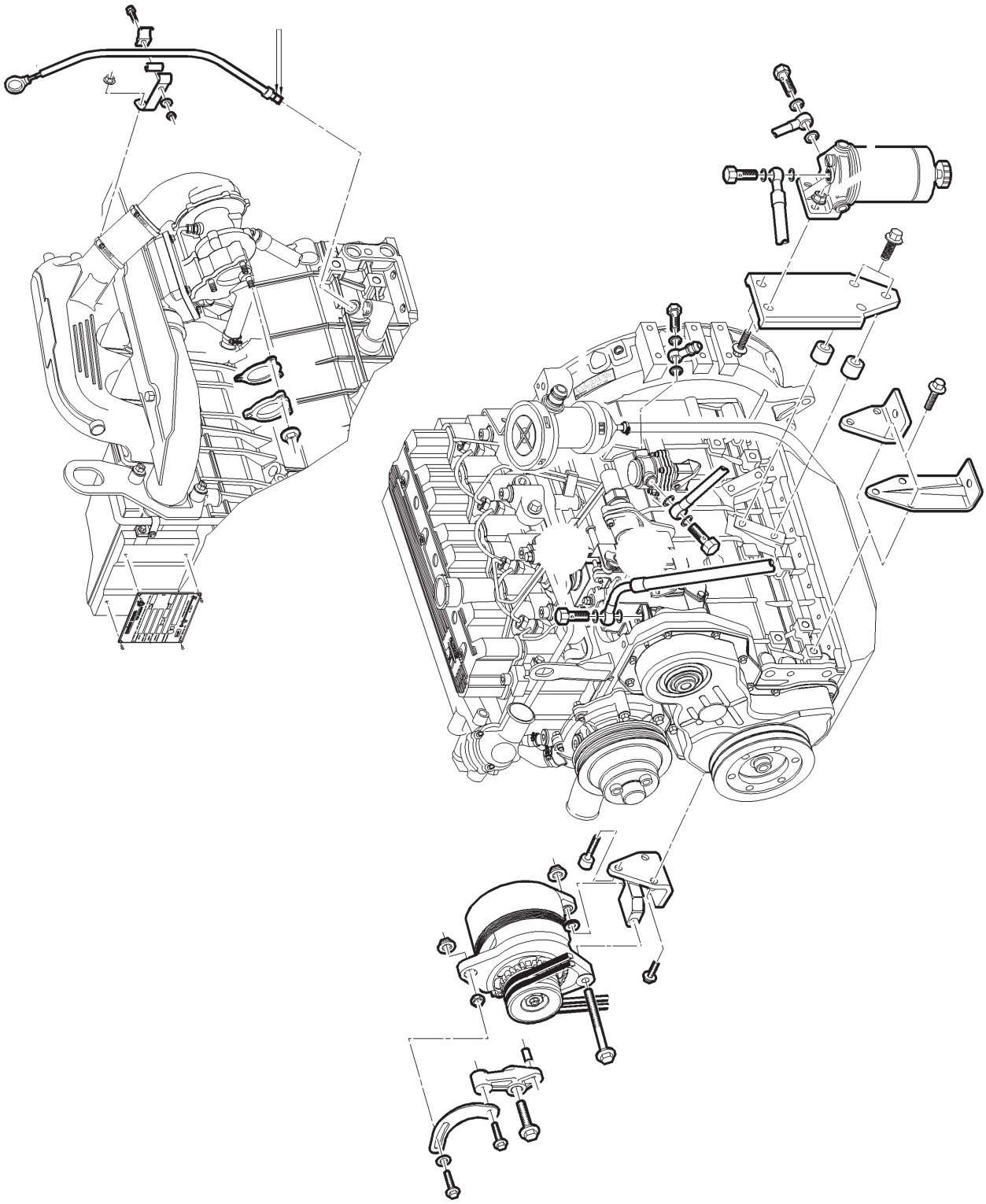
TAB. 2577

ENGINES 494



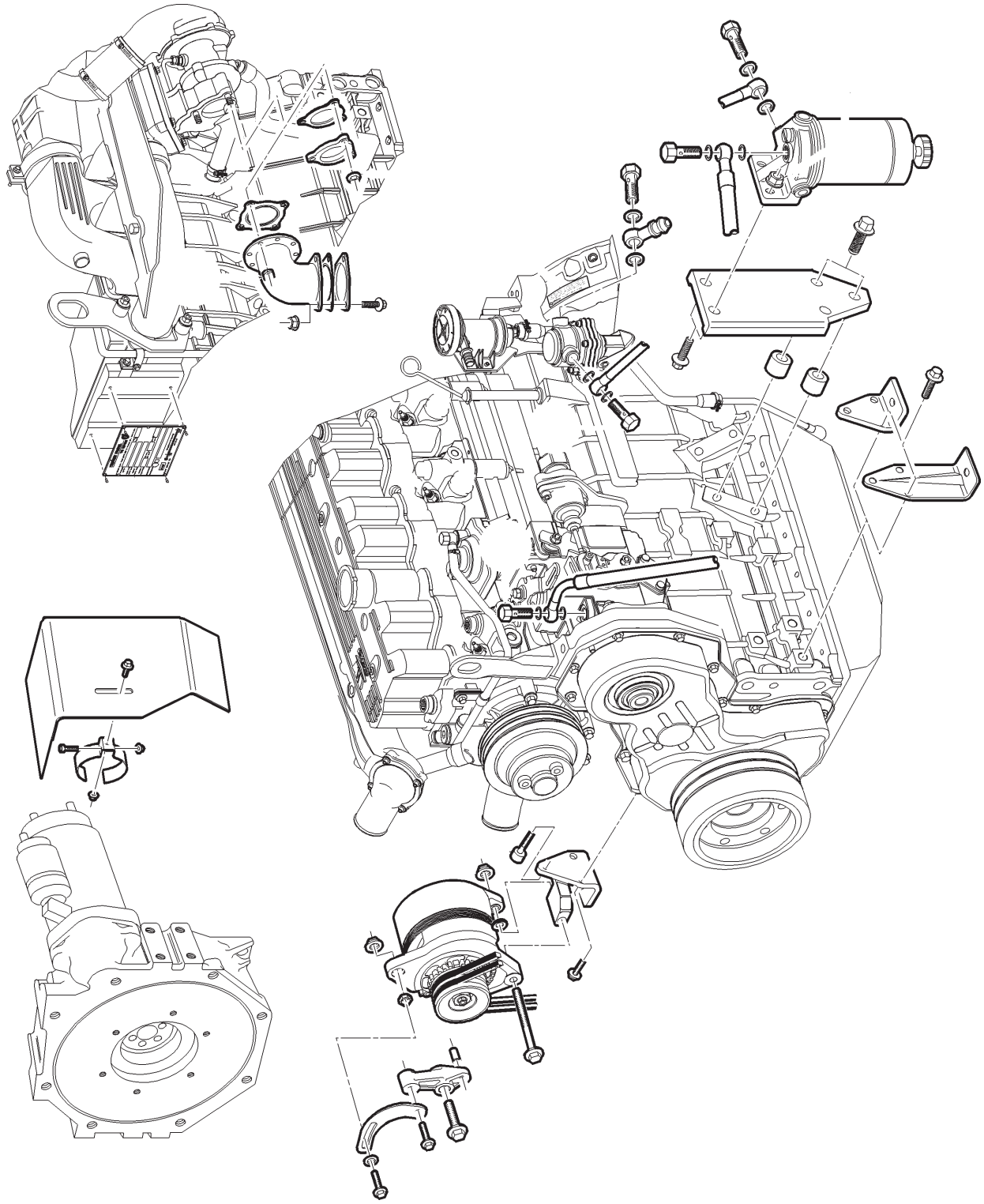
TAB. 2583

ENGINES 694



TAB. 2578

ENGINES 494



TAB. 2584

ENGINES 694

7.1 MAIN BEARINGS *(FIG. 7.1)*

Fit bearing **A** on special tool **B** **(TAB. 11.1 ref. B)** as shown in the figure.

Turn bolt **C** to withdraw the old bearing **D** from the crankcase **E** and simultaneously install the new bearing.

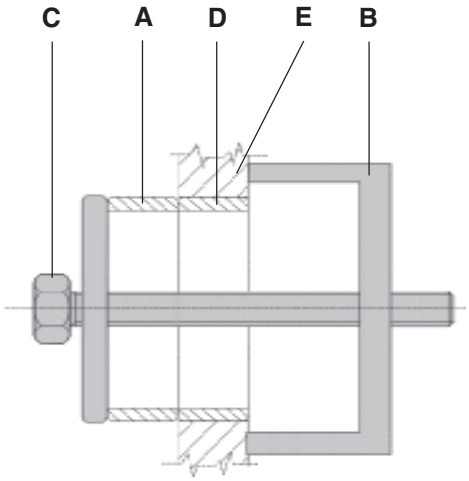


Fig. 7.1

7.2 CYLINDER LINER *(FIG. 7.2 - 7.3)*

Insert liner **F** in the corresponding bore in the cylinder block **G**.

Fit a dial gauge with a 0.01 mm graduated scale on special tool **(Tab. 11.1 ref. W)**.

Zeroset the gauge on the surface of the cylinder block.

Then position the contact point on the liner surface. The height measured **A** is then used to calculate the thickness of the shim to be interposed between the cylinder block and the liner to obtain the correct liner protrusion **B** from the cylinder block face.

For liner protrusion values = (0.01 - 0.06).

For liner shim thicknesses see **(TAB 8.2.5)**.

Remove the liner.

Fit the O-rings **D**: 2 black rings in the grooves near the neck of the liner and 1 brown ring at the bottom.

Apply a thin uniform layer of sealing compound (Loctite 986) to the upper sealing surface of the liner. Carefully remove any excess sealing compound.

Lubricate the lower centering spigot of the liner with graphite grease (Molyguard LMP-180).

Fit the shim of the correct size on the liner.

Insert the liner in the bore.

Tap the liner gently home using a wooden or rubber block.

Fix the liner at two diametrically opposed points using standard M14 bolts and clamps head.

Tighten bolts to 5 kgm.

Zeroset a dial gauge on the cylinder block surface and measure liner protrusion **B** at two opposite points on the transverse axis of the cylinder block.

Repeat the above procedure for each liner.

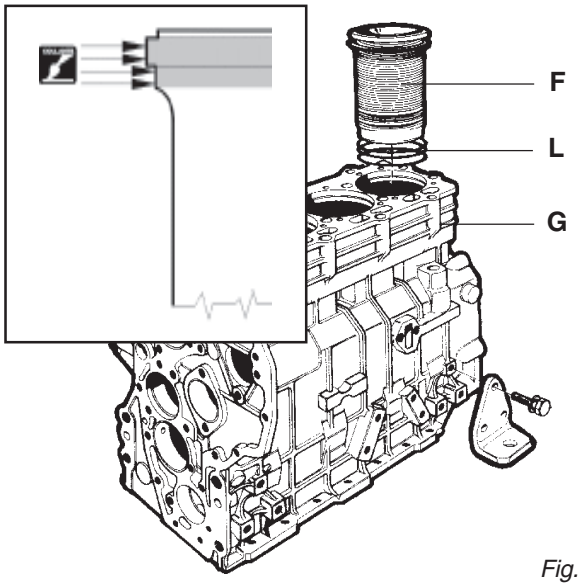


Fig. 7.2

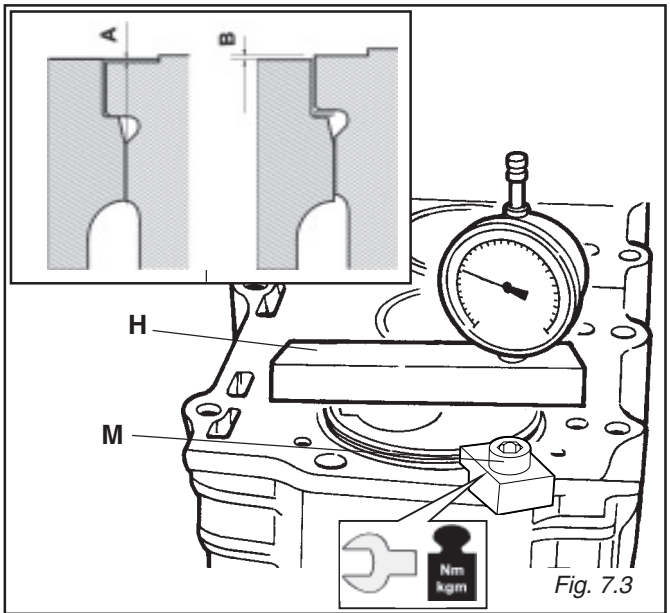


Fig. 7.3

IF THE HEADS CANNOT BE INSTALLED AND TORQUED WITHIN 1 HOUR, THEN THE LINERS HAD TO BE CLAMPED DOWN FOR 8 HOURS TO LET THE LOCTITE DRY. THEN THE CLAMPS CAN BE REMOVED AND THE HEADS INSTALLED

7.3 CAMSHAFT *(FIG. 7.4)*

Lubricate the camshaft bearing contact surfaces.

Insert the camshaft, being careful not to damage the bearing surfaces with the sharp edges of the cam lobes.

Fit the camshaft thrust plate and the gear and tighten bolts **A** to the specified torque values.

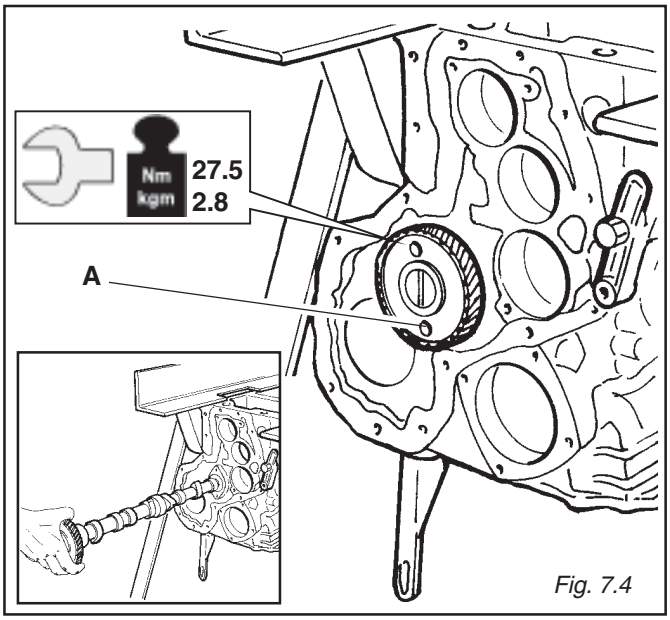


Fig. 7.4

7.4 CRANKSHAFT *(FIG. 7.5)*

Lubricate the main bearing and big-end bearing contact surfaces.

Insert the crankshaft complete with gear using the special tool **(TAB. 11.1 ref. H)** to avoid scoring or scratching the front bearing surface.

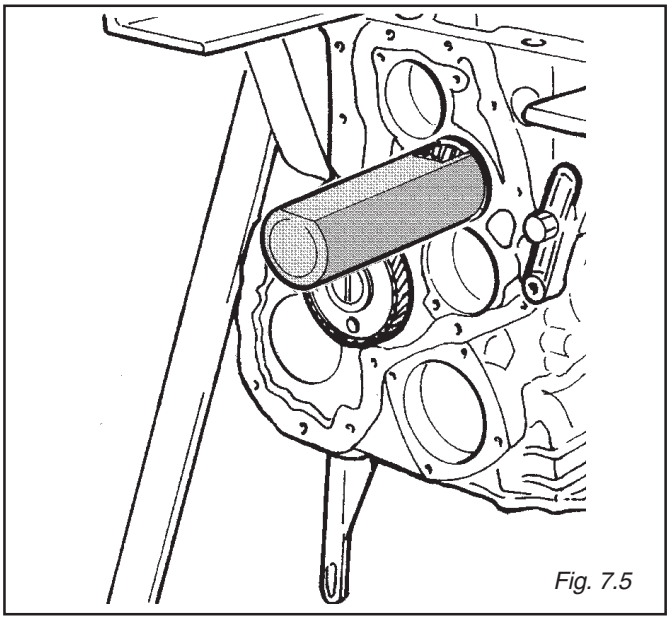


Fig. 7.5

7.5 CENTER MAIN BEARING CARRIER *(FIG. 7.6)*

Check that each main bearing cap is fitted in the correct position as shown by the alphanumerical marks as described in the section “Disassembly”.

Fit the relative main bearing.

Install the center main bearing carrier on the corresponding crankshaft journal, ensuring that the piston lubrication oil jet is directed towards the front of the engine (timing end).

Fix the bearing carriers by tightening retaining bolts **B** to the prescribed torque value.

Tighten cap bolts **C** to prescribed torque value.

Repeat the procedure for each main bearing carrier.

Then insert the main bearing carriers in their seats in the crankcase.

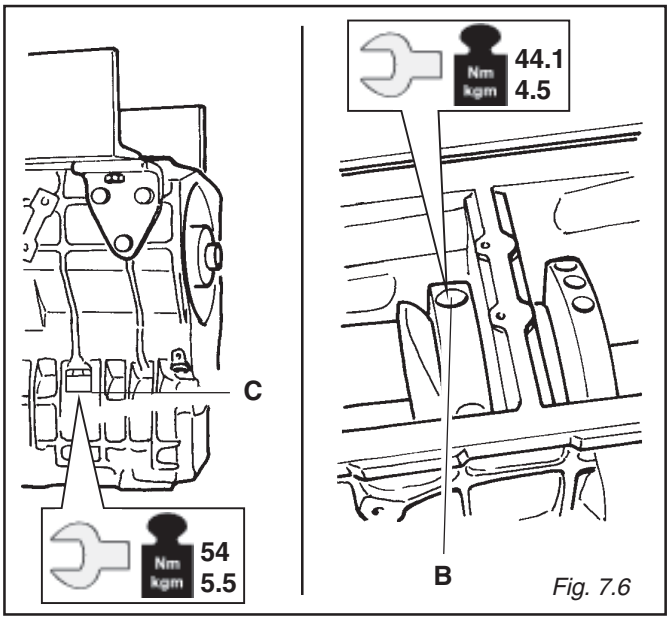


Fig. 7.6

7.6 REAR MAIN BEARING CARRIER *(FIG. 7.7)*

Fit bearing **A**.

Fit rear oil seal **B**.

Fit standard size thrust washer **C**.

Fit O-ring seal **D**.

Install the rear carrier in its seat in the crankcase making sure the oil ways coincide.

Tighten the carrier nuts **E** to the specified torque value.

DO NOT TOUCH AT ALL THE OIL SEAL INTERNAL LIP THIS TO REDUCE THE RISK OF OIL LEAKS.

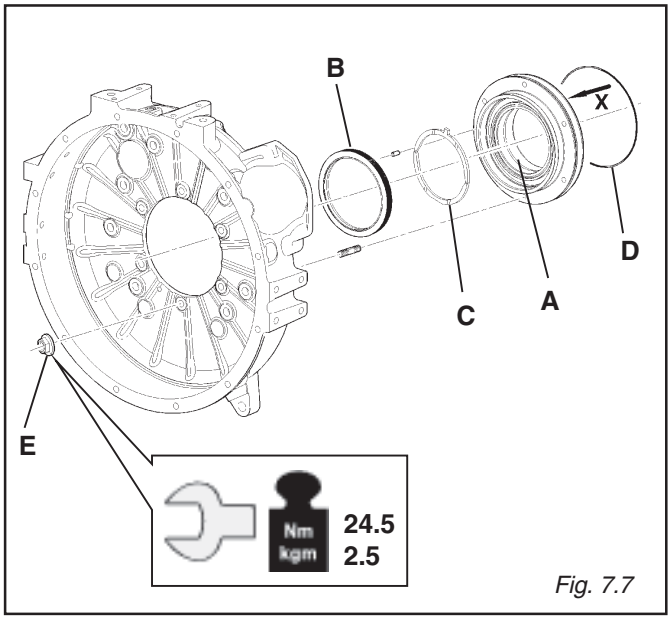


Fig. 7.7

7.7 FLYWHEEL BELL-HOUSING *(FIG. 7.8)*

Locate the flywheel housing on the spigot of the rear main bearing carrier.

Tighten bolts to specified torque value.

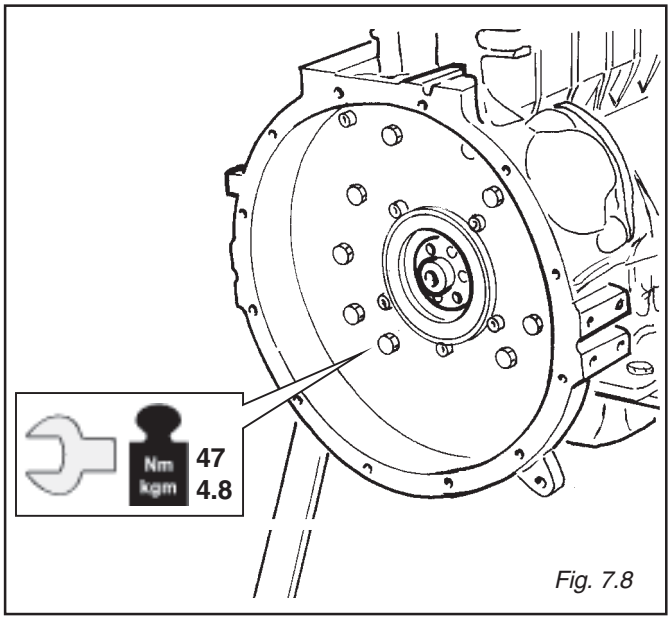


Fig. 7.8

7.8 FLYWHEEL *(FIG. 7.9)*

Position the flywheel fixing holes in line with the holes on the crakshaft.

We recommend the use of support plugs **(TAB. 11.1 ref. AA)** to facilitate this operation.

Install the special tool **B (TAB. 11.1 Rif. V)**, to lock the flywheel.

Follow the flywheel bolts tightening procedure as following described:

Lubricate with engine oil the screw head base and the thread.

Fit the 6 screws **A** and tighten to a **5.1 kgm (50 Nm) (36.88 lbf ft.)** torque with a ± 5% tolerance, starting from screw 1 and then tightening the opposite one (cross pattern tightening sequence). The tightening sequence is clockwise.

Check the crankshaft endfloat and consult the specifications indicate on the heading 7.10

Using a torque wrench equipped with a goniometer, **(TAB. 11.1 Rif. S)**, loosen one screw at a time and then tighten all screws **A** to a **2.05 kgm (20 Nm) (14.75 lbf ft.) torque + 75°** with a ± 5% tolerance, tightening the opposite one (cross pattern tightening sequence). The tightening sequence is clockwise.

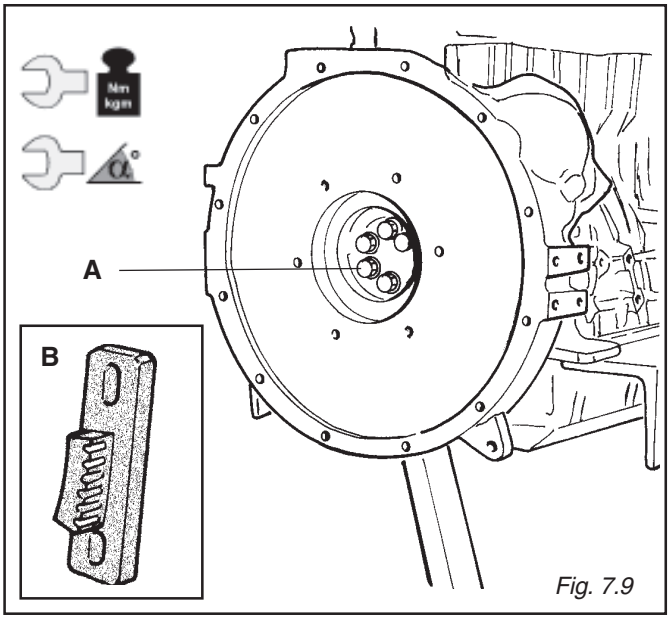


Fig. 7.9

WHILE USING NEW SCREWS, DO NOT LUBRIFY THEM AT ALL, SINCE THEY ARE ALREADY COATED WITH AN ANTISEIZURE TREATMENT.

7.9 CRANKSHAFT ENDFLOAT *(FIG. 7.10)*

Use a dial gauge **A** mounted on a support.

Force the crankshaft back and for using a lever, the maximum axial play is specified: 0.080 - 0.230 mm.

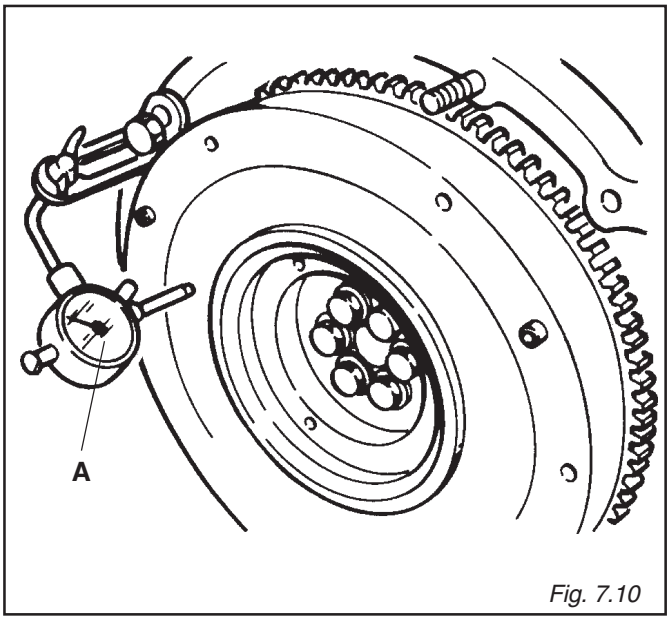


Fig. 7.10

7.10 CONNECTING-ROAD AND PISTON *(FIG. 7.11)*

Assemble the piston on the shaft of connecting rod **B** aligning the explosion chamber with the side of the connecting rod where the coupling numbers are located.
Insert pin **C** and secure it with the seeger rings **D**.
Assemble the rings on the piston positioning them as shown in (Fig. 7.12a):
1st Compression ring with trapezoidal shape.
2nd Compression ring with step profile at the bottom.
3rd Oil rake ring.
Put the combustion chamber, on the piston, in the direction of the camshaft: consequently, the number located on the connecting rod shaft will be pointing in the same direction.
Compress the rings using the commercial tool **A**.
Insert the piston complete with connecting rod shaft in the liner with the combustion chamber pointing in the direction of the camshaft.
We advise against the use of wads in materials that are harder than the piston and that leave a residue.

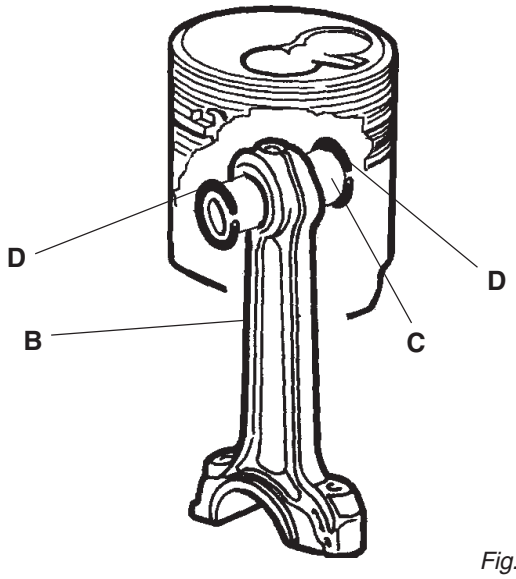


Fig. 7.11

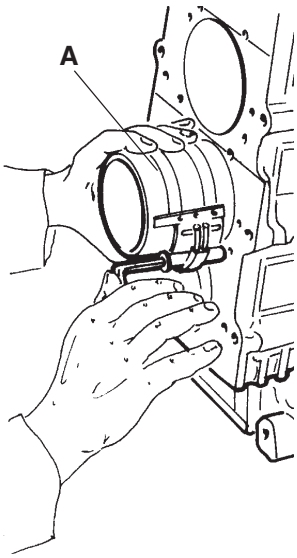


Fig. 7.12

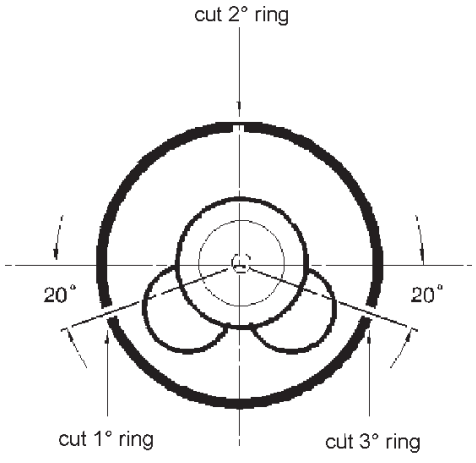


Fig. 7.12a

BIELLA ***(FIG. 7.13)***

Assemble the big-end bearing shells and caps, making sure that the numbers on the con rod big-end and cap correspond and are in line with the piston combustion chamber (same side).

Tighten cap bolts as follow indicate:

- Lubricate with engine oil the screw head base and the thread.
- Fit the screws and using torque wrench equipped with a goniometer **(TAB. 11.1 Rif. S)**, tighten to a **3.06 kgm (30 Nm) (22.14 lbf ft.) + 60°**.

WHILE USING NEW SCREWS, DO NOT LUBRIFY THEM AT ALL, SINCE THEY ARE ALREADY COATED WITH AN ANTISEIZURE TREATMENT.

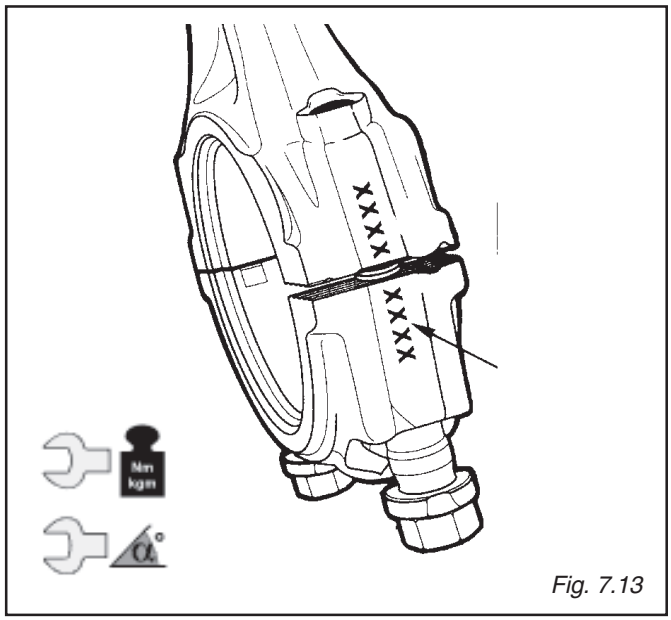


Fig. 7.13

7.11 OIL PRESSURE REGULATOR VALVE *(FIG. 7.14)*

Carefully clean the valve seat in the underside of the crankcase.

Assemble valve components as shown in the figure

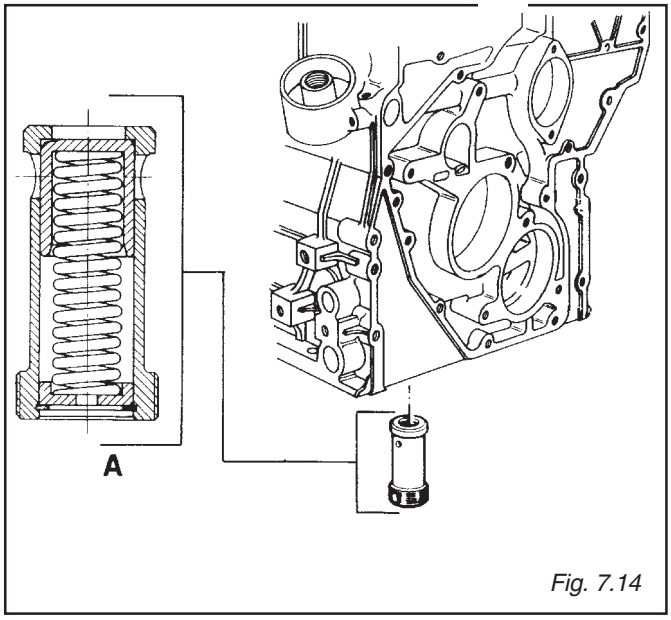


Fig. 7.14

7.12 OIL PICK-UP PIPE *(FIG. 7.15)*

Position the O-ring in its seat in the pick-up union.

Clean the seat in the crankcase .

Fit the oil pick-up pipe **A**.

Screw in bolts **B** and then tighten to specified torque value.

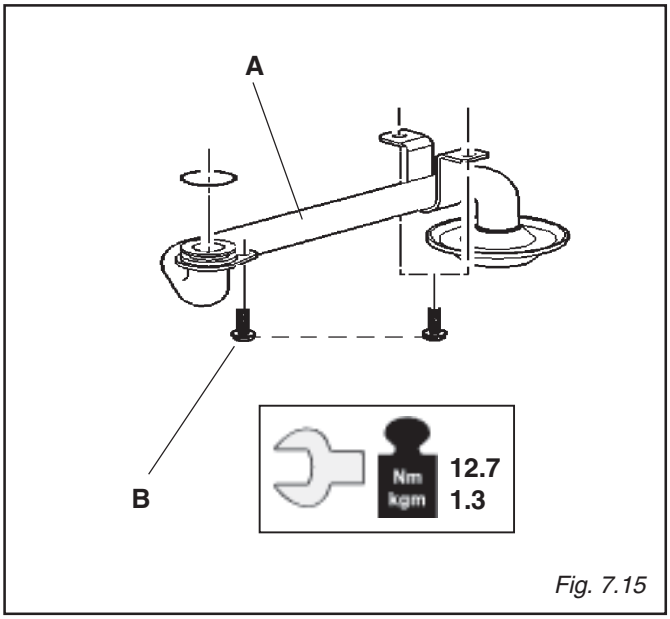


Fig. 7.15

7.13 OIL SUMP PAN WITH GASKET *(FIG. 7.16)*

Clean the sump pan mating surface.

Locate gasket **A** on crankcase.

Fit sump pan install the oil pan bolts. Torque bolts to specified torque value.

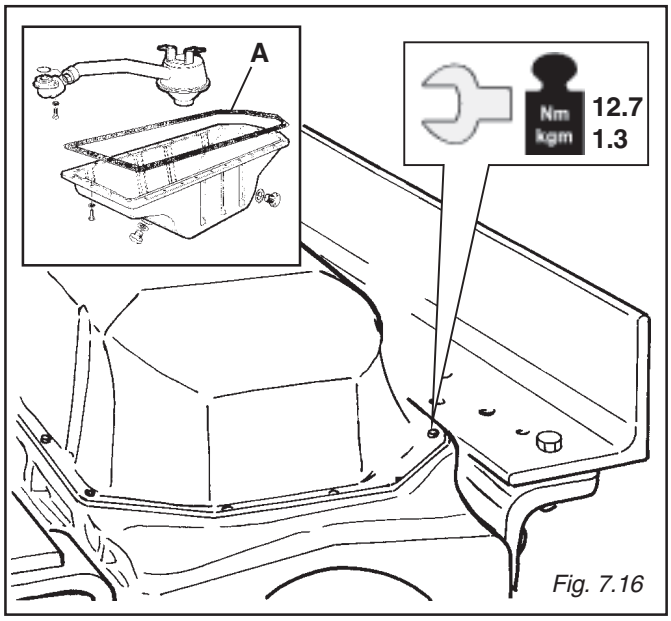


Fig. 7.16

7.13.1 OIL SUMP PAN WITH SILICON *(FIG. 7.16a)*

Clean the sump pan mating surface.
Assemble the steadying partition on the crankcase.
Distribute the sealing silicone evenly on the oil sump, position it on the crankcase, insert the fixing screws and tighten them.
In case of an emergency repair, apply a continuous and uniform bead of silicone sealer to oil pan. Install within 10 minutes (see the fig. 7.16b).

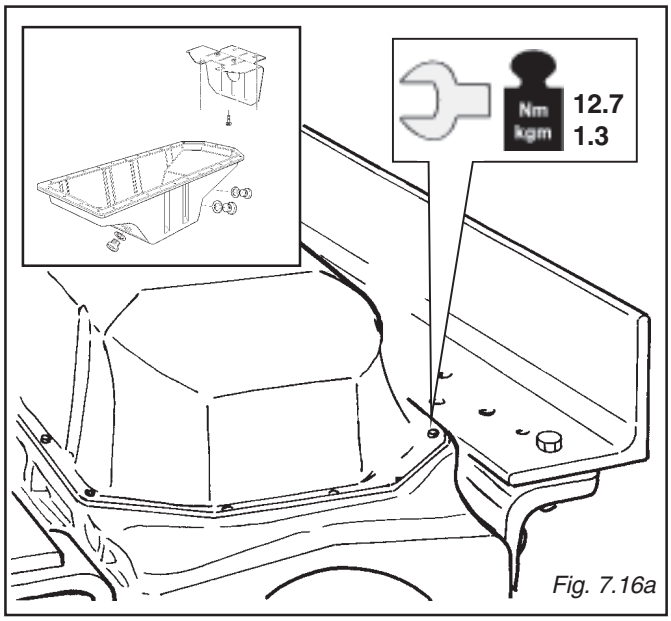


Fig. 7.16a

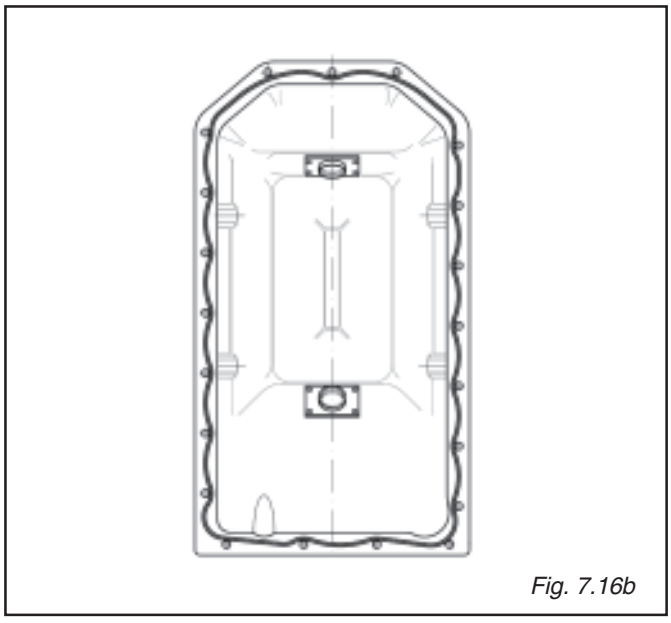


Fig. 7.16b

7.14 OIL PUMP *(FIG. 7.17)*

Check that the oil pump components are assembled as shown in the figure, making sure that the internal rotor is installed with the bevelled end towards the seat in the pump housing **C**.

Fit the oil pump, meshing the pump gear with the crankshaft gear.

Tighten bolts **D** to specified torque value.

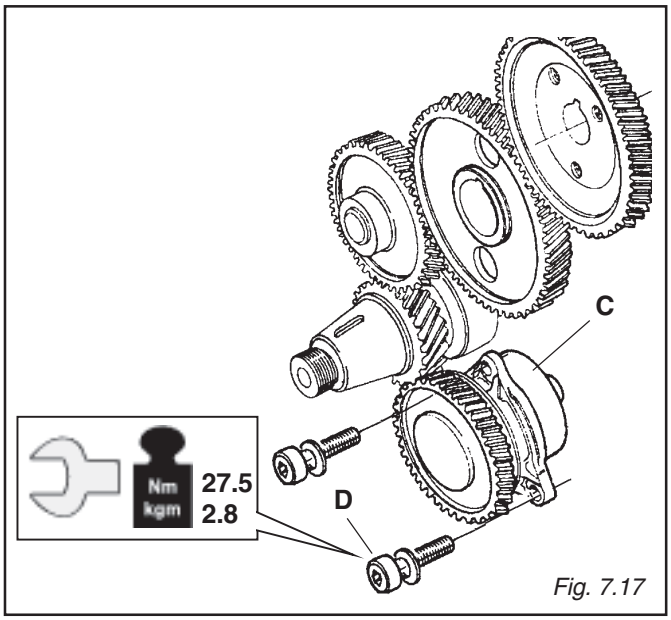


Fig. 7.17

7.15 INTERMEDIATE TIMING GEAR *(FIG. 7.18)*

Fit the intermediate gear with the reference notch aligned with the notch on the crankshaft gear.

Screw in the bolts, using the flat-head bolt in the lower hole so that the gear can rotate freely.

Tighten bolts to specified torque value**.**

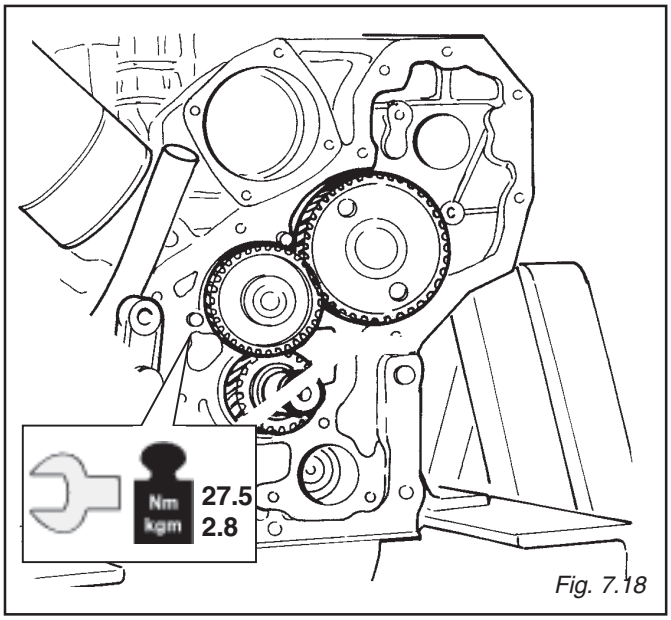


Fig. 7.18

DISTRIBUTION LAYOUT

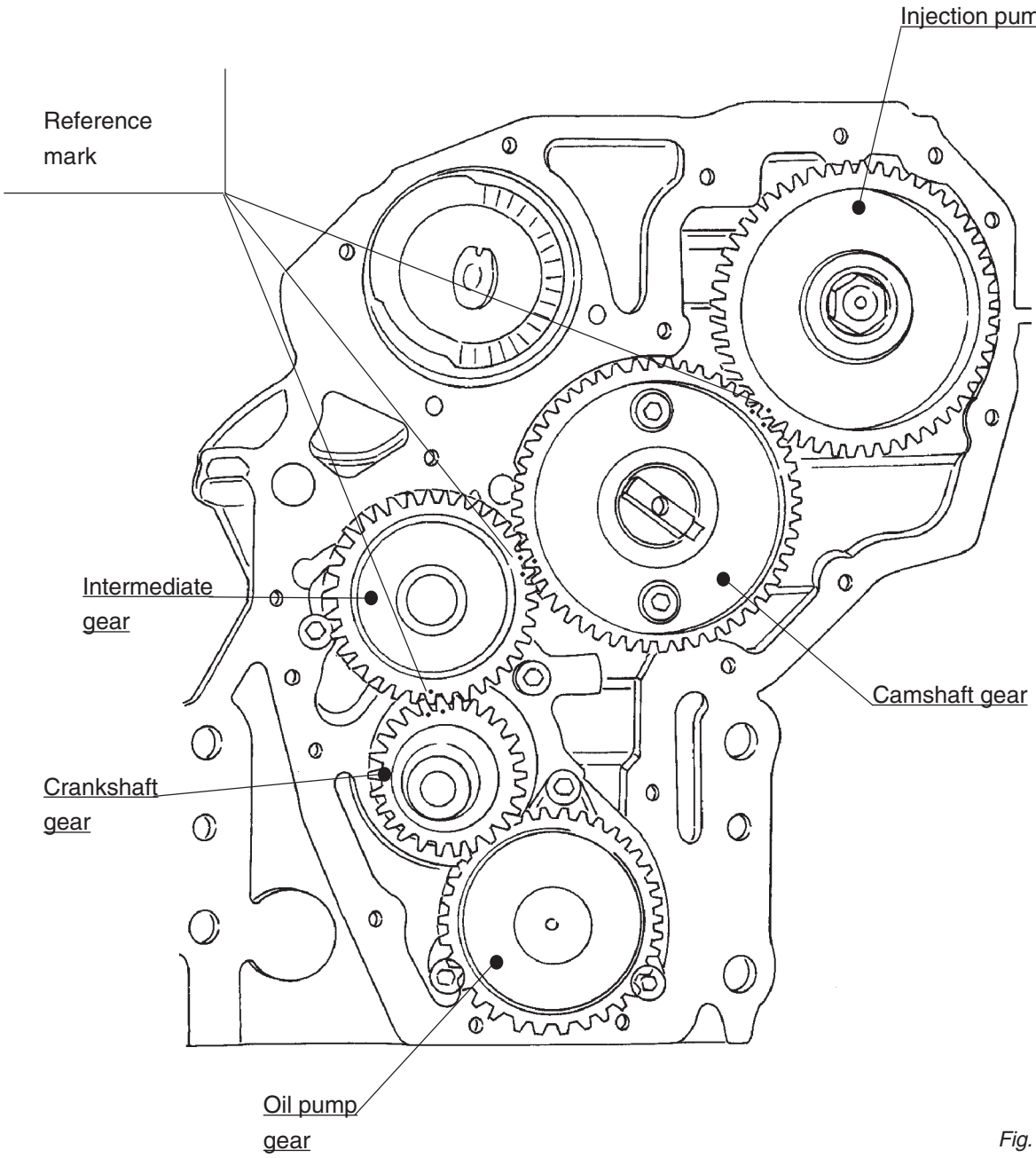


Fig. 7.18.1

7.16 FINDING TOP DEAD CENTER (TDC) *(FIG. 7.19 - 7.20)*

- Fit the front pulley to the crankshaft temporarily.
- Fit special tool **(TAB. 11.1 ref. T)** and position a pointer next to the graduated scale.
- Fit a dial gauge with 0.01 mm scale divisions on special tool **(TAB. 11.1 ref. W)** on top of the cylinder liner.

  Bring piston **A** of cylinder no. 1 (first from timing end) up to near TDC.
- Place the contact point of dial gauge **B** on the piston crown.
- Turn the crankshaft in the normal direction of engine rotation (clockwise as viewed from timing end) until the point where the needle of dial gauge **B** changes direction.
- Position the pointer in correspondence with 0° TDC on special tool **(TAB. 11.1 ref. T)**, making sure that it does not touch the dial.

  Refer to this indicator each time it is necessary to find TDC.

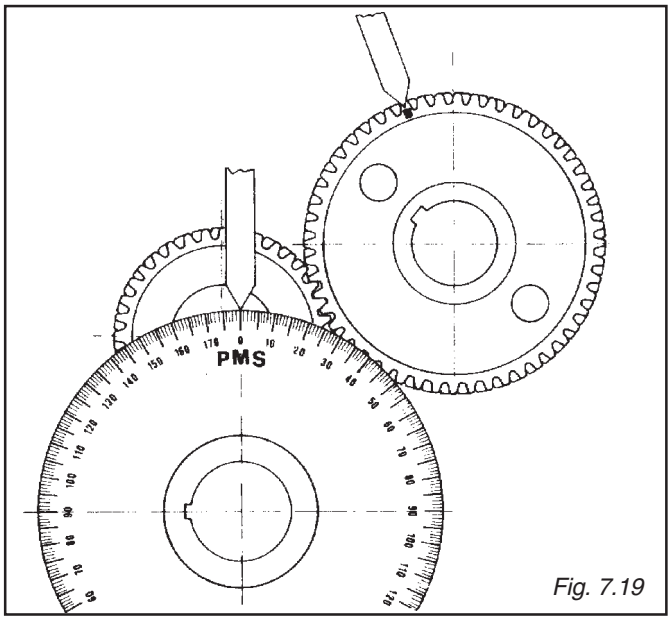


Fig. 7.19

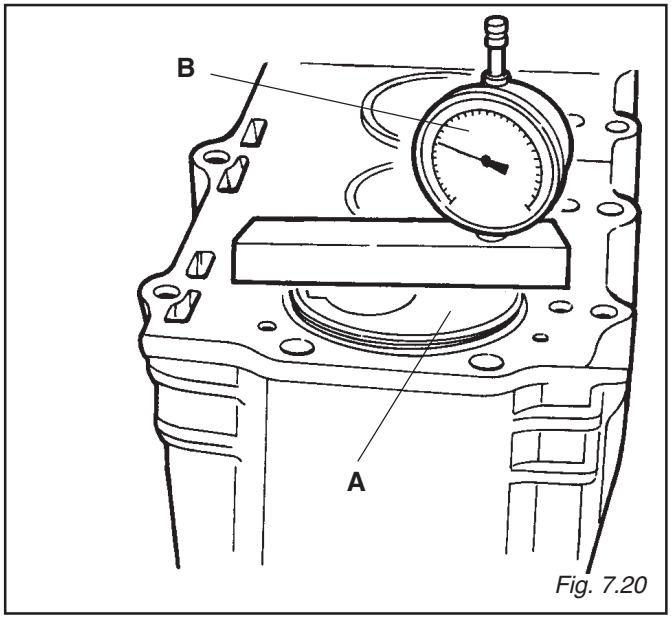


Fig. 7.20

7.17 PISTON-CYLINDER HEAD CLEARANCE *(FIG. 7.21)*

- Use special tool **(TAB. 11.1 ref. W)** and a dial gauge.
- Bring piston **A** (first piston on the front side) to TDC.
- Zeroset the dial gauge **B** on the cylinder block surface **C**.
- Position the gauge contact point **B** on the piston crown **A** and note the gauge reading.
- Repeat the procedure with the rest of the cylinders
- Select a suitable head gasket following the indications in **(TAB. 8.2.6)**.
- Intermediate thickness gaskets (identifiable by two notches along the edge) are included in the set of gaskets available at VM PARTS centers.

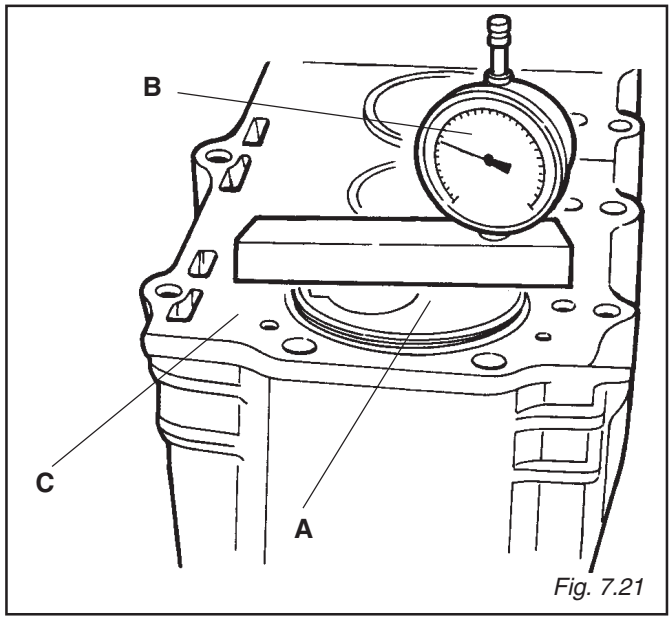


Fig. 7.21

7.18 HYDRAULIC TAPPETS *(FIG. 7.22-7.23-7.24-7.25)*

Using the special tool **(TA B. 11.1 rif. N)**, discharge the hydraulic tappet pushing down the internal spring few times with tool **X** (Fig. 7-22). This operation has always to be carried out to avoid push road damaging.

Install tappet **A** and align yoke **B** (Fig. 7-23) retainers in the original positions. Ensure that the draining hole **C** on the tappet side faces the crankshaft.

Install cylinder heads, intake/exhaust manifolds, push roads and the rocker arms in the original positions.

Before tightening the rocker arms the pistons must be located far 90° form TDC:

- Bring piston n°1 at TDC aligning the marks of front pulley and fornt cover.
- Turn crankshaft of 40°÷45° clockwise before TDC.

In this position, it is possible to torque the rockers arms without the risk of damages.

Install cylinder heads cover.

Wait at least 30 minutes to allow the tappets to be drained.

Make some crankshaft turns by hands to besure that everything turns free.

Start the engine, run it above idle until all hydraulic tappets have filled with oil, and have become quiet.

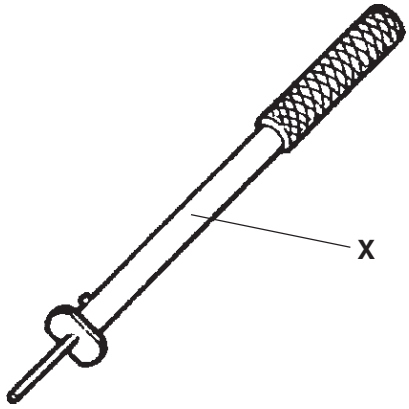


Fig. 7.22

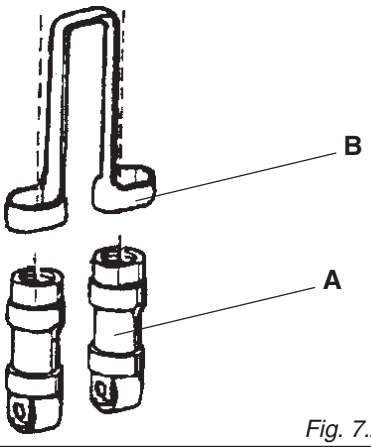


Fig. 7.23

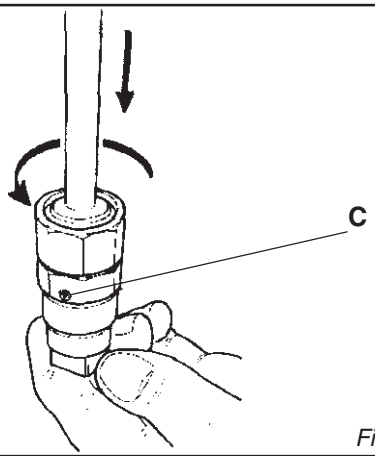


Fig. 7.24

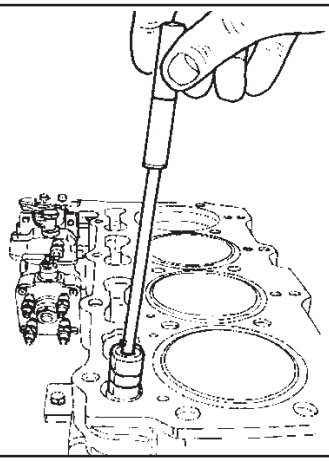


Fig. 7.25

7.19 CYLINDER HEAD ASSEMBLY *(FIG. 7.26-7.27-7.28)*

Locate the gaskets **C** on the crankcase plane and locate the cylinder heads.

To ensure that gaskets and cylinder heads are correctly aligned, use, respectively, the special tool **D (Table 11.1 ref. U)**.

Assembly the distance piece **G** and the clamps **F,** after head bolts are losely installed, install the intake and exhaust manifolds for dead alignment prior to final torquing of the head bolts.

If yuo use the old head screws,lubricate underside of bolt heads and the thread with Molycote type GRAPID PLUS.

WHILE USING NEW CYLINDER HEAD SCREWS, DO NOT LUBRICATE THEM AT ALL, SINCE THEY ARE ALREADY COATED WITH AN ANTISEIZURE TREATMENT.

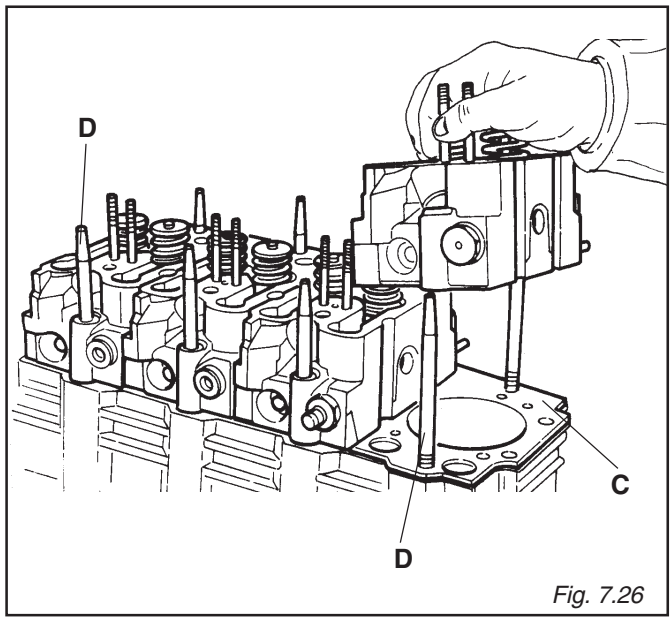


Fig. 7.26

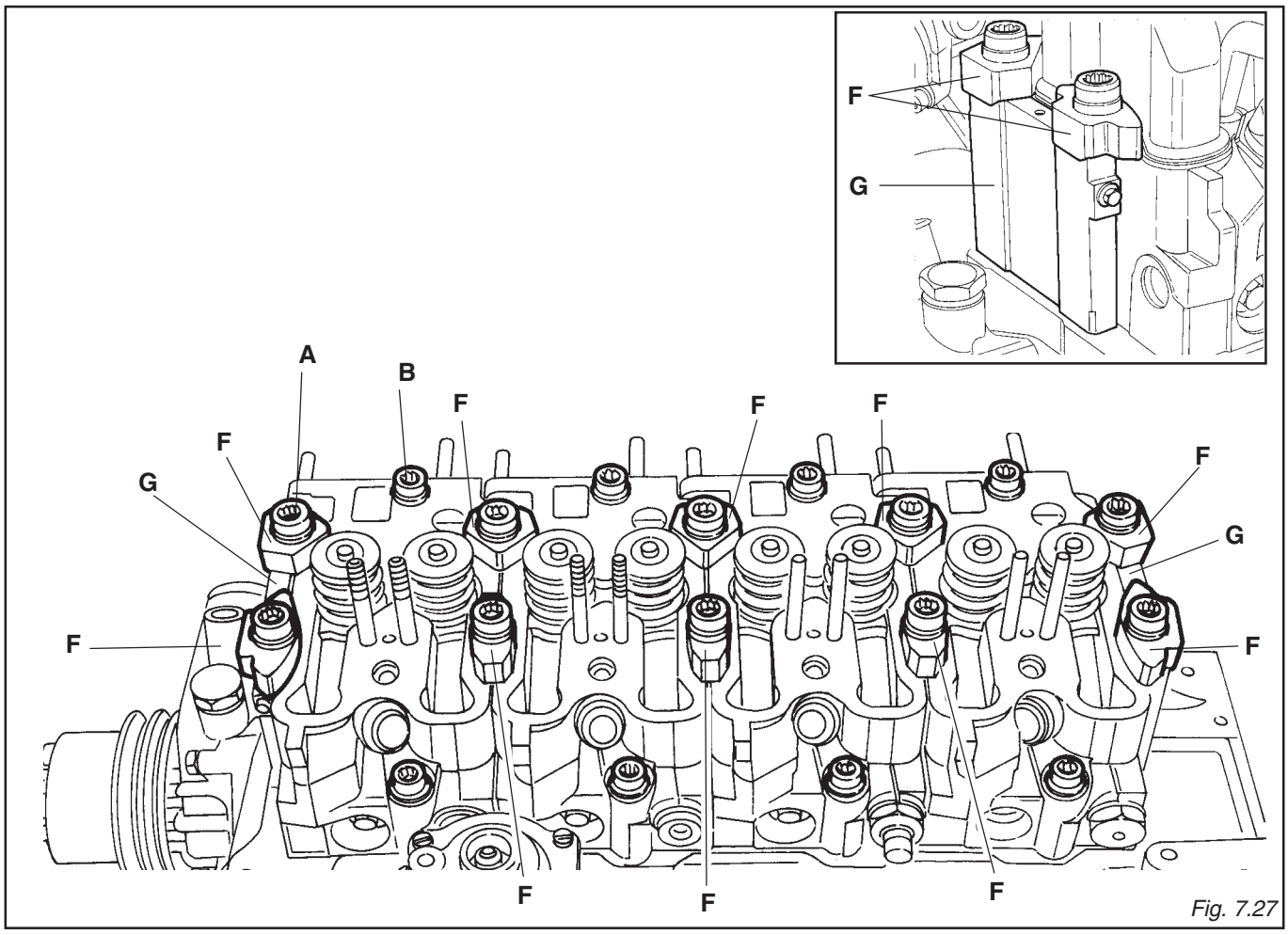


Fig. 7.27

TO TIGHTEN THE SCREWS USE THE SPECIAL TOOLS (TAB. 11.1 REF. O-P-Q-R-S) AND A TORQUE WRENCH CALIBRATED IN COMPLIANCE WITH ISO 6789

(FIG. 7.28)

1 Use the torque wrench to tighten the central screws as follows value **30 Nm (3 Kgm)**

ENGINE 4 CYL. **3-2-1-4-5-8-9-10-7-6**

ENGINE 6 CYL. **11-12-13-14-10-9-8-4-3-2-1-5-6-7**

2 Use the special tool **(Table 11.1 ref. S)** with angular value indication and tighten the central screws as follows value **65°**

ENGINE 4 CYL. from **1** to **10**

ENGINE 6 CYL. from **1** to **14**

3 Repeat the operation **2** following the same way

4 Use the torque wrench and tighten the external screws **M1** as **30 Nm (3 Kgm)**

5 Using the relevant torquing tool with angular value indication and torque the external screws as **85°**

6 Use the torque wrench and tighten the external screws **M2** as **30 Nm (3 Kgm)**

7 Using a relevant torquing tool with angular value indication and torque the external screws **M2** as **85°**

AFTER THE CYLINDER HEADS HAVE BEEN CORRECTLY ASSEMBLED AND TORQUED, RUN THE ENGINE AT SPEED FOR 20 MINUTES AND THEN SWITCH OFF.

8 RETIGHTEN AFTER RUNNING

WARNING: PERFORM THIS OPERATION WITH ENGINE COLD

9 CENTRAL SCREWS:

loosen one screw at a time, releasing it compleetely, then tighten with **30 Nm (3 Kgm)** torque plus rotation of **120°**

10 Side screws:

(M1 and M2) do not require retightening, use a dynamometrical wrench set at **90 Nm (9 Kgm)** for checking, if necessary.

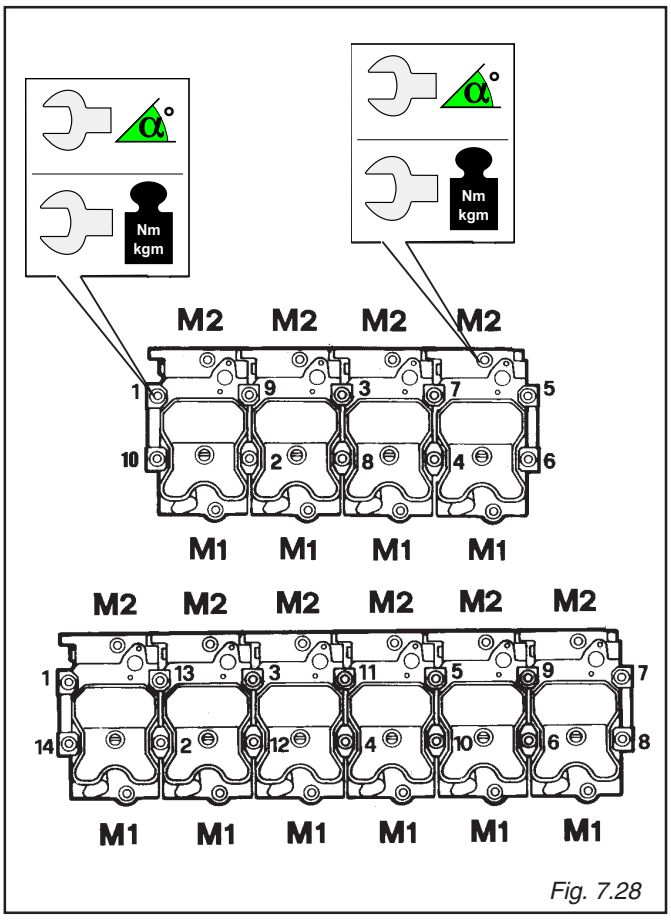


Fig. 7.28

7.20 INLET MANIFOLD *(FIG. 7.29-7.30)*

Assembly the gascket for inlet and exhaust manifold.

Fit the inlet manifold tightening the bolts **B** to the specified torque value.

Insert coupling pipe **F** from LDA to injection pump with the pipes union **D** and **E**.

Tighten the pipes union.

BE SURE TO ASSEMBLE ALL THE COPPER WASHERS.

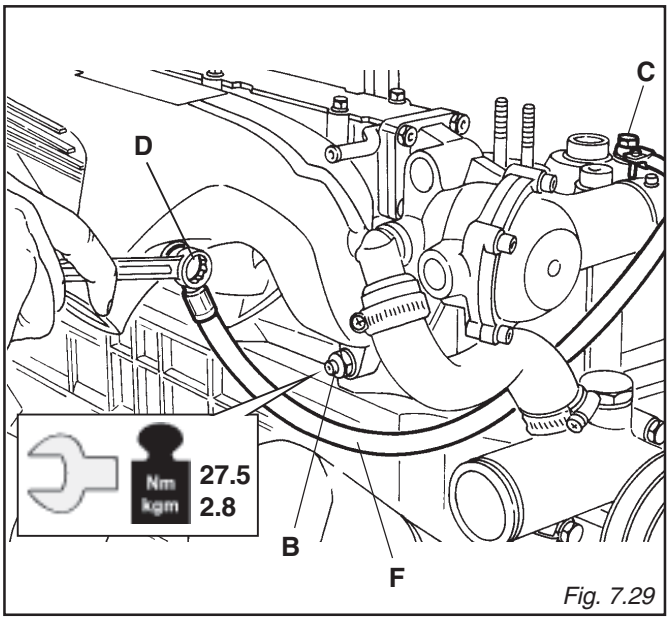
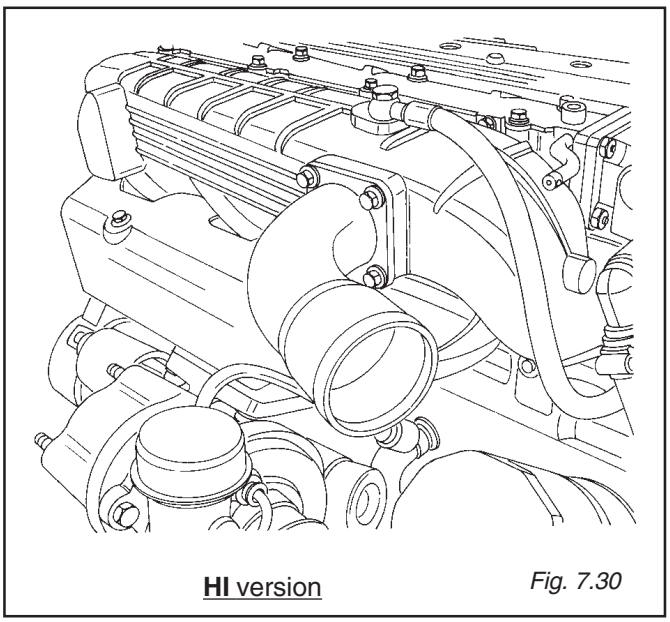


Fig. 7.29



HI version

Fig. 7.30

7.21 EXHAUST MANIFOLD *(FIG. 7.31-7.32-7.33)*

THE EXHAUST MANIFOLD IT'S BUILT-UP TWO PARTS. PUT THE EXHAUST MANIFOLD RINGS UP-DOWN AT 180°.

Mount the exhaust manifold **C** on the studs and tighten bolts **D** to the specified torque value.

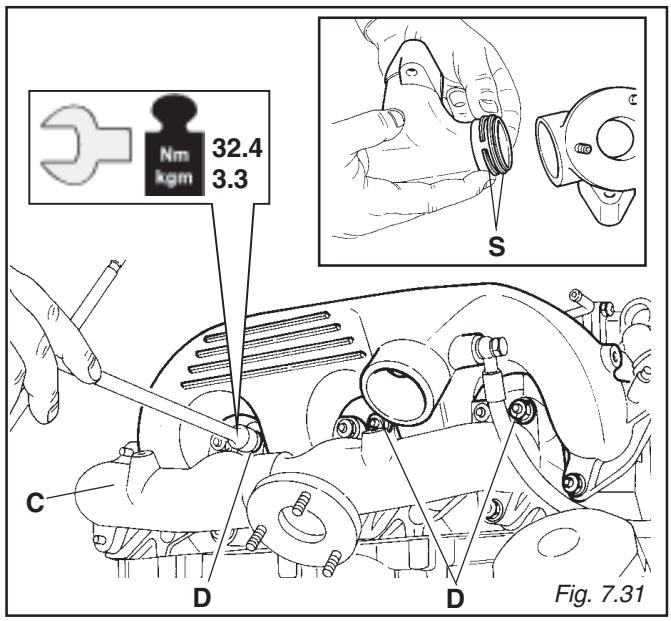


Fig. 7.31

(7.32)

Put the manifold heat shield **B** and tighten the bolds **A.**

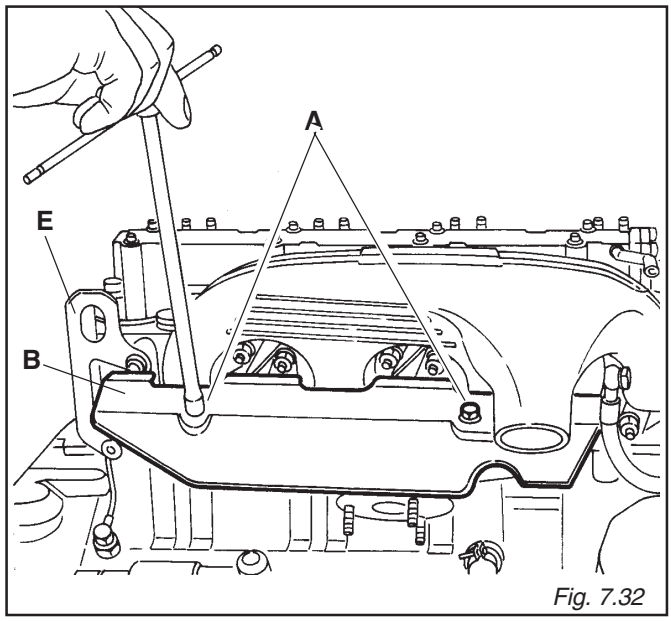


Fig. 7.32

(7.33)

Put the eyebolts **E** and **F,** tighten the nuts **G** and the screw **H**.

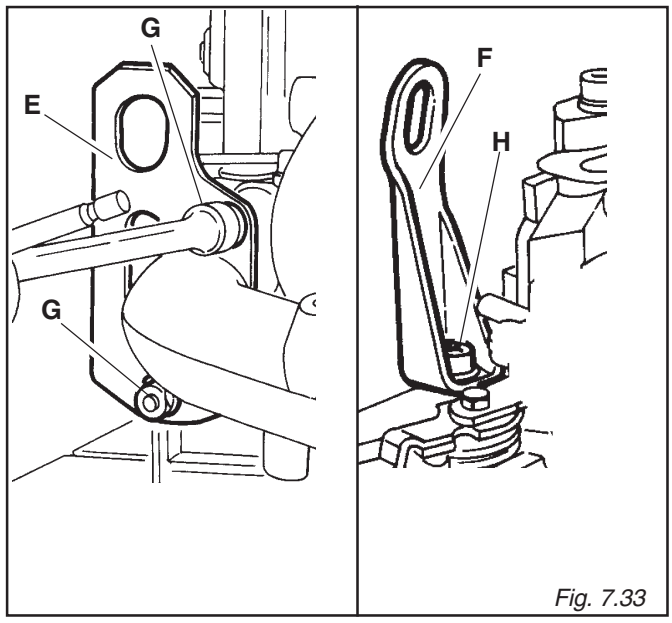


Fig. 7.33

7.22 TURBOCHARGER ASSEMBLY (FIG. 7.36)

Fit the turbocharger unit **H** making sure the gasket **L** is inserted and locked by means of nuts **M** tightened to the required value.

Tighten fixing screws **N** of clamps **P** tightening them.

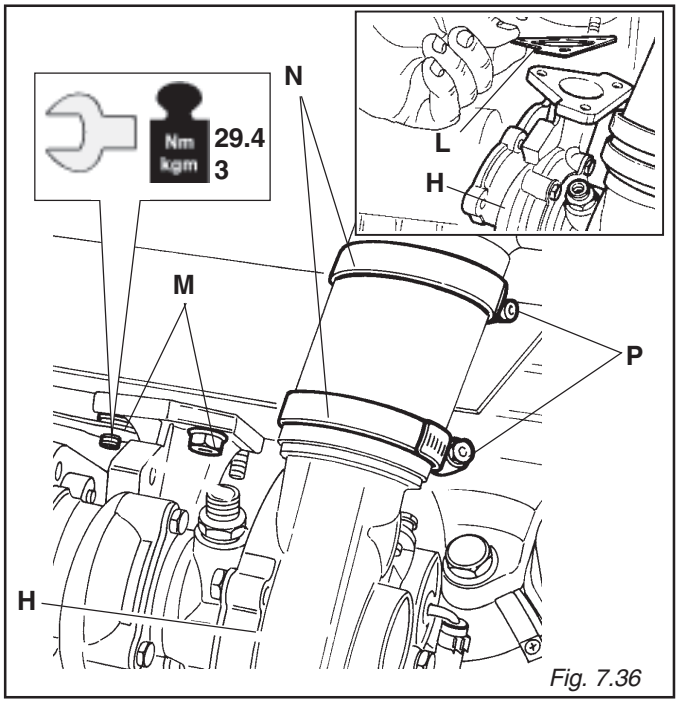


Fig. 7.36

7.23 TURBOCHARGER COUPLING PLATE *(FIG. 7.34 - 7.35)*

WITH THE ENGINE STOPPED CHECK TO ENSURE THAT THE WASTEGATE VALVE* (E) *IS CLOSED PERFECTLY.

(7.34)

Fit plate **C**, together with it's relative gasket **D**.

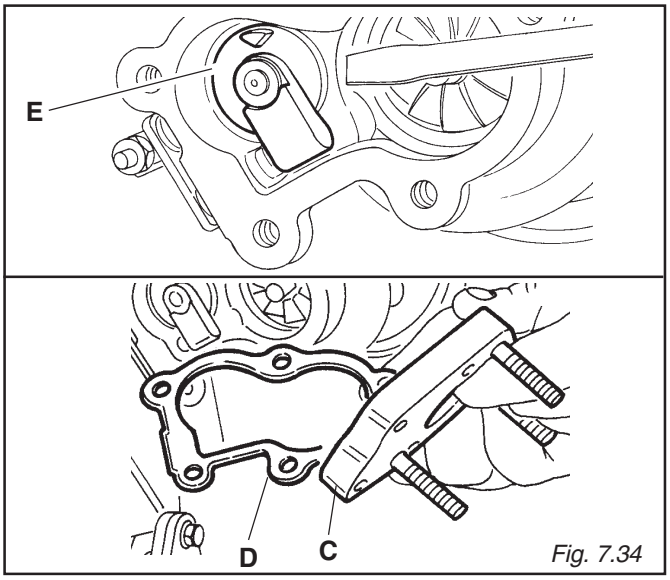


Fig. 7.34

(7.35)

Fit screws **A** and tighten them.

Lock nuts **B**.

Fit flange **F** and the relative gasket.

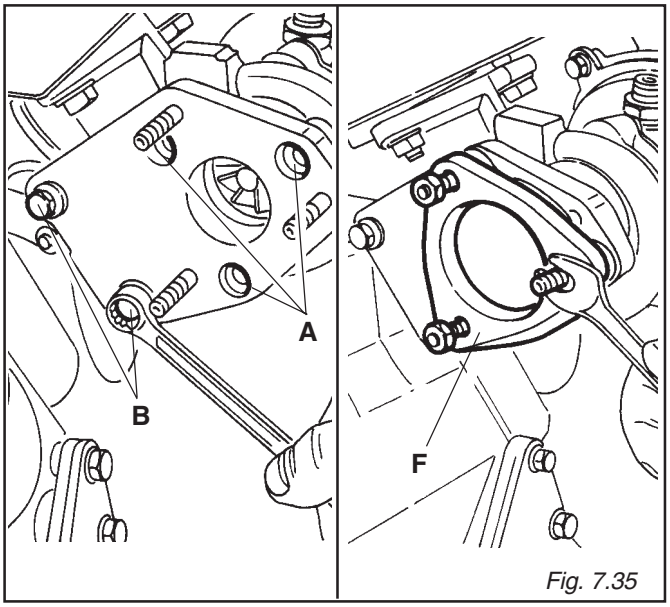


Fig. 7.35

7.24 OIL DELIVERY PIPE TO TURBOCHARGER *(FIG. 7.37)*

Fit the oil delivery pipe **A** to the turbocharger.
Block the tube **A** by means of connectors **B,** tightening them to the required value.

ALWAYS MAKE SURE TO FIT THE RELATIVE GASKETS.

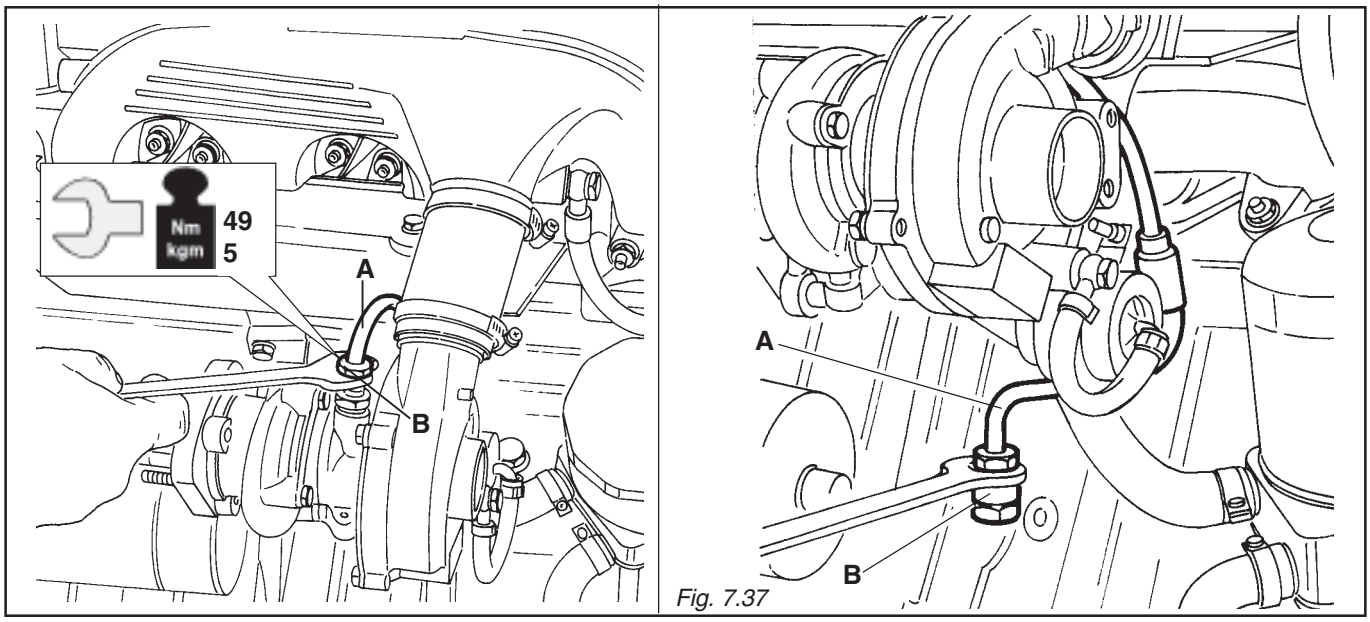


Fig. 7.37

7.25 OIL RETURN PIPE FROM TURBOCHARGER *(FIG. 7.38)*

Fit the oil return pipe **D,** locking it by means of nut.
Position bracket **E** fixing it by means of screws **F.**

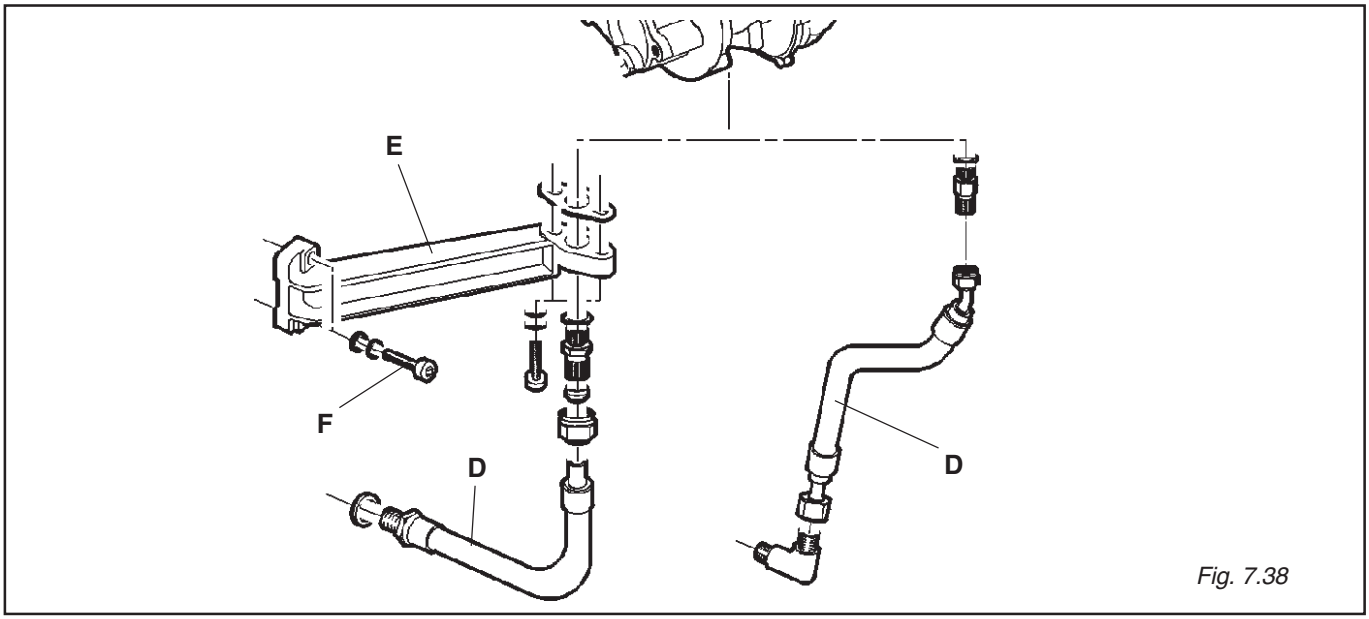


Fig. 7.38

7.26 ROCKER ARMS LUBRIFICATION PIPE *(FIG. 7.39)*

FIT THE ROCKER ARM LUBRIFICATION PIPE (A), ENSURING THAT THE CONNECTORS ARE FITTED WITH ALL THE RELATIVE GASKETS, AS SHOWN IN THE FIGURE.

Lock the pipe **A** by means of pipe unions **B,** tightening them to the required value.

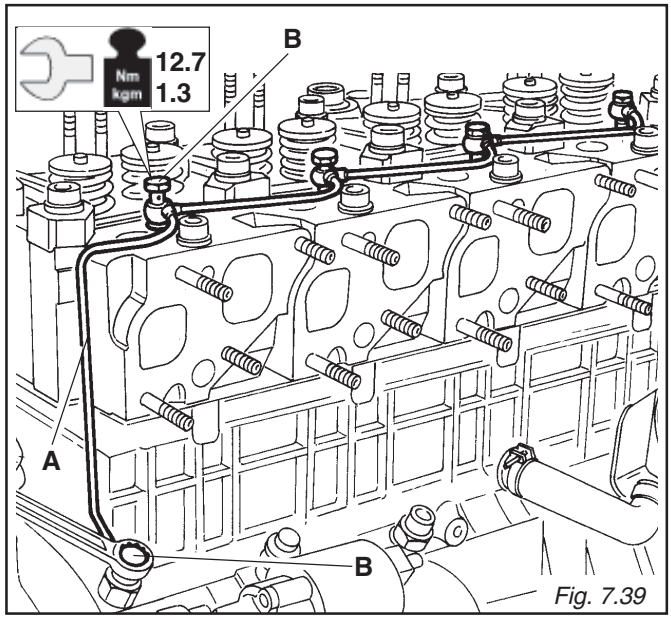


Fig. 7.39

7.27 ROCKER ARM RODS *(FIG. 7.40)*

Fit the rocker arm rods **C** manually.

ATTENTION: POSITION THE ROCKER ARM RODS (C) CORRECTLY ABOVE THE HYDRAULIC TAPPETS.

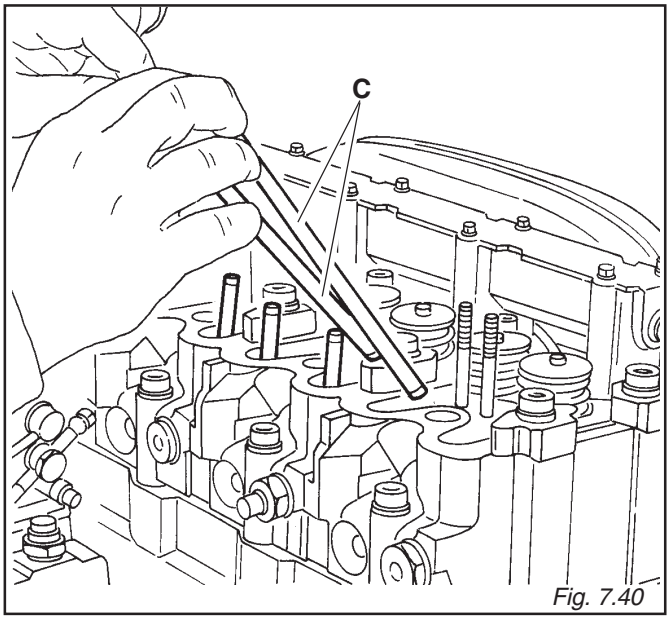


Fig. 7.40

7.28 ROCKER ARMS *(FIG. 7.41)*

Insert the rocker arms **A** on the stud bolts, and then the shim springs for clearance **B**.

Tighten the fixing nuts **C** to the required value.

LUBRICATE WITH SPECIAL OIL AND ADDITIVE

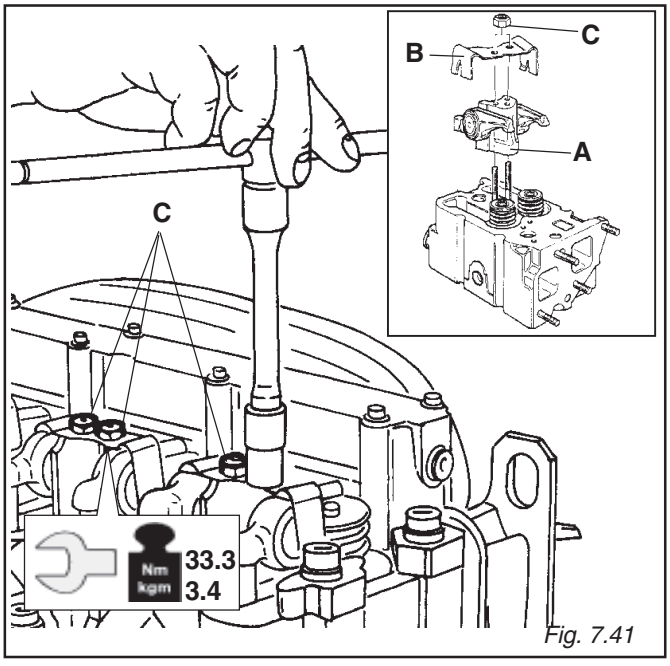


Fig. 7.41

7.29 GLOW PLUGS *(FIG. 7.42 - 7.43)*

Insert the glow plugs **A** and the plug **B** in their seats and tighten it to the required value.

TAKE CARE TO ENSURE YOU NOT INVERT THE ASSEMBLY POSITION OF THE GLOW PLUGS (A) WITH THE GLOW PLUG CAPS (B), WHICH HAVE THE FUNCTION OF MAINTAINING THE CORRECT COMPRESSION RATIO.
THE GLOW PLUGS (A) ARE PLACED ABOVE, VERTICALLY.

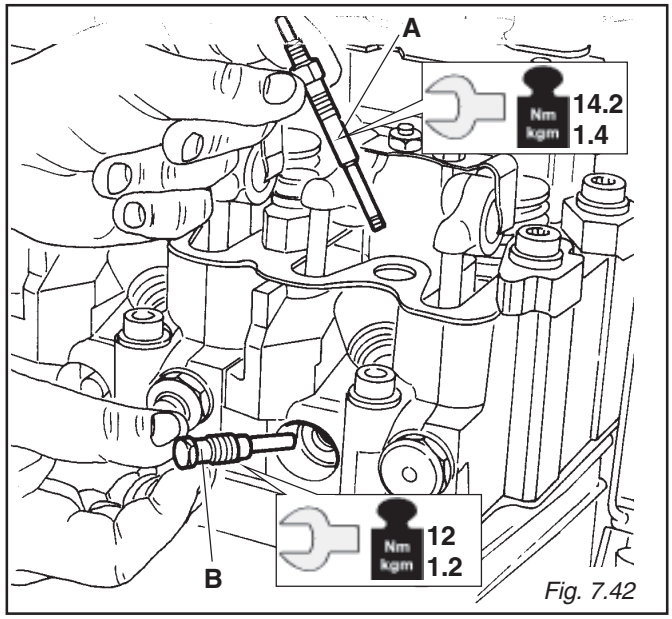


Fig. 7.42

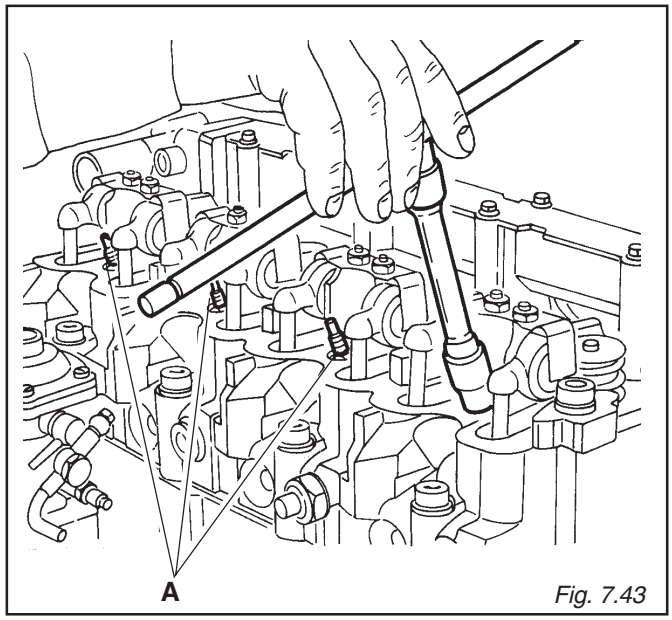


Fig. 7.43

7.30 CYLINDER HEAD COOLANT MANIFOLD *(FIG. 7.44)*

Position coolant **C** and the relative gaskets **D** on the engine block, and tighten the fixing screw **E** to the required value.

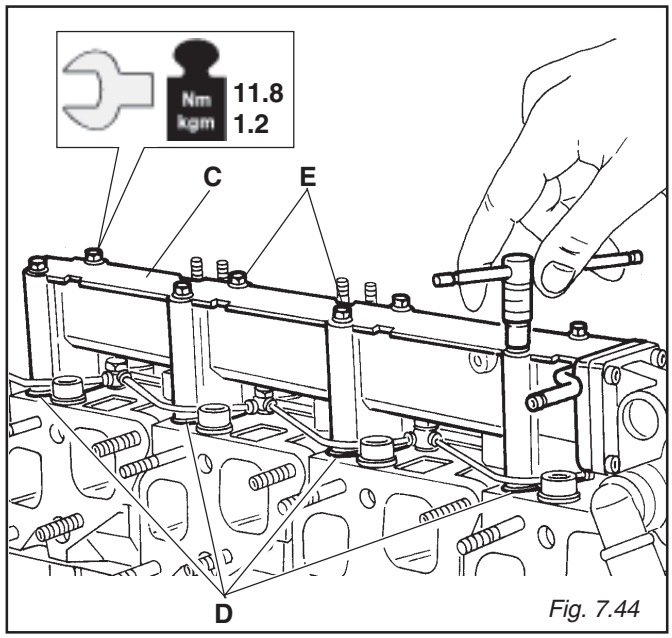


Fig. 7.44

7.31 ThERMOSTAT VALVE (Fig. 7-45)

Fit the thermostat valve **B**, with the deaeration hole upwards, as shown in the figure.

Fix the cover **A** by means of the relative screw **C** tightening them it.

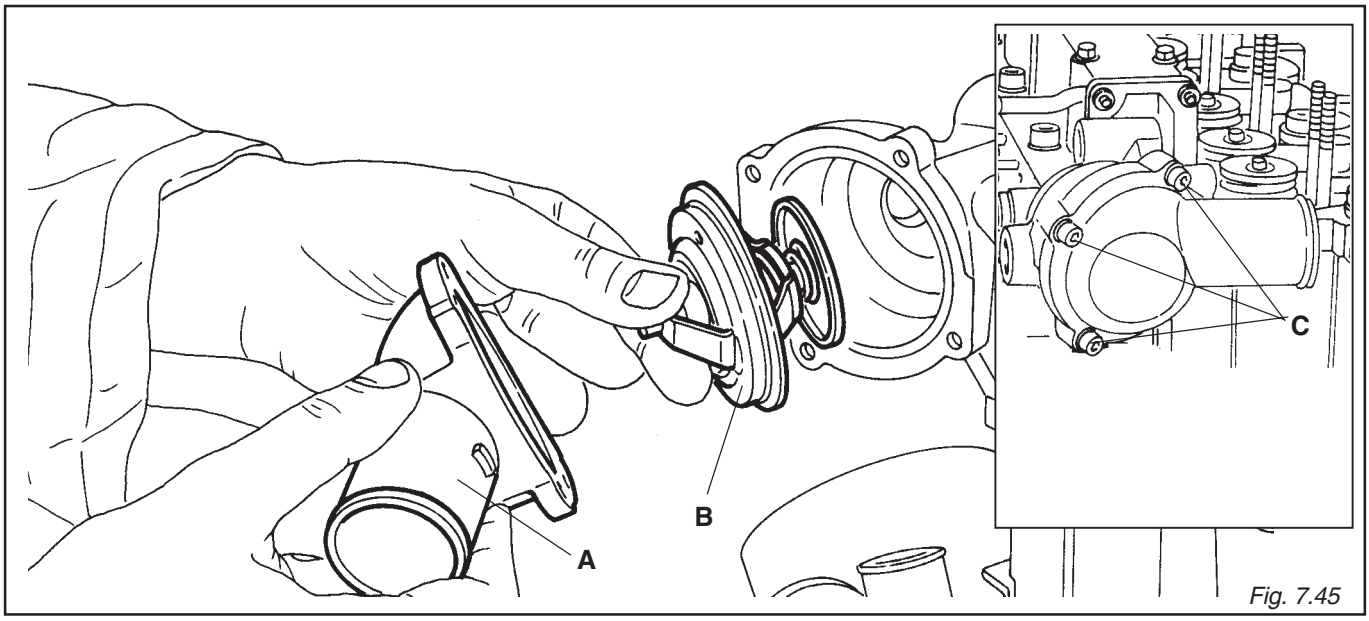


Fig. 7.45

7.32 CONNECTOR PIPE BETWEEN WATER PUMP AND THERMOSTAT VALVE (FIG. 7.46)

Fit the connector pipe **D** locking the clamp **E**, by means of screws **F**.

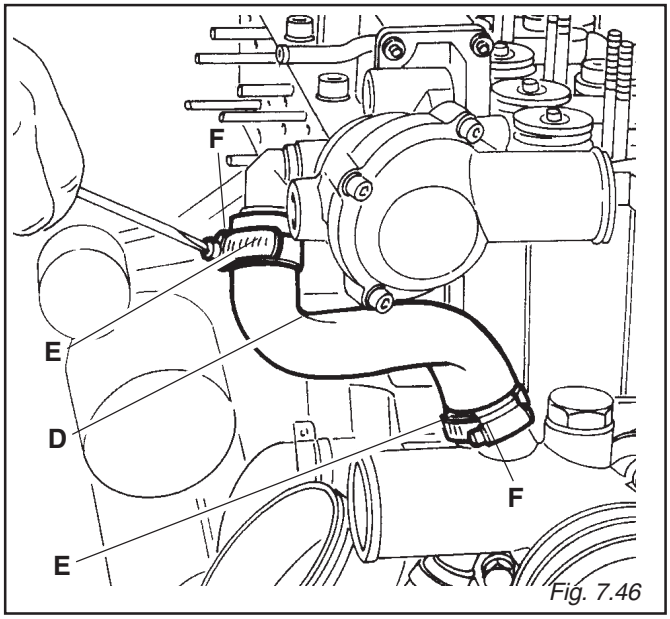


Fig. 7.46

7.33 ROCKER ARM COVER GASKET (FIG. 7.47)

Fit gasket **A**.

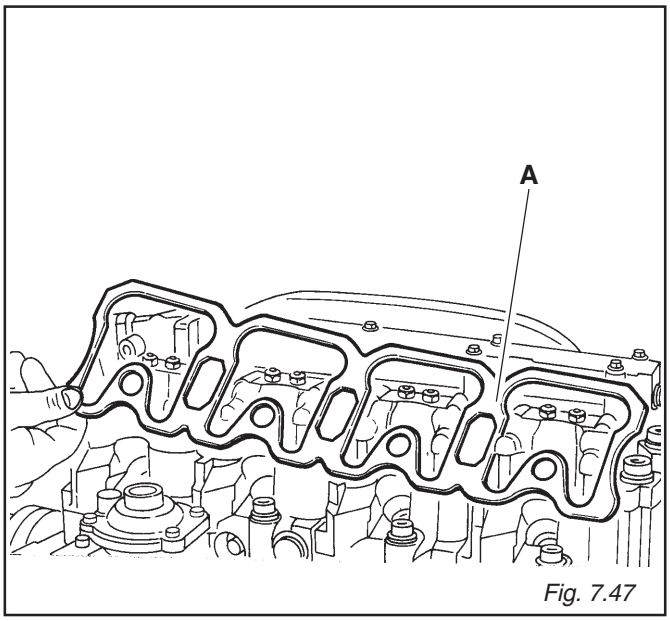


Fig. 7.47

7.34 ROCKER ARM COVER (FIG. 7.48)

Position cover **B** and fit locking screw **C,** tightening them to the required value.

Fit the breather pipe **D**.

Tighten clamp **E** using screw **F**.

THE ROCKER ARM COVER IN 6 CYLINDER ENGINES IS MADE OF TWO PARTS.

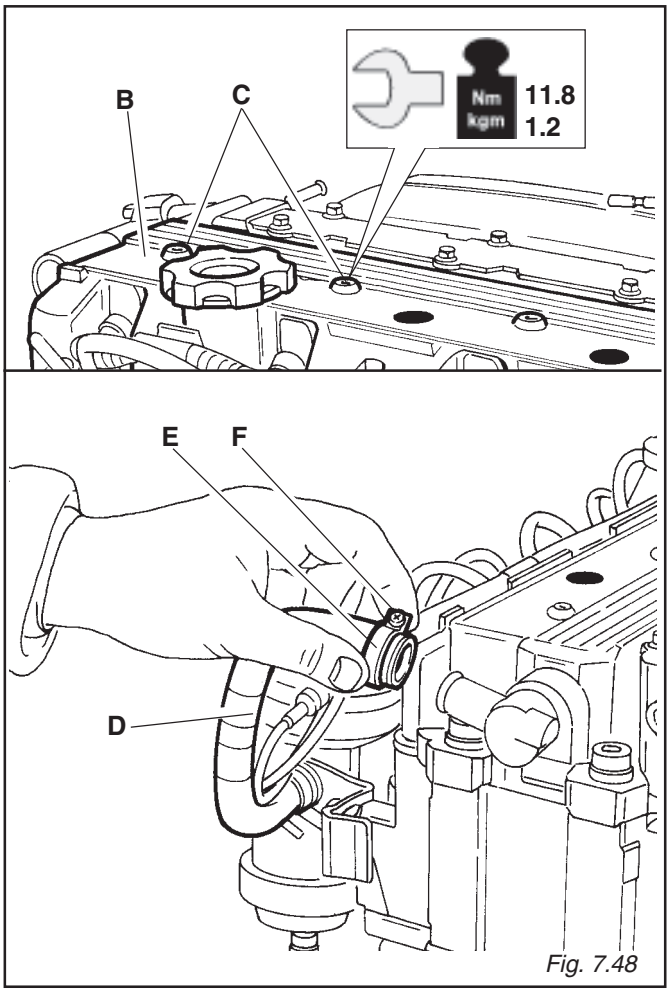


Fig. 7.48

7.35 INJECTORS *(FIG. 7.49)*

Fit the injectors **B** in their seats, and using the special tool **A** **(Tab. 11.1 ref. G)**, lock them in place.

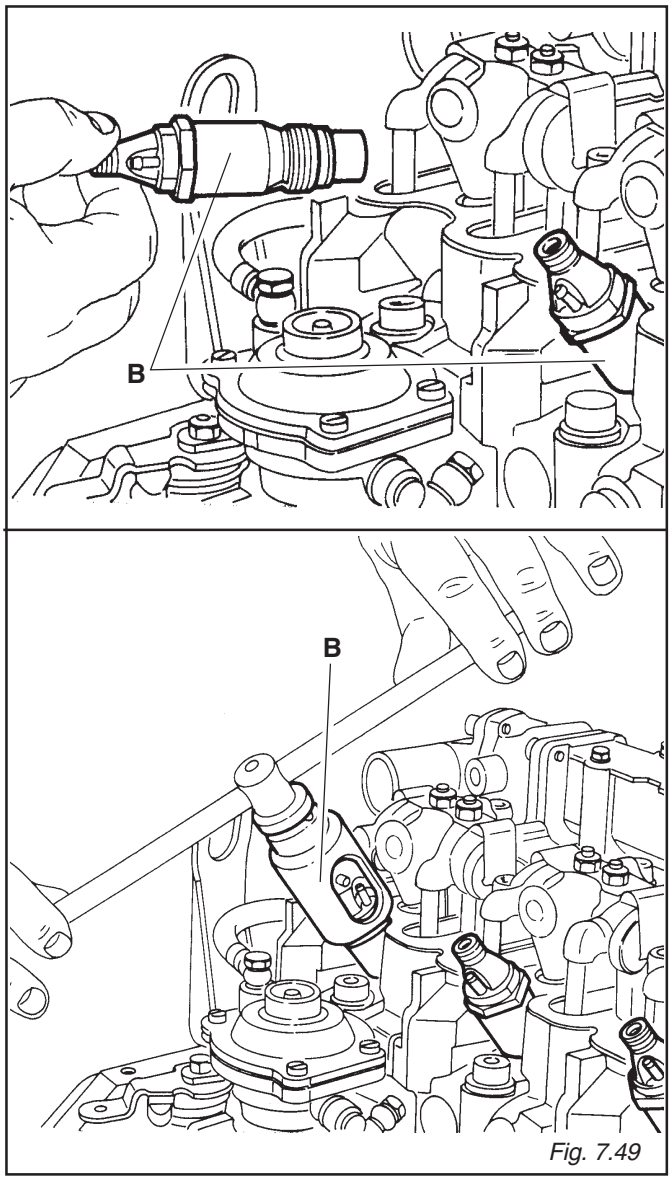


Fig. 7.49

7.36 OIL SEPARATOR *(FIG. 7.50 - 7.51 - 7.52)*

Fit the oil separator **A** by means of the special bracket **B.** Block the entire assembly by means of screw **C** tightening it.

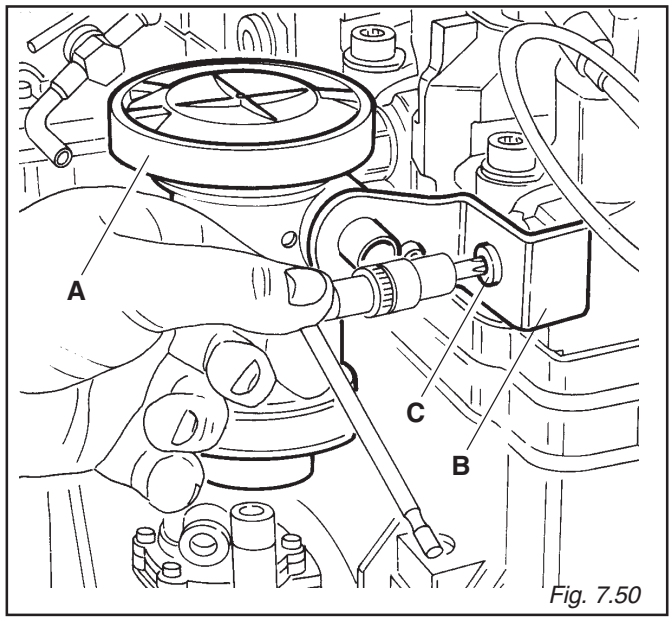


Fig. 7.50

(Fig. 7.51)

Connect the drain pipe **D** tightening clamp **E** by means of screw **F**.

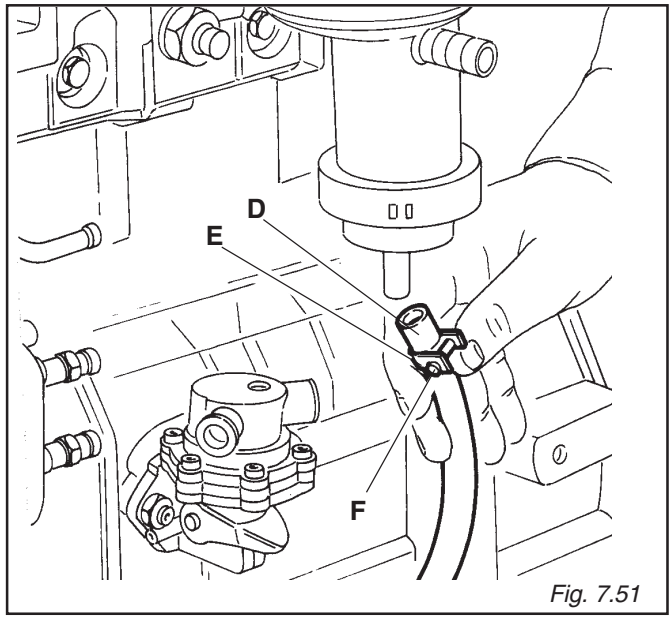


Fig. 7.51

(Fig. 7.52)

Connect the breather pipe **G**, tighten clamp **H** by means of locking screw **L**, tightening it, then connect the drain pipe **M** fixed by means of pipe union **P**, to the sump, and tighten it.

MAKE SURE THE RELATIVE GASKETS HAVE BEEN FITTED.

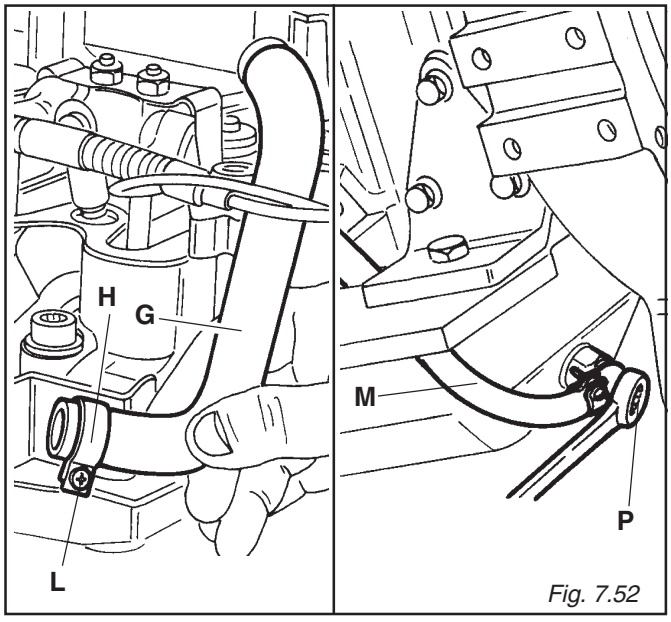


Fig. 7.52

7.37 GLOW PLUGS CABLE (FIG. 7.53)

Refit glow plugs cable **A**.

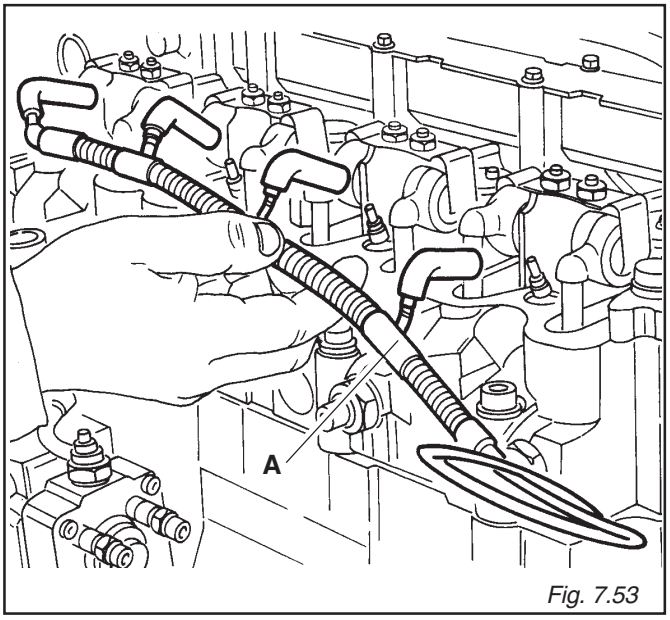


Fig. 7.53

7.38 INJECTION DELIVERY PIPES *(FIG. 7.54)*

Connect the injection delivery pipes **B** and lock them by means of connectors **C** and **D** by tightening to the required value.

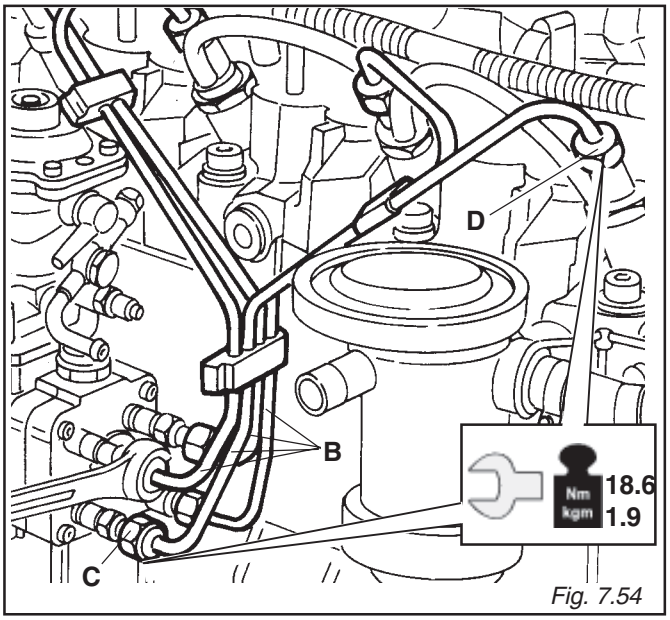


Fig. 7.54

7.39 INJECTION PUMP ASSEMBLY *(FIG. 7.55)*

Fit pump **E**.

Fit the injection pump in it's seating on the Crankcase the injection delivery pipes **B** and lock them by means of connectors **C** and **D** by tightening to the required value.

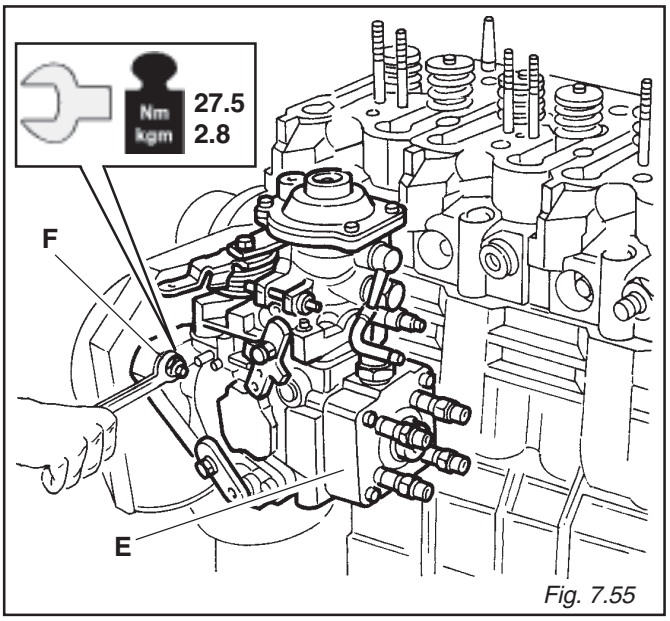


Fig. 7.55

7.39.1 INJECTION TIMING

- Fit the injection pump in its seat on the crankcase. Tighten the retaining nuts in the center of the adjustment slots.
- Check that the auto-advance lever **A** is in the rest position.
- Turn the pump shaft using a spanner on the nut and locknut to bring the key slot in correspondence with the feed pipe union for cylinder no.1 (first from timing end). This union is always the uppermost union on the crankcase side of the pump.
- Fit the crankshaft pulley temporarily.
- Fit special tool **B** **(TAB. 11.1 ref. T)** and turn the engine so that no. 1 cylinder is at the top of the compression stroke.

  Attach a pointer aligned with 0° (TDC) on the graduated scale of special tool **B**.
- Turn the engine back to 35÷40° before TDC.
- Then turn the engine in the normal direction of rotation (clockwise as viewed from timing end) to 25° before TDC.

  Remove the central screw **C** from the rear of the pump and fit special tool **(TAB. 11.1 ref. Z)** with a dial gauge **D**.
- Fit the pump drive gear, making sure that the tooth marked with a punch mark and/or the number of cylinders in the engine is positioned between the two punch-marked teeth on the camshaft gear.
- Tighten the injection pump gear nut to the specified torque of: **86.3 Nm (8.8 Kgm)**.
- Turn the engine counter-clockwise (as viewed from timing end) to find the point at which the needle on the dial gauge **D** stops moving. Zeroset the dial gauge at this point.
- Turn the engine clockwise (towards TDC) until the dial gauge indicates the value specified in the table on this page.

  This value should correspond to TDC.

  Small adjustments can be made as follows:
- Bring the engine to TDC.
- Loosen the injection pump retaining nuts.
- Turn the pump body until the dial gauge indicates the value specified in the table on this page.
- Re-tighten the pump retaining nuts and re-check the dial gauge reading.

INJECTION PUMP	
ENGINE TYPE	Pumping pre-stroke at TDC mm.
HR 494 HT2	0.78 ÷ 0.80
HR 694 HT2	0.88 ÷ 0.90
HR 494 HT3	0.72 ÷ 0.74
HR 694 HT3	088 ÷ 0.90
HR 494 HI3	0.72 ÷ 0.74

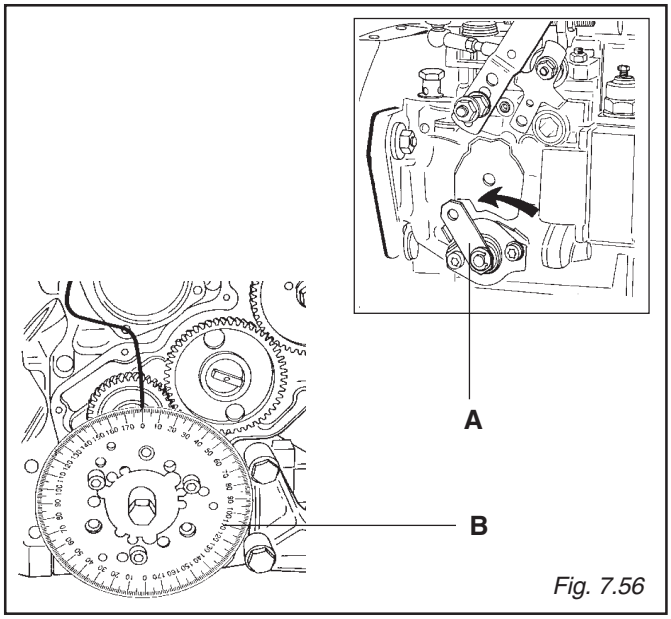


Fig. 7.56

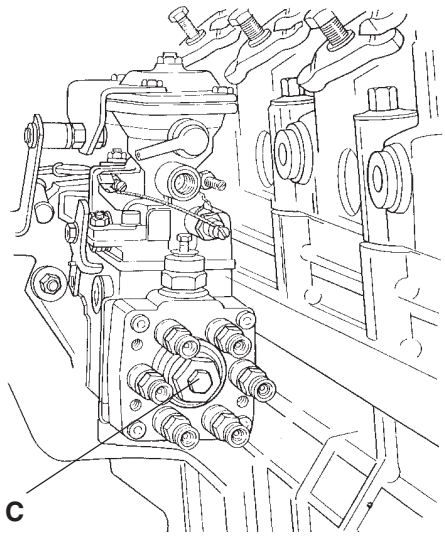


Fig. 7.57

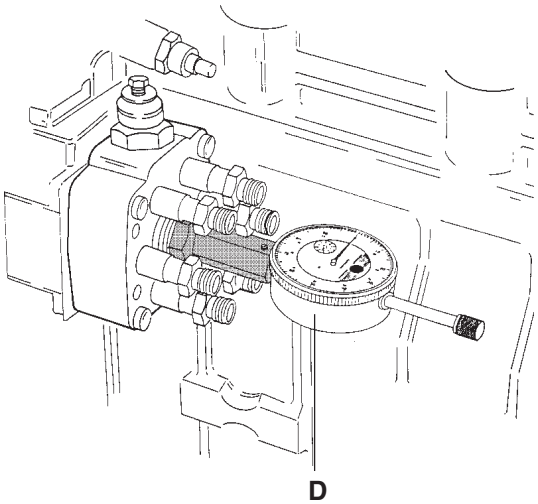


Fig. 7.58

7.39.2 KSB adjustment engine while carring out the fuel injection pump timing procedure. (Fig.7.59) (Fig. A).

- Loosen the lock screw **A** (Fig.A), and slide lever **B** and rod **C** on a rest position.

  This will release the pump advance lever and must be performed before carrying out the fuel injection pump timing procedure.
- Make sure that the cold start device is in the rest position (inactive).

KSB setting for correct operation(Fig. 7.59) (Fig. B).

- Loosen the adjusting collar assembly lock screw **A**, as shown in figure **A.**
- Rotate the lever **B** in a clockwise direction, until the collar assembly **D** stops against the black plastic coating **E** on rod **C,** as shown in figure **B.** A screw driver or pry tool may be used in the slot on the top of the lever to help overcome the mechanical force of the internal spring in the pump to properly position the lever.
- Tighten the lock screw **A** (Figure B)
- The KSB device is now in the working position and will function in the smoke control mode upon initial start-up and until the engine has reached normal operating temperature.
- The KSB device is controlled/activated by a water temperature switch in the cylinder head. It should be noted that the movement of the KSB upon engine warm-up is gradual and not instantaneous.

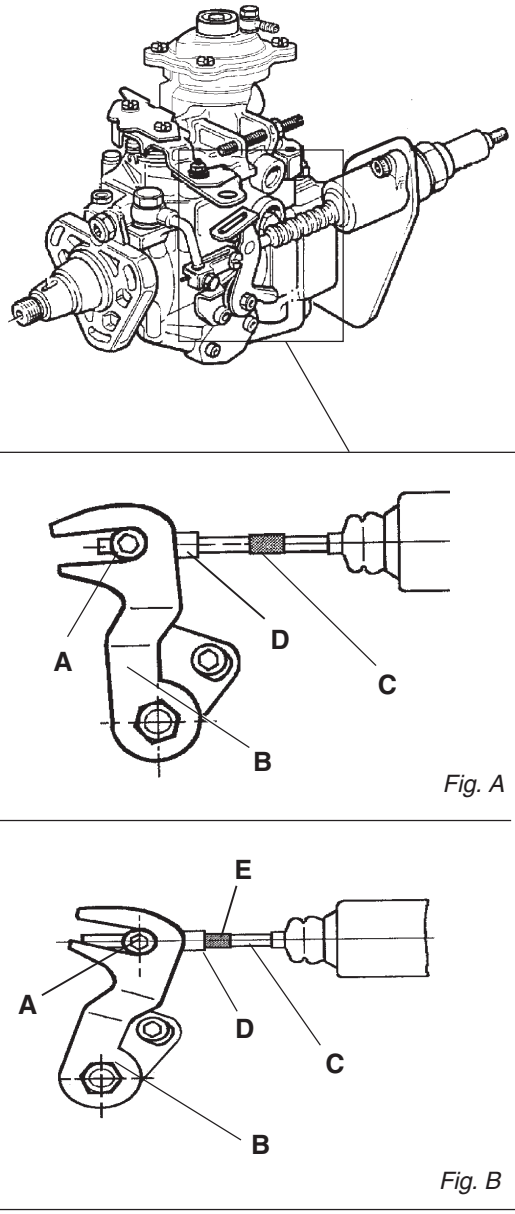


Fig. 7.59

7.40 INJECTOR FUEL FEED PIPES *(FIG. 7-60)*

Attach fuel feed pipes **A** see fig.7.60

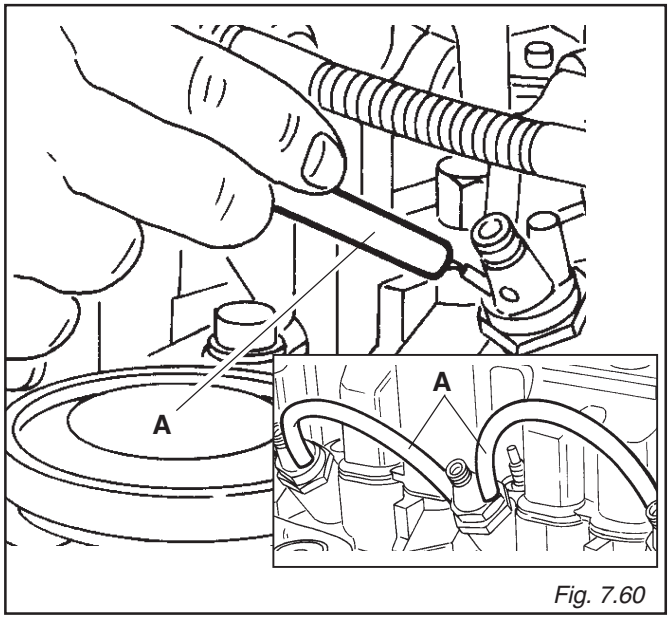


Fig. 7.60

7.41 PUMP FUEL FEED PIPE *(FIG.7-61)*

- Fit union **B** to the injection pump and tighten the union **C** with respective gasket **D**.

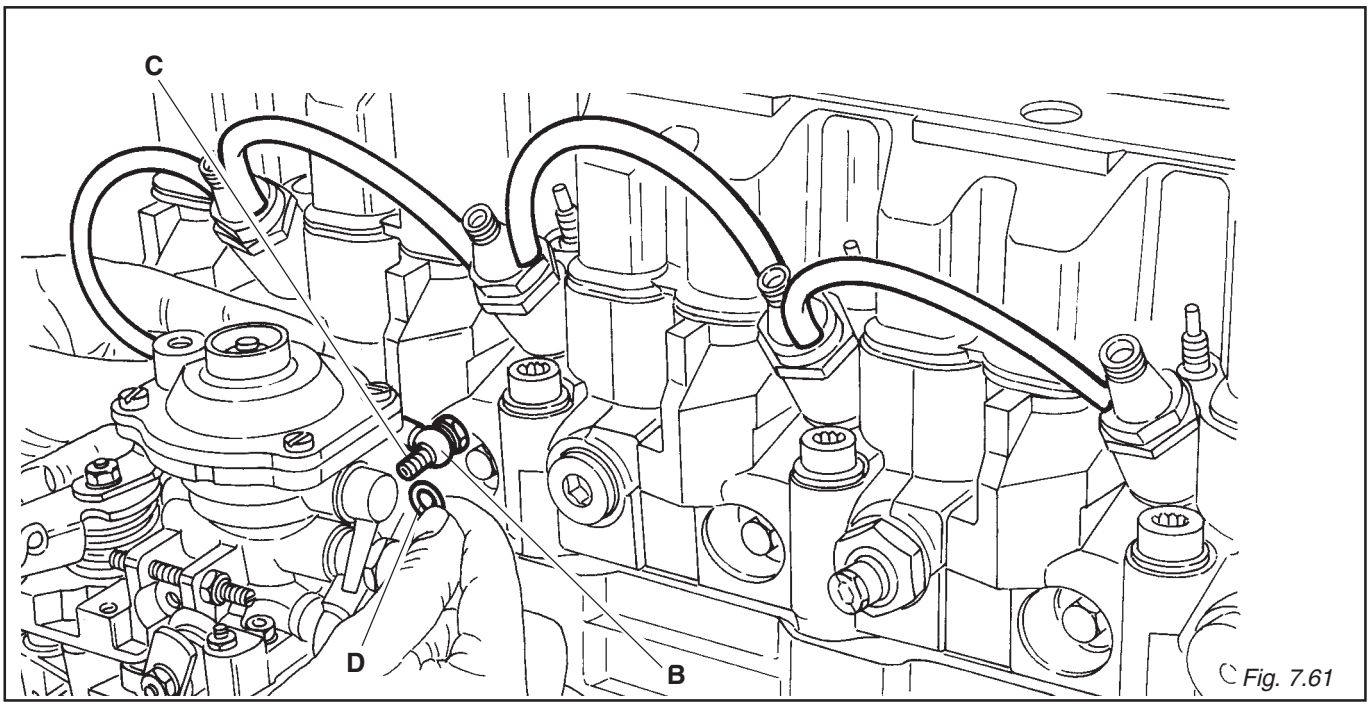


Fig. 7.61

7.42 TIMING COVER *(FIG. 7.62)*

ANTIFON COVER
Clean and degrease the surfaces in contact with the crankcase.
Apply a line of sealant along the entire perimeter **(A)**, without any gaps in the continuity and making sure you avoid the fixing holes, from the internal part of the cover.
Position the cover on the crankcase, which must have been previously cleaned and degreased, centring the reference pegs.
Insert the fixing screws and tighten them in a sequence to the torque setting indicated.

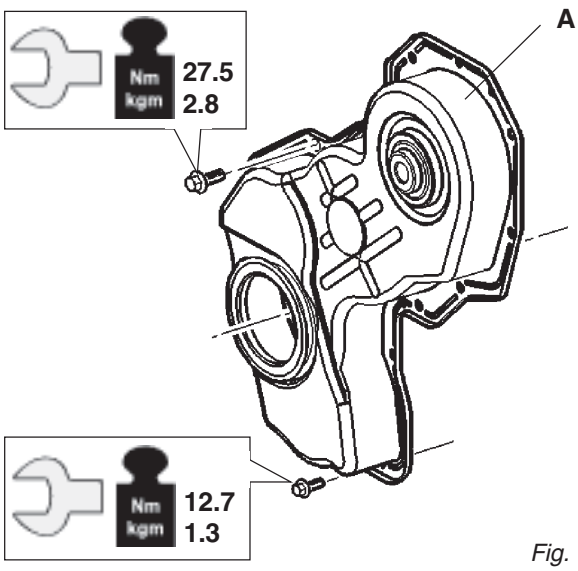


Fig. 7.62

7.43 COOLANT PUMP *(FIG. 7.63)*

Fit coolant pump **C** as shown in the figure.

Tighten bolts **D** to the specified torque.

Connect hose between pump **C** and thermostat valve **E**.

Tighten hose clamps**.**

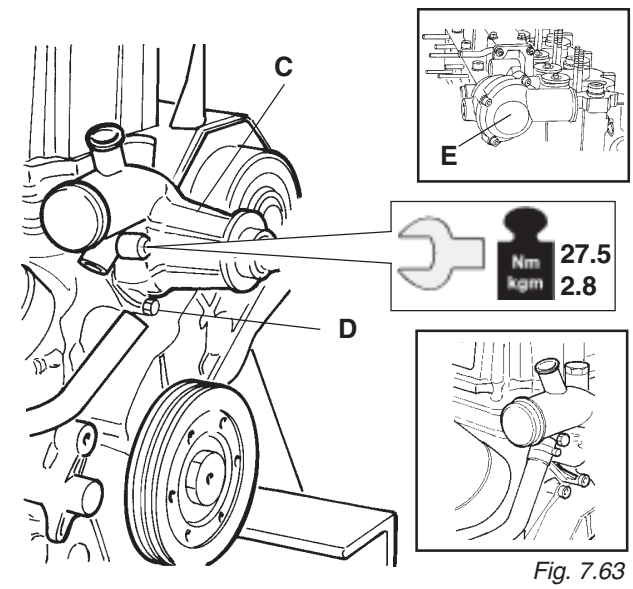


Fig. 7.63

Version **HI**

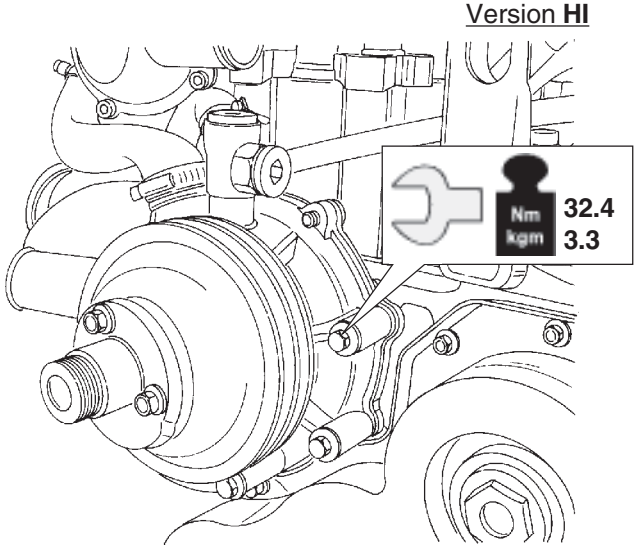


Fig. 7.63.1

7.44 TIMING COVER OIL SEAL *(FIG. 7.64)*

Fit together the two half rings **A** of special tool **(TAB 11.1 ref. I)** on timing cover **B**.

Fit the outer ring **C** of the tool as shown.

Gradually tighten bolts **D** to force the oil seal into its seat.

TIGHTEN BOLTS (D) EVENLY SO THAT THE OIL SEAL IS INSERTED STRAIGHT.

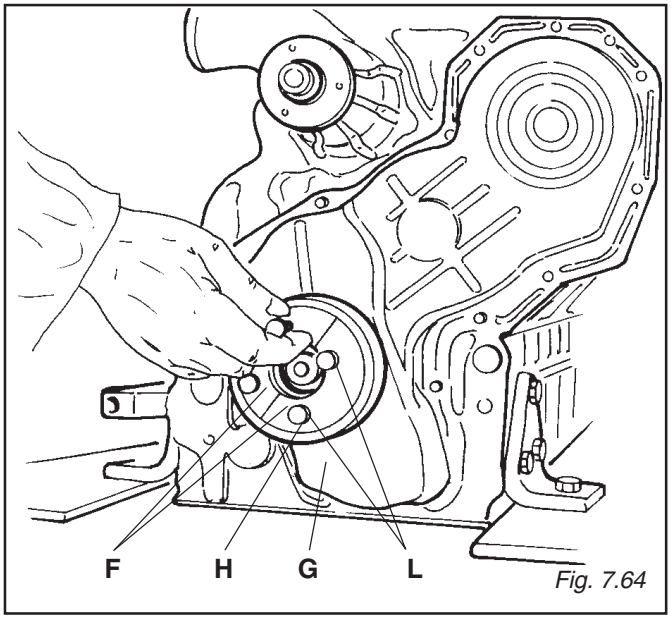


Fig. 7.64

7.45 CRANKSHAFT PULLEY *(FIG. 7.65)*

Fit pulley **A** to crankshaft.

APPLY SEALANT (LOCTITE 222) TO PULLEY NUT (B) BEFORE TIGHTENING TO SECURE PULLEY (A).

Tighten nut **B** to the specified torque.

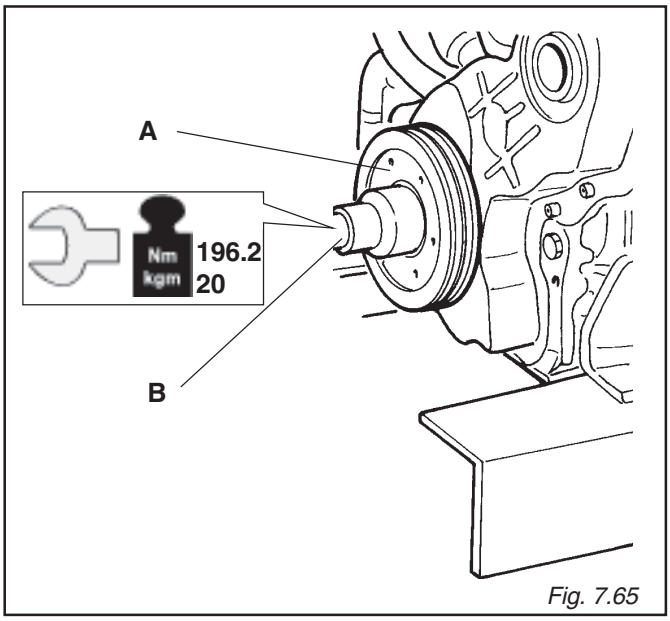


Fig. 7.65

7.46 OIL COOLER *(FIG. 7.66)*

(4-6 HT2 - 4 HT3-HI3) (FIG. 7.66)

(6 HT3) (FIG. 7.66a)

Fit oil cooler **C** as shown in the figure.

Tighten the internal union **B:**

for 4-6 HT2 / 4 HT3-HI3 to the specified torque value: **60 Nm (6.1 Kgm)**

for 6 HT3 to the specified torque value: **50 Nm (5.1 Kgm)**

Tighten the bolds **E**.

Connect the pipes and tighten clamps.

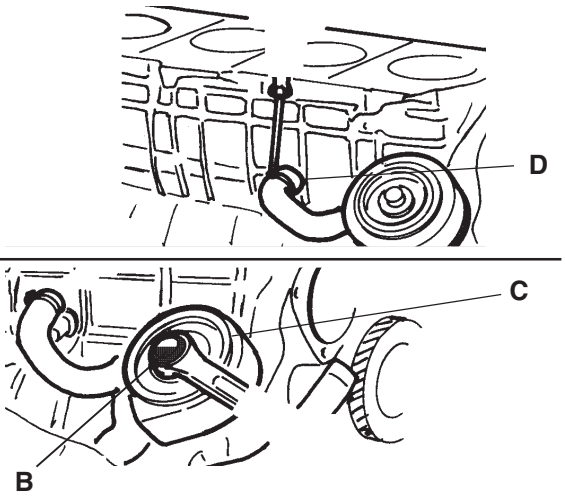


Fig. 7.66

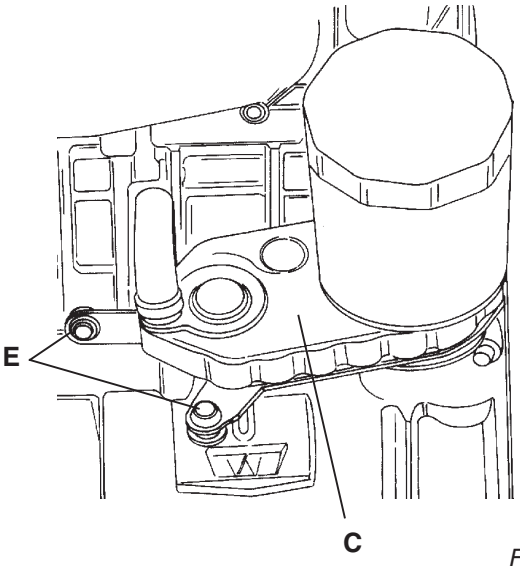


Fig. 7.66a

7.47 OIL FILTER *(FIG. 7.67)*

Lubricate the oil filter mounting and screw filter on to oil cooler using a standard commercial strap or chain wrench.

WARNING: WHEN TIGHTENING FILTER ONTO THE BASE, DO EXCEED IN THE TORQUE.

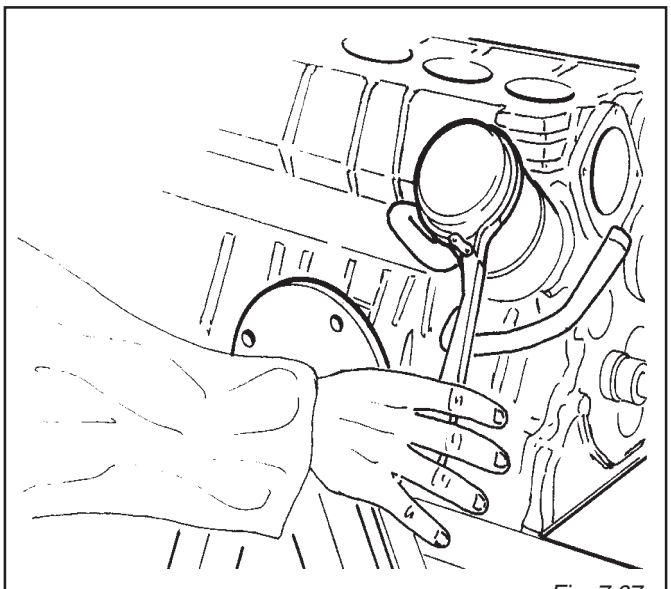


Fig. 7.67

7.48 COOLANT PUMP PULLEY *(FIG. 7.68)*

Fit pulley **A**.

Tighten nut **B** to specified torque value.

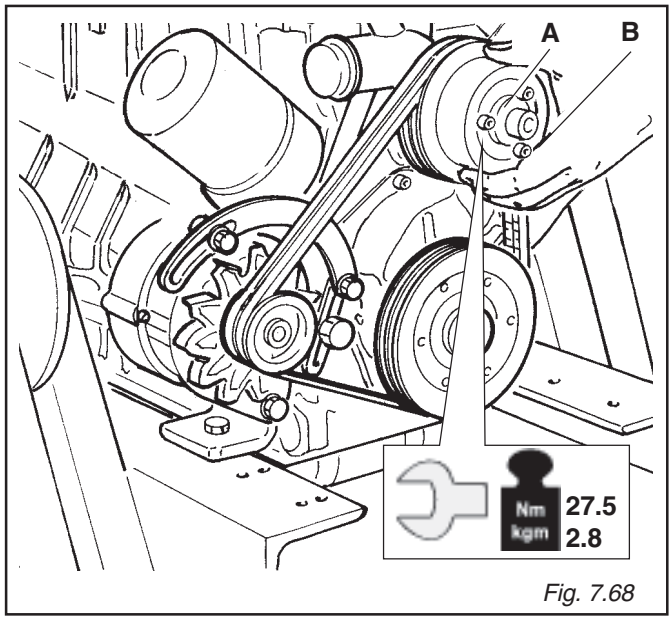


Fig. 7.68

7.49 ALTERNATOR *(FIG. 7.69)*

Fit the adjustment bracket **A** to the crankcase with nut **B** and tighten to specified torque value.

Fit alternator **C** and tighten nut **D** to specified torque value.

B = Nm kgm **47.1** **4.8**

D = Nm kgm **83.4** **8.5**

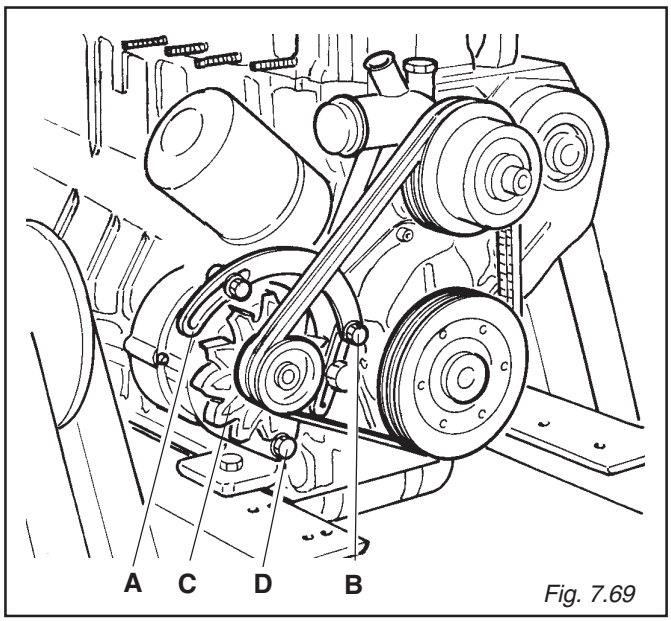


Fig. 7.69

7.50 DRIVE BELTS *(FIG. 7.70 - 7.70.1)*

Fit drive belts **G** to the pulleys as shown in the figure.

Move alternator **E** outwards to tension belts **G**.

Tighten nut **H** to specified torque value.

- To establish the correct tension of the belt (fig. 7.70), exert a pressure of 7÷ 8 Kg on the same, which shouldn't bend by more than 10mm.
- If the tension is taken using an electronic analyser, this should be placed in the tract indicated with an **L** (fig.7.70.1a) and making the belt vibrate to measure the values indicated below.
- New belt (first tensioning) 166 ± 4Hz
- Check (after 10 minutes running in) or after restarting 140 ± 4Hz.

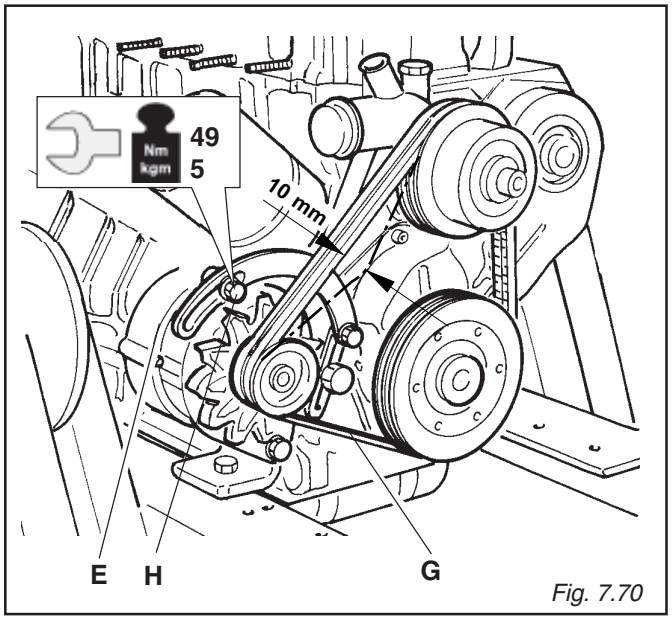


Fig. 7.70

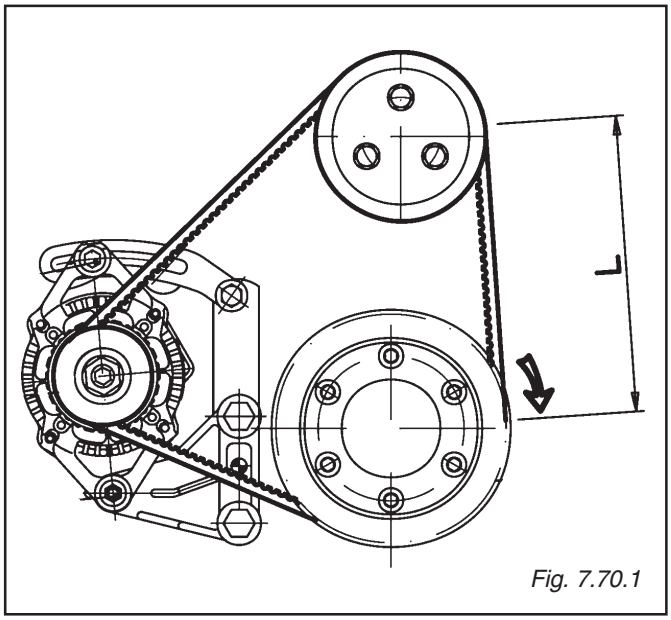


Fig. 7.70.1

7.51 FAN *(FIG. 7.71)*

Lock flywheel rotation using special tool **(TAB. 11.1 ref. V)** fixed with standard commercial screws.

Mount the fan **A** on the crankshaft pulley and screw in bolts **B** finger tight.

Tighten nut **B** (left-hand thread) to specified torque value: **27.5 Nm (2.8 Kgm)**.

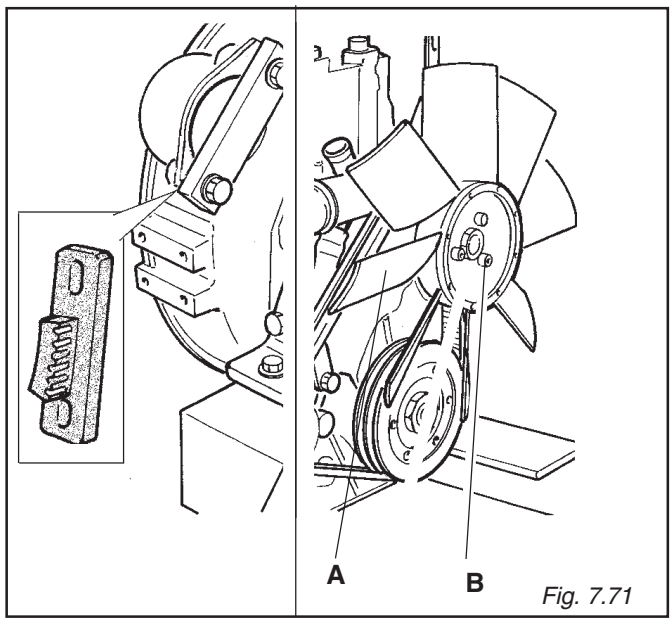


Fig. 7.71

7.52 STARTER MOTOR *(FIG. 7.72)*

Mount starter motor **D** on crankcase.

Tighten bolts **E** to specified torque value.

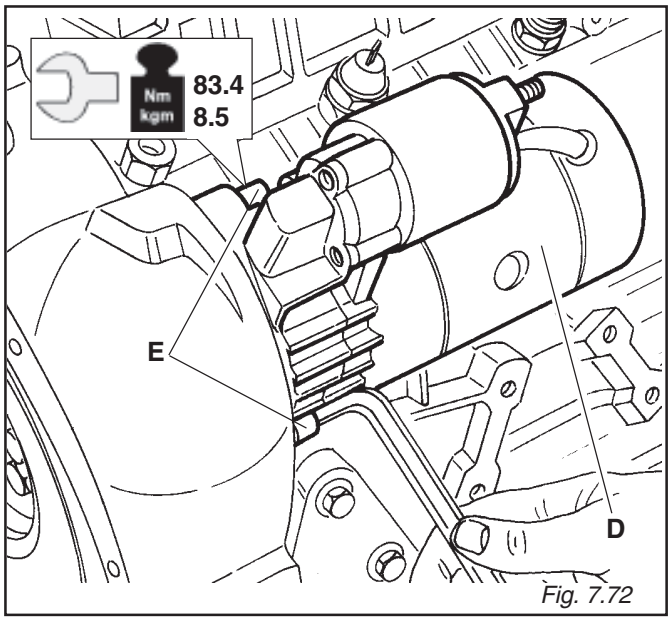


Fig. 7.72

7.53 FUEL SUPPLY PUMP *(FIG. 7.73)*

Fit pump **F** to the crankcase as shown in the figure, taking care not to damage the O-ring oil seal.

Tighten the self-locking nuts **G** to specified torque value.

WARNING: BEFORE FITTING THE FUEL PUMP (A), CHECK CONDITION OF THE O-RING AND REPLACE IF NECESSARY.

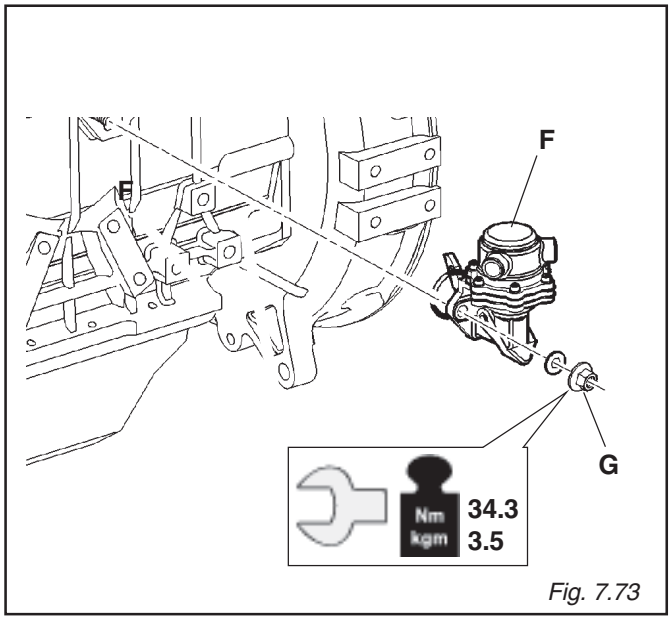


Fig. 7.73

7.54 FUEL FILTER *(FIG. 7.74)*

Fix the fuel filter support to the crankcase, connect the fuel filter pipes and tighten the banjo.

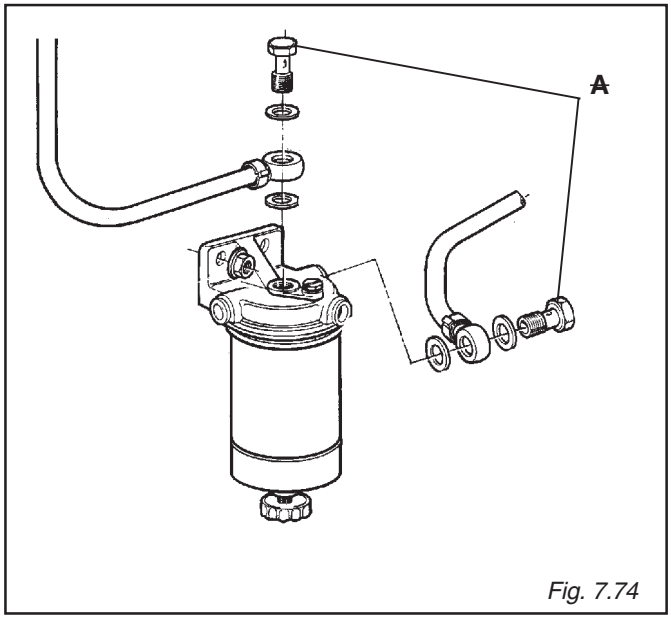


Fig. 7.74

TABLES

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8.1 TORQUE WRENCH SETTINGS STD. "B" SPECIFICATION (tolerance +5% -15%)

REF	DESIGNATION	THREAD	TORQUE		NOTES
			Nm	Kgm	
01	Banjo	M6x1	7,8	0,8	No Lubrificat.
02	Banjo LDA	M8x1	14,7	1,5	No Lubrificat.
03	Banjo	M10x1	25,5	2,6	No Lubrificat.
04	Banjo	M12x1,5	27,5	2,8	No Lubrificat.
05	Banjo	M14x1,5	39,2	4	No Lubrificat.
06	Nut	M5x0,8	5,4	0,6	No Lubrificat.
07	Nut	M6x1	10,8	1,1	No Lubrificat.
08	Nut	M8x1,25	27,5	2,8	No Lubrificat.
09	Nut	M10x1,5	47,1	4,8	No Lubrificat.
10	Nut	M12x1,5	18,6	1,9	No Lubrificat.
11	Compressor support nut	M12x1,75	68,6	7	No Lubrificat.
12	Nut	M16x1,5	53,9	5,5	No Lubrificat.
13	Pressure sensor	M10x1 Con.	17,7	1,8	No Lubrificat.
14	Pressure sensor	M12x1,5	24,5	2,5	No Lubrificat.
15	Pressure sensor	M14x1,5	39,2	4	No Lubrificat.
16	Trasmitter	M14x1,5	39,2	4	No Lubrificat.
17	Cnnection	M16x1,5	58,8	6	No Lubrificat.
18	Connection - plug	M18x1,5	63,7	6,5	No Lubrificat.
19	Connection	M20x1,5	68,6	7	No Lubrificat.
20	Plug	M10 X 1	39.2	4	No Lubrificat.
21	"	M14x1,5	37,3	3,8	No Lubrificat.
22	"	M 20x1,5	88,20	9	No Lubrificat.
23	"	M22x1,5	78,5	8	No Lubrificat.
24	Trasmitter	M10x1	32,4	3,3	No Lubrificat.
25	Trasmitter	M18x1,5	49	5	No Lubrificat.
26	Valve	M30x1,5	88,3	9	No Lubrificat.
27	Screw	M5x0,8	5,4	0,6	No Lubrificat.
28	"	M6x1	10,8	1,1	No Lubrificat.
29	"	M8x1,25	24,5	2,5	No Lubrificat.
30	"	M10x1,5	47,1	4,8	No Lubrificat.
31	"	M12x1,75	83,4	8,5	No Lubrificat.
32	"	M4	2,9	0,3	No Lubrificat.
33	"	M14x2	88,2	9	No Lubrificat.
34	Collar clamp with SM9 screw	M4	1,5	0,15	No Lubrificat.
35	DIN 3017 clamp from 16-27 to 32-50	senza fine	4,6	0,47	No Lubrificat.
36	DIN 3017 clamp from 40-60 to 140-160	senza fine	5,6	0,57	No Lubrificat.

8.2 DIMENSIONS

8.2.1 Crankshaft

REF.	DESCRIPTION	DIMENSIONS
A	Diameter of front main bearing journal	62.985 ÷ 63.005 mm
B	Diameter of center main bearing journal	63.005 ÷ 63.020 mm
C	Diameter of rear main bearing journal	before the modification 69.985 ÷ 70.000 mm after the modification 79.985 ÷ 80.000 mm from serial number: 64B/44846 65B/17359
	Conicity of rear main bearing journal	-0.015 ÷ -0.030 mm
D	Diameter of crankpin con-rod	53.955 ÷ 53.940 mm
	Undersizer **A-B-C-D**	0.250 mm
A-B-C	Roughness	0.22 µm
D	Roughness	0.18 µm

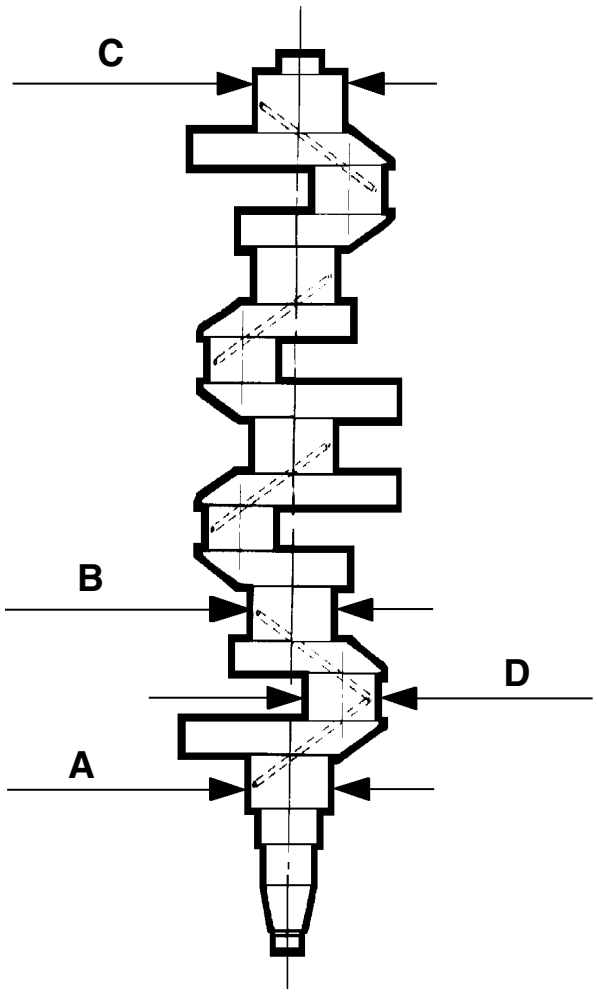

Fig. 8.2.1a

REF.	DESCRIPTION	DIMENSIONS
A	Radius	R = 3 0 /- 0.3 mm
B	Radius	R = 2.5 +/- 0.15 mm

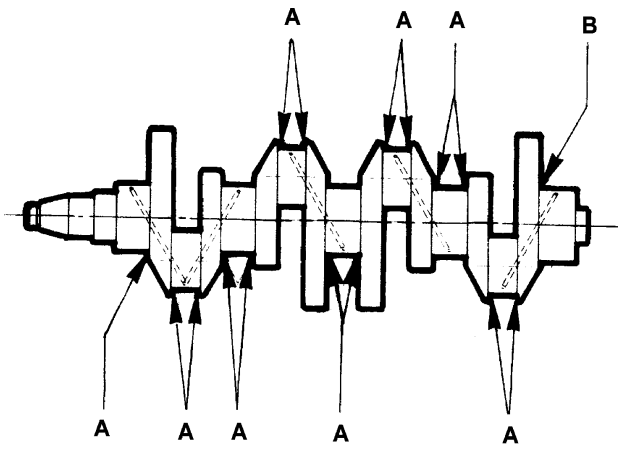

Fig. 8.2.1b

8.2.2 Camshaft

RIF.	DESCRIZIONE	DIMENSIONE
A	Diameter inlet	39.450 ÷ 39.550 mm
A1	Diameter exhaust	38.550 ÷ 38.650 mm
B	Lift inlet	6.85 mm
B1	Lift exhaust	7.30 mm
C	Diameter front journal	53.495 ÷ 53.510 mm
D	Diameter central main journal	53.450 ÷ 53.470 mm
E	Diameter rear main journal	53.480 ÷ 53.500 mm
	Undersizer **C-D-E**	0.250 mm
C-D-E	Roughness	0.8 µm

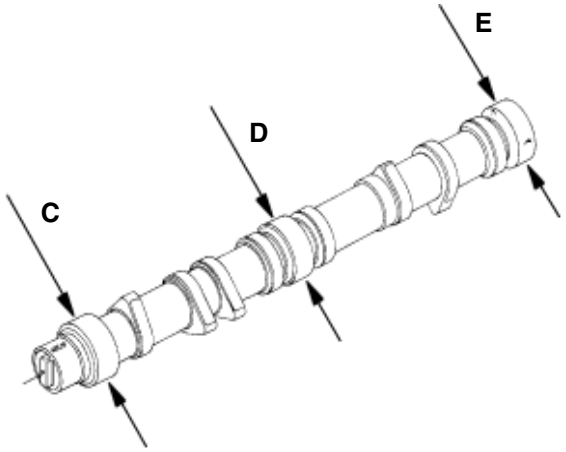

Fig. 8.2.2a

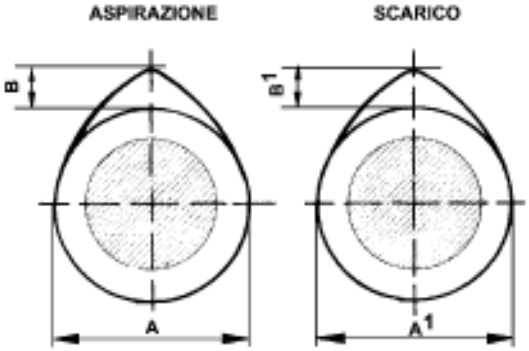

Fig. 8.2.2b

8.2.3 THRUSTWASHER

REF.	DESCRIPTION	DIMENSIONS
	Standard	2.310 ÷ 2.360 mm
	1st oversizer + 0.10	2.410 ÷ 2.460 mm
	2nd oversizer + 0.20	2.510 ÷ 2.560 mm

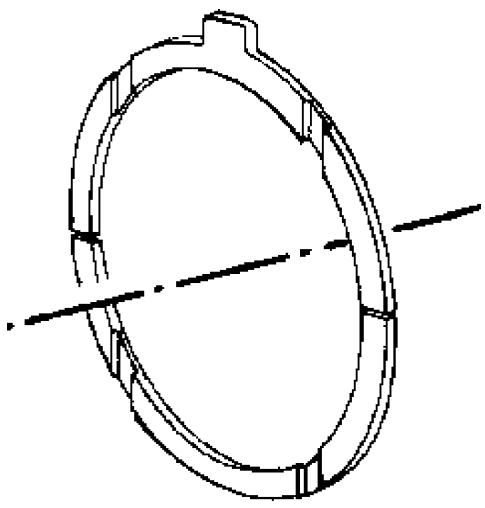

Fig. 8.2.3

8.2.4 Cylinder head gasket

Cylinder head gasket selection according to piston protrusion

Piston protrusion from cylinder block	0.53 ÷ 0.62 mm
Gasket	1.42
Piston clearance	0.80 ÷ 0.92
Piston protrusion from cylinder block	0.63 ÷ 0.72 mm
Gasket	1.52
Piston clearance	0.80 ÷ 0.89
Piston protrusion from cylinder block	0.73 ÷ 0.85 mm
Gasket	1.62
Piston clearance	0.77 ÷ 0.89
MAX PISTONS PROTRUSION DISALIGNIMENT	4 cyl. = 0.11 6 cyl. = 0.13

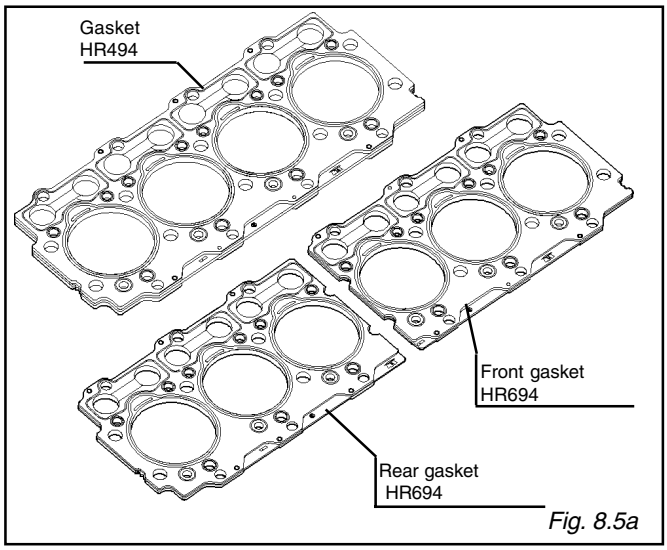

Fig. 8.5a

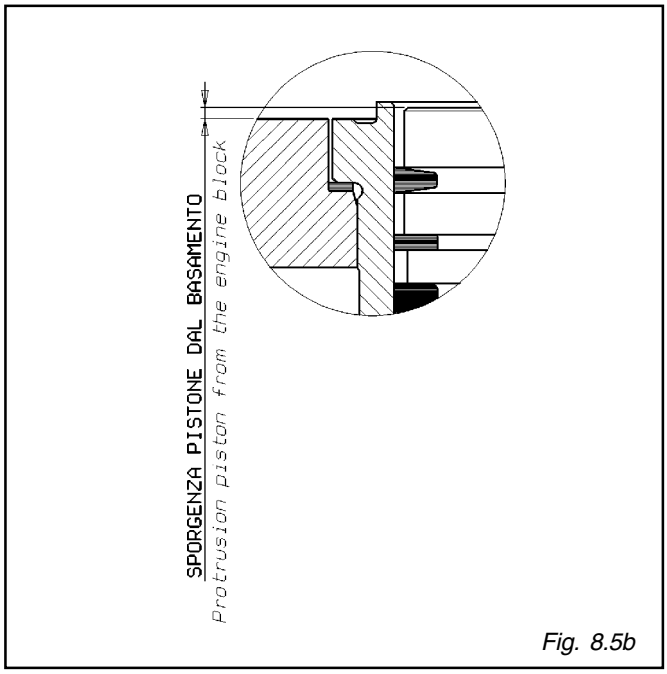

Fig. 8.5b

8.2.5 Cylinder head gasket identification

IDENTIFICATION	DIMENSIONS
	Thickness installed
Without mark	1.42 mm
n. 2 mark	1.52 mm
n. 1 mark	1.62 mm

8.2.6 Oil jet valve into the main bearing carrier

The oil jet valve opening at a pressure of:

150 - 200 kPa (1.5 - 2.0 bar)

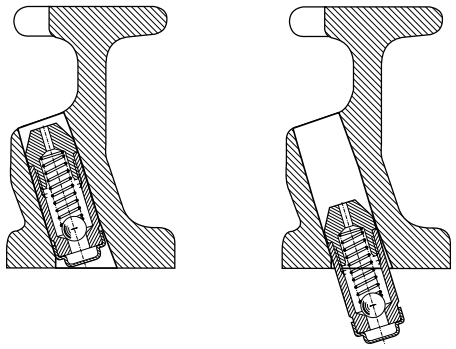

Fig. 8.2.6

8.2.7 Shims for cylinder liners

Are available the following shims **A**:

0.15 - 0.17 - 0.20 - 0.23 - 0.25 mm.

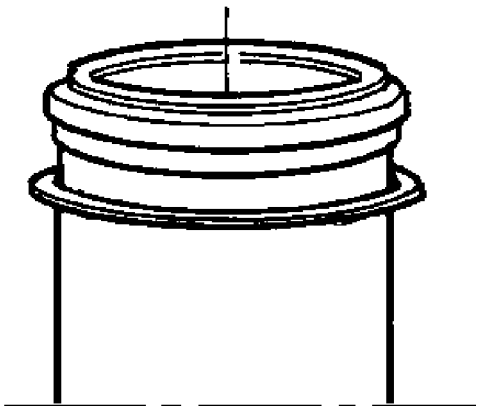

Fig. 8.2.7

8.3 PRICIPAL TECHNICAL DATA TABLES

DISTRIBUCTION:

α = 26° (Opens before TDC inlet valve)
β = 36° (Closes after TDC exaust valve)

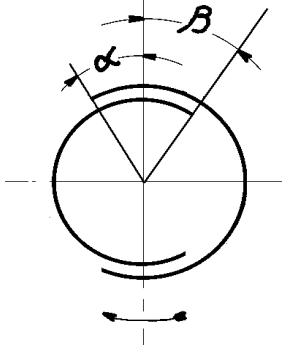

Fig. 8.15

VALVE TRAIN CONTROL ON ROLLER TAPPETS

Check with a dial gauge the cam lift is 1 mm. with the following angle position.

α = 8° (After TDC inlet valve)
β = 16° (Before TDC exaust valve)

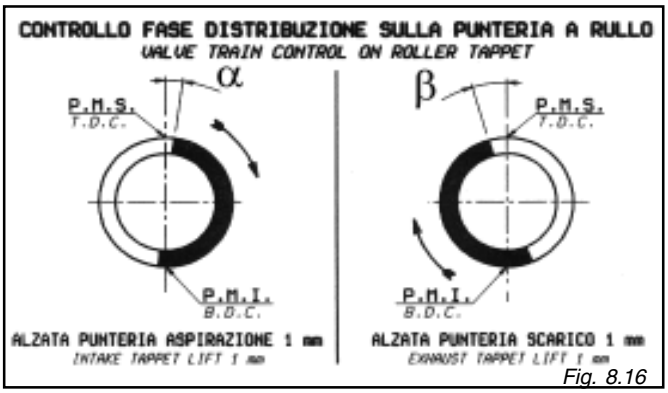

Fig. 8.16

FIRING ORDER:

HR494: 1 - 3 - 4 - 2
HR694: 1 - 5 - 3 - 6 - 2 - 4

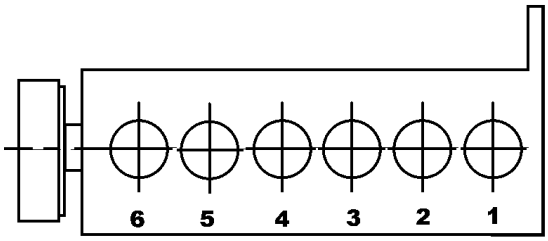

Fig. 8.18

8.4 CONVERSION FACTORS TABLES

	To Convert From	To	To Convert Multiply By
Length	mm	inch	0.03937
	cm	inch	0.3937
	m	foot	3.2808
Area	mm^2	sq. in.	0.00155
	m^2	sq. ft.	10.76
Volume	cm^3	cu. in.	0.06102
	litre, dm^3	cu. ft.	0.03531
	litre, dm^3	cu. in.	61.023
	litre, dm^3	imp. gallon	0.220
	litre, dm^3	U.S. gallon	0.2642
	m^3	cu. ft.	35.315
Force	N	lbf	0.2248
Mass	kg	lb.	2.205
Power	kW	hp (metric)	1.36
	kW	bhp	1.341
	kW	BTU/min.	56.87
Torque	Nm	lbf ft.	0.738
	Nm	kgf m	0.102
	kgf m	lbf ft.	7.233
Pressure	bar	psi	14.5
	atmosphere	psi	14.7
	kPa	in H_2O	4.0
	in H_2O	psi	0.0361
	in Hg	psi	0.490
	bar	kgf cm^2	1.0197
Fuel Consump.	g/kWh	g/hph	0.736
	g/kWh	lb/hph	0.00162
Inertia	kgm^2	$lbft^2$	23.734
Flow	l/s	cu.ft./min.	2.1189
Speed	m/s	ft.per/min.	196.85
Temp.	°F=1.8x°C+32		

	To Convert From	To	To Convert Multiply By
Length	inch	mm	25.40
	inch	cm	2.540
	foot	m	0.3048
Area	sq. in.	mm^2	645.2
	sq. ft.	m^2	0.093
Volume	cu. in.	cm^3	16.388
	cu. ft.	litre, dm^3	28.320
	cu. in.	litre, dm^3	0.01639
	imp. gallon	litre, dm^3	4.545
	U.S. gallon	litre, dm^3	3.785
	cu. ft.	m^3	0.0283
Force	lbf	N	4.448
Mass	lb.	kg	0.454
Power	hp (metric)	kW	0.735
	bhp	kW	0.7457
	BTU/min.	kW	0.0176
Torque	lbf ft.	Nm	1.356
Pressure	psi	bar	0.0689
	psi	atmosphere	0.0680
	in H_2O	kPa	0.25
	psi	in H_2O	27.7
	psi	in Hg	2.04
	kgf cm^2	bar	0.98
Fuel Consump.	g/hph	g/kWh	1.36
	lb/hph	g/kWh	616.78
Inertia	$lbft^2$	kgm^2	0.042
Flow	cu.ft./min.	l/s	0.47194
Speed	ft.per/min.	m/s	0.00508
Temp.	°C=.55x(°F-32)		

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9.0 RUNNING TESTS AND ADJUSTMENTS

The instructions in the following chapter "Running tests and adjustments" apply to all the series engines.

9.1 PRE-STARTING CHECK

On completion of engine assembly, proceed as follows:

- Mount the engine on a suitable base or dynamometer, or install in the vehicle.
- Check level of oil in sump.
- On engines fitted with oil-bath air filters, also check oil level in filter.
- Connect the starter motor and the injection pump solenoid valve (Bosch or Stanadyne) to the battery.

9.2 FILLING THE COOLING CIRCUIT

Fill the circuit with a coolant mixture including 50% fresh demineralised water and 50% antioxidant antifreeze (inibited ethilene glicol) that meets the ASTM D 3306 requirements.(available from specialized sales outlets).

WARNING: TAKE CARE WHEN HANDLING ANTIOXIDANT ANTIFREEZE AVOID CONTACT WITH EYES AND SKIN.

WARNING:
DO NOT INGEST ANY OF THE LIQUIDS USED IN THE ENGINE.

Run the engine for a few minutes until all parts of the system are full of coolant and free from air bubbles.

Check the level and top up if necessary.

WARNING:
THE COOLANT LEVEL MUST BE CHECKED OUT EVERY DAY AND IF NECESSARY IT MUST BE TOPPED UP WITH IDENTICAL MIXTURE.
AVOID TO REFILL WITH DIFFERENT REFRIGERANT MIXTURE DIFFERENT FROM THE ONE WHICH IS ALREADY IN THE CIRCUIT.
THE COOLANT MIXTURE MUST BE TOTALLY DRAINED AND REPLACED AT LEAST EVERY 24 MONTHS.
FOR COOLING SYSTEM CAPACITY, SEE CHAP. 2.

WARNING:
THE USE OF A COOLANT WHICH DOES NOT COMPLY WITH THE ABOVE SPECIFICATIONS COULD CAUSE DAMAGE TO ENGINE COMPONENTS AND WILL INVALIDATE THE WARRANTY.

9.3 BLEEDING AIR FROM THE FUEL SYSTEM *(FIG. 9.2)*

Before bleeding the system, check that the fuel supply pump is primed so it can deliver the maximum quantity of fuel. Prime the pump by operating the priming lever **A**; the lever will move freely for the initial part of its travel and then will encounter more resistance, confirming the pump is being operated.

If this second working stroke is only short, turn the crankshaft through 180° to release the pump from the pump control cam on the camshaft.

- To bleed the air from the system, loosen off the bleed screw **B** on the fuel filter and operate the lever **A** until a continuous flow of fuel is obtained from the bleed screw.

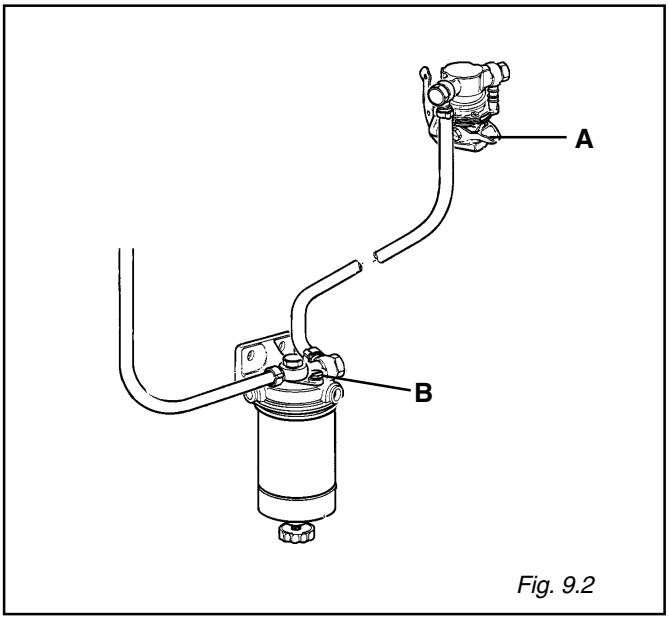

Fig. 9.2

WEAR SAFETY GOGGLES TO PROTECT AGAINST RISK OF FUEL SPRAYING OUT UNDER PRESSURE.

WEAR GLOVES TO PROTECT SKIN FROM CONTACT WITH FUEL.

9.5 IDLE RUNNING TEST

All adjustments are to be made with the engine hot and with the aid of a tachometer.

- Run the engine at low speed to warm it up to normal operating temperature.
- Connect a 10 kPa pressure gauge to the last main bearing carrier oil line on the crankcase and check the oil pressure while the engine is running.
- Check for possible oil or water leaks, abnormal noise or vibration.
- Check the electrical system.

9.6 ENGINE SPEED ADJUSTMENT *(FIG. 9.4)*

Idle speed and maximum no-load engine speed are to be set on the test bench.

- Check that the engine idle speed is a specified in the table on page 2.5. Adjust if necessary by way of screw **A** (Bosch injection pump).

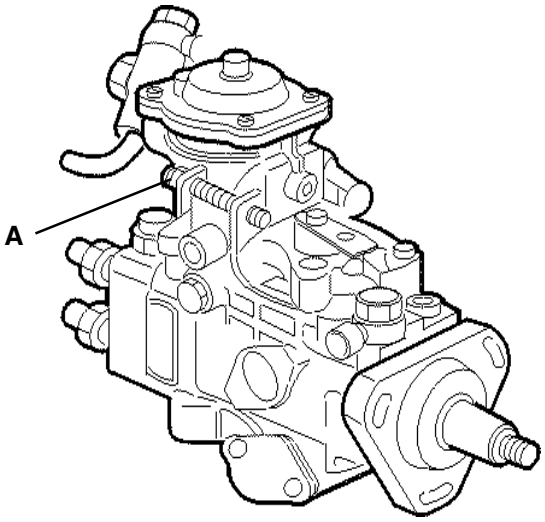

Fig. 9.4

9.7 RUNNING-IN

After replacing parts requiring running-in or after a full engine overhaul, do not exceed 70% of the maximum power rating for the first operating hours.

9.8 EXHAUST BACK PRESSURE *(FIG. 9.5)*

Attach a liquid U-tube pressure gauge to the exhaust (after the turbocharger on turbocharged models). The optimum back pressure values at max rpm are:

HR494 HT2-3/HI3 **20** kPa (0.2 bar - 2.9 psi)

HR694 HT2-3 **20** kPa (0.2 bar - 2.9 psi)

If the back pressure is over **25** kPa (0.25 bar - 3.7 psi) check the exhaust pipe or muffler.

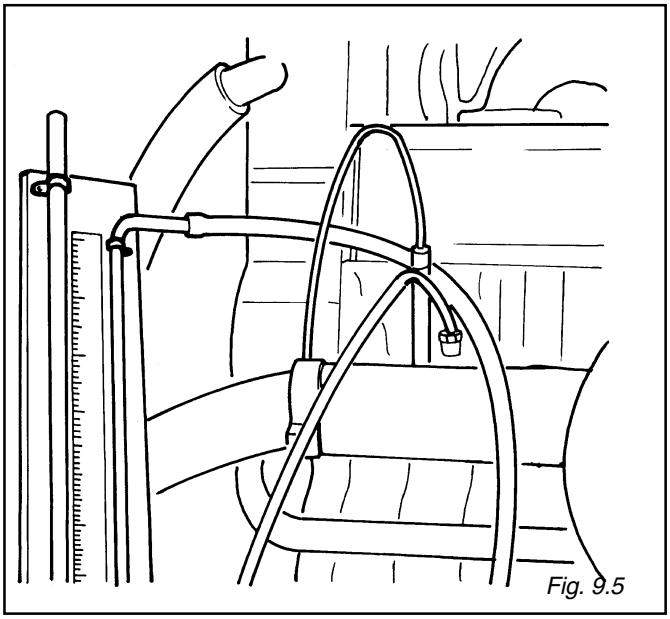

Fig. 9.5

9.9 ADJUSTING FUEL FLOW RATE

Fuel flow rate is normally set on the engine test bench. Due to the difficulties involved in testing the fuel flow rate when the engine is installed in the vehicle, we recommend that, before proceeding with any adjustments, you make sure that the problem is in fact due to an insufficient or excessive fuel supply.

9.10 BOSCH ROTARY INJECTION PUMP *(FIG. 9.6)*

Turbocharged engines only: turn screw **A** to adjust the quantity of fuel delivered at maximum engine speed (screw in to increase flow, screw out to reduce flow). To adjust the quantity of fuel delivered up to 2000 rpm, turn ringnut **B** (clockwise to increase flow, counter-clockwise to reduce flow).

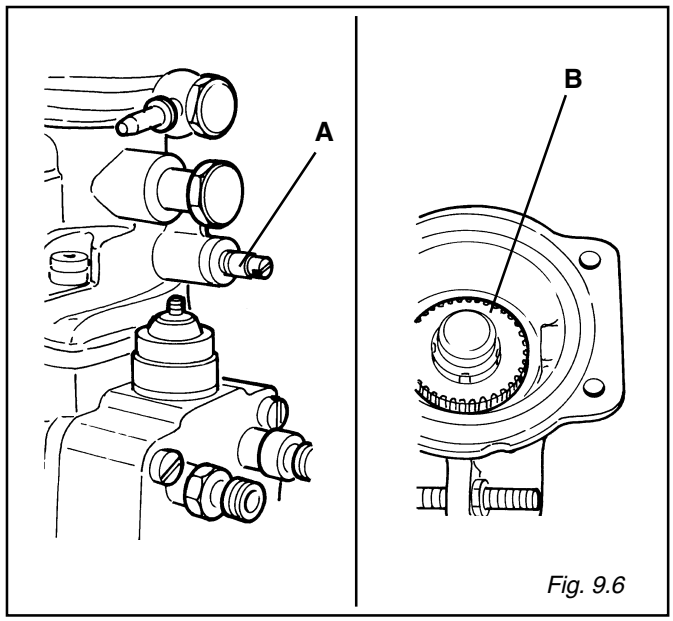

Fig. 9.6

Maximum permissible exhaust fume index under-load (Bosch scale).

Engine type	Fume index	Engine RPM
HR494HT2	3.5	1500 rpm
HR694HT2	3.0	1500 rpm
HR494HT3	1.2	1500 rpm
HR694HT3	2.3	1500 rpm
HR494HI3	1.5	1500 rpm

9.11 FUEL SUPPLY PUMP PRESSURE *(fig. 9.7)*

Install a pressure gauge before the injection pump inlet and check that the supply pressure is no less than **20** kPa (0.2 bar)(2.9 psi).

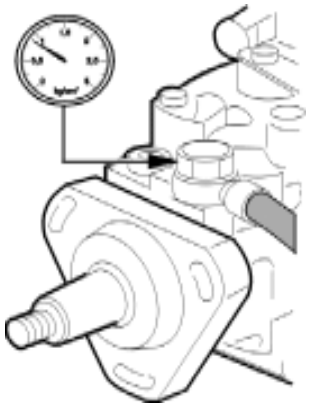
Fig. 9.7

9.12 ENGINE SUCTION PRESSURE

Check the suction pressure after the filter, before the inlet manifold. Maximum permissible suction pressure is:

oli filter **2.5** kPa (0.025 bar - 0.36 psi)

dry filter **1.5** kPa (0.015 bar - 0.21 psi).

9.13 OIL PRESSURE TEST *(FIG. 9.8)*

Test the oil pressure at the union provided on the crankcase. The oil should be at a temperature of 80° ÷ 90°C (176 ÷ 194°F).

Idle speed = 120 ÷ 160 kPa
(1.2 ÷ 1.6 bar)
(17.4 ÷ 23.2 psi)

Max under load = 350 ÷ 450 kPa
(3.5 ÷ 4.5 bar)
(50.7 ÷ 65.2 psi)

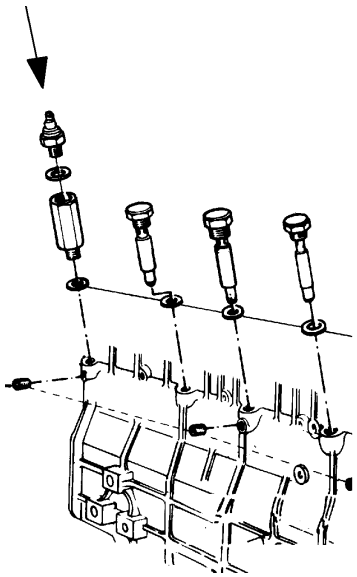

Fig. 9.8

9.14 COMPRESSION TEST *(FIG. 9.9)*

Check the pressure developed in each cylinder. Insufficient compression will cause power loss, increased fuel and oil consumption, exhaust fumes, difficult starting and partial seizure.

Test procedure

- To take away all the injctors.
- Clean the injector seat and install the compression tester.
- Zeroset the dial and crank the engine with the starter motor .
- Repeat the operation with the other pistons.
- Check the battery conditions.

  During the test the battery must be in the optimal condition, because in different case there are several possibility to do a wrong test.
- If low readings are obtained or if the difference among different cylinders exceeds **500** kPa (5 bar)(72.5 psi), check piston rings, valves, cylinder liners and pistons.

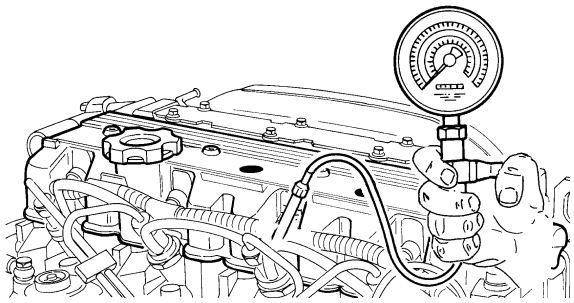

Fig. 9.9

9.15 TROUBLESHOOTING

PROBLEM	POSSIBLE CAUSES
FAILS TO START	A1 - A2 - A3 - A4 - A5 - A6 C1 - C2 - C3 - C4 - D3 - E1 - E3
STARTS THEN STOPS	A1 - A2 - A3 - A5 - D5 - E4 - E6 - E7
POOR ACCELERATION	A1 - A2 - A3 - A4 - A5 - D1 - D2 - D4
RUNS UNEVENLY	A4 - B2 - E4
BLACK SMOKE	A6 - D1 - D2 - D4 - E1 - E2
WHIT SMOKE	B2 - D5 - E1 - E2 - E7
OVERHEATS	B1 - B4 - B5 - D2 - D3 - D4 - D6 - E5
LOW OIL PRESSURE	B1 - B3 - B4 - B5 - B6 - B7 - E6
EXCESSIVE NOISE	A6 - E5 - E6 - E8
OIL PRESSURE TOO HIGH	B3 - B6
LACK OF POWER	A6 - A8 - D1 - E2 - E7

	PROBLEM	POSSIBLE CAUSES
FUEL SYSTEM	FUEL PUMP CLOGGED OR FAULTY	A1
	FUEL LINES CLOGGED	A2
	FUEL FILTER CLOGGED	A3
	INJECTION PUMP FAULTY	A4
	AIR IN FUEL SYSTEM	A5
	INJECTORS CLOGGED, DIRTY OR FAULTY	A6
	INJECTION PUMP ADJUSTMENT INCORRECT	A8
LUBRICATION SYSTEM	OIL PUMP	B1
	OIL LEVEL TOO HIGH	B2
	OIL PRESSURE RELIEF VALVE	B3
	OIL VISCOSITY TOO HIGH	B4
	OIL LEVEL TOO LOW	B5
	OIL PRESSURE REGULATOR VALVE FAULTY	B6
	PRESSURE GAUGE OR PRESSURE SENSOR FAULTY	B7
ELECT. SYST.	BATTERY DISCHARGED	C1
	INCORRECT OR LOOSE ELECTRICAL CONNECTIONS	C2
	STARTING SWITCH FAULTY	C3
	STARTER MOTOR FAULTY	C4
MAINTENANCE	AIR FILTER CLOGGED	D1
	EXCESSIVE LOAD	D2
	TIMING NOT SUFFICIENTLY ADVANCED	D4
	IDLE SPEED TOO LOW	D5
	COOLANT RADIATOR CLOGGED	D6
REPAIRS	PISTON RINGS STICKING	E1
	POOR VALVE SEATING	E2
	VALVE STICKING	E3
	REGULATOR SPRINGS FAULTY	E4
	FAN FAULTY	E5
	MAIN OR BIG-END BEARING SEIZED	E6
	CYLINDER LINERS WORN	E7
	VALVE CLEARANCES INCORRECT	E8

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APPLICATIONS

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10.1 USE AT LOW TEMPERATURE

(Fig. 10.1 - 10.2 - 10.3)

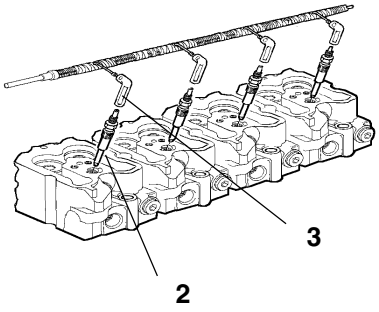
For ambient temperature below -20 °C:
it is available a fuel filter with heater.
For different requirements consult VM Motori s.p.a.
NOTE: at output 5 of the BOSCH 12 V power plant, don't apply loads over 1.2 W.
For higher loads use the screen represented in figure 10.3, that uses a BOSCH micro relay cod. 0 332 207 304.

Fig. 10.1

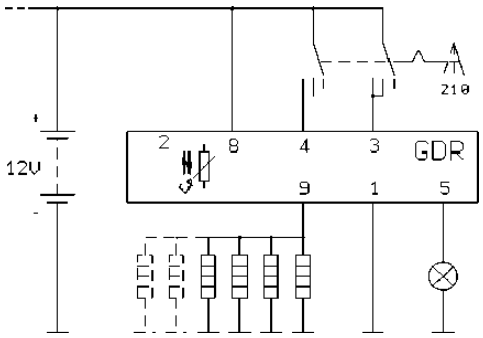
1	Control unit
2	Glow plugs
3	Conductor
S	Injection keyswitch
H	Glow plugs lamp
R	Glow plugs

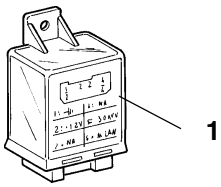
Fig. 10.2

G1	battery
S	injection keyswitch
F1-2	fuse
K	relay
CT	thermostat
R	resistor



Control unit
BOSCH 12V





Control unit
CIAM 42V

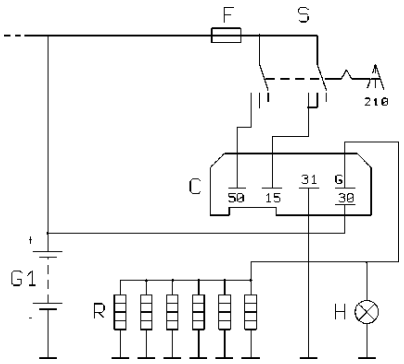
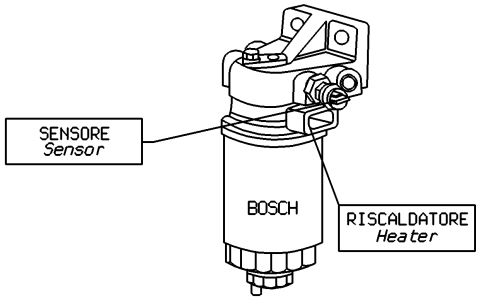


Fig. 10.1



CONNETTORI, TERMINALI E TENUTE NECESSARIE PER INTERFACCIARSI CON IL SENSORE E IL RISCALDATORE MARCA PACKARD.
Connector, terminals and seals needed to match their relevant seat on the sensor and the heater PACKARD MADE.

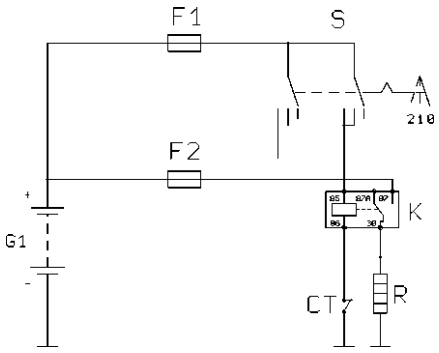


Fig. 10.2

(Fig. 10.3) **Application for power over 1.2 W with BOSCH control unit**

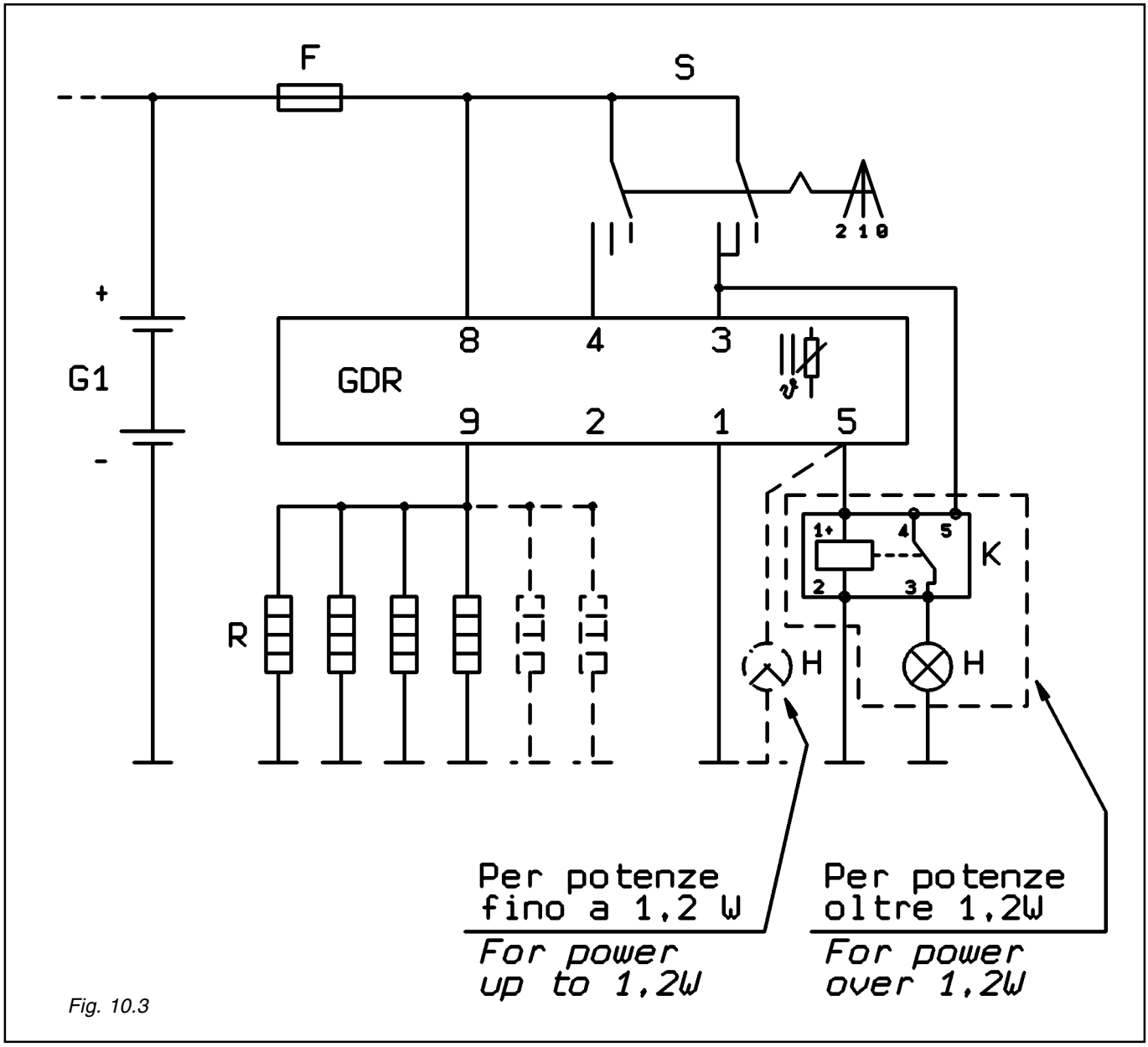


Fig. 10.3

SPECIAL TOOLS

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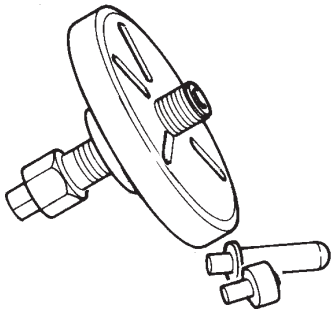
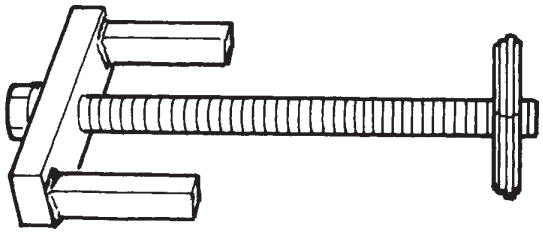
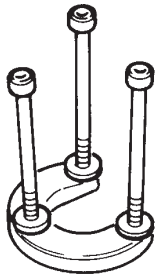
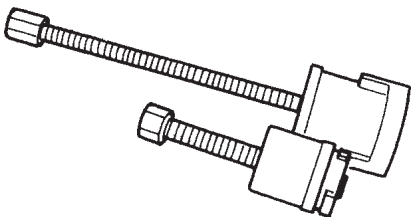
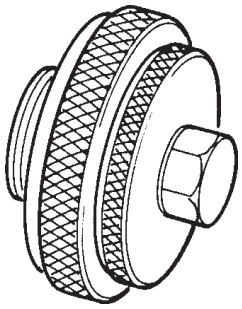
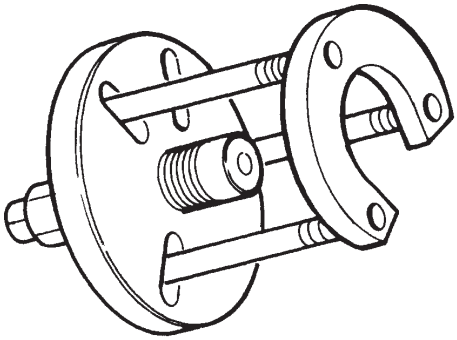
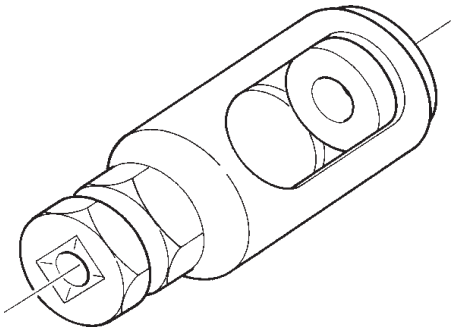
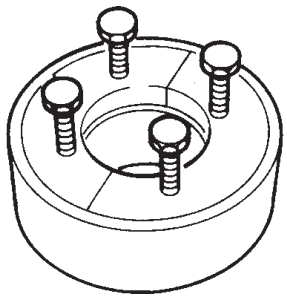
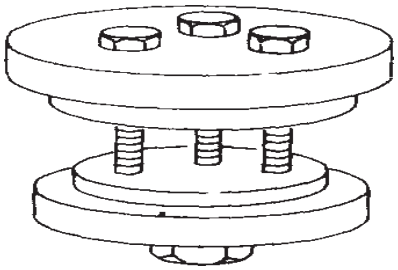
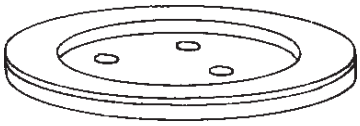
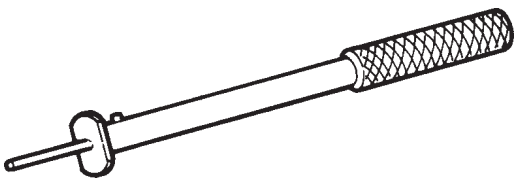
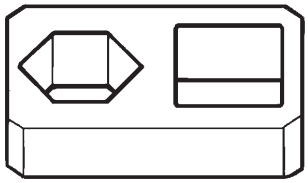
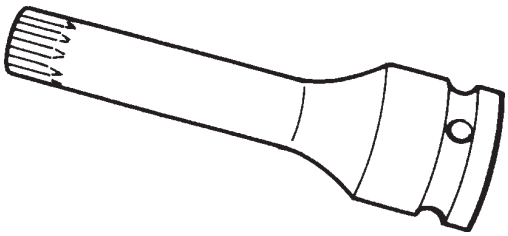
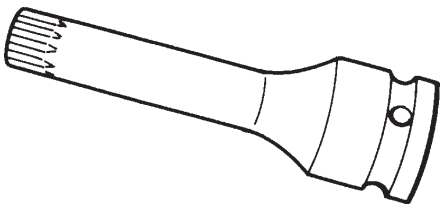
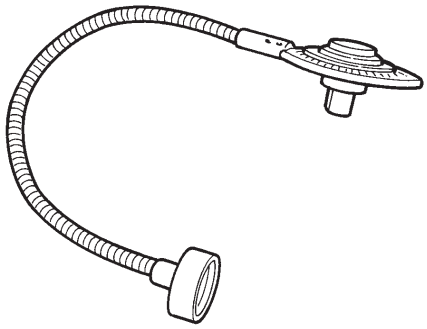
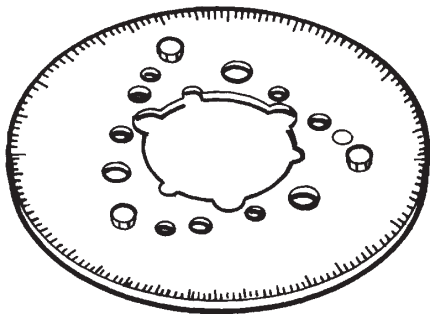
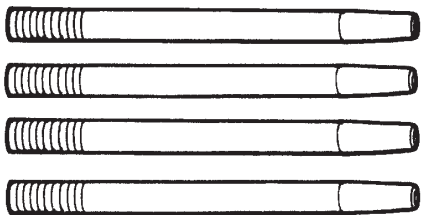
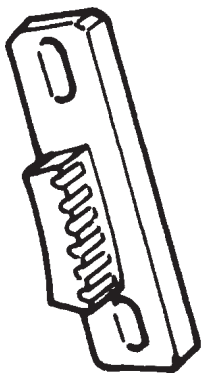
11.1 SPECIAL TOOLS

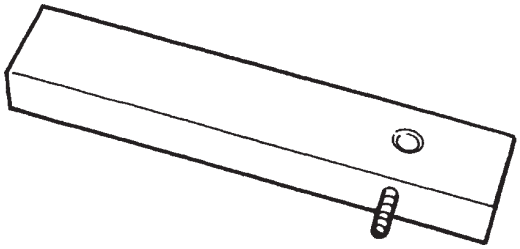
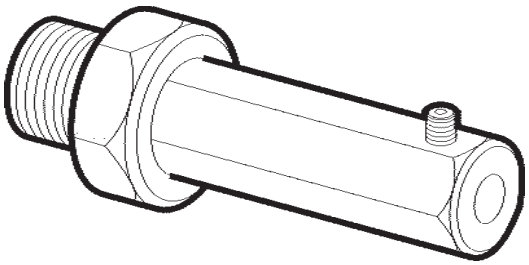
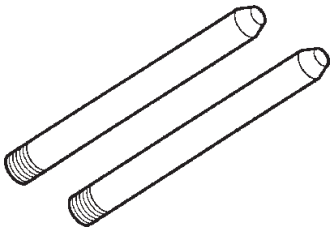
SPARE P.N.	DESIGNATION	TOOL
68400001B A	Pulley remover	
68400012A B	Cylinder liner extractor	
68400013B C	Crankshaft gear puller	
68400015A D	Cranckshaft and camshaft bearing remover/installer	

SPARE P.N.	DESIGNATION	TOOL
68400025A E	Injection pump extractor	
68400028A F	Cranckshaft gear puller complete with pulley extractor. (This tool comprises tools A+C)	
68400033F G	Injector assembly/disassembly	
68410006A H	Cranckshaft/gear cover assembly tool	

SPARE P.N.	DESIGNATION	TOOL
68410009F I	Timing cover oil seal assembly	
68410010F L	Rear seal assembling tool (with rear and bearing removed from the engine), diameter of rear main bearing journal 70 mm	
68410011F M	Rear seal assembling tool (with rear and bearing assembled on the engine), diameter of rear main bearing journal 70 mm	
68410012F N	Assembly/disassembly hydraulic tappets tool	

SPARE P.N.	DESIGNATION	TOOL
68420012A O	Offset tool for cylinder head tightening	
68420016F P	XZN wrench for cylinder head bolt (12 mm)	
68420017F Q	XZN wrench for cylinder head bolts	
68420015F R	XZN wrench for cylinder head bolts (14 mm)	

SPARE P.N.	DESIGNATION	TOOL
68420019F S	Angular torque wrench	
68450003A T	Graduated disc (timing check)	
68460003A U	Cylinder head assembly dowels	
68480003A V	Flywheel ring gear clamp	

SPARE P.N.	DESIGNATION	TOOL
68490007A W	Cylinder liner protusion gauge	
68490014F Z	Dial gauge mounting for Bosch injection pump timing	
68460005F AA	Two pins for flyweel assembly	

revision: 1 of 28.03.03

KEY TO DEFINITIONS

R/R = removal and re-installation
U.d.P. = unit of power

INTERPRETING THE CODE OF THE OPERATION

Cod. **3Z - EAA / 4**
The first code group identifies the operation performed (ex: **3Z** = replacement)
The second group separated by a dash, identifies the component (ex: **EAA** = camshaft)
The number after the slash, identifies the quality of components involved in the operation, this number can be omitted if there are no other similar components on the engine.

1°) exsample: **3Z - EAA**

replacement — camshaft

This type of code is used when there are no other similar components or multiple components on the engine.

2°) exsample: **10Z - OAA / 1** test function on **1** injector

or

10Z - OAA / 6 test function on **6** injectors

this type of code is used when there are other similar components or multiple components on the engine.

OPER. No.	ENGINE - REMOVE AND REINSTALL	CYL. No.	P/U	IND.	MAR.
14Z-AAA	**Remove and Reinstall engine:** of the application.			4.0	
3Z-AAA	**Replace Short Block Assembly:** With new or reconditioned assembly; does not include reconditioning of parts. Includes retorque cylinder heads and reset tappets.	4 6		11.0 11.5	

OPER. No.	ENGINE OVERHAUL	CYL. No.	P/U	IND.	MAR.
7Z-AAA	**Major Engine Overhaul:** – Steam clean and completely dismantle; clean all parts; flush all oil and water passages and replace plugs; check crankshaft for size and wear and inspect all parts. – Check the cylinder wear and if necessary replace them. – Replace, or renew where necessary, camshaft and auxiliary drive bushes, main and big end bearings and thrust washers. – Inspect and replace timing gears, as necessary. – Replace water pump, oil pump and turbocharger. – Overhaul turbocharge – Clean head and disassemble completely; inspect all parts and magnaflux head (Magnaflux crack detector); and Hydraulic test (pressure the cylinder head at ~2 bar (29 psi) dip it in a hot water +50-60°C (+122-140°F) for two minutes and check for air bubble.) Check longitudinal and horizontal warpage on head surface; replace valve guides or ream as needed. Grind valves and seats; replace valves and/or seats, as required. Check springs, keepers and retainers and replace as required. Lap valves and reassemble. – Test bench – Valve clerance adjustmente (this procedure has to be carried out for engine equipped with mechanical tappets.)	4 6		25.0 32.5	
8Z-AAA	**Partial engine overhaul:** – Steam clean parts and partial dismantle (cylinder heads and pistons). Clean the disassembled parts, replace plug (only if worn), check liners dimension and wear. – Hone cylinder liners and replace the compression rings. – Check or replace, valves, guide valves and seats grind – Inspect and replace timing gears, as necessary. Inspect and renew, as required water pump, oil pump and turbocharger. – Engine assembly following the procedure at chapter 7 (assembly) – Test bench – Valve clerance adjustmente (this procedure has to be carried out for engine equipped with mechanical tappets.)	4 6		10.0 12.0	
2I-AAA	**Oil consumption rectification:** – Remove cylinder head, lube oil pan and oil pump. – Remove all pistons and connecting rods. – Deglaze all cylinder bores. – Clean and check pistons for wear, renewing as necessary and replace all piston rings. – Check condition of oil pump and renew if necessary. – Reassemble all parts using new gaskets.	4 6		10.2 15.5	

OPER. No.	ENGINE OVERHAUL	CYL. No.	P/U	IND.	MAR.
8Z-DAA	**Top overhaul (cylinder heads and/or gaskets):** – Remove cylinder head(s) and gasket(s). – Remove all traces of jointing compound and old gasket. – Check cylinder head(s) and reseat valves. – Fit new gasket and replace head(s), Check atomisers and service as necessary. – Torque head and set valve clearance. – Run engine and check for leaks. – Retorque head(s) and reset tappets.	4 6		8.5 10.5	
8Z-KDA	**Additonal time for turbocharged units.** For use on specific operations listed below:	4 6	1.0 1.0		
3Z-ABA	**Cylinder Block - Replace:** – Steam clean complete engine, dismantle, clean and inspect all component parts. – Reassemble engine complete into new bare block with same or new pistons, using new rings main and big end bearings and thrust washers, gaskets and seals, and torque to specifications. – Run engine and check for leaks. – Retorque head and reset tappets.	4 6		11.0 16.5	
3Z-DAA	**Replace Cylinder Head/Gasket (Each):** – R&R and renew rocker arm assembly – R&R intake manifold – R&R exhaust manifold – R&R water manifold from heads – R&R rocker arm lubricating pipe – fit new gasket	4 6		4.5 6.0	
9Z-DAA	**Retorque cylinder head assembly and reset tappets (Mechanical tappets).**	4 6		1.0 1.2	
9Z-DAA	**Retorque cylinder head assembly - no reset tappets (Hydraulic tappets).**	4 6		0.6 0.8	
10Z.DGA	**Major Valve Job:** – Clean and disassemble head assembly. – Inspect all parts and renew or replace as necessary. – Reassemble head assembly.	4 6		1.1 1.5	

OPER. No.	BASIC ENGINE	CYL. No.	P/U	IND.	MAR.
3Z-DGG 3Z-DGF	**R&R valve guides (all):** Includes: R&R cylinder head.	4 6		7.5 9.0	
3Z-BAA	**R&R Crankshaft:** – R&R rear crankshaft seal. – R&R flywheel housing. – R&R oil pan and strainer. – R&R oil pump. – R&R vibration damper. – R&R thrust washers. – R&R timing gear cover. – R&R head. – R&R main bearings. – R&R pistons and connecting rods.	4 6		13.0 15.0	
3Z-MCE	**Replace Front Crankshaft Oil Seal:**	4 6		0.5 0.7	
3Z-BIG	**R&R rear crankshaft seal:**	4 6		0.7 0.7	
3Z-BOA 3Z-BHA 3Z-BIA	**Replace Main Bearings: (Replace All including rear and front)** – R&R oil pan and strainer.	4 6		12.5 14.5	
3Z-BIA	**Replace main rear bearing:** – R&R Flywheel housing.	4 6		1.0 1.0	
3Z-BOA	**Replace main front bearing:** – R&R Replace timing gear housing and gasket.	4 6		1.7 1.7	
3Z-QBB	**Replace small end bushing:** – R&R connecting rod.	4 6		7.7 10.2	
3Z-GEA	**Replace oil heat exchanger (modine type).**	4 6		0.5 0.5	

OPER. No.	BASIC ENGINE	CYL. No.	P/U	IND.	MAR.
3Z-QAA	**Replace main front bushing (one pair):** – R&R oil pan and strainer.	4 6		13.3 15.3	
3Z-QAD	**Replace main rear bushing:** – R&R flywheel housing.	4 6		0.9 0.9	
3Z-BLA	**Replace Crankshaft Pulley/Damper Assembly:**	4 6		0.3 0.3	
3Z-JAF	**Replace Fan Belt:**	4 6		0.3 0.3	
3Z-BFA	**Replace Flywheel Assembly:**	4 6		0.2 0.2	
3Z-BFE	**Replace starter ring gear:**	4 6		0.5 0.5	
3Z-MAA	**Replace Flywheel Housing:** – R&R flywheel assembly.	4 6		0.5 0.5	
3Z-BAF 3Z-BAG 3Z-EAC 3Z-BGL 3Z-PAC	**Replace timing gear assembly:** – R&R timing gear cover. (excluding camshaft on 4-6 cylinders).	4 6		1.7 1.7	
3Z-MCA	**Replace timing gear housing and gasket:** – R&R crankshaft pulley/damper.	4 6		0.7 0.7	
3Z-MCE	**Replace timing case cover oil seal:**	4 6		0.5 0.5	
3Z-HAA	**Replace Water Pump Assembly:**	4 6		0.5 0.5	
3Z-HAL	**Replace water pump pulley:**	4 6		0.2 0.2	

OPER. No.	BASIC ENGINE	CYL. No.	P/U	IND.	MAR.
3Z-PAC	**Replace fuel pump drive gear:** – R&R timing gear cover and gasket.	4 6		1.2 1.2	
3Z-BAF	**Replace crankshaft gear:** – R&R timing gear cover and gasket.	4 6		1.8 1.9	
3Z-CAA/1	**Replace One Piston and Connecting Rod:** – R&R Cylinder head and gaskets. – R&R oil pan and strainer.	4 6		6.5 9.0	
3Z-CAA/4 3Z-CAA/6	**Replace all pistons and connecting rods:** – R&R cylinder heads and gaskets. – R&R oil pan and strainer.	4 6		7.5 10.0	
3Z-CAD	**Replace piston rings on all pistons:** – R&R all pistons and connecting rods.	4 6		7.6 10.1	
3Z-AIA/4 3Z-AIA/6	**Replace all liners:** – R&R one connecting rod.	4 6		7.8 10.3	
3Z-AIA/1	**Replace one liner:** – R&R one connecting rod.	4 6		6.8 9.3	
3Z-EAA	**Replace camshaft assembly:** – R&R all push rods. – R&R timing gear assembly. – R&R timing gear cover and gasket. – R&R rocker arms. – R&R oil pan. – adjust valve clearance.	4 6		6.5 8.5	
3Z-EAF	**Replace camshaft oil seal (rear):** – R&R Flywheel housing.	4 6		0.7 0.7	
3Z-DFA/4 3Z-DFA/6	**Replace Rocker Shaft Assembly:** – Adjust all tappets.	4 6		1.5 1.8	

OPER. No.	BASIC ENGINE	CYL. No.	P/U	IND.	MAR.
3Z-DFA/1	**Replace Rocker arm assembly :(each)** – Adjust tappets.	4 6		0.5 0.5	
3Z-ECA	**Replace all pushrods:** – R&R rocker arm assemblies.	4 6		1.6 1.9	
3Z-EBB	**Replace all tappets (Hydraulic tappets):** – Replace Cylinder Head/Gasket.	4 6		5.0 6.5	
3Z-DGH/1 3Z-DGI/1	**Replace One Valve Spring Assembly:** – R&R valve cover and gasket.	4 6		0.8 0.8	
3Z-DGH/4/6 3Z-DGI/4/6	**Replace all valve spring assemblies:** – R&R valve cover and gasket.	4 6		2.0 2.5	
3Z-MHA	**Replace Valve Cover and Gasket:**	4 6		0.3 0.4	
3Z-KAA	**Replace Air Intake Manifold:**	4 6		0.4 0.6	
3Z-KDA	**Replace Turbocharger:**	4 6		0.6 0.6	
3Z-MBA	**Replace Oil Pan and Gasket**	4 6		0.4 0.5	
3Z-KBA	**Replace Exhaust Manifold:**	4 6		0.3 0.5	

OPER. No.	FUEL	CYL. No.	P/U	IND.	MAR.
3Z-OAA/1	**Replace One Injector Assembly:**	4 6		0.2 0.2	
3Z-OAA/4 3Z-OAA/6	**Replace all injector assemblies:**	4 6		0.8 1.0	
3Z-OAB/1	**Replace one nozzle assembly:**	4 6		0.3 0.3	
3Z-OAB/4 3Z-OAB/6	**Replace all nozzle assemblies:** – Test all nozzles.	4 6		0.4 0.6	
10Z-OAA/1	**Remove and test atomiser: (each)** – R&R high pressure fuel lines.	4 6		1.5 2.0	
10Z-OAA/4 10Z-OAA/6	**Remove and test all atomisers:** – R&R high pressure fuel lines.	4 6		2.5 3.0	
3Z-PAA	**Replace fuel injection pump assembly:** – Check fuel pump timing. – R&R high pressure lines.	4 6		2.0 2.0	
3Z-OFA	**Replace fuel lift pump:**	4 6		0.2 0.2	
10Z-PAA	**Check fuel pump timing:**	4 6		0.5 0.5	
12Z-OEL	**Bleed fuel system:**	4 6		0.1 0.1	
3Z-SGD	**Replace fuel pump stop solenoid:**	4 6		0.5 0.5	

OPER. No.	FUEL	CYL. No.	P/U	IND.	MAR.
3Z-OEC	Replace Fuel Filter Element:	4 6		0.2 0.2	
3Z-OCA	Replace High Pressure Fuel Line: (Each)	4 6		0.2 0.2	
3Z-OCA	Replace high pressure fuel lines: (all)	4 6		0.5 0.5	

OPER. No.	LUBRICATION	CYL. No.	P/U	IND.	MAR.
3Z-GAA	**Replace oil pump assembly:**	4 6		1.2 1.2	
3Z-GGA	**Replace oil pump relief valve:** – R&R oil pan and strainer.	4 6		0.6 0.7	
3Z-GAQ	**Replace rocker arm pipes assembly:**	4 6		0.5 0.6	
3Z-GID	**Replace oil breather assembly:**	4 6		0.2 0.2	
3Z-GBA	**Replace Oil Filter Element:**	4 6		0.2 0.2	
3Z-GAO	**Replace oil pickup tube and screen:**	4 6		0.6 0.7	

OPER. No.	COOLING	CYL. No.	P/U	IND.	MAR.
3Z-IAA	Replace Radiator Fan:	4 6		0.5 0.5	
3Z-HDA	Replace Thermostat Assembly:	4 6		0.1 0.1	
3Z-HHA	Replace Radiator Assembly:	4 6		1.0 1.0	

OPER. No.	ELECTRICAL AND INSTRUMENT	CYL. No.	P/U	IND.	MAR.
3Z-SEA	**Replace Alternator:**	4 6		0.3 0.3	
3Z-SEF	**Replace Current Voltage Regulator:**	4 6		0.4 0.4	
3Z-SGA	**Replace Starter Motor Assembly:**	4 6		0.3 0.3	
3Z-SGD	**Replace starter solenoid assembly:**	4 6		0.2 0.2	
3Z-SAA	**Replace Wiring Harness:**	4 6		1.0 1.0	